THE UNIVERSITY OF CALGARY

Territoriality in Collaborative Tabletop Workspaces

by

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A DISSERTATION

SUBMITTED TO THE FACULTY OF GRADUATUE STUDIES

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE

DEGREE OF DOCTOR OF PHILOSOPHY

DEPARTMENT OF COMPUTER SCIENCE

CALGARY, ALBERTA

MARCH, 2005

UNIVERSITY OF CALGARY

FACULTY OF GRADUATE STUDIES

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Abstract

Traditional tables have long been the preferred work environment for many co-located collaboration tasks such as planning, scheduling, brainstorming, design and layout activities. However, as computers become pervasive in corporate and educational settings, access to digital information is becoming more important during collaboration. Consequently, researchers have begun exploring tabletop display systems in order to facilitate access to digital media during tabletop collaboration. However, there are many open issues related to the design of collaborative tabletop interfaces, such as whether these systems should automatically orient workspace items or enforce ownership of workspace content.

Understanding the natural work practices that people use during tabletop collaboration with traditional media (e.g., pen and paper) can help address these issues. Interfaces that are modeled on these practices will have the additional advantage of supporting the interaction skills people have developed over years of collaborating at traditional tables. To gain a deeper understanding of these work practices this dissertation builds on previous studies of traditional tabletop collaboration and gains new insights through two new observational studies. These investigations indicate that the use of territorial behaviour on a tabletop workspace provides important benefits for collaborators' task and group interactions.

The practice of tabletop territoriality was further investigated through in-depth analyses of the workspace interactions that occurred in the observational studies. The findings from these analyses reveal that collaborators tend to establish three types of tabletop territories when sharing a tabletop workspace: *personal*, *group*, and *storage* territories. These tabletop territories facilitate collaborative interactions on a table by providing commonly understood social protocols that help people organize and share the tabletop workspace. These social protocols help clarify which workspace regions should be used for joint task work, for assisting others, for independent activities, and

for storing task resources. They also provide lightweight mechanisms to reserve and share task resources.

The insights gained from this investigation led to the development of a set of design recommendations for collaborative digital tabletop workspaces. These recommendations were then successfully applied to the development of a digital tabletop workspace that supports the practice of tabletop territoriality and collaboration.

Publications from this dissertation

Material, ideas, figures, and tables from this dissertation have appeared previously in the following peer-reviewed publications. The following list show long papers and short papers. After each paper, the chapters from which the material is used are noted.

Scott, S.D., Carpendale, M.S.T, Habelski, S. (in press). Storage Bins: Mobile Storage for Collaborative Tabletop Displays. *IEEE Computer Graphics and Applications: Special Issue on Large Displays* (accepted March 18, 2005). (Chapter 6).

Scott, S.D., Carpendale, M.S.T, & Inkpen, K.M. (2004). Territoriality in Collaborative Tabletop Workspaces. In *Proceedings of CSCW'04: ACM Conference on Computer-Supported Cooperative Work*, November 6-10, 2004, Chicago, IL, USA, pp. 294-303. (Chapters 3, 4, 5)

Scott, S.D. (2003). Territory-Based Interaction Techniques for Tabletop Collaboration. Doctoral Symposium Presentation. In *Conference Supplement of UIST'03: ACM Symposium on User Interface Software and Technology*, November 2-5, 2003, pp. 17-20. (Chapters 3, 4, 5)

Scott, S.D., Grant, K.D., & Mandryk, R.L. (2003). System Guidelines for Co-located, Collaborative Work on a Tabletop Display. In *Proceedings of ECSCW'03: European Conference Computer-Supported Cooperative Work*, September 14-18, 2003, Helsinki, Finland, pp. 159-178. (Chapter 2)

Technical acknowledgements

The tabletop groupware introduced in Chapter 6 was developed in collaboration with several others. It is often impossible to state the exact amount of each person's contribution or the exact evolution of the design. However, the following notes provide some indication of involvement for the various components of the test-bed groupware environment and the casual storage mechanisms that were used in this research.

1. Early versions of the tabletop groupware test-bed environment were built by me. in collaboration with Sheelagh Carpendale. This version included basic functionality for interacting with OpenGL visual components and simple, in-context marking-style menus. This test-bed environment was then evolved by Uta Hinrichs for a related project[1]. This environment was then further developed by myself and Stefan Habelski for the purposes of evaluating the casual storage mechanisms. My involvement was largely on the interaction design side, while Stefan implemented much of the later developments – including the integration and extension of Russell Kruger's RNT interaction technique (Kruger et al., 2005) into the test-bed environment.

2. Early versions of territory-based interface components were designed in collaboration with Sheelagh Carpendale and built by me, including primitive versions of a casual storage mechanism. The concepts and experiences from these versions were used to develop the two casual storage mechanisms described in Chapter 6 in collaboration with Stefan Habelski. The flexible boundary container component was originally implemented by Uta Hinrichs (for a related project[1]) and we evolved this container into the current version of storage bins.

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[1] Hinrichs, U., Carpendale, S., & Scott, S.D. (2005). Interface Currents: Supporting Co-Located Collaborative Work on Tabletop Displays. Technical Report 2005-773-04. Department of Computer Science, University of Calgary. Calgary, AB, Canada.

Acknowledgements

The completion of this dissertation has been a long journey, with many important people advising me and supporting me along the way. I am deeply grateful to so many people, too many to name here, yet I will try my best to thank those that have made the most profound impact on this research project and to me personally as I have endeavoured to complete it.

First, I thank my supervisors, Drs. Kori Inkpen and Sheelagh Carpendale, for their advice, mentorship, and friendship. I would like to thank Kori for introducing me to HCI and CSCW. I am grateful for her continued encouragement and belief in me – and for knowing that I could do a Ph.D. long before I did. I am grateful to Sheelagh for welcoming me to Calgary midstream and helping guide my thesis in new and exciting directions. I really appreciate the different perspectives that Kori and Sheelagh both have and I hope to enjoy many years of continued work with them.

I would also like to extend special thanks to Dr. Saul Greenberg, the final member of my committee. It was a pleasure to work with Saul. He brought yet another perspective to the table and encouraged me to consider new aspects of my research, which helped shape and improve the final results. Thanks also to my Thesis Examiners Drs. Mike Chiasson and Tom Rodden for providing insightful comments on my work.

I am also grateful to my funding sources, which have allowed me to focus my time and efforts on this research: Alberta Ingenuity, Alberta's Informatics Circle of Research Excellence (iCore), Natural Science and Engineering Research Council of Canada (NSERC), University of Calgary, Motorola and the Province of British Columbia, Pacific Metals/Leon Lotzar, Hugo Eppich, Bel Construction Ltd., and Simon Fraser University.

I would also like to thank all the research colleagues I have had the pleasure of working with, from my beginnings at the EDGE Lab at SFU, to the newly formed

EDGE Lab at Dalhousie, and finally to the Interactions Lab at U of Calgary. Each of these research communities has contributed to my professional and personal growth in so many ways. I would also like to acknowledge several people who have gone above and beyond for me during this time. To my former office-partner, lab mate and friend, Regan Mandryk: she inspires me in so many ways, I cannot wait to call her Doctor too! To the full- and part-time table researchers at iLab, Russell Kruger, Uta Hinrichs, Stefan Habelski, Edward Tse, and Ryan Schmidt: they have all left their mark on me and my research and I am truly grateful. I would like to thank Dr. Michael Boyle, who, along with being a technical genius, was also so very generous with his time. I would also like to say a special thanks to Stephanie Smale, who has added so much to my life over the past year in Calgary and will make leaving all that much harder.

This dissertation would never have been completed without the continued support of my family and friends. They have provided unwavering encouragement throughout this process. Thanks to my parents, Sandy and Bill, for instilling in me a belief that I could do anything I set my mind to and for the many pep talks during the times when I was feeling discouraged. I would especially like to thank them for understanding that this degree was important enough to keep me so far away for so long. Thanks also to my Aunt Margaret for being so supportive over the years.

Thanks to my wonderful, talented, and loving sister, Shannon, for the visits, care calls, and beautiful 'thinking of you' cards. Your support has meant the world to me from the beginning to the end of this degree. Thanks also to my brother-in-law, Sean, who has become such a wonderful friend. Now I come to the honorary member of the Scott family, my cherished friend Tracy. I could not have asked for a more wonderfully persistent friend, who always knew when I needed a care call or a chocolate bar in the mail! I am grateful for her continued support, both personally and professionally.

Finally, I am also grateful to my new family, Bob, Jenny, and Stuart Histon. I truly value their understanding and support over the last few years, especially at the end when the thesis writing was so all consuming.

Dedication

I owe thanks most of all to my wonderful friend and partner, Jonathan Histon. You moved to Calgary for me. You understood when I wanted to do 'one last piece of research', even when it was keeping us apart. You stayed up countless nights to 'walk me home' after many, many late night writing sessions. You sent me flowers when I was having a bad day. You left me secret notes. You brought me roses, just because. You pushed me when I needed it. You backed off when I needed it. You gave up endless hours of your time proof-reading chapters of this thesis. And, you always knew when and how to make me laugh! Your constant love and support kept me sane. For all this and more, I dedicate this dissertation to you.

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Chapter 1.   Introduction

Traditional tables have long been the preferred work environment for many collaboration tasks such as planning, scheduling, brainstorming, design and layout activities (see Figure 1). However, as computers become pervasive in corporate and educational settings, access to digital information is becoming more important during collaboration. Consequently, researchers have begun exploring tabletop display systems in order to facilitate access to digital media during tabletop collaboration. The concept of a tabletop display was first introduced by Wellner (1991; 1993) over a decade ago with his Digital Desk system. Recent technological advances have increased the feasibility of tabletop displays and have fuelled renewed interest in this research direction (e.g., Rekimoto & Saitoh, 1999; Shen et al., 2002; Streitz et al., 1999).
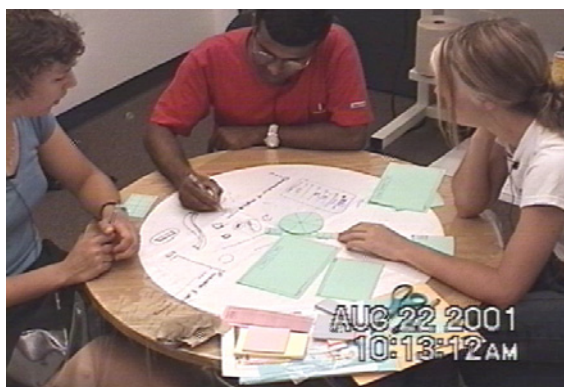
(a)   **(b)**[2]

Figure 1. Typical tabletop collaboration activities.

As of yet, there is no standard configuration for tabletop systems. Researchers investigating software interface issues for tabletop displays are often required to design and build their own system. Many researchers have used simple prototypes that top-project a computer display onto a traditional table (e.g., Patten et al., 2001; Shen et al.,

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[2] © Balmoral Hall School, used with permission.

2002). Others have constructed more elaborate systems involving rear-projected tabletop displays (e.g., Cutler et al., 1997; Ullmer & Ishii, 1997) and self-illuminating displays (e.g., Streitz et al., 2002; Ståhl et al, 2002) on custom-built tables. These systems also use a wide variety of input devices, such as mice (e.g., Scott, et al., 2002; Kruger & Carpendale, 2002), direct touch (e.g., Streitz et al., 2002; Ståhl et al, 2002), and tracked physical objects (e.g., Ullmer & Ishii, 1997; Patten et al., 2001). Figure 2 illustrates a variety of past and present tabletop displays.
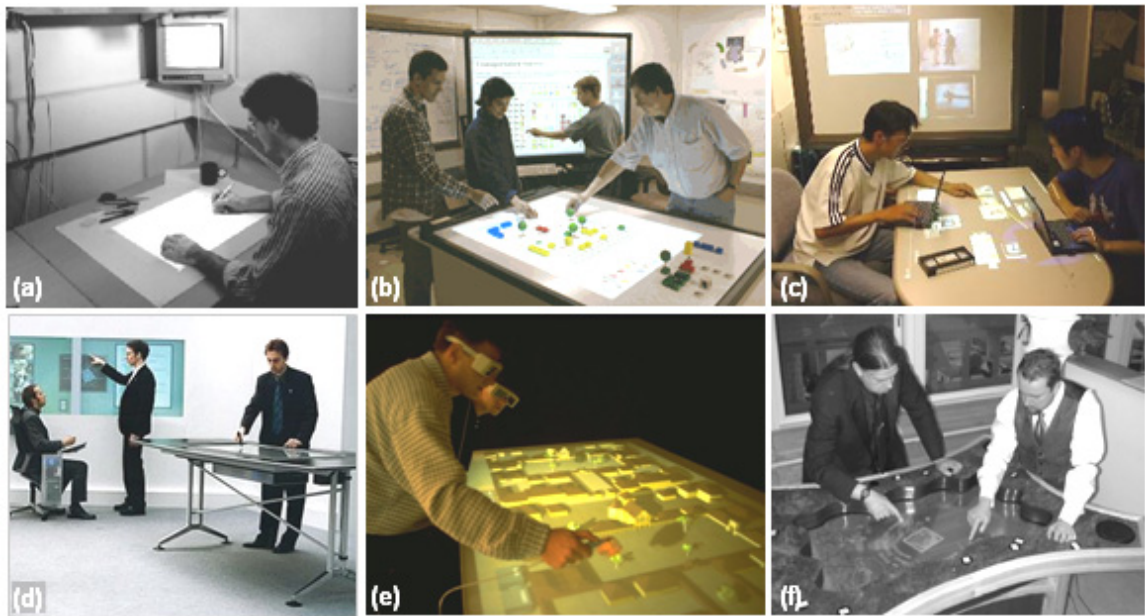
Figure 2. Examples of six tabletop systems: (a) the DigitalDesk (from Wellner, 1993); (b) Envisionment and Discovery Collaboratory (from Arias et al., 1999); (c) the Augmented Surfaces tabletop (from Rekimoto & Saitoh, 1999); (d) the InteracTable (from Streitz et al., 2002); (e) the Responsive Workbench (from Agrawala et al., 1997); and (f) the Pond (from Ståhl et al., 2002).

Constructing a tabletop display is only the first step toward providing interactive support for collaborative tasks. Standard software interfaces are not well suited to large-screen tabletop displays. For example, these interfaces often place frequently accessed items such as the 'start' bar, at a display's edge. This type of positioning can result in these items being physically difficult to reach, especially for people situated across the table. While increasing the size of the display surface offers more space for collaborative tasks, it exacerbates difficulties with reach. Furthermore, altering the display by placing it horizontally onto a tabletop introduces orientation issues because people can approach the display from different sides. Textual information can be difficult to read when

viewed upside down or at an angle, and the state of standard interface components can become ambiguous when viewed from different angles. For example, the same

Figure 3. State ambiguity is introduced by viewing a button from opposite sides of a tabletop display.

button can look ready to press when viewed right way up, and look depressed when viewed upside-down (Figure 3).

These difficulties represent a fundamental challenge to the transfer of standard digital interaction components directly to collaborative tabletop interfaces. In order to create effective collaborative tabletop systems, tabletop interface developers must have access to more appropriate basic system components. These new components would be the tabletop equivalent to standard interface components that are available to desktop application developers, such as buttons, menu bars, and dialog boxes.

When designing the fundamental components of any interactive system, we must return to the basic principle that the system should enable the activities (i.e. tasks and goals) that the users wish to perform, in a way (i.e. using known skills and processes) that they wish to perform them (Dix et al., 1998; Landauer, 1988). Therefore, redesigning the interface and interactions for a tabletop display requires an understanding of *what* activities people will perform in that environment and *how* they wish to perform them. Given the considerable experience people have using traditional tables for collaborative activities, it is likely they have established certain habitual ways of working with and sharing items in a tabletop workspace that are commonly understood and expected by others. Just as sharing a verbal language can help people communicate with each other, a shared understanding of ways to share task resources and the workspace can help people collaborate more effectively. For the purposes of this dissertation, these ways of work will be referred to as work practices. The overarching goals of this dissertation are to investigate *what* work practices might exist and *how* they are used during traditional tabletop collaboration and to apply this knowledge to the development of more suitable collaborative tabletop display technology.

This dissertation presents a general investigation of collaborative tabletop work practices and then focuses on one particular work practice, that of establishing tabletop territories in a shared tabletop workspace. I approach this research as a computer scientist and an interface designer. Thus, I am interested in understanding these tabletop work practices for the purpose of informing interface and interaction design. My goals are to show that careful investigation of traditional work practices can identify core actions and interactions that are essential to the collaboration process and to show that an understanding of these actions and interactions can lead to more suitable interface components and interaction techniques for collaborative tabletop systems.

The remainder of this chapter discusses the scope and overall research context of this dissertation, introduces the concept of territoriality, describes the problem and goals of the research in more detail, explains the methodological approach used in this research, and provides an overview of the remaining chapters in the dissertation.

1.1 Background and Research Context

This dissertation falls under the general research field of human-computer interaction (HCI). HCI is concerned with studying humans interacting with computer technology, including the social impacts of technology, and improving technology design to better support such human activities as work, education, or entertainment (e.g., Dix et al., 1998; Carroll, 2002). Within HCI, several research areas focus specifically on the use of computers to support collaborative activities, including computer-supported cooperative work (CSCW) (e.g., Greenberg, 1991; Baecker, 1993) and computer-supported collaborative learning (CSCL) (e.g., Koschmann, 1996; Hiltz, 1988). Since tabletop collaboration occurs in many domains, including work, home, and school, this research falls under the general study of computer-supported collaboration, which encompasses both CSCW and CSCL. More specifically, this research explores situations in which small groups of people (e.g., two-six people) are collaborating around a tabletop workspace while physically present in the same room (i.e., while co-located). Figure 4 illustrates the research context of this dissertation.

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┌─────────────────────────────────────────────────────┐
│  Human-Computer Interaction                          │
│   ┌───────────────────────────────────────────────┐ │
│   │  Computer-Supported Collaboration             │ │
│   │   ┌─────────────────────────────────────────┐ │ │
│   │   │  Co-located Groupware                   │ │ │
│   │   │   ┌───────────────────────────────────┐ │ │ │
│   │   │   │  Small groups                     │ │ │ │
│   │   │   │   ┌─────────────────────────────┐ │ │ │ │
│   │   │   │   │  Tabletop Displays          │ │ │ │ │
│   │   │   │   └─────────────────────────────┘ │ │ │ │
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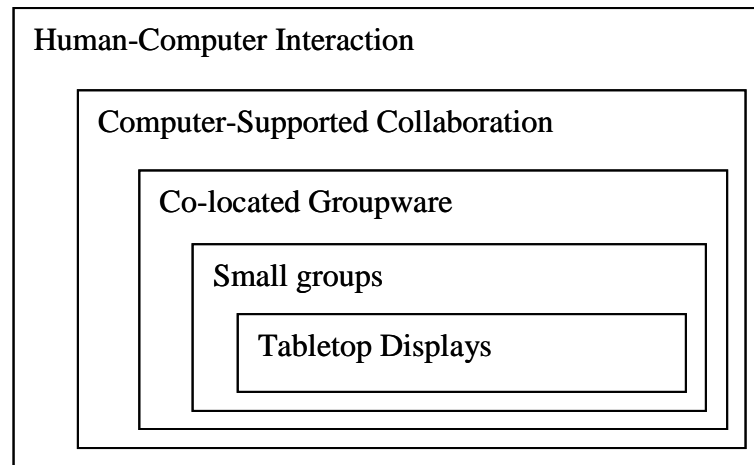
Figure 4. Research Context

In order to manage the complexity of the social dynamics during the collaborations under study, only peer collaborators were investigated in this research. Group members recruited for this research had similar social positions (e.g., all students), had equivalent assigned roles, and had equal access to information and materials during the collaborative sessions. Real world examples of such collaboration include students working together on a group assignment and a sub-committee of city councilors discussing a proposed community development plan from a local housing developer. While many of the actions and interactions may be the same in other social contexts, introducing power relationships or inequalities, such as competition among group members, may introduce differences that can affect the collaborative processes in each of these different contexts. Although there are often minor differences implied in the terms group, team, and collaborators, in this dissertation, these terms will be used interchangeably to refer to a number of peers gathered together for a period of time to perform joint work.

Co-located collaboration research has concentrated on supporting teamwork using digital information on shared desktop computers (e.g., Bier & Freeman, 1991; Stewart et al., 1999; Bricker et al., 1999; Scott et al., 2003), on electronic whiteboards (e.g., Myers et al., 1998; Tatar et al., 1991; Streitz et al., 2002), and on tabletop displays (e.g., Rekimoto & Saitoh, 1999; Deitz & Leigh, 2001). As shown in Figure 2, there have been a number of approaches to displaying and interacting with digital media in a

tabletop workspace. A brief overview of these approaches is presented next, with a discussion of some of their advantages and disadvantages. In order to set the scope of this research, the discussion ends by clarifying the type of tabletop systems that are the main focus of this research.

Tabletop systems that make use of tangible user interfaces (TUIs), such as the systems shown in Figures 2b and 2c, provide natural interactions by allowing people to interact with familiar physical objects such as blocks or bricks (Rauterberg et al., 1997; Fitzmaurice et al., 1999; Patten et al., 2001), architectural/urban planning models (e.g., Underkoffler & Ishii, 1999; Arias et al., 1999), and tagged textbooks (Koike et al., 2000). However, there are many unresolved issues surrounding TUIs such as providing appropriate mappings between object form and digital meaning, introducing possible clutter of physical objects if one-to-one mappings are used, and providing appropriate access to meta-functionality in applications that are difficult to represent physically (Underkoffler & Ishii, 1999).

Researchers have also explored augmented reality (see Figure 2e) and fully-immersed, virtual reality tabletop display systems. These systems enable users to view and interact with three-dimensional models and environments, which can be extremely useful for such tasks as exploring or modifying three-dimensional product designs (e.g., Buxton et al., 2000) or in training simulations for medical practice (e.g., Agrawala et al., 1997; Cutler et al., 1997). However, in order to view the digital information in these systems people must wear head-mounted displays (as shown in Figure 2e). In a collaborative environment, such headgear may hinder collaboration because important non-verbal communication cues such as gaze and eye-contact are often fully or partially obscured. Moreover, collaborators often have different views of the environment. These factors can interfere with essential communication tools such as gesturing and deictic references (e.g., pointing to an object when verbally referring to it) (Bekker et al., 1995; Bly, 1988; Gutwin et al., 1996).

Due to the limitations of TUIs and virtual and augmented reality tabletop workspaces, this research focuses on interface and interaction design for two

Figure 5. Two-dimensional digital tabletop display.

dimensional digital tabletop workspaces, such as the digital tabletop system pictured in Figures 2d, 2f, and 5. These tabletop systems provide collaborators with a relatively large, shared horizontal digital display area, in which people can interact directly with the table surface via fingers or a pen-type input device. Henceforth in the dissertation the phrases tabletop system, tabletop display, or digital tabletop workspace will all refer to this type of technology, unless otherwise specified.

Since there are currently no off-the-shelf tabletop displays available, most existing tabletop displays have been prototypes with basic interfaces and limited functionality (e.g., Ståhl et al., 2002; Streitz et al., 1999; Shen et al., 2002). As the development of tabletop systems becomes easier through advances in multi-user touch surfaces (e.g., DiamondTouch (Deitz and Leigh, 2001), SmartSkin (Rekimoto, 2002), and the DViT SMARTBoard™ (www.smarttech.com)) and in software toolkits for developing tabletop groupware interfaces (e.g. DiamondSpin (Shen et al., 2004) and DiamondTouch Toolkit (Diaz-Marino et al., 2003)), more complex tabletop interfaces are just beginning to appear. As these technological advancements are relatively recent, there are few

comparative studies of either the software or hardware interfaces for existing tabletop systems. Moreover, many of these systems are either proprietary or have been built for research purposes on specific hardware and software platforms and, thus, are difficult to compare. Furthermore, while these tabletop systems are improving, they still do not support fluid interaction with digital media for complex collaboration activities.

When distributed groupware researchers were faced with similar technological challenges in the early stages of developing graphical distributed groupware applications, such as shared remote whiteboard applications, this community performed a number of observational studies of groups working in traditional collaborative environments to help understand what type of functionality and interaction design would be appropriate for these new groupware applications (e.g., Bly, 1988; Tang, 1991; Bekker et al., 1995; Coiera, 1996; Gutwin et al., 1996). Several of these investigations involved observational studies of collaboration on traditional tables (Bly, 1988; Tang, 1991; Gutwin et al., 1996). Although these studies were performed for the purposes of informing the design of distributed shared workspaces, the descriptions of these studies report many important tabletop collaboration practices that are also valuable for the design of digital tabletop systems. For example, this research has revealed that people often interact concurrently in the workspace and that they often transition between working closely together and working independently in the workspace (e.g., Tang, 1991; Gutwin et al., 1996). However, the data reported from these investigations, as true of any observational research, have been filtered for the distinct purpose being investigated (Maxwell, 1996).

As a means to inform distributed groupware design, reports of these investigations contain only a subset of the activities and behaviours that occurred during the collaborative sessions and, thus, lack sufficient details about the interaction subtleties important for the design of tabletop groupware interfaces. For instance, Tang's (1991) investigation of tabletop work practices identified partitioning as key resource for mediating group interactions. However, he did not detail how or why partitioning facilitates collaboration, and these details may impact the design of systems developed to support this work practice. This dissertation addresses this issue by conducting new

observational studies designed to investigate collaborators' spatial interactions on traditional tables specifically for the purpose of informing tabletop system design.

These new observational studies reveal that partitioning is part of a more complex practice of establishing *tabletop territories* on a tabletop workspace, which is part of the broader human behavioural practice of establishing *territories* in our physical environments. Taylor (1988) defines human territoriality as:

> "An interlocking system of attitudes, sentiments, and behaviors that are specific to a particular, usually delimited, site or location, which, in the context of individuals, or a small group as a whole, reflect and reinforce, for those individuals or group some degree of excludability of use, responsibility for, and control over activities in these specific sites." (p. 81).

Taylor further specifies that territories "range in size from chairs, seats, or sides of a table, to street blocks" (Taylor 1988, p. 89). There is little debate about the fact that people are territorial, or that this behaviour helps to mediate people's social interactions (e.g., Altman, 1975; Edney, 1976; Sack, 1986; Taylor, 1988); however, there are varying theories about precisely how territories are socially established. For example, Altman (1975) claims that a territory is established through laying claim to a space, while Edney (1976) claims that territories are created through the association of a space to a person due to repeated use or the passage of time. However, since the purpose of this research is to inform interface and interaction design, it will be directed towards developing an understanding of the processes and work practices in use rather than then underlying sociological and psychological issues. It is these processes and work practices that this research endeavours to support through the design of suitable tabletop groupware interfaces and interaction techniques. The precise moment at which people socially attribute an area as 'a territory' is an intellectual debate left for the social scientists.

1.2 Problem Statement and Research Hypothesis

The problem addressed by this dissertation is that collaboration is currently not well supported by digital tabletop systems. Current software interfaces do not effectively support collaborative work at a tabletop display, at least in part because standard interface components are not appropriate for large, horizontal displays. Therefore, the

fundamental components of tabletop groupware interfaces need to be redesigned. At this early stage in the redesign process, though, a better understanding of the low-level actions and interactions is needed in order to create effective higher-level tabletop applications. That is, the interface components and interaction techniques that will provide the basic building blocks for tabletop groupware designers must first be developed – similar to interface components such as buttons, sliders, and drop-down menus used in standard desktop applications – before effective tabletop groupware systems can be developed.

As yet, there are few investigations of people's basic interactions on collaborative tabletop systems to help inform the redesign process. Furthermore, technical limitations of existing tabletop systems may in fact hinder the actions and interactions that people wish to perform or the manner in which they would perform these actions. People are known to adapt their behaviour when provided with less than ideal tools, often developing 'work-arounds' when technology does not suit their task needs (Luff et al., 1992). In contrast, previous research has shown that traditional tables provide a rich, unrestricted interaction environment, in which people have considerable experience collaborating with paper-based media (e.g., Bly, 1988; Tang, 1991; Gutwin et al., 1996).

It is quite likely that the actions and interactions that facilitate successful collaboration in these environments are not restricted to the use of paper-based media. Based on this supposition, the central research hypothesis of this dissertation is that *studying how people manipulate and share paper media on a table can be used to develop collaborative tabletop technology that enables dynamic interactions with digital media and facilitates effective co-located collaboration.* Studying collaboration on traditional tables, of course, has limitations for understanding how people will wish to interact in a digital tabletop workspace, yet such studies should provide a valuable first step in the redesign process.

1.3 Research Goals

The research hypothesis will be addressed through the following research activities: a general investigation of traditional tabletop work practices based on the literature and

several exploratory studies; a focused investigation of a specific work practice – tabletop territoriality – to help articulate and operationalize the essential components of this practice; the development of recommendations for the design of tabletop workspaces grounded in an understanding of this work practice; and the development and evaluation of a specific tabletop interface component that supports tabletop territoriality. These activities define the four research goals of this dissertation.

Goal 1. **To identify work practices that facilitate task and group interactions during traditional tabletop collaboration.** In order to achieve this goal, I conducted a literature review on tabletop workspace behaviour patterns from the relevant computer science and social-psychological fields. I focused on the behaviours that people use to manipulate and share paper-based media on a table while working in small groups in a co-located environment. I also conducted two exploratory observational studies of traditional tabletop collaboration involving paper-based media to provide further insight into tabletop work practices.

Goal 2. **To select one specific work practice and investigate this practice in detail in order to inform digital tabletop system design.** In order to achieve this goal, I conducted detailed analyses of the field notes and video data collected for the studies in Goal 1, focusing on the work practice of tabletop territoriality. This work practice was investigated because it appeared to facilitate task and group interactions on traditional tables; thus, it offered potential for identifying factors which would influence effective sharing of a digital tabletop workspace.

Goal 3. **To develop a set of design recommendations for digital tabletop workspaces that will support the investigated work practice.** Based on the implications arising from the analyses performed for Goal 2, I developed a set of design recommendations for digital tabletop workspaces. These recommendations provide guidance for the design of tabletop groupware interfaces and of the physical tabletop display. I also provide specific examples of how to apply these recommendations to the design of tabletop interfaces and interactions.

Goal 4. **To apply the design recommendations to the development and evaluation of a digital tabletop workspace that supports the investigated work practice.** Based on the design recommendations developed in Goal 3, I developed a tabletop groupware interface component that facilitates organizing and sharing digital media during collaboration. I also conducted an exploratory evaluation that examined the general usability of the interface component and shed light on its ability to support tabletop territoriality and collaboration in general.

1.4 Methodological Approach

A qualitative research approach was chosen to improve our understanding of tabletop collaboration because of the success researchers in other disciplines have had using this mode of inquiry to investigate little understood phenomena (Firestone 1987; Maxwell, 1996; Miles and Huberman, 1994). Since the design of tabletop displays is still in its infancy, choosing the more traditional variance theory approach of quantitative hypothesis evaluation may be premature without first developing more focused research questions. Two of the research purposes for which qualitative studies are particularly suited include "[i]dentifying *unanticipated* phenomena and influences, and generating new grounded theories" and "[u]nderstanding the *process* by which events and actions take place" (Maxwell, 1996, p. 19, emphasis in the original text). My research goals are to better understand the practices involved in traditional collaboration – that is, to understand the *process* of interacting in a tabletop workspace – and to produce technology innovation from this understanding. A qualitative research approach is well suited for these purposes.

Traditional qualitative methods, such as biography, phenomenology, grounded theory, ethnography, and case study, rely heavily on observer field notes, participant interviews, and examination of products of the environments (e.g., documents and social networks created in the environment) (Creswell, 1998). These data do not provide the level of detail required to elucidate the subtleties of the work practices that the technology would need to support. For example, field notes rely on the observer's ability

to record details of the scene they are observing. Most people cannot watch the scene and write their notes in parallel; thus, some behaviour will be missed by the observer or it happens so quickly – or is so subtle – that even when the observer is watching, its significance is missed and not recorded. As a result, CSCW researchers have begun using a method called Interaction Analysis (Jordan & Henderson, 1995), which draws from traditional qualitative research approaches, but also incorporates the use of video data and artefact analysis.

Following the Interaction Analysis approach, this dissertation carefully examines collaborators' interactions with artefacts in tabletop workspaces through video taping these interactions, transcribing these interactions, coding the transcripts, analyzing the coded data, and developing theory from these analyses. The coding phase of Interaction Analysis typically involves a team of interdisciplinary researchers iteratively developing a coding scheme over several weeks of group discussions of the video data. Since a team of interdisciplinary researchers was not available for this project, and the focus of this investigation was much narrower (i.e. interactions on a tabletop workspace) than is typical for Interaction Analysis (e.g., interactions within an entire work context), the *open coding* method from the grounded theory research approach (Strauss & Corbin, 1998) was employed. This coding method begins with a loosely defined coding scheme created by first examining the data, then iteratively creating a more complete and focused coding scheme as the researcher becomes more familiar with the data.

1.5 Results and Contributions

This research builds on previous knowledge and practices in CSCW and contributes original ideas, knowledge, and practices to the fields of CSCW and HCI. There are four major contributions from this research:

1. It identifies important work practices that facilitate collaboration in traditional tabletop environments. Previous CSCW research has mentioned many but not all of these practices, but the potential importance of some have not been explicitly

related to the design of tabletop systems, nor have their collective importance been previously articulated.

2. It identifies and defines the specific work practice of tabletop territoriality. This research extends previous CSCW research that recognized tabletop partitioning as a practice for coordinating task and group interactions by revealing that workspace partitioning is part of the more complex practice of tabletop territoriality. Moreover, the specific role each type of tabletop territory plays in collaboration has not been previously identified.

3. It develops a set of design recommendations for digital tabletop workspaces. These recommendations apply to both the design of tabletop groupware and of the physical characteristics of a tabletop display. These recommendations are timely because they challenge emerging trends in the design of tabletop displays. Furthermore, these recommendations also highlight critical implications for groupware design that generalize beyond tabletop environments to co-located technologies in general, as well as to the design of distributed groupware.

4. It demonstrates that tabletop groupware can be developed to support the practice of tabletop territoriality and collaboration in general. The experimental findings demonstrate that qualitative research that involves careful investigation of traditional collaborative work practices can result in successful innovation in collaborative system design.

This research also provides additional contributions to the field of CSCW and HCI through the development of new analytic methodologies, and the development of new interface components. An original analysis method was developed for investigating tabletop workspace interactions. This method can also be applied to investigations of other two-dimensional workspaces. This research also introduces a novel tabletop groupware interface component designed to support casual storage of workspace items. This storage mechanism supports the organization and sharing of digital objects during tabletop collaboration. Finally, designs for several other tabletop groupware interfaces are presented that incorporate more complex workspace functionality to support many

of the work practices identified in this dissertation. These contributions will be discussed in more detail in the remaining chapters.

1.6 Organizational Overview

The organization of the remaining chapters reflects the qualitative research methodological approach of this work by first presenting the studies that were performed to explore interactions in traditional tabletop workspaces and a summary of the general findings. These findings highlighted a specific phenomenon, that of territoriality, that was then further explored by revisiting the study data with this new focus. The understanding gained from these focused analyses led to the design of a novel interface component that was then implemented and evaluated.

Chapter 2 sets the foundations for this dissertation by presenting a brief overview of technologies that have been designed to support co-located collaboration and then focuses on previous research relating tabletop collaboration at both digital tabletop displays and traditional tabletop workspaces. This review takes an interdisciplinary approach, drawing in relevant findings from the human-computer interaction, computer-supported collaboration, and relevant social-psychological literature. This chapter ends by providing some background of territorial behaviour from the human territoriality literature.

Chapter 3 describes the two core observational studies of this dissertation. These studies investigate small group collaboration in both casual and formal settings. The focus of these studies was on understanding how collaborators use and share objects on the table surface as well as how they use and share the table space. These studies revealed that, across all settings and tasks, certain activities appeared to be performed by certain people in particular areas of the workspace and that this behaviour appeared to be territorial in nature.

Chapter 4 revisits the observational data from these two studies with a focus on understanding territoriality in a shared tabletop workspace. The analyses presented in this chapter reveal general characteristics of three distinct types of tabletop territories:

personal, group, and storage territories, as well as insights into how these territories help collaborators coordinate their interactions with the task resources and the tabletop workspace.

Chapter 5 synthesizes the results from these two analyses, with territory-related findings from the literature to provide a more comprehensive understanding of the role that each tabletop territory plays in collaboration. The chapter then discusses how to apply this understanding of tabletop territoriality to the design of digital tabletop workspaces.

Chapter 6 describes the design and evaluation of a mobile storage mechanism, called a *storage bin*, a new tabletop groupware interface component for storing workspace items. The design of storage bins is presented along with an exploratory user study that compares the use of storage bins with a storage mechanism similar to those currently in the literature.

Chapter 7 concludes the dissertation by indicating how the research goals have been addressed by this work. The contributions of this work are then summarized. Finally, the chapter discusses possible future research directions that could further the ideas developed in this work.

Chapter 2. Background

Developing technology to support the activities of co-located collaborators has been an increasingly popular research endeavour in the Computer-Supported Cooperative Work (CSCW) research community. A variety of solutions have emerged that can roughly be categorized into four classes of technology: extensions of the standard desktop personal computer (PC), interactive wall-style displays, digital tabletop systems, and group-aware ubiquitous devices. A parallel can be found in tools commonly used throughout our daily lives to accomplish different activities (e.g., using a PC to work out a budget, using a whiteboard to explore a design idea, using a table to organize photos from a family vacation, and using a notepad to jot down some grocery items). Thus, it is likely that future collaboration settings will comprise a combination of these technologies; each used to support particular types of activities. To investigate this approach, several technology solutions have been developed that combine a number of the individual technologies into an integrated interaction environment.

Before an effective suite of technologies can be developed, it is essential to understand the potential activities afforded by each technology and how to design the interfaces and interaction techniques for that technology to best support those activities. For this reason, this dissertation focuses specifically on the design of collaborative tabletop systems. However, this research has been conducted with the underlying assumption that collaboration performed on these systems will be performed within the context of a larger working environment, which will likely contain other forms of collaborative and personal technologies. To provide the reader a general understanding of this broader context, Section 2.1 first reviews other co-located collaboration technologies. The chapter then focuses on collaborative tabletop systems. Section 2.2 reviews the state of the art in collaborative digital tabletop technology and findings from

initial studies of these technologies. Section 2.3 then discusses findings from investigations of traditional tabletop workspaces. Finally, Section 2.4 provides a brief overview of the human territoriality literature.

2.1 Co-located Collaborative Technologies

This section presents various approaches to supporting co-located collaboration with technology, including extensions to the standard desktop computer (Section 2.1.1), interactive walls (Section 2.1.2), group-aware devices (Section 2.1.3), and integrated interaction environments that are composed of several co-located technologies (Section 2.1.4).

2.1.1 Desktop Extensions

One approach to supporting co-located collaboration has been to extend the hardware and software capabilities of traditional, desktop personal computers (PC). Multiple peripheral devices are attached to a single PC, and specialized software, called Single Display Groupware (SDG) (Stewart et al., 1999) is developed to support the multi-user interaction of shared interface

Figure 6. A desktop SDG system (from Tse et al., 2004).

components (see Figure 6). Several peripheral devices that have been used include: handheld computers (Myers et al, 1998; Myers et al, 2000), joysticks (Bricker et al., 1999), and mice (e.g., Bier & Freeman, 1991; Stewart et al., 1999; Kruger & Carpendale, 2002; Scott et al., 2003; Stanton & Neale, 2003).

Yet, even providing support for additional input devices on a desktop computer has proven to be a non-trivial step. Popular computer operating systems and applications do not distinguish between these multiple devices, forcing users to share control of the system cursor. To compensate, specialized SDG software has been developed to provide users with simultaneous, multi-user interaction for both

collaborative work (Bier & Freeman, 1991; Myers et al., 1998; Tse et al., 2004; Rogers & Lindley, 2004) and collaborative learning (Stewart et al., 1999; Scott et al., 2003; Stanton & Neale, 2003) environments. Unfortunately, these are generally one-off solutions. Recently, toolkits have emerged to overcome many of the common difficulties encountered in developing SDG applications (Bricker et al., 1999; Hourcade & Bederson, 1999; Tse & Greenberg, 2004).

Desktop SDG systems appear to be most useful for periods of closely coupled collaboration among peers, especially since group members have to sit quite close together when interacting with the system. Thus far, these systems have been found to be most successful at supporting groups of school children working together on educational games or story authoring activities (Stewart et al., 1999; Scott et al., 2003). In general, children appear to enjoy collaborating in this environment and tend be more engaged in the collaborative activity compared to situations when children are required to share control of the application on a non-SDG computer (Scott et al., 2003). Other research has reported that adults often find this type of collaboration environment socially awkward (Kruger & Carpendale, 2002; Rogers & Lindley, 2004), which corroborates observations from the social-psychology literature that adults tend to maintain larger interpersonal distances than children when interacting with others (Aiello, 1987). Despite these findings, one particular adult activity that may benefit from this interaction environment is pair programming, a practice from the extreme programming software engineering paradigm where pairs of programmers work together at a single computer to develop an application (Beck & Andres, 2004).

2.1.2 Interactive Walls

Another approach to supporting co-located collaboration has been to develop various forms of large, electronic whiteboards (see Figure 7) and wall-sized displays. These interactive walls comprise a large, interactive display surface on which group members can interact directly with a system pen (e.g.,
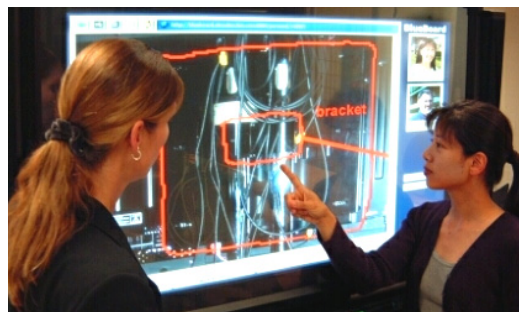
Figure 7. The BlueBoard interactive whiteboard (from Russell et al., 2002).

Pedersen et al., 1993; Mynatt et al., 1999; Guimbretière et al., 2001; Churchill et al., 2004) or by using a remote device, such as a laser pointer, handheld computer, or wireless keyboard and mouse (Myers et al., 1998; Greenberg et al., 1999; Buxton et al., 2000; Brignull et al., 2004).

Interactive wall displays can be used to support a variety of group activities, such as brainstorming, planning, data exploration, and presentations (e.g., Pedersen et al., 1993; Mynatt et al., 1999; Guimbretière et al., 2001; Russell et al., 2002; Russell et al., 2004). When an interactive wall is placed in a peripheral location in an open office or in a commonly frequented place like a lunch room or corridor, the display can be used to provide group-related information, such as on-going project information, announcements, or presence information, which can help foster group cohesion and provide informal awareness (e.g., Buxton et al., 2000; Greenberg & Rounding, 2001; Russell et al., 2002; DiMicco-Morris et al., 2004; Tollinger et al., 2004). When equipped with simple interaction tools and import and export capabilities, interactive walls can also serve as a useful tool for supporting serendipitous collaboration stemming from unscheduled encounters (Russell et al., 2002; Izadi et al., 2003; Brignull et al., 2004; Russell et al., 2004).

While interactive walls are becoming perhaps the most ubiquitous co-location collaboration technology because of their ability to support many group activities, this technology has some disadvantages. Interaction at an interactive wall tends to be imbalanced, with group members tending to take turns interacting with the board and

often developing roles where one person becomes the 'interactor' and the other group members sit or stand back from the board during the collaborative activity (Russell et al., 2002; Rogers & Lindley, 2004). Turn-taking is required in these environments because most existing interactive walls do not support concurrent interaction. However, since similar turn-taking behaviour has also been observed in traditional white boards (Tang, 1989), it is not clear that people would

Figure 8. Collaborators sharing digital media across two ConnecTable displays (from Tandler et al., 2001).

interact concurrently even if this behaviour was supported by the technology. Russell et al. (2002) have reported two factors which may contribute to such turn-taking behaviour: it can be difficult to see what others are doing on a wall display without stepping back from the display, and people often find it socially uncomfortable to interact shoulder-to-shoulder with others at a wall.

2.1.3 Group-aware Devices

Recent advancements in wireless networking capabilities and the push toward ubiquitous computing (Weiser, 1991) have lead to the appropriation of co-located personal devices to enhance group interactions. For example, several methods have emerged for associating several personal displays (e.g. laptops, tabletPCs) to facilitate sharing digital media across these devices, eliminating the overhead of determining network addresses for each device or having to transfer files via a shared network location. In the ConnecTables system, when two tablet-sized, tabletop displays are pushed together, proximity sensors on each device detect the adjacent device, coupling the two devices together (Tandler et al., 2001). Users can then easily transfer objects from one display to the other (see Figure 8).

Mobile displays such as laptops, handhelds, and tablets have also been augmented with sensors such as accelerometers, proximity sensors, and touch sensors, to detect 'association' events, such as 'bumping' two devices together (Hinckley, 2003), shaking

two devices in unison (Holmquist et al., 2001), simultaneously pushing buttons on two devices (Rekimoto et al., 2003), and drawing a pen stroke from one display to another display (Hinckley et al., 2004). These events associate the displays to allow digital media to be easily moved across devices, similar to the ConnecTables system. The portability of tablets and handhelds equipped with these association techniques make these technologies quite useful for supporting ad hoc collaboration and meetings mainly focused on discussion and exchange of information. Similar to interacting in the desktop SDG environment, the small size of these displays – even when joined together – can cause social discomfort among collaborators who have to huddle around them to interact. Thus, association and subsequent interaction techniques required for sharing information across these devices should be designed to allow users to interact at a socially comfortable distance (Hinckley et al., 2004).

For some activities, this separation can be achieved by semantically partitioning the information displayed on each personal device. For example, in the Genie collaborative learning game, children explore genetics by mating virtual creatures which are distributed across different handheld computers (Mandryk et al., 2001). One aspect of the game allows the children to analyze the traits of potential offspring using a 'what-if' feature. This feature distributes different information across the various displays after various candidate creatures have been transferred from several 'participant' handhelds to a 'manager' handheld. Partitioning information across the displays allows each child to view personally relevant information on their own display and encourages discussion among group members.

2.1.4 Integrated Technology Environments

Recognizing that groups perform many types of activities that may benefit from an assortment of technological tools, researchers have explored several integrated technology environments. The earliest of these environments were developed to support typical meeting-room

Figure 9. The i-Land collaboration environment (from Streitz et al., 2002).

activities by providing each group member with a desktop computer that was networked to a large, shared vertical display (Stefik et al., 1987; Elwart-Keys et al., 1990; Streitz et al., 1994). However, these environments provided limited flexibility and cumbersome interaction techniques. As each component technology and networking capabilities have matured, more sophisticated 'smart' rooms have emerged that provide collaborators with various collaborative and personal technologies integrated with an underlying common groupware architecture. This underlying architecture allows digital media to be easily moved across any of the devices in the environment. Examples of these 'smart' rooms include the Interactive Landscape (i-Land) environment, shown in Figure 9 (Streitz et al., 1999; Streitz et al., 2002), and Stanford's iRoom (Fox et al., 2000; Johanson et al., 2002).

Rather than a room full of smart equipment, smaller groups often only need a few devices. For these situations, systems consisting of a large, tabletop display integrated with an adjacent wall display may be more appropriate (e.g., Rauterberg et al., 1997; Rekimoto & Saitoh, 1999). This collaborative environment allows group members to work closely together with task media on the tabletop and to view peripherally important information on the wall or text-heavy media that may be easier for the group to read and discuss at a shared orientation. Some systems also provide group members with smaller 'private' displays connected to a larger, public display, such as a wall or a tabletop (e.g., Greenberg et al., 1999; Rekimoto & Saitoh, 1999; Shen et al., 2003; Magerkurth et al., 2004).

Each type of technological device used in these systems has affordances that can potentially foster or hinder group interaction (Mandryk et al., 2002). Larger displays inherently invite collaboration (Buxton et al., 2000; Eden et al., 2002). Sharing a display can facilitate conversation better than displaying the information (even if it is the same) across multiple displays (Scott et al., 2003). The devices that are available in a collaboration environment and their relative configuration should be designed to suit the potential users and their likely task activities. An example of an integrated technology environment that was designed with both the affordances of the devices and the needs of its users in mind is Rodden et al.'s (2003) travel agent kiosk system. The system is composed of three integrated, flat-panels (two near-horizontal and one vertical) that display related, but semantically different information across all three screens. The agent sits shoulder-to-shoulder with a travel client, and the displays provide a shared view of the trip information and a shared point of reference for their discussions. A set of smaller displays were chosen for this system (as opposed to wall or tabletop displays) in order to maintain the privacy of the client in an office environment.

2.2 Digital Tabletop Workspaces

As discussed in Chapter 1, there are many types of digital tabletop interaction environments, including:

- single-user digital desk and drafting-style systems (e.g., Wellner, 1991; Wellner, 1993; Siio, 1995; Arai et al., 1995; Buxton et al., 2000; Ashdown & Robinson, 2005),

- tables that use tangible user interfaces (e.g., Ullmer & Ishii, 1997; Arias et al., 1999; Underkoffler & Ishii, 1999; Patten et al., 2001; Eden et al., 2002),

- augmented- and virtual-reality (i.e., semi- and full-immersed) tabletop systems (e.g., Krueger et al., 1995; Agrawala et al., 1997; Durbin et al., 1998; Forsberg et al., 1998; Leibe et al., 2000; Regenbrecht & Wagner, 2002), and

- large-screen, direct-touch tabletop displays (e.g., Streitz et al., 1999; Shen et al., 2001; Shen et al., 2002; Scott et al., 2002; Ståhl et al., 2002; Wu & Balakrishnan, 2003; Hancock & Booth, 2004; Kruger et al. 2005; Rogers & Lindley, 2004).

This dissertation focuses on improving the interface and interaction design of the last type of tabletop system both because of its potential for supporting collaboration and because of the limitations of the other systems (discussed in Section 1.1). Thus, this review will focus on these types of collaborative tabletop systems. This section is organized as follows: the state of the art in collaborative digital tabletop technology is reviewed (Section 2.2.1), then the interfaces and interaction techniques available in these systems are described (Section 2.2.2), and finally, findings are presented from several studies which have investigated these systems (Section 2.2.3).

2.2.1 Digital Tabletop Systems

There are currently no 'off-the-shelf' collaborative tabletop systems. The simplest way to assemble a tabletop system is to top-project a digital display onto a traditional table and to use a commercial ultrasonic pen tracker, such as a mimio (www.mimio.com), to enable interaction with the digital media, as shown in Figure 10 (e.g., Scott, et al., 2002; Shen et al., 2002; Pianesi et al., 2005). An ultrasonic pen tracker can also be used to interact on a rear-projected tabletop surface, as shown in Figure 11 (Rogers & Lindley, 2004). As a collaborative input device, ultrasonic trackers have several disadvantages: the tracking tends to be too slow for real-time interaction; the inaccuracy of its sensing capabilities can cause difficulties interacting with small interface objects such as menu items (even on a fairly low-resolution display – 1024x768 pixels covering a ~120x90cm table), and only one pen can be tracked at a time, forcing users to share a single pen or coordinate their interactions when using multiple pens (Shen et al., 2002; Pianesi et al., 2005).

Figure 10. A top-projected tabletop using a Mimio pen. The tracking sensor is located near the bottom left user (from Pianesi et al., 2005).

Figure 11. A rear-projected tabletop using a Mimio pen. The tracking sensor is located to the left of the users (from Rogers & Lindley, 2004).

Using a touch-sensitive overlay allows users to interact with either their finger or a pen, which can solve the speed and accuracy problems (to at least the accuracy of a finger or pen tip). Figures 12 and 13 show two collaborative tabletop systems that use large, touch-sensitive plasma displays mounted horizontally into a tabletop frame: the Pond (Ståhl et al., 2002) and the InteracTable (also pictured in the i-Land environment in Figure 9) (Streitz et al., 2002; Wilkhahn, 2003). Unfortunately, touch-overlays still only provide single-touch interaction capabilities: when two simultaneous touches occur, they are "averaged," placing the cursor halfway between the touches. This behaviour is frustrating since it occurs even for accidental simultaneous touches, forcing collaborators to constantly coordinate their interactions with the system (Ståhl et al., 2002).

All of the tabletop systems just described have appropriated input technologies originally designed for interactive wall displays, where turn-taking behaviour is quite

Figure 12. The Pond (from Ståhl et al., 2002).

Figure 13. The InteracTable (from Wilkhahn, 2003).

natural, as discussed in Section 2.1.2. However, collaborators using a table often wish to interact concurrently with the tabletop surface, as reported during observations of the above systems (e.g., Ståhl et al., 2002; Shen et al., 2002). This desire to support concurrent, multi-user interaction on collaborative tabletop displays has led to the recent development of special-purpose tabletop input devices, such as MERL's DiamondTouch (Deitz & Leigh, 2001) and Sony's SmartSkin (Rekimoto, 2002) direct-touch input surfaces. Both of these input devices can detect concurrent interaction from multiple users, as well as multiple touches from a single user.

DiamondTouch users are required to sit on or hold a receiver pad as they touch the device surface. This activates antennas located under the surface, which react to a (weak) electric current coupled through the user. This technology enables the system to know 'who' is touching 'where' (or at least which receiver is associated with each touch point). SmartSkin uses a similar grid of antennas under its surface, but in this system, each touch location contains a transmitter/receiver pair that acts as a capacitor that uses a finger (or any other conductive surface) to activate that location. This method of touch detection does not provide the capability to know who is touching where or if the same person is touching in multiple locations. To date, only basic prototypes have been created using the SmartSkin detection method. However, MERL has produced several prototype versions of the DiamondTouch (88cm and 107cm diagonal surfaces) and has distributed them to several universities interested in investigating collaborative tabletop interface issues[3]. Two DiamondTouch tabletops are shown in Figure 14. The ability to detect multiple users and to detect touches across several surface locations at once provides opportunities for new methods of interaction, as will be discussed below.

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[3] MERL donated both prototype models (DT88 and DT107) to our university laboratory.

Figure 14. Two examples of DiamondTouch tabletop systems (from Shen et al., 2004 (left), and Rogers et al., 2004 (right)).

The availability of the DiamondTouch input technology has enabled tabletop researchers to focus on the software interface and interaction issues related to supporting collaborative tabletop activities, as evidenced by the increased number of tabletop publications in recent years that focus on new interfaces and interactions with these interfaces (e.g., Shen et al., 2003; Everitt et al., 2004; Ringel et al., 2004; Ringel-Morris et al., 2004; Rogers et al., 2004; Ryall et al., 2004). Prior to this, most tabletop publications focused on introducing new technology platforms with only simple, prototype interaction capabilities (e.g., Agrawala et al., 1997; Arias et al., 1997; Rekimoto & Saitoh, 1999; Streitz et al., 1999; Fox et al., 2000; Hancock, 2003; Streitz et al., 2001). The ability to focus on the interface and interaction techniques has helped the community better understand some of the requirements of supporting tabletop collaboration in a digital workspace, as will be discussed in more detail below. However, this dissertation will show that the fact that the hardware technique used by the DiamondTouch does not scale beyond the currently available 77x98cm input surface (MERL representative, Kathy Ryall, personal communication, 2004), limits its suitability for supporting many adult collaborative activities, especially if more than two people are seated at the tabletop.

Another method of providing multi-user interaction is to use multiple tracked input devices, such as Polhemus Fastrak (http://www.polhemus.com) styli, to interact with the tabletop surface (see Figure 15). Fastrak styli can be tracked with six degrees-of-freedom over the tabletop surface (x, y, z, yaw, pitch, and roll), enabling the system to determine the location of a user and their

Figure 15. A collaborative tabletop workspace using tracked Fastrak styli.

handedness, which can be useful for providing customized interfaces (Hancock, 2003). This technology also enables the system to determine when a person is using his or her stylus to point at a distance object on the table, facilitating new possibilities for allowing a person to access a distant object on the table (Parker et al., 2004). However, using the Polhemus Fastrak styli requires writing customized code to calibrate the styli locations with the displayed tabletop workspace, making this approach challenging to initially set up. This technology also requires people to use tethered styli to interact with the tabletop, potentially constraining their interactions.

Computer vision technology enables concurrent multi-user interaction without forcing users to use a tethered input device (or remain seated in a tethered chair like DiamondTouch users). Some systems mount cameras above or below the table to detect the users' workspace interactions, such as the DialogTable (Walczak et al., 2004) shown in Figure 16. This approach enables users to perform complex hand gestures to

Figure 16. The DialogTable (from Walczak et al., 2004).

interact with the system, such as the grasping gesturing being used on the DialogTable in Figure 16. However, due to the fairly limited resolution of most video capture

technology, these systems are limited to fairly-low-resolution real-time interaction across a large tabletop surface. Thus, interaction is limited to manipulation of fairly large on-screen objects (e.g., Rekimoto et al., 1999; Walczak et al., 2004). For systems using cameras mounted above the table, occlusion can also be an issue, especially with multiple people interacting in the workspace.

Figure 17. The DViT Table.

Using multiple cameras and constraining their views to only a small area above the interaction surface, as done in the SMARTBoard DViT interactive whiteboard (www.smarttech.com), can enable higher-resolution input capabilities. The DViT technology uses small, infra-red (IR) cameras, one in each corner of the interactive surface, together with an array of IR LEDs located along each edge of the interaction surface, to detect the location of up to two simultaneous touches. This input technique allows people to use either their finger or a pen to interact with the board, whichever they prefer. While this technology was originally designed for interactive wall displays – and thus only provides minimal support for concurrent multi-user interaction – its ability to provide high-resolution input across a large surface (typically 152.4cm x 121.9cm) provides a good compromise for exploring collaborative tabletop interface and interaction issues. When installed horizontally on a tabletop frame the display is large enough that two users can collaborate at the tabletop without feeling crowded (see Figure 17).

The above discussion has focused on the input capabilities of collaborative tabletop systems, yet the output technology these systems use can also impact interactions with the system. The majority of collaborative tabletop systems use a data projector to project a digital image down onto a tabletop surface (see Figures 10, 14, 15, and 17). Top-projection has been the display method of choice for several reasons:

- projectors are fairly inexpensive (compared to plasma displays for example),

- they are relatively easy to install with a mirror to redirect the image throw downward,

- they can provide a larger display surface than most plasma displays (especially for the price),

- they do not require a custom designed table, only a smooth, reflective surface, and

- they allow collaborators to easily sit or stand around any side of the table (as compared to a rear-projected table that typically reserves one side of the table for the projector mount and image throw).

In addition, opaque input surfaces like the DiamondTouch and SmartSkin require a top-projected display.

The main disadvantages of a top-projected tabletop display are occlusion from people's arms and body when leaning over the table or interacting on the surface and the available display resolution. Intuitively, one might expect that occlusion would be a major issue, yet in reality it appears to cause little disruption to users' interactions with top-projected systems. This is likely because we are typically interested in the objects in front of or beside our hand or arm: we are quite accustomed to moving our hands in our physical environment to see what is underneath them.

Currently, the standard display resolution available from the average data projector is only 1024x768 pixels. Projecting this onto a large tabletop surface provides 'fat' pixels, limiting the possible complexities that can be built into a collaborative tabletop interface. High-resolution projectors are slowly becoming available (e.g., NEC's GT6000 provides 1400x1050 pixel resolution), but in the meantime, one way to provide a high-resolution display capable of providing more complex interfaces is to tile multiple projectors across a tabletop surface. Figure 17 above shows a top-projected tabletop that tiles two high-resolution projectors to create a 2048x1280 pixel display across a

152x122cm (5x4 feet) table surface – a tabletop display that is just beginning to provide the same pixel per inch resolution as a 21-inch monitor set to 640x480 pixel resolution.

A variety of technologies have been used to create collaborative tabletop systems, each system having its own advantages and disadvantages for supporting collaborative work. Recent hardware innovations, such as the DiamondTouch, SMARTBoard DViT, and higher resolution projectors, have greatly improved the ability of these systems to support collaborative work, creating sufficiently viable collaborative environments for researchers to begin focusing on developing table-specific software interfaces and interaction techniques for these systems. The following section reviews these software developments. As the reader will see, the capabilities of the hardware technologies used in a tabletop system can strongly influence the type of software interfaces and interaction techniques that can be developed for that system.

2.2.2 Digital Tabletop Interfaces and Interaction Techniques

As discussed in Chapter 1, standard desktop interfaces are not particularly well suited to collaborative tabletop displays. Also, many standard interaction techniques used in desktop environments rely on the availability of several mouse buttons, such as drag and drop interactions or invoking a pop-up menu with the right mouse button. On a direct-touch surface, mouse buttons (or their equivalents) are not usually available, requiring the development of new types of interaction methods to perform the sophisticated interactions available in the desktop environment. With the advances in tabletop hardware discussed above, table-specific software interfaces and interaction techniques have begun to appear. Many are adaptations from existing desktop interface components to address table-specific issues, and others depend on the richer input capabilities enabled by some tabletop systems.

Techniques for handling orientation. The majority of table-specific interfaces and interaction techniques have been developed to address the orientation issue: because people can sit or stand at different sides of the table, they are often looking at the interface from a different viewing angle than their collaborators. Several techniques have

emerged to address this issue. This section provides a brief overview of these techniques, for a more comprehensive review see (Kruger, 2004).

One approach to addressing the orientation issue is to allow collaborators to easily copy digital objects, allowing collaborators to orient their own copies toward themselves for easier reading and manipulation (e.g., Streitz et al., 2001). Another approach is to allow a collaborator to toss an object across the table toward a collaborator and automatically rotate the object as it approaches the opposing table edge (e.g., Streitz et al., 2001). Yet another approach has been to provide a circular tabletop interface that automatically orients objects towards the edge of the interface as workspace objects are moved across the display, facilitating passing objects to others and bringing objects toward one's self (e.g., Shen et al., 2002; Vernier et al., 2002; Shen et al., 2004).

Another approach to handling orientation is to simply leave it to the users by providing mechanisms to manually rotate tabletop objects. For example, some systems enable a person to make a simple 'rotation' gesture to rotate an object, such as drawing a circular gesture on the tabletop surface with one's finger atop a workspace object (e.g., Rekimoto & Saitoh, 1999; Streitz et al., 2001). Other systems provide a rotation icon in the corner of each workspace object that someone can simply drag to reorient the object (e.g., Vernier et al., 2002; Shen et al., 2004). These manual rotation techniques all rotate workspace objects in place, separating a rotating action from a moving action. Two recently developed orientation techniques, Drag (Mitchell, 2003) and Rotate 'N Translate (RNT) (Kruger et al., 2005), provide manual rotation techniques that integrate the actions of rotating and translating, just as we do when we manipulate objects in the physical world (Wang et al., 1998). These techniques both allow an object to be simultaneously rotated and translated in a single fluid motion using a single touch point (see Figure 18). Drag achieves this interaction by simulating a friction force (or 'drag') as the item is moved across the table, while RNT uses pseudo-physics to produce an action that appears to be easier to predict and control during interaction (Kruger et al., 2005).
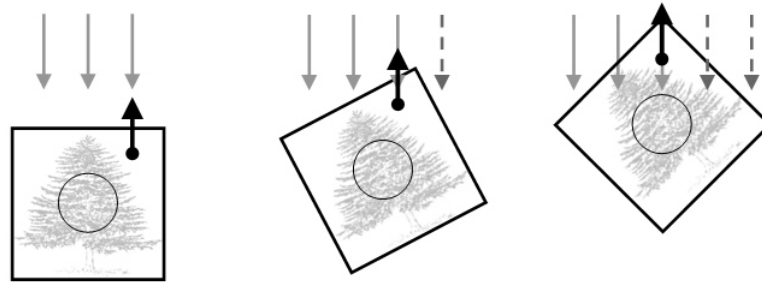
Figure 18. An object being simultaneously rotated and translated with the RNT technique: the black arrow represents the touch-point moving across the table and the grey arrows represent the opposing force that is applied to the object as it moves. It rotates until the opposing force stabilizes (from Kruger et al., 2005).

Gesture-based interaction techniques. Input technologies capable of detecting multiple touch points or input across a series of pixels, such as the SMARTBoard DViT (www.smarttech.com), DiamondTouch (Deitz & Leigh, 2001), and SmartSkin (Rekimoto, 2002) input surfaces, and vision-based systems like the DialogTable (Walczak et al., 2004), enable more complex gestures to be used while interacting with the digital media. For example, these systems enable two-finger gestures which can be used for performing such actions as rotation, menu selection, and parameter adjustments (see Figure 19) (e.g., Rekimoto, 2002; Diaz-Marino et al., 2003; Wu & Balakrishnan, 2003; Tse, 2004).

Entire hand and arm gestures have also been developed to allow tabletop users to perform such actions as: rotating the workspace, erasing workspace objects, selecting one or more workspace items, collecting or spreading a group of items, and displaying private information behind a 'hand barrier' (e.g., Rekimoto, 2002; Wu & Balakrishnan, 2003; Tse, 2004; Walczak et al., 2004).

Figure 19. A two-finger gesture for adjusting the orientation angle of an object via a 'parameter adjustment widget' (from Wu & Balakrishnan, 2003).

Support for individual interactions. A collaborative tabletop system must support both the interactions of individuals at the table and the interactions between group members. Most tabletop systems provide at least some support for both of these types of interactions. The DiamondSpin tabletop groupware toolkit (Shen et al., 2004) provides several features designed to support several people acting independently when seated around a tabletop, and facilitates the development of applications for the DiamondTouch input surface. For example, DiamondSpin provides the ability to duplicate the system menu and to relocate these menus along any edge of the tabletop workspace, a feature incorporated into the Personal Digital Historian (Vernier et al, 2002; Shen et al., 2002), the UbiTable (Shen et al., 2003), and the TableForN (Shen et al., 2004) tabletop groupware applications pictured in Figure 20. These menus provide each user access to any system feature. However, the results from this dissertation, and observations reported in DiamondSpin-related papers, suggest that making some functionality easily accessible to each group member may be detrimental to the collaborative activity, especially for functionality which affect the entire workspace such as clearing the workspace or switching workspace views (e.g., Ringel-Morris et al., 2004).

The DiamondSpin toolkit also provides the ability to include a 'magnet' feature, which allows any user to temporarily reorient all workspace items toward themselves to provide that user a better view of all workspace items (Shen et al., 2004; Rogers et al., 2004). Another useful feature for individual group members provided by DiamondSpin is the ability to drag an open pop-up menu closer to one's self, causing the menu items to
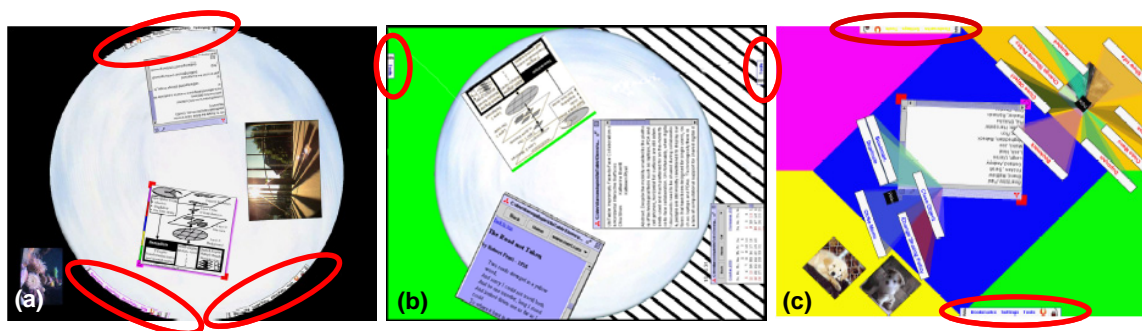
Figure 20. Personal menus (circled) along the workspace edge in several DiamondSpin-based tabletop workspaces (images from Shen et al., 2004).

automatically reorient toward the individual as they move across the tabletop; thus, making it easier to read and access the items (see Figure 20c).

Support for group interactions. Many tabletop systems also provide features that help group members interact together on the tabletop, share media, and coordinate their interactions. The ability to pass workspace items across the tabletop is an important feature during tabletop collaboration. Being able to rotate the object toward one's collaborator as it is being passed is also helpful as it can serve to 'invite' interaction from that person (Rogers et al., 2004; Kruger et al., 2004). DiamondSpin incorporates such a 'passing' feature into its circular interfaces, automatically reorienting workspace items as they are moved toward someone else on the table (as discussed above) (Shen et al., 2004; Rogers et al., 2004). Also, the tossing mechanism discussed above, which reorients an item as it approaches the opposing table edge, is another useful passing technique (Strietz et al., 2001). Neither of these techniques, though, allows a user to precisely control the orientation of the item as it is being passed, the orientation depends only on the item's current location in the workspace. The RNT (Kruger et al., 2005) and Drag (Mitchell, 2003) techniques enable a user to control the exact orientation of an item as it is being passed, allowing more control of what message is intended to be communicated by the passing action (e.g., 'please help me with this', 'here, take this', 'what do you think?') (Kruger et al., 2004).

The DiamondSpin toolkit also provides several features intended to facilitate a group working together on the same tabletop object, such as providing a workspace view that allows users to easily enlarge objects placed in the centre of the tabletop and providing a manual resize control on each workspace item (Vernier et al., 2002; Shen et al., 2002). The underlying BEACH groupware architecture (Tandler et al., 2001; Streitz et al., 2002) of the InteracTable (Streitz et al., 1999; Streitz et al., 2001) provides an alternative method for several group members to share the same workspace object. This system allows users to work on multiple copies of a workspace item that are linked to the same underlying virtual object. Thus, changes made to any copy are reflected in all of

the other copies. The impact of this interaction method to group interactions has not yet been investigated.

Support for concurrent individual and group interactions. DiamondSpin (Shen et al., 2004) also provides the ability to create visibly distinct 'personal' and 'public' spaces on the tabletop. The UbiTable shown in Figure 20b has two personal spaces and a public space between these two spaces, while the TableForN shown in Figure 20c has four personal spaces – one in each corner – and a public space in the centre of the workspace. Providing these visibly demarcated spaces can be used to facilitate automatic reorienting of tabletop content and for controlling access to workspace objects (Shen et al., 2003; Ringel et al, 2004; Ringel-Morris et al., 2004). The UbiTable further enables each user to associate a laptop with the tabletop workspace to provide a 'private' space for each user (Shen et al., 2003), a feature also provided by the Augmented Surfaces tabletop display (Rekimoto & Saitoh, 1999).

One might expect that the visibly distinct 'personal' and 'public' spaces would correspond quite naturally to the personal and group territories that will be discussed in this dissertation; however, the observations described in this dissertation suggest that such visible demarcations of the workspace may in fact hinder natural territorial behaviour on a tabletop. These observations also suggest that providing a laptop for group members to use during tabletop collaboration may interfere with natural work practices used to coordinate task and group interactions, and thus should be done with care. These points will be revisited in later chapters.

Coordination support for sharing objects. The DiamondSpin toolkit has also been used to develop several interaction techniques designed to help group members coordinate access to shared workspace objects, including the release, relocate, resize, and reorient techniques (Ringel et al., 2004). These techniques provide various methods for the current user or 'owner' (the giver) of a workspace object to grant permission to a collaborator (the receiver) to use the object. Release requires the giver to be touching the object when the receiver touches the object, then the giver lifts their hand, releasing the object to the receiver. Relocate requires the giver to move the object from their

'personal' space to the 'public' space, where the receiver can then use the object in that space, or move it into their own personal space. Reorient requires the giver to rotate the object toward the receiver (in their implementation, there was only two users located on opposite sides of the table). Finally, resize requires the giver to expand the object by using a resize icon before the receiver can access it.

Compared to the normal social protocols that mitigate interactions with shared tabletop resources in traditional tabletop workspaces, these sharing techniques place a heavy onus on the current user (or the last person to use the object) to explicitly grant their collaborator permission to use an object. Of these four sharing techniques, the relocate technique most closely resembles the typical territorial behaviour that people use to share or reserve traditional tabletop items, as will be discussed in Chapters 4 and 5. Not surprisingly, people tended to find this technique easiest to learn and use in a comparison of the four sharing techniques (Ringel et al., 2004).

In summary, collaborative tabletop systems introduce a number of challenges for interface design (e.g., handling orientation and designing for multi-user interaction), while at the same time the new input capabilities in many of these systems provides new opportunities for interaction (e.g., multi-finger, gesture-based interaction, person-specific interfaces and access control). This section has provided an overview of how tabletop groupware designers have currently addressed these challenges and taken advantage of these opportunities in their design of table-specific interface and interaction techniques. The following section discusses how some of these interfaces and interaction techniques have been used during small-group collaboration, focusing on how the capabilities of the digital tabletop workspace (e.g., the available software and hardware) fit into the work practices that people used to accomplish their task activities.

2.2.3 Digital Tabletop Work Practices

Many of the early tabletop systems were simple, proof-of-concept prototypes, thus, formal investigations of collaborative activities being performed on these systems have only recently been performed. Most of these studies have involved groups of users collaborating at a DiamondTouch (Deitz & Leigh, 2001) tabletop using tabletop

groupware applications developed atop the DiamondSpin toolkit (Shen et al., 2004). This section reviews the findings from these studies in order to understand how the available software and hardware tabletop technologies were used during collaborative activities in these interaction environments. The findings are discussed according to the common work practices that emerged during an examination of these study results. In particular, this examination found that: people share workspace items, people assist each other; people partition the workspace; and people rarely 'personalize' the entire workspace.

People share workspace items. The sharing of workspace items was one work practice that was often observed during study activities that afforded closely coupled interactions, such as designing a calendar on a circular layout (see Figure 21) and story-sharing (see Figure 22). While sharing a workspace item, participants tended to turn-take and engage in discussions related to the item (Shen et al., 2002; Rogers et al., 2004). To facilitate this practice, people frequently enlarged workspace objects, such as photos and documents, to discuss them with other group members (Shen et al., 2002; Rogers et al., 2004). Rogers et al. also found that people were much more likely to rotate workspace items towards their collaborators than towards themselves. Their participants often rotated an item towards someone else while making suggestions, requesting confirmation, and inviting comments from that person (or persons).

Figure 21. The Calendar Designer workspace (from Rogers et al., 2004).
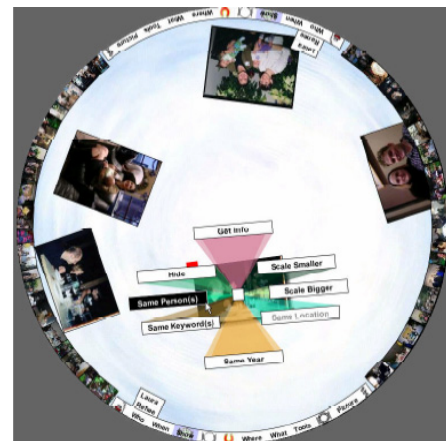
Figure 22. The Personal Digital Historian workspace (from Shen et al., 2002).

To better understand how to facilitate the sharing of workspace items, Ringel et al. (2004) compared the four access control techniques described above (i.e., release, relocate, reorient, resize). In their study, participants used each technique to perform a document passing task. The results showed that participants preferred the relocate technique, found it the easiest to learn, and found it the most 'natural' to use (Ringel et al., 2004). Interestingly though, the authors report several occurrences of participants moving the document directly from their own personal space to their partner's personal space during the relocate condition. This action was considered an 'error' by the system since the participant was supposed to place the document in the public space to pass it to their partner. Yet, moving the document directly into their partner's personal space parallels the real world action of someone placing a piece of paper on a table in front of someone else for them to read, an action quite likely to happen in our everyday life. This action would typically not be considered unacceptable behaviour, as it was in Ringel et al.'s study. Thus, people's natural sharing behaviour may be hindered by providing explicit access control techniques.

People assist each other during workspace interactions. In tabletop environments where users had to share access to the system, collaborators who were not currently interacting with the tabletop tended to assist the current 'interactor.' For example, in a collaborative trip planning activity people often pointed and gestured at interface items to make suggestions to the interactor (Rogers & Lindley, 2004). Also, during a collaborative urban planning activity people would often remind the current interactor which mode the system was in or how to use certain interface tools to prevent them from making errors (Eden et al., 2002).

Shen et al. (2002) observed collaborators assisting each other while operating interface menus. For example, they reported several instances of a user opening a menu followed by their partner selecting an item from it. Often groupware applications 'lock' out interaction from other people when someone is currently using a workspace object. For example, many of the co-located collaboration coordination policies proposed by Ringel-Morris et al. (2004) do not allow concurrent access to the same interface

component. However, the type of assistance observed in Shen et al.'s study would not have been possible if a lock-out policy had been enforced by the system. These studies provide evidence that people try, within system limits to assist each other cooperatively.

Many of the coordination breakdowns which motivated the development of Ringel-Morris et al.'s coordination policies (e.g., reaching in front of someone else on the table, or taking an item before someone is finished with it) may have occurred because collaborators were working in an impoverished collaboration environment. These coordination breakdowns may also have occurred because users did not feel sufficiently 'attached' to any of the task items they were using during the study – a point that will be revisited later in this chapter. Providing a more appropriate digital tabletop workspace may elicit more appropriate social responses. For example, as will be discussed below, providing a sufficiently large table facilitates coordination in a tabletop workspace. In addition, as will be discussed in the territoriality section below, real groups, using real task materials may be more likely to 'behave' because of perceived ownerships they feel (for themselves and for their collaborators) for items in the workspace.

People sometimes partition the workspace. The practice of partitioning the workspace was observed by Eden et al. (2002) during their urban planning study. Their participants tended to take responsibility for different areas of the virtual map covering the tabletop workspace. They also observed that areas of responsibilities tended to shift as the task progressed. Also, participants located close to certain interface items often became responsible for interacting with them (e.g., becoming responsible for a button for switching the current mode).

This practice was also observed in a recent study by Ryall et al. (2004), which investigated different sized groups performing a 'magnetic poetry' assembly task on different sized tables. In their study, participants often partitioned their interactions in the workspace while searching for word tiles on the tabletop, tending to take on responsibility for searching the word tiles nearest them on the table. Figure 23 shows the task and an activity map from this study (the four markers – triangles, squares, circles, and crosses – each represents an individual's touch actions, while the white shows

interaction with the poem container). The activity map represents the interactions of a four-person group performing the task. Notice that the activity in the areas near each person is dominated by that person. Also notice that the interaction with the poem container (indicated in white) is dominated by the lower user, who became responsible for assembling the poem using the word tiles that the other group members were collecting. Finally, notice the overlap of participants' activity near the centre of the table and the edges of each person's area. The authors attribute this behaviour to the phenomenon called Diffusion of Responsibility (Darley & Latane, 1968): areas on the table where more than one

Figure 23. The 'magnetic poetry' task being performed by a 3-person group (upper) and an activity map of a 4-person group performing the task (from Ryall et al., 2004).

person could reach were often considered the responsibility of "someone else" by each user, and thus no one took responsibility for these areas. Groups needed more explicit coordination to interact in these areas. Ryall et al. (2004) also noted that groups using the smaller table in the study tended to have more overlap in their interactions and required more negotiation to share the table.

The combined implication is that while performing activities which afforded loosely-coupled interactions in the workspace (i.e., a task which could be easily divided into sub-tasks), the responsibility for different areas of the workspace was divvied up among group members (either implicitly or explicitly). These results correspond very closely to the activity results from an in-depth analysis of a traditional tabletop collaborative activity (see Section 4.3). The findings from Ryall et al. suggest that the

workspace practice of tabletop territoriality also occurs in digital tabletop workspaces. Their study also indicates that providing a sufficiently large table can facilitate the coordination of group members' interactions on a shared tabletop workspace by providing fewer overlapping reach areas and, thus, fewer areas where group members' sense of responsibility is diffused.

People rarely 'personalize' the entire workspace. Rogers et al. (2004) found that the practice of using a 'personalized' view by any one participant in their calendar design task was very rare. For example, their participants rarely used the Calendar Designer's 'magnet' feature, which temporarily reorients all workspace items to their own viewpoint. The authors hypothesized that this action would be consider rude since it temporarily excludes other group members from the activity. In fact, as reported by Everitt et al. (2004) and Ringel-Morris et al. (2004), the use of the magnet feature, and other 'global' workspace features such as switching views of task content, can be disruptive to the overall group activity, especially if another group member is currently doing something in the workspace when the action is invoked.

In summary, studies of digital tabletop workspaces have demonstrated that these systems provide many useful features which help collaborators share workspace items, assist others in the workspace, and delegate task activities. These studies have also revealed that some system features can be detrimental to the collaboration process in some situations (e.g., the 'magnet' tool provided by the DiamondSpin toolkit). However, most of these systems are still fairly primitive compared to standard desktop interfaces. Understanding the behaviours that people perform when completing tasks on traditional tabletop workspaces can help us better understand what issues still need to be resolved in digital tabletop workspaces in order to support real work on these systems.

2.3 Traditional Tabletop Workspaces

This section reviews the findings from several observational studies which have investigated small-group collaboration on traditional tables. Findings are incorporated from several research communities: studies from distributed collaboration researchers

intended to inform distributed groupware design, studies from the social psychology research fields intended to understand general interpersonal interaction, and recent studies from co-located collaboration researchers intended to inform tabletop groupware design. This section first describes these studies (Section 2.3.1). In order to provide the context for the findings from these studies, Section 2.3.2 describes the tabletop workspaces and traditional media that were used in these studies. Finally, the findings are discussed according to the work practices that were observed in these studies (Section 2.3.3). Organizing the findings into work practices enables us to compare the behaviours observed in these studies with the behaviours observed in the studies of digital tabletop workspaces (see Section 2.3.3).

2.3.1 Studies of Traditional Tabletop Collaboration

Several observational studies have been conducted within the distributed CSCW research community investigating collaboration at a physically shared tabletop workspace. These studies focused on understanding collaborative design and construction activities (e.g., creating layouts, assembling puzzles, creating concept maps) for the purpose of informing shared workspace activities in distributed groupware applications (e.g., a remote whiteboard) (Bly, 1988; Tang, 1991; Gutwin et al., 1996). While this research was aimed at informing distributed technology, many of the observations reported in these papers are also relevant for informing the design of co-located tabletop technology.

Research from social-psychology can also help us understand how people collaborate in traditional tabletop workspace and interact with each other in general. In particular, research pertaining to proxemics (i.e., the study of people's use of space) (e.g., Hall, 1966; Sommer, 1969; Hall, 1974; Aiello, 1987) and to environmental psychology (i.e., the study of how our surroundings affect our behaviour) (e.g., Gifford, 1987; Fisher et al., 1984) provides insights relevant for better understanding collaborative behaviour in general and how a tabletop workspace as an interaction environment can affect this behaviour.

New observational studies investigating traditional tabletop collaboration have recently emerged within the co-located CSCW research community (Kruger et al., 2004; Pianesi et al., 2005). These studies were specifically designed to inform the design of

tabletop groupware. Thus, these studies focused on exploring the nuances of task and group interactions within the context of a tabletop workspace. In particular, Kruger et al. (2004) investigated the issue of orientation on a table, which, as discussed in Section 2.3.2, is an important issue for tabletop groupware interfaces. This research revealed that orientation plays three key roles during tabletop collaboration: it helps people comprehend information, coordinate their interactions, and mediate their communication.

Pianesi et al. (2005) investigated common meeting activities through both observational studies and focus groups. Preliminary results from these investigations provide important insights for the design of digital tabletop workspaces. In contrast to the collaborative activities investigated in the other traditional tabletop studies (e.g., design and construction tasks), the participants' conversation was the main focus of the meeting activities they investigated. That is, the focus of the activity was 'off the table.' However, people often use items in their workspace to support the discussion of ideas (Brinck & Gomez, 1992). Thus, Pianesi et al.'s results focused on informing the design of tabletop workspaces that support these 'off the table' activities. These results are also important for supporting other types of tabletop activities, including 'on the table' activities like design and construction tasks, because such tasks often involve periods of discussion and negotiation related to completing the task activities. Thus, a deeper understanding of people's tabletop behaviour during conversation-based activities may help us to better support this aspect of group work.

2.3.2 Tables and Materials Used in the Traditional Tabletop Studies

To provide some context for the behaviours that were observed in the traditional tabletop studies (described below in Section 2.3.3), this section briefly describes the physical tables and the task resources that were available to the participants in these studies. Knowing what tools and type of workspace these collaborators had at their disposal helps us to understand the possible ways that people could have interacted in the workspace, while the studies identify how they actually interacted.

In all of the observational studies, participants performed the collaborative task while seated at a small to moderate sized rectangular table, as depicted in Figure 24, which shows several

Figure 24. Examples of the table settings in the traditional tabletop studies. (a: from Tang, 1991; b: from Pianesi et al., 2005).

of the tabletop workspaces from these studies. In the collaborative design studies by Bly (1988) and Tang (1991), collaborators used pens and markers to create their designs on a large sheet or pad of paper placed on the table. Similarly, participants in Pianesi et al.'s (2005) study of meeting room activities shared a large drawing surface, but instead of paper, their participants used whiteboard pens and erasers to write and draw on a regular whiteboard that was placed horizontally on the table.

In Gutwin et al.'s study (1996), pairs of participants created a newspaper layout activity while seated on the same side of the table. They were given pre-made cut-outs of paper articles, pictures, and headlines with which to compose a two-page newspaper layout. In Kruger et al.'s (2004) study, pairs of participants, seated across the table from one another, performed a collaborative puzzle solving activity that involved arranging 25 small, rectangular puzzle pieces to create an image that matched a supplied puzzle key (i.e., a picture of the complete puzzle).

2.3.3 Traditional Tabletop Work Practices

Some of the work practices discussed below will be familiar to the reader, as the first three correspond to work practices reported above in Section 2.2.3, including sharing workspace items, providing assistance to other collaborators, and partitioning the workspace. However, the studies of traditional tabletop workspaces have also revealed several distinct work practices currently not possible (or difficult) in existing digital tabletop workspaces, including transitioning between workspace activities, adapting to the given table space, transitioning between tabletop and external work, and using a variety of seating positions. Understanding these work practices can help us to refine the design of digital tabletop workspaces to more effectively support collaborative interactions.

People share tabletop objects. Sharing tabletop objects was a commonly observed work practice during traditional tabletop collaboration, particularly during periods of close-coupled interaction (Bly, 1988; Tang, 1991; Gutwin et al., 1996; Kruger et al., 2004). Many of the ways that participants in the traditional tabletop studies shared tabletop objects correspond to the findings from the digital tabletop studies. For example, Bly (1988) also observed that tabletop collaborators often engage in discussions related to shared tabletop items (e.g., sketches) and typically took turns when interacting with these items. Similar to sharing behaviour on digital tabletops, participants working with traditional media also made use of size and orientation to share objects with their collaborators. For instance, Tang (1991) observed that people tended to draw intentionally large when drawing design items to share with other group members. He also observed that people would sometimes draw design items oriented towards someone in order to engage that person in discussion. Similar behaviour was reported by Kruger et al. (2004): the act of rotating a tabletop item was often used to invite their partner to discuss the item. Similar to the sharing behaviours that were observed in the digital tabletop studies, these traditional tabletop interactions – orienting items and drawing larger designs – typically occurred in the central area of the table.

Though many of the traditional tabletop sharing behaviours parallel the sharing behaviours observed in the digital tabletop studies, Kruger et al.'s (2004) careful investigation of orientation revealed that participants often used orientation in ways that do not correspond well to any of the current 'automatic' orientation techniques used in digital tabletop workspaces. For example, they observed that people often used variant orientation (i.e., orientations not orthogonally aligned to any table edge), which often eased the task of reading or communicated valuable information to other group members. As a consequence, the automated orientation techniques described above in Sections 2.2.2 which orient objects orthogonal to the workspace edge may not always be appropriate.

The traditional tabletop studies have also revealed several benefits to the practice of sharing tabletop objects that have implications for the design of tabletop groupware. Tang (1991) found that pointing or motioning to a shared object during a discussion provided a clear spatial relationship to the object for both the gesturer and the other group members, which appeared to facilitate the group communication. Interacting with shared objects has also been found to help maintain the group focus and facilitate awareness within the group because body positioning and eye gaze of group members attending to the same object can be easily interpreted by other group members (Suzuki & Kato, 1995). These findings suggest that in digital tabletop systems which provide each group members copies of a digital object, a gesture made to one copy of the object may be more difficult to interpret because it requires the other group members to perform a spatial translation to determine the specified location on their own copies.

People assist each other during workspace activities. The practice of assistance was frequently observed in the traditional tabletop studies (Bly, 1988; Tang, 1991; Gutwin et al., 1996; Kruger et al., 2004). Gutwin et al. (1996) and Kruger et al. (2004) observed that their participants often assisted their partners by passing them task resources, often without solicitation. During Bly's (1988) observations of collaborative design activities, she observed people assisting each other by making modifications to design objects created by their partner. This cooperative behaviour parallels the tendency of people to

cooperatively operate system menus, as was observed in the digital tabletop studies. In these studies, participants relied on social protocol to mediate their interactions with shared objects. Enforcing strict 'ownership' of workspace items in a digital tabletop system may hinder these cooperative behaviours during tabletop collaboration, possibly negatively impacting activities like collaborative design.

In Gutwin et al.'s (1996) study of traditional tabletop collaboration, they observed that people frequently glanced around the tabletop workspace to help them stay apprised of their partner's actions, likely contributing to their ability to anticipate when a collaborator needed help. The results of this dissertation corroborate Gutwin et al.'s hypothesis that being able to monitor the actions of others in the workspace facilitates the practice of assistance. The importance of a shared workspace enabling this monitoring behaviour will be discussed further in Chapter 5.

People sometimes partition the workspace. The practice of workspace partitioning has been observed in several traditional tabletop studies, particularly in activities that lend themselves to periods of loosely-coupled interactions. In Tang's (1991) and Kruger et al.'s (2004) traditional tabletop studies, their participants appeared to use proximity and orientation to establish personal and group spaces on the table. Tang observed that during design activities, people establish a personal space in close proximity to them on the table to explore ideas on their own before presenting them to the group. Kruger et al. observed similar establishment of personal spaces during collaborative puzzle solving activities. In their study, participants appeared to use their personal space to reserve pieces for their own use. Kruger et al's study also revealed that items located in someone's personal space were typically oriented towards that person.

Tang and Kruger et al. also observed the use of various orientations in the group space (i.e. the table area typically located near the center of the table). In Tang's study, he noted that different orientations appeared to correspond to distinct design concepts. He observed that participants often made additions to a particular design using a similar orientation to convey support for that idea. In Kruger et al.'s study, participants often made use of two orientations while solving a puzzle: one corresponding to the puzzle key

(i.e. a picture of the finished puzzle) and one corresponding to the puzzle being assembled. The deliberate use of various orientations to support different concepts in the group space was not reported in the digital tabletop studies; possibly because most of the tabletop groupware applications investigated in those studies automatically oriented items towards the workspace edge (see Section 2.2.3). Automatically orienting workspace items in this manner partially supports the use of orientation to semantically group items because people can place related items near each other in the workspace, causing the system to apply a similar orientation to these items. However, in the traditional tabletop studies, semantically grouped items were not always placed directly beside each other on the table (Tang, 1991; Kruger et al., 2004).

The practice of workspace partitioning relates directly to the work practice of tabletop territoriality that will be explored throughout the remaining chapters in this dissertation. The broader implications of Tang's and Kruger et al.'s observations for the design of digital tabletop technology will be discussed in more detail in Chapter 5.

People transition between workspace activities. Several of the traditional tabletop studies revealed that people often transition between workspace activities, such as reading, writing, drawing, and gesturing (Bly, 1988; Tang, 1991). In these studies, this practice was performed fluidly and rapidly with the available traditional media (e.g., pens and paper). Many existing digital tabletop systems, however, distinguish between textual and graphical marks, forcing users to explicitly indicate their intention to write or draw by switching application modes. This distinction may hinder the practice of rapid transitioning between various activities involving digital media.

People adapt their interactions to the available table space. Studies of people's use of traditional media has shown that one of the advantages of using these media for collaboration is that they enable people to easily adapt their interactions when the available workspace is not big enough to suit all of their task needs (Luff et al., 1992). For example, when people begin to run out of room on a whiteboard or a piece of paper, they can easily begin writing smaller or up the side of the workspace edge (or in the margin of a printed text). On a table surface, people often pile traditional media to

create more room for working (Malone, 1983). In many digital workspaces, it is often more difficult for people to adapt their interactions. For example, changing text size typically requires introducing mode operations to select the precise font size and moving unused items out of the way often requires closing or minimizing items, which may hinder quick access to them if they are needed again later.

However, even though people can easily adapt their interactions, doing so often compromises their work. Participants in Pianesi et al.'s (2005) investigation of small group meetings complained of running out of space on the table to work. In follow-up focus group sessions, these participants expressed the desire for better tools for managing the limited table space and for tools that could help them organize tabletop objects functionally during their meetings. These possible tabletop workspace features will be discussed in Chapters 5 and 6.

People transition between tabletop and external work. Studies of general co-located collaboration work practices have revealed that synchronous group interaction, typical of tabletop collaboration, is only one part of daily collaborative activity (Luff et al., 1992). Group members will often need to incorporate work generated externally, such as documents, design sketches, and agendas, into their activities on a table. Consequently, it is important for collaborative tabletop systems to support the transition between mutually focused work and independent work done beyond the tabletop environment (Elwart-Keys et al., 1990; Mandviwalla & Olfman, 1994). The practice of transitioning between tabletop and external work is not well supported by existing collaborative tabletop workspaces because of the limited import and export capabilities of these systems.

People use a variety of seating/standing arrangements. Researchers in the social-psychological fields have found that during tabletop collaboration, people tend to use a variety of seating arrangements during tabletop collaboration, both in relation to the table and in relation to other group members. Several factors can influence people's preferred locations, which in turn can influence the interpersonal interactions within the group (Sommer, 1969). The physical properties of the table, such as size or shape, can

influence seating positions. People typically have various 'distance zones' at which they interact comfortably with others (Hall, 1966).[4]   People generally feel comfortable working at 'arm's length' since this preserves their personal space (Hall, 1966). Culture and age can also affect a person's preferred interaction distances (Hall, 1974). For example, young children tend to prefer closer interactions than adults (Aiello, 1987). Consequently, children tend to favour side-by-side or corner seating arrangements during tabletop activities compared to the face-to-face seating arrangement more commonly preferred by adults (Sommer, 1969).

The collaborative task can also influence users' preferred arrangement at the table. Activities that require coordinated actions may best be supported by close user positions, because this positioning can enhance workspace awareness (Suzuki & Kato, 1995; Sommer, 1969). When the group activity is focused on conversation, adults generally prefer to sit in a face-to-face or corner seating arrangement (Sommer, 1969). In order to support these different kinds of tabletop activities, the technology must be flexible enough to allow users to interact from a variety of positions around the table.

In summary, many of the work practices that have been observed during traditional tabletop activities correspond to the work practices observed during the investigations of digital tabletop workspaces.   However, there were also subtle differences between how these work practices were carried out in each type of tabletop workspace, which reveal shortcomings of existing tabletop groupware interfaces and interaction techniques. This section also described several other work practices used during traditional tabletop collaboration – revealed by the traditional tabletop studies and relevant research from other areas of study – that are currently difficult or impossible to perform in current digital tabletop systems. Identifying these work practices and their benefits to the collaboration process highlights areas for further consideration in digital tabletop workspace design.

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[4] Hall identified four distance zones: Intimate (touching – 18 inches), Personal (1.5 – 4 feet), Social (4 – 12 feet), and Public (+12 feet).

2.4 Human Territoriality

To this point, this chapter has focused on providing the reader with an understanding of the table as an interaction environment (i.e. a place to do work) and with a general understanding of the types of activities and interactions that should be supported in this environment. Chapter 3 will continue this line of investigation by presenting new observational studies of traditional tabletop collaboration and a general analysis of the tabletop work practices observed in these studies. However, the remaining chapters of this dissertation will then focus specifically on the work practice of tabletop territoriality, which was revealed by the general analysis presented in Chapter 3.

It is important to acknowledge, though, that focusing on the territorial behaviour tabletop collaborators is but one way to interpret the interaction data collected from these studies. Since this work practice is part of a chorus of practices that people employ to help them perform task activities and interact with others, the analyses performed could also have focused on various other practices. Moreover, the use of different analysis methods, rather than the affinity diagramming and the spatial action analysis methods described in Sections 4.1.1 and 4.2.1, may have revealed different, and possibly equally as useful, results. For example, the data could have been analyzed from the information ecology perspective which focuses on understanding the flow of information in an environment and the use of that information throughout the task activities (e.g., Pirolli & Card, 1995; Gutzdial, 1997).

However, initial review of the data from the observational studies, using an open coding analysis process (Strauss & Corbin, 1998), revealed that people appeared to be partitioning their interactions in the workspace. Tang (1991) reported similar partitioning behaviour in his investigations of collaborative design activities. He identified this partitioning practice as a key resource for mitigating task and group interactions during tabletop collaboration. His analysis, though, did not focus on this practice; thus, it provides few details about exactly how this practice helps coordinate tabletop interactions. Pinelle et al. (2003) have identified coordination as a critical component of successful collaboration that should be supported by collaboration

technologies. This claim provided the underlying motivation to investigate the partitioning behaviour indicated by the initial analysis of the observational data. Further analyses of the study data (presented in Chapter 4) revealed that the partitioning behaviour was part of a more complex practice of tabletop territoriality.

To help us understand this practice in the broader context of human interaction, this section discusses the more general phenomenon of *human territoriality*. Over our lifetime we have developed many strategies to mediate our interactions with the people we encounter and work with in our homes, in our workplaces, on the street, on a table, and so on. One such strategy is human territoriality. As discussed in Chapter 1, territoriality helps mediate people's social interactions (e.g., Altman, 1975; Edney, 1976; Sack, 1986; Taylor, 1988). Fisher et al. (1984) state that, in contrast to territorial behaviour in animals, for humans, "many of the purposes territoriality serve are not as closely related to survival, and they may be seen primarily as "organizers" on a variety of dimensions (e.g., they promote predictability, order, and stability in life)" (p. 178).

2.4.1 Defining Human Territoriality

While there is little agreement in the literature on a precise definition of territoriality (see Table I for several examples), most researchers agree that territoriality involves the use of or access to a physical space and 'ownership' or 'rights to' that space, and may also involve the concepts of defence, exclusivity of use, personalization, and identity (e.g., Altman, 1975; Edney, 1976; Sack, 1986; Fisher et al., 1984; Gifford, 1987; Taylor, 1988). Gifford (1987) explains the lack of agreement on a precise definition as a "matter of emphasis" (p. 137). For example, as shown in Table I, some researchers emphasis the 'control' aspect of territoriality (e.g., over a space or a person), while others emphasis the 'preservation' aspect of territoriality (e.g., its ability for one to maintain personal space in a crowded place).

Taylor's definition of territoriality was given in Chapter 1 (also see Table I) to establish the complexity of human territoriality: how territoriality manifests in our behaviour changes over place and time and is highly context dependent. As this definition suggests, and as this dissertation will show, the level of territorial behaviour exhibited in a tabletop workspace is context dependent: the available table space, the group size, the task activities, and other factors influence people's territorial behaviour during tabletop collaboration.

For the purposes of the remaining discussion, though, the simpler, operational definition of territoriality offered by many environmental psychologists will suffice.

Table I. A sample of the variety of definitions of human territoriality in the literature.

Territoriality as a means to assert some level of control or ownership over a space.

"Human territoriality can be viewed as a set of behaviours and cognitions an organism or group exhibits, based on perceived ownership of physical space."

(Fisher et al., 1984, p. 176)

"Territoriality is a pattern of behavior and attitudes held by an individual or group that is based on perceived, attempted, or actual control of a definable physical space, object, or idea and may involve habitual occupation, defence, personalization, and marking of it."

(Gifford, 1987, p. 137)

"Territorial functioning refers to: an interlocking system of attitudes, sentiments, and behaviors that are specific to a particular, usually delimited, site or location, which, in the context of individuals, or a small group as a whole, reflect and reinforce, for those individuals or group some degree of excludability of use, responsibility for, and control over activities in these specific sites."

(Taylor 1988, p. 81)

Territoriality as a means of maintaining a desired level of personal space and privacy.

"Territorial behaviour is a self/other boundary-regulation mechanism that involves personalization of or marking of a place or object and communication that it is "owned" by a person or pup. Personalization and ownership are designed to regulate social interaction and to help satisfy various social and physical motives. Defense responses may sometimes occur when territorial boundaries are violated."

(Altman, 1975, p.107)

Territoriality as a means to control or influence people, phenomena, or relationships.

Territoriality is "the attempt by an individual or group to affect, influence, or control people, phenomena, and relationships, by delimiting and asserting control over a geographical area. … [Territories] are the results of strategies to affect, influence, and control people, phenomena, and relationships."

(Sack, 1986, p. 19)

Fisher et al. (1984) state that:

> "Human territoriality can be viewed as a set of behaviours and cognitions an organism or group exhibits, based on perceived ownership of physical space." (p. 176)

This definition highlights an important aspect of territoriality that this dissertation reveals to be a key aspect of the territorial behaviour exhibited on a table: the notion that territorial behaviour stems from the 'perceived ownership' of space. This view of territoriality is also reflected in Altman's (1975), Gifford's (1987), and Taylor's (1988) discussions of human territoriality. As this dissertation will show, when people are interacting in a shared tabletop workspace, they exhibit more territorial behaviour (i.e., more exclusivity of use) in areas of the table where the 'ownership' (or sense of 'responsibility for') those areas is implicitly commonly understood among group members (see Section 4.2).

2.4.2 Three Types of Human Territories: Primary, Secondary, and Public

Many environment psychologists distinguish between three main types of territories used by humans: primary, secondary, and public (e.g., Altman, 1975; Fisher et al., 1984; Gifford, 1987). These territories differ across a number of dimensions, including the associated level of perceived ownership, how serious an intrusion by another person or group is perceived to be, and the typical duration of use or occupancy of the space in question (Fisher et al., 1984). Examples of primary territories include a house or a dorm room. These places have a fairly permanent level of perceived ownership and are likely to be defended if an intrusion from a 'non-owner' occurs. A classroom, on the other hand, is an example of a secondary territory. This type of territory has a moderate level of perceived ownership, in that the students and teachers using the classroom are perceived to be one of a number of 'qualified' users. Finally, an area on the beach, a restaurant table, and seats on a bus are all examples of public territories. These territories are characterized by low perceived ownership of the space, short duration of use, and generally being available to a large number of possible users or occupants.

With respect to these three types of human territories, work tables likely fall somewhere between a secondary and a public territory, depending on the context. For example, whether a table is located in someone's personal office, in a communal meeting room, or in a cafeteria may affect the perceived level of ownership of the space on the table and the resulting level of territorial behaviour that is exhibited. Whether the contents of the table are owned by a particular group member will also likely affect the level of territorial behaviour exhibited. However, for most 'peer' collaborations, it is likely that, because group members have come together for some shared purpose, they would perceive a fairly equal level of ownership to the space on a table they are sharing. Thus, for our purposes we will consider most work tables as public territories. Taylor (1988) asserts that people exhibit 'minimal territorial functioning' in public territories, which helps in "facilitating usage and minimizing conflict" (p. 222).

2.4.3 Design of a Space Can Affect Territorial Behaviour

Poorly designed public territories can hinder people's ability to exhibit their preferred level of territorial behaviour, sometimes leading to social discomfort and disorder. Altman (1975) claims that:

> "The occupant of a public territory is at the mercy of a culture or spatial designer. For example, the crowded elevator and the crowded subway or bus do not really allow very much space per person … and restaurants sometimes seat different parties overly close to one another. Thus if the design of a public territory is bad, there may not be efficient boundary-control mechanisms. One might expect, therefore, that people will often have to rely heavily on other mechanisms, such as nonverbal and verbal behaviors, to assist in regulation of privacy in public settings." (p.120)

While Altman speaks about territoriality as a means of maintaining a desired level of personal space and privacy (which is the focus of his research), it is also likely that other aspects of territoriality, such as the role it plays in mediating people's social interactions, may also be affected by poor space design. The results of this dissertation support this supposition. As will be discussed further in Chapters 4 and 5, territorial behaviour during tabletop collaboration appears to help people coordinate their task and group interactions. The results of several investigations discussed in this dissertation suggest

that in situations where collaborators have a compromised tabletop workspace (e.g., the table is too small or people are seated too close together) people tend to exhibit less territorial behaviour, resulting in an increased need for explicit verbal and non-verbal negotiation to share the tabletop space.

An important point to acknowledge here is that most research in human territoriality focuses on how people can effectively avoid conflict, maintain personal space and privacy, protect their homes and possessions, and so on. However, in collaborative situations, especially among peers, people are likely willing to make some personal compromises, such as being willing to maintain a smaller personal space and being willing to share their possessions, in order to gain the benefits of working with others. Thus, understanding precisely how territorial behaviour can help people *work together* on a tabletop workspace, as well as understanding which aspects of a tabletop workspace affect people's territorial behaviour is essential. This knowledge can help us design effective digital tabletop workspaces which allow people to exhibit an appropriate level of territorial behaviour to best support their collaborative interactions. This knowledge can also help us better predict the consequences of developing certain workspace features that may benefit some aspects of the collaboration experience, but that may potentially restrict people's ability to exhibit territorial behaviour. Understanding what these tradeoffs are will help designers make informed design choices.

2.5 Chapter Summary

This chapter provides a foundation for the concepts that will be explored in the rest of this dissertation. It has shown that, while existing digital tabletop systems are beginning to provide useful features for supporting co-located collaborative activities, these systems still do not support many of the important work practices that collaborators use during traditional tabletop collaboration. The findings from the digital tabletop studies and the traditional tabletop studies show that there are subtleties in collaborators' interactions with traditional media that current digital tabletop workspaces are unable to support.

These subtleties appear to provide richness to the collaboration by increasing the ability to communicate one's intentions and coordinate group interactions.

Gaining a better understanding of the subtleties of traditional tabletop work practices can help us understand how to design the features of digital tabletop workspaces to provide a similarly rich collaboration environment. For this purpose, Chapter 3 presents two observational studies specifically design to elucidate the work practices used in traditional tabletop collaboration. Chapter 4 then looks in detail at the specific work practice of tabletop territoriality, which relates closely to the practice of workspace partitioning discussed above in Sections 2.2.3 and 2.3.3. The current chapter describes the theoretical foundations of the general behavioural practice of human territoriality, which helps to ground our discussions of territorial behaviour throughout the following chapters.

This dissertation is only one step towards developing a digital tabletop workspace that enables all of the key work practices discussed in this chapter. In particular, understanding how to design a digital tabletop workspace that integrates into collaborators' broader work context needs further investigation.

Chapter 3. Observational Studies

To complement the research presented in the previous chapter, this chapter presents a new investigation of co-located collaboration, specifically designed to inform the design of co-located groupware systems, and collaborative tabletop systems in particular. This investigation presents two observational studies of traditional tabletop collaboration: one in a casual setting and one in a more formal setting. The purpose of these studies was to discover work practices that might be important for tabletop system design.

To help understand the low-level actions and interactions that tabletop groupware interfaces will need to support, these studies focused on collaborators' use and sharing of objects on the table surface, as well as their use and sharing of the table surface itself. The first study involved groups and individuals playing various tabletop games in a casual, drop-in environment. This initial study was used to explore how different tasks, the number and type of artefacts being used, the shape and size of the table, and the number of participants at a table impact collaborative tabletop interactions. The second study then focused on a subset of these factors by investigating small groups (i.e. two-three people) performing one particular type of activity (a collaborative layout planning task) in a laboratory setting. In order to carefully analyze participants' tabletop interactions, the sessions in this study were videotaped.

The remainder of this chapter presents these studies in more detail. First, the experimental methodology for the first tabletop study is presented, followed by general observations from the study. Next, the experimental methodology for the laboratory study is presented, followed by general observations from the study. Then, the tabletop practices observed in both of these studies are summarized and discussed. Finally, the importance of one of the observed tabletop work practices – the establishment of distinct personal, group, and storage areas on the table – is discussed.

3.1 Study 1: Tabletop Interactions in a Casual Setting

This observational study explored the use of artefacts and table space by individuals and small groups interacting on a variety of tables in a casual setting. The study involved individuals and groups playing various tabletop games in a drop-in activity area. Most of the tabletop activities could either be done alone or in a group.

3.1.1 Experimental Methodology

3.1.1.1. Participants and Setting

On August 9, 2002, three activity tables and an observation table were setup in one corner of the atrium area on the lower level of Dalhousie University's Faculty of Computer Science, in Halifax, Nova Scotia, Canada (see Figure 25). The atrium area was a frequent hang-out for students and faculty. At one end it contained a coffee shop. Vending machines and a small kitchen area were at the other end with couches and tables in between. The observational area was setup near the kitchen area of the atrium. Observations were taken during a five-hour period from 2:30pm-7:30pm. Over the course of the observational period, 18 people participated in the various activities. Some participated for several hours, while others participated for as little as 10 minutes. Most participants appeared to be students from the ages of 20-30, including males and females of varying ethnic origins.
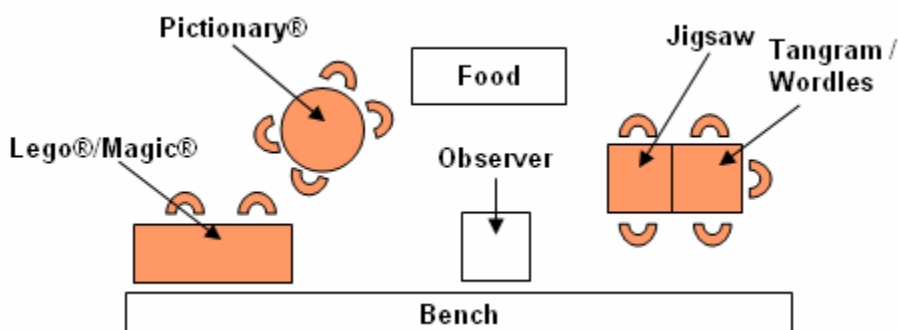
Figure 25. Observation area showing the initial configuration of the three activity tables.

Due to the "drop-in" nature of the activities, an implied method of subject consent was used. Large signs were posted advising people that by partaking in any of

the activities at the activity tables they were consenting to be observed by the researcher (see Appendix A). These signs were placed on the walls behind each table and entering and leaving the observational area. The signs also advised participants that additional information about the study was available at the researchers' observation table, which was well labelled and located in the observational area. Since consent was implied through participation, it was decided beforehand that no observations would be recorded of children in the area; however, this was not an issue as no children were present during the session.

3.1.1.2. Experimental Tasks

Given the 'drop-in' nature of the study, the tabletop activities had to be fairly common activities, familiar to participants, or have simple, obvious rules that could be explained easily by quick-reference instructions located at each table. All activities had information sheets outlining their basic instructions (see Appendix A for the precise instructions provided at each table). Each activity table contained a different type of activity:

- *The Puzzle Table* consisted of two adjoining tables (76 cm² each). The table contained several puzzles: Tangram, a word puzzle, and a jigsaw puzzle. Tangram is a puzzle involving the arrangement of seven geometric shapes to form silhouettes depicted in a booklet supplied on the table. The word puzzle involved guessing phrases from word clues. Figure 26 shows the components of these activities. Five chairs were arranged around the tables (two on each long side and one at the end furthest from the observation table).

Figure 26. Puzzle table activities. From left to right: jigsaw puzzle, Tangram, word puzzle.

- *The Pictionary® Table* consisted of a round table (94 cm in diameter) containing the Pictionary® game. In this game, teams competed to advance around a game board by identifying target phrases drawn by teammates. Figure 27 shows the components of the Pictionary game. Four chairs were placed around the table.

Figure 27. The Pictionary® game.

- *The LEGO® Table* consisted of one rectangular table (61x153 cm) containing a variety of Lego® blocks. Activity instructions at the table suggested re-designing the university's Computer Science building. Figure 28 shows the

Figure 28. The LEGO® activity.

same LEGO® blocks being used for a construction task. Two chairs were placed along one long side of the table and a bench along wall provided seating on the other long side.

These activities were included because they represented a variety of McGrath's (1984) collaborative task types: Planning (Tangram, Jigsaw), Creative (Pictionary, LEGO), Intellective (Tangram, Word Puzzle, Jigsaw), and Contest (Pictionary). These tasks represent a wide variety of activities that people do at a table, including manipulating items, sharing items, discussing items and ideas with collaborators, and constructing a group product. These tasks also provided the opportunity to observe both individual and group interaction at a table.

An unexpected opportunity arose during the observational session to observe another tabletop activity. During the first few minutes of the observational period, a student who had become aware that I wished to observe people playing tabletop games from the posted signs asked me if I would be interested in observing him and his friends

playing the *Magic*[5] card game in the observational area. Although strictly competitive games were specifically omitted from the tasks listed above, the opportunity was seized because at that point in time no other participants were in sight. They were directed to play on the Lego® table since, based on pilot test data, the Lego® activity was expected to be the least informative for artefact manipulation on the tabletop surface[6]. While primarily a card game played in the hand, a game of Magic™ also involves placing cards on the table and uses game pieces that resemble small black and white stones.

3.1.1.3. Procedure

There was no set procedure for this phase of the study. Since the goal was to observe the natural interactions[7] of people during tabletop activities, no specific behaviour was imposed on the participants. Participants were free to take part in any or all of the activities and to help others perform the activities. During the 5-hour observational period, participants were free to perform the activities in any order and for as short or as long a time period as they desired.

3.1.1.4. Data Collection

Field notes were recorded of activities from the three activity tables. Observations focused on participants' use of artefacts (i.e., what items where used and how they were used) and use of the tabletop surface (i.e., where items were used and where they were stored). Observations were taken at one table at a time, depending on where there appeared to be the most complex use of the tabletop workspace (i.e., activity involving significant movement of task items was favoured over activity where people were

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[5] *Magic: The Gathering*® is a role-playing card game with game-specific cards and several game pieces.

[6] A pilot study showed that much of the interesting object manipulation during construction of Lego® structures occurs off of the table – in participants' hands or above the table in 3D space. Although we decided to retain the Lego® activity, it was considered a low priority activity for observation because it was less applicable to the development of a 2D interface.

[7] More specifically, behaviour that is as natural as possible while still gaining consent from participants to be observed.

engaged in discussion and not interacting with the table). Most of the observations were recorded at the Puzzle Table as it attracted more people than the other tables, often having 2-4 people at a time interacting with the puzzles.

3.1.1.5. Data Analysis

In order to obtain a general understanding of how participants interacted with items on the table and the tabletop surface itself, the field notes – which contained both textual notes and rough sketches of the tabletop interactions – were reviewed. This review focused on understanding how different types of tabletop artefacts were used and manipulated. For example: when people were currently using artefacts, how and where were these items manipulated? When people were done with artefacts, where were these artefacts placed? Did people typically slide, rotate, or pass items along the tabletop surface or did they typically perform all object manipulations above the tabletop surface? Where did people interact alone with tabletop artefacts and where did they tend to share artefacts with others? The results of this analysis are described below.

3.1.2 General Findings from Study 1

Overall, participants' interactions with tabletop items were fluid and dynamic. They were opportunistic in their use of the table space, using whatever space was available, even nearby box lids, laps, and chairs. Furthermore, people shared the space easily, fluidly expanding and contracting their interaction areas as the number of people and the activities changed at the table. Multiple people frequently interacted in the workspace concurrently and gestured to artefacts on the table as they collaborated. People would often touch or hold task materials on the table as they were discussing them or as they were thinking about the task. For example, while one group of three participants were trying to assemble one particularly challenging Tangram silhouette, one participant was touching the partially assembled tangram pieces as he was watching another teammates draw out different configurations on a piece of paper. Groups often used a mix of tightly-coupled collaboration and independent interactions in the workspace during the

different activities.   Participants also made use of non-task-related items in the workspace during their interactions, such as food and beverages.

The field notes revealed similar patterns of tabletop interaction on the three activity tables.   Whether interacting alone or in a group, participants appeared to partition the tabletop workspace into several interaction areas. The field notes revealed three types of interaction areas: *personal*, *group*, and *storage*. These areas appeared to help people organize their interactions with both task items and with others at the table.   The area directly in front of each person tended to be used by that person exclusively, while the middle area of the table tended to be used by all group members.   People would sometimes break away from the current group activity to explore an idea on their own and write on pieces of paper on the table in front of themselves. This idea would often be later incorporated into the group conversation.   Participants also appeared to use certain areas on the table for storing items.   These areas typically emerged on the periphery of the personal and group areas, but were also located on other convenient surfaces, such as spare table edge space, nearby chairs, puzzle box lids, people's laps, and the floor.

The boundary between two areas tended to be quite flexible and was often determined by the location of items on the table and the specific activity that was being performed. For example, while a person was working independently on something, they would often use a large area in front of them to organize the items they were using, but some of this space was often incorporated back into the group work area when the person once again joined the group activity.

3.2 Study 2: Tabletop Interactions in a Formal Setting

The second observational study involved three small groups (2-3 participants each) performing a layout planning activity on a table using traditional media in a laboratory setting.

3.2.1 Experimental Methodology

3.2.1.1. Participants and Setting

During the week of August 19, 2002, this phase of the study took place in a usability laboratory in the Faculty of Computer Science at Dalhousie University, in Halifax, Nova Scotia, Canada. Seven university students from a variety of academic backgrounds were paid to participate in the experiment. In order to observe various approaches to the planning process, participants were recruited via three different types of study advertisements. Group 1 comprised two self-identified 'non-technology' students (one female Business student and one male Medical student). Group 2 comprised two 'visual arts' students (one female and one male Fine Arts student). Group 3 comprised three students familiar with 'computer-aided design software' (two female Architecture students and one male Computer Science student).

The experimental set-up consisted of a round table (94 cm in diameter), surrounded by several chairs, located in the middle of the laboratory (see Figure 29), side tables along one side of the room containing experimental material, a video camera and

Figure 29. The experimental set-up for study 2[8].

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[8] The year shown in the date on all the pictures from this study is incorrect, it should be 2002. The year was set incorrectly on the video camera for the duration of the study.

sound equipment set-up in one corner of the room, and a chair beside the camera for the observer. Small, clip-on microphones for each participant were connected to the video camera via a sound mixer.

3.2.1.2. Experimental Task

Each group was asked to create a furniture layout plan for a reading room in a library. The layout plan was to be created on a white, circular cardboard Floor Plan (61 cm in diameter) located on the experiment table. Participants were given paper supplies to create the furniture layout, including paper icons of furniture and Post-it™ notes, pens, and scissors to make custom items. At the beginning of the activity, piles of related furniture items were located in the middle of the Floor Plan and the other resources were piled on the table edge beside the Floor Plan.

The groups were asked to incorporate several design requirements, provided to each group member on an instruction sheet during the experiment. These requirements included several potentially conflicting items that were hoped to encourage participants to discuss tradeoffs that they would need to make in order to create the finished layout. Some sample instructions included the need to provide discussion space for groups to work and quiet space for individuals to study, and the need to accommodate as many people as possible while providing an inspiring environment (see Appendix B for the full list of instructions).

3.2.1.3. Procedure

The experimental session began with welcoming remarks from the experimenter, a brief explanation of the experiment, and the participants signing consent forms. The experimental task was then described and participants were given roughly forty-five minutes to complete the task. They were asked to inform the experimenter when they were done. Once the group had finished, they spent about five minutes presenting their final layout plan to the experimenter. At the end of the experiment, participants were paid and thanked for their participation.

3.2.1.4. Data Collection

Each layout session was videotaped and audiotaped, and field notes were recorded. Twenty-nine, forty-three, and thirty-eight minutes of data were collected from Groups 1-3, respectively. Observations recorded in the field notes focused on participants' use of tabletop artefacts and their use of the table surface.

3.2.1.5. Data Analysis

Similar to the analysis performed on the Study 1 data, both the field notes and video data from the study were reviewed to help gain a general understanding of how participants interacted with tabletop artefacts and of how they shared the work surface. Even in this general analysis, the video data helped to reveal more subtle behaviours than was possible to observe in real-time through field note data in Study 1. The general findings revealed by this analysis are discussed below.

3.2.2 General Findings from Study 2

Similar to participants' tabletop game playing interactions in Study 1, participants' interactions with task artefacts and the tabletop workspace were fluid and dynamic throughout the layout planning sessions. The review of the field notes and video data revealed that group members easily shared task resources and the table space, and for the most part, gracefully avoided conflicts for shared task materials and areas of the workspace by anticipating and accommodating the interaction of others. Collaborators often interacted concurrently in the workspace. They frequently used both hands to manipulate items in the workspace to create furniture arrangements with the supplied furniture icons or to create custom items using Post-it™ notes, scissors, and pens. Participants also used the table surface to demonstrate spatial concepts to others. For example, during one group's discussion of a particular furniture arrangement, one participant illustrated the possible traffic flows around the furniture by drawing on the Floor Plan with her finger.

The majority of sessions followed a similar temporal pattern. In general, after some initial discussion of the overall plan for the library layout, participants then worked

independently in the workspace. However, there were also many short periods of time when participants worked closely together in the workspace, interacting with the same artefacts in quick succession. These interactions involved both cooperatively modifying furniture arrangements and passing artefacts to one another over or via the table surface. These episodes of close collaboration were often triggered by an individual asking for help from their partner(s) or by someone noticing something a collaborator was doing in the workspace and offering unsolicited help or advice.

The field notes and video data also revealed the use of the three types of interaction areas observed in Study 1: personal, group, and storage. Again, the area directly in front of each person at the table appeared to be reserved for use by that person. Participants often used this area to write on Post-it™ notes, create custom items, and read their instruction sheets. Although all of the furniture items were initially piled in the central area of the Floor Plan, by the end of all three sessions, these piles had all been relocated to the table edge beside the Floor Plan. Also, resource items that were being used by a particular person were typically piled near that person, whereas resource items being shared among group members were typically located somewhere more easily accessible by everyone at the table.

Unlike the dynamically changing personal areas observed during Study 1, participants' typically restricted their personal activities to a small area between the edge of the cardboard Floor Plan and the edge of the table. Similarly, most of the Floor Plan appeared to be shared by all group members, although people often took responsibility for creating and modifying the furniture arrangements in the Floor Plan area directly in front of them.

3.3 Discussion of Tabletop Practices Observed in Studies 1 and 2

The general tabletop practices observed during Studies 1 and 2 are listed in Table II. Many of these practices correspond to previously reported tabletop practices that were discussed in Chapter 2. However, the list also extends the previous research by providing

an understanding of these practices in the context of the tabletop surface and the artefacts located on that surface. This context is important for the design of tabletop systems because whether an action typically occurs above the table or on the table, or on the table edge or in the centre of the table, impacts how technology can enable this action. For example, previous research has found that people use gestures in a co-located environment and that these gestures often occur in relation to the participants and the artefacts in a workspace (Bekker et al., 1995; Bly, 1988; Gutwin et al., 1996; Tang, 1991). However, the fact that tabletop collaborators gesture both above the table and directly on tabletop artefacts or the table surface itself (Practices 1 and 2 in Table II) has not been previously articulated.

Table II. General tabletop practices observed during the two studies.

Use of Gestures
1. Participants frequently used gestures both over the table and directly on the table surface, often touching items on the table while referring to them, without moving the items.
2. Participants demonstrated spatial concepts directly on the table surface, e.g., drawing a shape with a finger on the table.
Interactions with Artefacts / Collaborative Interactions
3. Participants frequently interacted with both hands in the workspace.
4. Participants frequently interacted concurrently in the workspace.
5. Participants often passed items to each other above and on the table (e.g., pens, Post-it™ notes).
6. Different participants interacted with the same objects in quick succession, often handing off items to each other via the table surface (e.g., pens, tangram pieces).
7. Group members transitioned between independent and tightly-coupled group work on the table.
8. Participants would sometimes temporarily disengage from the group activity to pursue a thought or activity individually.
9. Participants often retrieved items for their partner(s) both with and without solicitation.
Use of the Table Space
10. Distinct areas on the workspace emerged during the evolution of the task, including personal, group, and storage areas.
11. Participants shared task materials in the workspace, but often kept their own "pile" of frequently used materials close to them.
12. Participants put non-task items on the workspace, e.g. beverages and food.

This observed property of gesturing behaviour suggests that tabletop system designers should not assume that people intend to 'interact' with a digital object as soon as they touch it, as most touch-sensitive systems currently do. In many touch-sensitive tabletop systems, there is no 'button' to click to indicate when someone is ready to manipulate the digital environment. This may require new types of interactions that can easily distinguish between when someone is gesturing in the workspace and when they wish the system to react to that action. Recent interaction techniques have been developed for pen-based computers in order to circumvent the need for point-and-click interaction. These techniques hold promise for allowing a distinction between gesturing and active interaction on a tabletop interface. For example, the *crossing* technique proposed by Apitz and Guimbretière (2004) uses the concept of goal crossing to initiate interaction with digital items in the workspace instead of button clicking.

Another finding from these studies that extends previously reported work practices is the observation of the emergence of three distinct types of tabletop areas during the tabletop sessions (Practice 10 in Table II). Previous research has reported the use of two distinct work spaces on a table: personal and group spaces (see Section 2.3.3). Yet, what factors affect the development of these spaces and if, or how, these spaces change over the course of the collaboration has not been discussed. Moreover, the establishment of storage areas was not reported by these earlier investigations. One explanation for the lack of attention to storage areas is that these earlier studies involved collaborative tasks which required fewer task materials, potentially reducing the need to store items not currently in use.

The personal, group, and storage areas appeared to help people organize and perform their tabletop activities, akin to *territories* in our broader environment (e.g., a roommate's 'side of the room'), which help us to mediate our social interactions (Altman, 1975; Fisher et al., 1984; Taylor, 1988). Thus, these areas appear to serve as *tabletop territories*. Providing similar organizational and task support during collaboration on a digital tabletop system would allow people to focus on completing their task activities rather than wasting time explicitly having to coordinate their actions in the workspace.

Thus, further investigation of the establishment and use of tabletop territories may provide useful insights for the design of tabletop systems. The following chapter explores this issue further by presenting in-depth analyses of the data from Studies 1 and 2, focused specifically on understanding the role of personal, group, and storage territories in tabletop collaboration.

3.4 Chapter Summary

This chapter presented the methodological details of two observational studies that investigated traditional tabletop interactions of groups and individuals performing a variety of tabletop activities, in both a casual and formal setting. The general findings from these studies provide important implications for the design of collaborative tabletop systems. These findings highlight the importance of understanding the behaviour that occurs during tabletop collaboration in the context of both the table surface and the artefacts being used on the table. These findings also reveal that collaborators appear to exhibit territorial behaviour while sharing a tabletop workspace, resulting in the establishment of three distinct types of tabletop territories during collaboration: personal, group, and storage territories. The desire to further understand precisely how this tabletop practice helps collaborators mediate their task and group interactions led to more detailed analyses of the data from these two studies. These detailed analyses are presented in the next chapter.

Chapter 4. Investigating the Practice of Tabletop Territoriality

The previous chapter presented the methodology and initial findings of two observational studies that were specifically designed for investigating work practices used by individuals and small groups when interacting with traditional media on tables. One work practice revealed by those findings was the use of tabletop territories during collaborators' interactions in the tabletop workspace. The findings from Studies 1 and 2 revealed that collaborators establish three distinct types of tabletop territories during collaboration: *personal*, *group*, and *storage* territories. These tabletop territories appeared to help collaborators organize and share task resources and the tabletop workspace itself. This chapter revisits the observation data from Studies 1 and 2, and presents focused analyses aimed at gaining a deeper understanding of the practice of tabletop territoriality and how traditional media supports this practice. From this knowledge, we can begin to understand how tabletop interfaces can be designed to provide similar support for organizing and sharing task resources in a digital tabletop workspace.

The remainder of this chapter is organized as follows. First, the field notes from Study 1 are re-analyzed with a focus on tabletop territoriality. Then, an in-depth video analysis of participants' tabletop interactions from Study 2 is presented. Finally, the chapter concludes with a summary of the findings from these two analyses.

4.1 Territorial Analysis of Study 1

To help understand the general characteristics of the three types of tabletop territories and their use during the observed tabletop interactions, a more focused analysis was performed on the field note data from Study 1. These field notes were composed of both textual notes and rough sketches of participants' tabletop interactions.

4.1.1 Data Analysis

The first step of this analysis involved reviewing the field notes from Study 1 to identify any overall interaction patterns that appeared to correspond to each type of tabletop territory. Next, the field notes were analyzed using the *affinity diagramming* analysis method (Holtzblatt & Jones, 1993) to help reveal the particular characteristics of each type of tabletop territory. Affinity diagramming, a method commonly used for analyzing field study findings, helps reveal logical groupings within study data through a gradual sorting process (explained below). Separate affinity diagrams were produced for each of the three tabletop territories. To prepare the data for this process, each tabletop activity or interaction that appeared to correspond to (at least) one of the tabletop territories was recorded on a separate, small piece of paper[9] (one for each territory it corresponded to). The recorded observations were then separated into three groups – one for each type of tabletop territory – and then each group was used to create a separate affinity diagram.

For each affinity diagram, space was first cleared on a table surface, creating the analysis space. Next, an arbitrary observation was selected and placed in the analysis space. Then, for each subsequent observation, if it appeared to relate to the first observation, it was grouped with the first; if not, a new group was started elsewhere in the analysis space. As each observation was added to the analysis space, new groups emerged, previous groupings were reconsidered, and observations were moved between groups as a better understanding of the relationships between observations emerged. This process continued until all recorded observations had been added to the analysis space and the groups finally stabilized. Once group stabilization occurred, a category name was then assigned to each group and the results were recorded.

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[9] Following the advice from an experienced creator and facilitator of card sorting techniques, Tom Dayton, paper was used instead of the Holtzblatt and Jones' (1995) suggestion of Post-it™ notes. During a tutorial on card sorting methods (Lafrenière, et al., 2000), Dr. Dayton claimed that people using sticky notes for information sorting often leave items in their initial location because they are 'stuck' to the surface, potentially inhibiting the development of more appropriate item groupings. In contrast, using non-sticky paper facilitates moving items between groups to help the emergence of appropriate and useful categorizations.

4.1.2 Results and Discussion

A general review of the field notes and the affinity diagramming process revealed many interesting characteristics of personal, group, and storage territories, including what purpose each territory served for task and group interactions, the typical activities that occurred in each territory, and some spatial properties of each territory. Identifying these characteristics can help us understand how to facilitate the establishment and use of tabletop territories in a digital tabletop workspace. Identifying:

- the purpose of each tabletop territory helps to clarify *what functionality* should be supported, as well as *who requires access* to that territory and that functionality,

- the typical activities that occur in each territory helps to clarify *what type of task interactions* should be enabled in that territory and suggests tools that may facilitate these task interactions, and

- the spatial properties of each tabletop territory helps to clarify *where* specific system functionality and interaction capabilities should be located in the digital tabletop workspace.

This can also help us understand how to provide appropriate software tools and features that enhance – and do not hinder – interactions with tabletop items within each tabletop territory. The following sections present the results for each type of tabletop territory in more detail. Where appropriate, specific examples from the field notes are provided to help demonstrate how these territories were used during the tabletop game play.

4.1.2.1. Characteristics of Personal Territories

The characteristics of personal territories revealed by the affinity diagramming process and by the review of the field notes are summarized in Table III. These results show that personal territories were used by participants working alone at the table to perform their main task activities, such as assembling the jigsaw puzzle or sorting and comparing puzzle pieces. Table III also shows that participants also used their personal territories to temporarily disengage from the group to perform independent activities, such as

exploring an alternative solution to a tangram or word puzzle, and to reserve task resources.

Table III also reveals that personal territories were an important resource for other group members who often monitored what their collaborators were doing in their personal territories. In an example from the tangram task, shown in Figure 30, Excerpt 1, a participant, P_B (bottom), used his personal territory to explore an alternate solution to the current tangram problem while the rest of the group continued to work in the group territory. When he thought he had the solution, he returned to the group territory to try out the idea with the actual tangram pieces (called tans). The other group members referred to the drawing located in his personal territory to help them

Table III. Characteristics of personal territories.

Personal Territories
Purposes
working on main task activities, by individuals alone at the table
working individually on same task that the group is working on in group space (e.g. exploring a tangram solution)
temporarily holding group resources
monitoring a collaborator's activities (sometimes used as a reference area for others)
assistance from other group members (e.g., counting cards in Magic™)
Typical Activities
reading, writing, and drawing (e.g. Pictionary™, word puzzle)
comparing items
assembling task products (when alone at the table) (e.g. puzzle, tan silhouette)
placing task items (e.g. cards in Magic™)
searching of task items (e.g. puzzle pieces)
sorting task items (e.g. puzzle pieces)
people leaned on the table in these spaces
Spatial Properties
generally located in front of each person at the table
fluctuates as people come and go from the table
individuals alone at the table use larger personal territories than people in groups
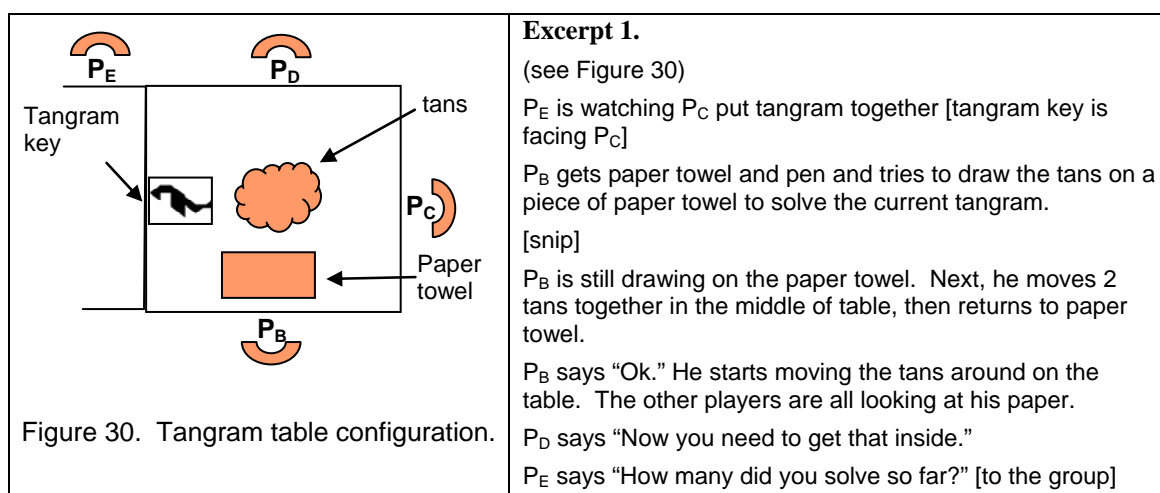
	Excerpt 1.
  Figure 30. Tangram table configuration.	(see Figure 30)
	P_E is watching P_C put tangram together [tangram key is facing P_C]
	P_B gets paper towel and pen and tries to draw the tans on a piece of paper towel to solve the current tangram.
	[snip]
	P_B is still drawing on the paper towel. Next, he moves 2 tans together in the middle of table, then returns to paper towel.
	P_B says "Ok." He starts moving the tans around on the table. The other players are all looking at his paper.
	P_D says "Now you need to get that inside."
	P_E says "How many did you solve so far?" [to the group]

understand his actions in the group territory.

On occasion, group members also offered assistance in someone else's personal territory. In an example from the Magic™ game, shown in Figure 31, Excerpt 2, the player P_3 (top right) assists another player, P_4 (top left), in P_4's personal territory. Throughout the game P_3 offered P_4 (who appeared to be the least skilled Magic™ player in the group) suggestions, instructions, and clarification of the rules. In this episode, P_3 helps P_4 count the game cards located in P_4's personal territory. Though this space was typically reserved for P_4's use, P_3, in the role of 'tutor', appeared to be welcome to assist P_4 in this area.
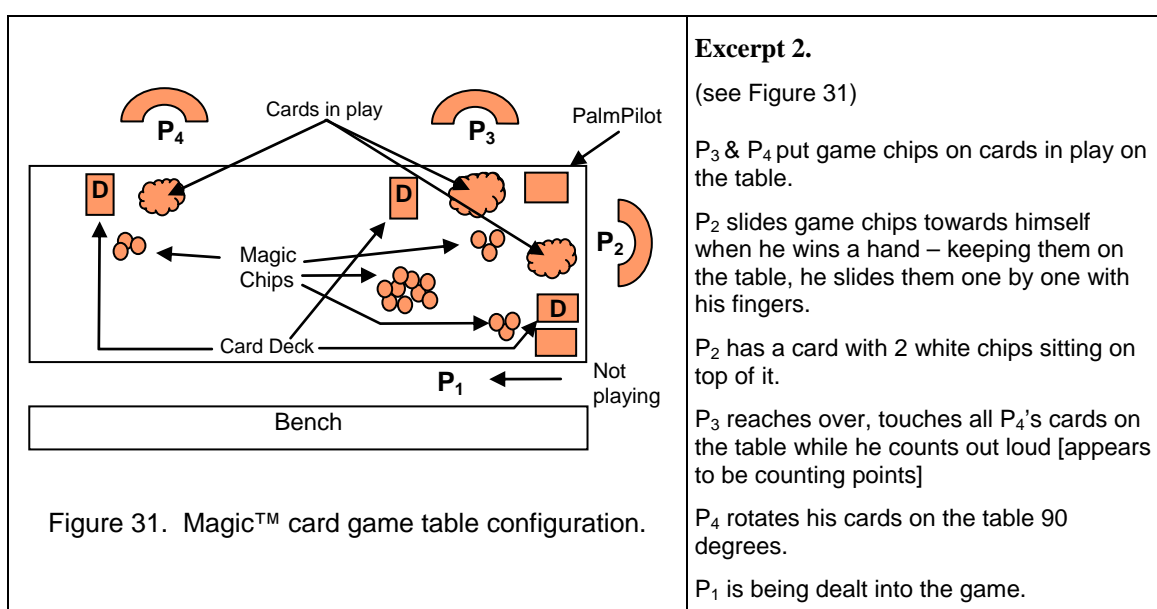
	Excerpt 2.
  Figure 31. Magic™ card game table configuration.	(see Figure 31)
	P_3 & P_4 put game chips on cards in play on the table.
	P_2 slides game chips towards himself when he wins a hand – keeping them on the table, he slides them one by one with his fingers.
	P_2 has a card with 2 white chips sitting on top of it.
	P_3 reaches over, touches all P_4's cards on the table while he counts out loud [appears to be counting points]
	P_4 rotates his cards on the table 90 degrees.
	P_1 is being dealt into the game.

These two episodes both illustrate the importance of allowing group members to view, and sometimes access, other group members' personal territories. The ability to monitor the artefacts and the interactions of others in their personal territories helps group members anticipate when assistance may be needed and helps them to understand their collaborators' motivations for actions that they may perform later in the group territory.

Table III also shows that the typical actions within the personal territories included: reading, writing, and drawing; searching and sorting task artefacts; comparing task items; and placing, arranging, rotating, and moving items. It is important for tabletop systems to provide access to tools and functionality to support these tasks in or near each group member's personal territory to enable them to work independently in these territories and to provide enough space to accommodate these activities. Table III also shows that people sometimes lean on the table in their personal territories (i.e. on the table edge in front of them). To accommodate this behaviour, a touch-sensitive tabletop system would need to be designed with this issue in mind. For example, a tabletop system could provide a non-active ledge for people to lean on or could ignore this type of touch on the table.

Personal territories were typically established on the tabletop area directly in front of each person (Table III). Also, people working in a group at the table tended to restrict their personal territories to a smaller area than a person interacting alone at a table. Personal territories also tended to expand and contract, depending on the number of people at the table and whether a person was currently working independently or in concert with the group. During the study, the tangram task attracted the most fluctuation of concurrent participants, varying from one to four concurrent players – even though there were only seven tans available for manipulation. The example shown in Figures 32 and 33, Excerpt 3, illustrates how fluidly the territory boundaries changed as group membership changed at the table. In this episode, P_D (upper right, Figure 33) joins P_E (upper left) who is already engaged in trying to solve one of the tangram silhouettes. When P_D arrives at the table, P_E 'invites' P_D's assistance by moving the task

items away from his personal territory and into a more communal area on the table – one closer to P_D. When P_D leaves the table, P_E then reclaims the items by subtly changing their location and orientation back toward himself. This episode illustrates how easily people accommodated changes in group membership through fairly slight adjustments to the orientation and location of the task resources. This accommodation typically occurred with no accompanying verbal remarks related to the availability of task resources, yet people appeared to implicitly understand these actions to be an invitation to join the task interactions.

Figure 32. Early tangram table configuration.

Figure 33. Tangram table configuration after P_D arrives.

Excerpt 3

(see Figure 32)

P_E is still working (alone) on the same tangram. There's a 'work area' and 'holding area' for the pieces.

Whenever he's trying a new combination of tan positions, he puts the pieces in the work area. When something doesn't work, he slides the pieces to the left or to the right of the work area. When moving tans into new positions, he often holds the piece in his hand and turns it, or turns it on its 'edge' against the table to 'flip' the piece.

A new guy has joined P_E in position P_D to help with the tangram. P_E's explaining what he's doing. P_D's looking at the tans as P_E manipulates them on the table.

The tans are now more in front of P_D – P_E pushed them over and is working on them from the side. (see Figure 33)

[snip]

P_D is now moving tans around the table. He attempts to move the pieces again, but P_E is moving the pieces. P_D keeps his hands on the table near the work area. P_D & P_E both have their hands besides the work area, within 1-2 inches to the left (P_D) and right (P_E). P_D is just resting his left hand and P_E is manipulating the tans.

[snip]

P_D gets a phone call and leaves the table.

P_E shifts the tans back towards him – just a bit. It's still on the adjoining table and he's still in the same seat. He tilts the orientation of the working area towards him a bit.

In summary, personal territories provided participants a space for performing their main task activities when they were alone at the table and for performing independent activities when they were part of a group at the table. However, these results also reveal that personal territories also played an important role in the overall collaboration process. Participants appeared to monitor their collaborators' interactions in their personal

territories to help them understand their collaborator's interactions in the workspace and to help them anticipant when assistance may be appropriate.

4.1.2.2. Characteristics of Group Territories

The analysis revealed that group territories only emerged when there was more than one person at the table. Individuals performed their tabletop activities using personal and storage territories only.

The characteristics of group territories revealed by the affinity diagramming process and by the review of the field notes are summarized in Table IV. These results show that the group territory appeared to be free for use by all members of the group to perform the main task activities, such as assembling a tangram silhouette or interacting with the Pictionary® game board. The results also show that people working in their personal territories sometimes refer to items located in the group territory to assist with their individual task activities. Thus, it is important for a tabletop system to allow people to simultaneously view their personal territory and the group territory to be able to

Table IV. Characteristics of group territories.

Group Territories
Purposes
working on group product by several members of the group
working on group product by an individual, while others in group discuss the problem (e.g., tangram)
placement of reference items for individual work when task is offloaded to personal territory to try new ideas (e.g., tangram)
assistance from other group members (e.g., tangram, Pictionary™ game timer)
Typical Activities
assembling task product (e.g., tangram)
sorting
displaying group-related information (e.g., game board in Pictionary™)
Spatial Properties
generally located in a central area on the table, easily accessible by all members (not all members can easily reach all of the group territory, but typically everyone can reach most of the space)
existence of sub-group territories when there are sub-groups working at the table (e.g., Pictionary™ and at the puzzle table, there were different groups working on different things at once – jigsaw, tangram, and word puzzles)

quickly glance between these two territories. Moreover, as illustrated in Excerpt 3, people often transition quickly between using the personal and group territories, so easy access to both territories should also be provided.

Although assistance from other group members sometimes occurred in the personal territories, it occurred more often in the group territory. Assistance often resulted from one group member explicitly asking for help on a task activity. Unsolicited assistance was also observed as a result of someone noticing that one or more collaborators were having difficulties with a particular task activity. One example of unsolicited assistance is shown in Figure 34, Excerpt 4, from the tangram task. In this episode, the participant, P_D (top right), assists his partners, P_B and P_C (left side and bottom, respectively), as they are assembling the tangram silhouette in the group territory. As P_D watches his collaborators try different possibilities in the group territory, he offers verbal suggestions, accompanied by gestures above the table surface.

Figure 34. Tangram table configuration.

Excerpt 4.

(see Figure 34)

They switch the tangram key to a new silhouette.

In the middle of the table, P_B and P_C are both sliding, picking up, replacing, and arranging tans. P_D is pointing and suggesting moves but not placing.

P_D – "What about the small triangle?"

P_B – "You had it right the first time." Pointing to the tans with the pen. He starts drawing on the paper towel again.

P_D – "You had the neck right before."

A more subtle example of unsolicited assistance in the group territory was observed during the Pictionary™ game. At one point during the game a player, P_H, noticed that a player from the opposing team, P_J, intended to flip the game timer. With no explicit request from P_J, P_H moved the game deck to create more space by the timer. This action provides one example of a commonly observed behaviour: group members accommodating the actions of others in the group territory. Group members frequently monitored what others were doing in the workspace, particularly in the group territory. Monitoring the actions of others in the group territory enabled people to anticipant the

needs of their collaborators and helped group members coordinate their interactions in this shared space.

Typical actions that occurred within the group territories included assembly of the task product (e.g., moving, rotating, sorting, comparing, and arranging puzzle pieces) and displaying information relevant to all group members. Since this study only involved tabletop games, obviously other types of interactions may be necessary for completing other tabletop activities. In general however, the activities necessary to complete the main task activities need to be supported in the group territory, as well as any support tools that the system may provide for facilitating these activities.

As shown in Table IV, there was typically only one group territory, which was located in the central area of the table and extended to the areas between group members' seating positions. When sub-groups were present, multiple sub-group territories tended to be established on the table. These sub-group territories were typically located along the table edge between sub-group members' seating positions. Therefore, tabletop systems being used for activities that lend themselves to the formation of sub-groups, should enable such task interactions along the table edge between users. Placing fixed interface components in this area may hinder such interactions.

In summary, the group territory serves as the main working space for completing the collaborative task interactions. The results also revealed that people easily shared the group territory. Group members also tended to monitor the actions of others in this space to help accommodate their collaborators' actions and to provide assistance when appropriate.

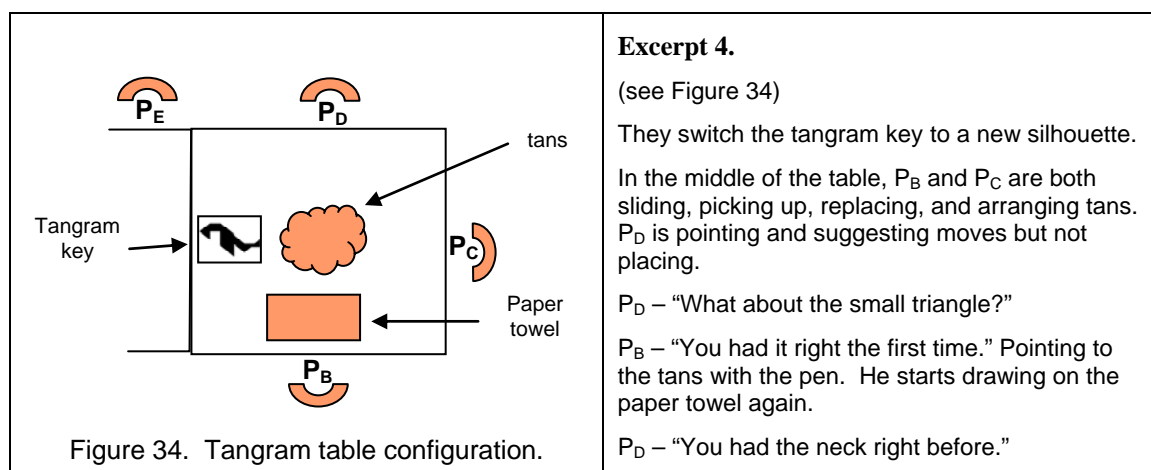### 4.1.2.3. Characteristics of Storage Territories

The characteristics of storage territories revealed by the affinity diagramming process and by the review of the field notes are summarized in Table V. These results show that storage territories served as a place to store task resources (such as loose puzzle pieces and spare pads of paper or pencils), reference items (such as the tangram key), and non-

Table V. Characteristics of storage territories.

Storage Territories
Purpose(s)
place to store task resources (e.g., puzzle pieces, pencils, spare paper)
placement of non-task items (e.g., bowls, cups, etc.)
placement of reference items (e.g., puzzle key in tangram, box lids in jigsaw puzzle)
Typical Activities
searching, when brought closer (e.g., puzzle)
loose arrangement of items
piling
storing items
movement of items in 'bunches' to personal territory (e.g., a group of puzzle pieces were piled/spread out for use)
Properties
often located at the periphery of the personal and group territories
multiple storage areas
moveable storage areas (e.g. puzzle box lid)
full & partial storage areas – some appear to be more 'temporary' than others
can be piled (e.g. jigsaw puzzle box lids)

task items (such as food and drinks). Establishing storage territories appeared to help participants organize task and non-task items in the workspace. This characteristic of storage territories will be discussed in more detail below.

Table V also reveals that the typical activities that occurred within the storage territories all relate to organizing stored task resources. Participants often piled, searched, and sorted items within the storage territories. Items were often moved between storage territories and the other tabletop territories, sometimes one item at a time and sometimes groups of items at a time.

Table V also reveals that the contents within the storage territories were typically very loosely arranged: little effort was made to keep the storage areas strictly organized. Items were typically kept in partial orders in the storage territories. For example in the jigsaw puzzle task, participants typically created separate piles of items in the storage

territories for various classes of puzzle pieces. Figure 35 illustrates an instance of the jigsaw puzzle being assembled. In this figure, the box lids located above the puzzle assembly area contained loose, mostly non-edge pieces. A pile to the right of the participant's personal territory contained the four corner pieces, randomly arranged. Several loose edge pieces and some

Figure 35. Jigsaw puzzle task during assembly.

partially assembled edge pieces were loosely arranged along the left table edge. Edge pieces under consideration were scattered in the middle of the assembled edge pieces.

The ability to loosely arrange items in the storage territories allowed people to exert only the necessary amount of effort to organize the workspace as the task evolved. As the participant in Figure 35 came across each corner piece in the pile of pieces in the box lids, he added them to the pile to the right of the partially assembled puzzle. At the time of discovery, he was not ready to add them to the assembled edge. Storing them in this pile allowed him to separate them from the other, non-classified, pieces and access them more efficiently when he was finally ready to add them to the assembled puzzle. Enabling this type of informal interaction within storage territories enabled varying levels of workspace organization. As the task evolved and became more organized, people spent more time arranging items in the workspace; yet before those final stages of the task, people tended to want more casual access to task resources. Tabletop systems should support these varying levels of resource organization by allowing casual storage of items in the workspace.

The above example also illustrates some of the spatial properties of storage territories. In general, storage territories typically emerged on the periphery of the personal and group territories, but were also located on other convenient surfaces, such as spare table edges, nearby chairs, puzzle box lids, people's laps, and the floor. Multiple storage territories were often kept on the table. Table V also shows that some storage

territories were temporary in nature, containing artefacts that were quickly reincorporated into the main activity.

Participants took advantage of creating storage territories on conveniently mobile surfaces like the puzzle box lids, which could be slid on the table, held above the workspace, or stacked to create more space. The example shown in Figures 36 and 37, Excerpt 5, demonstrates a participant exploiting the mobility of the puzzle box lids, in which he is storing extra puzzle pieces. The episode takes place in the early stage of the puzzle assembly. The participant is trying to complete the puzzle edge by removing edge pieces from the box lids, working with them in his personal territory until he exhausts his attempts to match these pieces, and then searching for more pieces in the box lids. By bringing the lids closer to him, he can more easily see and reach the loose pieces. Furthermore, by holding the box lid above the table (near the end of the excerpt) he can search for the puzzle pieces without disturbing the partially assembled puzzle on the table surface.
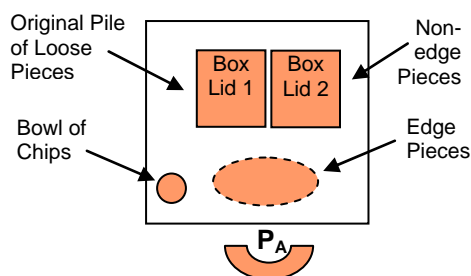
| Figure 36. First puzzle configuration. | **Excerpt 5.**

(see Figure 36)

P_A moves the box lids closer to him – box lid 2 is about 3 inches from edge of the table. As he's digging through the box lid 1 to find all of the edge pieces he's sliding the box lids towards him – it's not a separate action – he's dragging the edge with his wrist as he's digging in the box. P_A leans over the box to look inside.

Once he finishes pulling edge pieces out he pushes both lids to the center again – he still has non-edge pieces in both lids.

…

P_A is scanning edge pieces – picks up box lid 2 – pushing through the pieces, replaces and picks up box lid 1.

P_A replaces the lid without removing any pieces.

…

(see Figure 37)

P_A's sliding the pieces around inside the finished edges.

P_A's finishing off the edges – He's rooting in box lid 1 again looking for missing edge pieces [he said this].

P_A found a piece that connects to an edge piece – he |

 Figure 37. Second puzzle configuration.	connects it on the table. He's holding box lid 1 in his left hand, leaning back in his chair, rooting through the pieces with his right hand. He sets the box lid back on the table and sighs.
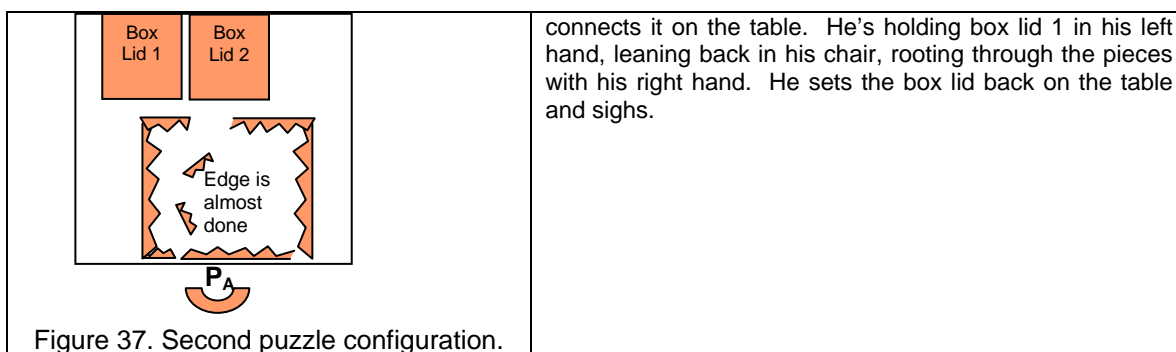
Are All Storage Territories Alike?

It is currently unclear whether there is a distinction between 'personal storage' and 'group storage' territories. This may depend on who 'owns' the items contained in the storage territories. In this study, most items on the tables were provided by the experimenter, so in a sense they were

Figure 38. Storage territories in the Pictionary™ game (circled).
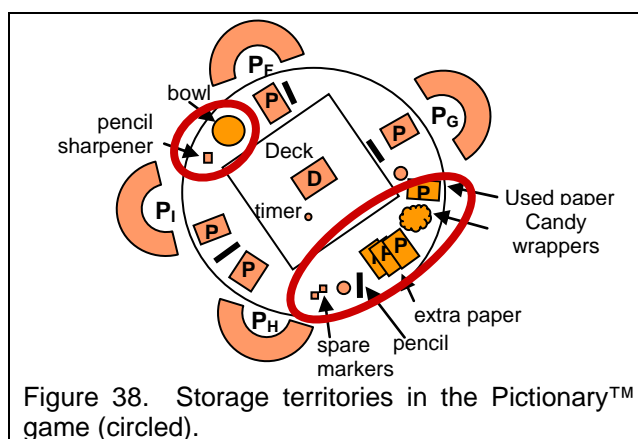
all 'public' items for the collaborators and tended to be treated as such. For example, several 'general' storage territories emerged along the table edge in the Pictionary™ game for storing miscellaneous game resources, see Figure 38. Items stored in these territories were accessed by various group members during the game.

In contrast, during the Magic™ game, each player stored his own card deck and any accumulated game 'point' chips near his personal territory. This was the only game

 Figure 39. Collaborative use of a storage territory in the Magic™ game (circled).	**Excerpt 6.** (see Figure 39) P$_4$ puts 2 cards that were face up on the table in front of him on top of the cards to the right of his deck. P$_3$ – "You have to put your graveyard face up" P$_4$ flips over the cards he just placed to the right of his deck.
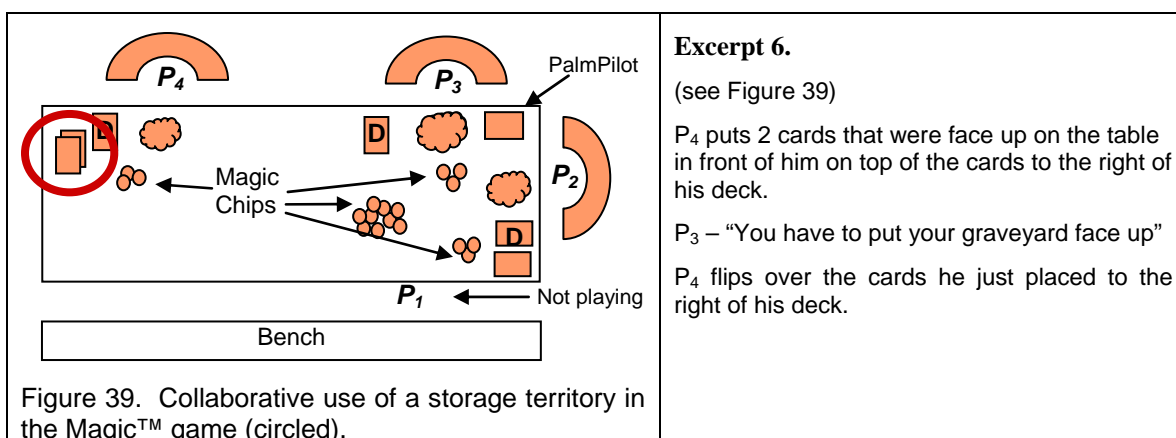
where participants played with their own personal game resources. Furthermore, unlike typical card games where everyone uses cards from a common deck, each Magic™ player used cards from their own personal deck. While each player's store of game resources was typically used by them alone, there were a few occasions where players referred to items in a storage territory near another player. This behaviour is illustrated Figure **39**, Excerpt 6, where one of the players P_3 (top right) comments on how P_4 (top left) has arranged the cards stored beside him. As previously mentioned, P_3 appeared to be 'coaching' P_4 during the game. Consequently, this relationship may have impacted the behaviour observed in this episode.

Many factors may have contributed to the different uses of storage territories observed in these two examples, such as nature of the game or the type of game artefacts that were used. More investigation into this issue is necessary to clarify whether there are various 'kinds' of storage territories. However, during the observed interactions, social protocol appeared to mediate access to items contained within each storage territory. Tabletop systems that also relied on social norms to control access to digital items contained within any established storage territory would perhaps eliminate the need to explicitly distinguish between different types of storage territories.

In summary, storage territories provide a space for group members to store and to organize artefacts on the table. Organization of items within the storage territories tends to be fairly unstructured, enabling people to casually arrange items with a minimal level of effort. This behaviour appears to help the evolution of task activities, especially before the final, polished stages of a task are reached. The analysis also revealed that, when possible, participants took advantage of creating storage territories on mobile containers, which enabled easier access to resource items.

4.1.3 Summary

The focused analysis performed on the field notes from Study 1 revealed that personal, group, and storage territories all play an important role in both task and group interactions.

Personal territories provide a space for people to perform task activities such as reading, writing, assembling, and sorting resource items while alone or while disengaged from other group members. They also appear to serve an important collaborative role by providing a visible, accessible area for other group members to monitor a teammate's independent activities and to provide assistance when necessary.

The analysis revealed that collaborators typically establish one central group territory on the table. The group territory provides a space for collaborators to work together on the task product and to assist each other in task activities. It also appears that sub-group territories can emerge when sub-groups are present at the table.

Finally, the analysis revealed that storage territories provide a space for organizing resource items on the table. When possible, people take advantage of the ability to create storage territories on mobile surfaces that can be moved around on the table or held above the tabletop workspace to provide more convenient access to stored items.

These findings demonstrate where people typically perform certain task interactions on the table, which can help us understand what the most appropriate arrangement of system tools and functionality might be in digital tabletop workspaces. They also show that the visibility of actions on the table, including in other group members' personal territories, can help people anticipate when their collaborators' may require assistance.

The following section continues this exploration of tabletop territoriality with a more in-depth investigation of collaborators' spatial interactions on the table, helping us to further understand the role of tabletop territories during their task and group interactions.

4.2 Territorial Analysis of Study 2

The analysis of the Study 1 data revealed many interesting characteristics of personal, group, and storage territories, yet the level of detail given by the field notes was insufficient to provide a precise understanding of where and how people interacted in the tabletop workspace. Also, it is inevitable that certain actions and interactions were missed or their potential significance was too subtle to notice in real-time during the observational period. To gain a more fine-grained understanding of people's spatial interactions during tabletop collaboration, an in-depth analysis was performed on the video data from Study 2. To enable this analysis a method of decomposing the workspace into interaction zones was developed. This new video analysis method, called a *spatial action analysis,* is described next, followed by the results of this analysis.

4.2.1 Data Analysis

The analysis of the video data from Study 2 followed the *open coding* method from the grounded theory research approach (Strauss & Corbin, 1998). Using this analysis method, the coding scheme used to categorize the data was iteratively developed over iterative reviews of the data. At the outset of Study 2, a very general tabletop interaction coding scheme was used to begin understanding the data. These codes, shown in Table VI, were designed to help understand the types of actions that people do on the table surface during their collaborative activity. They were also designed to help reveal how the table surface was used during various types of activities with different types of artefacts. Looking at the data from both Studies 1 and 2 with these codes in mind helped reveal the practice of tabletop territoriality. However, these initial codes did not account for precisely *where* actions were taking place, making it difficult to understand precisely where the tabletop territories were being established. Hence, a more specific coding scheme was developed to help understand the spatial relevance of collaborators interactions, as will be discussed in the next section.

Table VI. Initial coding scheme for analyzing Study 2 data.

Artefact Use:
sliding (artifact is being moved, without being lifted from the table)
lifting (artifact is being raised from the table)
orienting/rotating (artifact is be rotated on the table)
holding (artifact is being held in a person's hand – either on or off of the table surface)
placing (artifact is carefully placed on the table)
passing (artifact is being passed from one person to another directly)
deposit (artifact is being passed from one person to another indirectly via the table)
tossing/dropping (artifact is tossed, loosely placed, on the table)
twirling/twiddling (artifact is being manipulated in a person's hand without apparent purpose)
Artefact Status:
in focus (artifact is currently being used)
on reserve (artifact will/may be used at a later time)
obsolete (artifact will definitely not be used again)
Artefact Type:
task (task-related artifact, e.g., paper, pen, scissors)
non-task (non-task related artifact, e.g., pop can, mittens on table)

4.2.1.1. Spatial Action Analysis

To help understand the significance of participants' interactions within the tabletop workspace a new video analysis method was developed, called a *spatial action analysis*. This analysis method involved first partitioning the tabletop workspace into various interaction regions, or zones. These zones formed the basis for the revised coding scheme for the video analysis. Because the interactions occurred on a round table, a compass-style partitioning was used, along with a centre-to-table edge partitioning. That is, the table was divided into 16 *directional zones* (see Figure 40) and 4 *radial zones* (see Figure 41). Participants' tabletop activity was then transcribed from the video data using Kruger's (2004) TranscriptionHelper transcription tool. Transcripts included all tabletop actions, the initiator of each action, the location of each action, the location of each participant, and any conversation related to the tabletop actions. Finally, to aide in the

analysis process the transcripts were then coded using the qualitative analysis tool QSR NVivo™ (Richards, 1999) for the following information:

- the directional zone of each tabletop action (N, NNE, NE, ENE, E, ESE, SE, SSE, S, SSW, SW, WSW, W, WNW, NW, NNW),

- the directional zone of each participant at the table, and

- the radial zone of each tabletop action (Center, Midway, Floor Plan Edge, Table Edge).
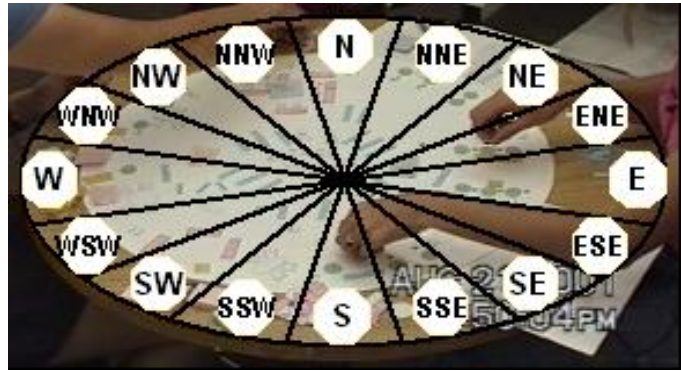
Figure 40. Directional Zones.
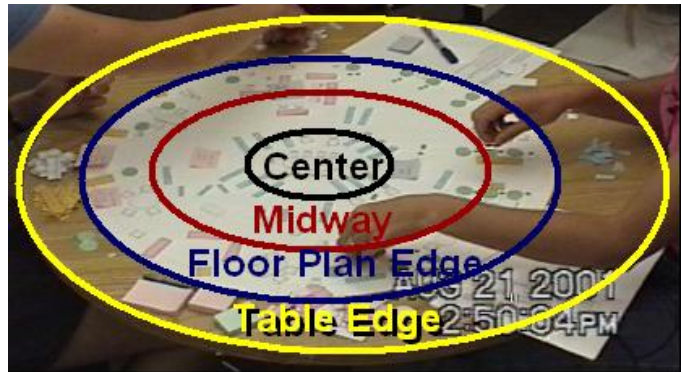
Figure 41. Radial Zones.

4.2.1.2. Activity Plots: Visualizing the Results of a Spatial Action Analysis

In order to help interpret the results of the spatial action analysis, an *activity plot* was created for each study participant. Each activity plot summarizes the tabletop activity that *one group member* performed in each tabletop zone during their *entire collaborative session* (i.e., each person's activity plot represents that person's activity while they were interacting at the table with their partner). The tabletop activity performed in each zone is represented by a dot centred in the corresponding zone. The size of the dot in each zone corresponds to the *relative* amount of activity the participant performed in that zone, as compared to the maximum amount of actions that occurred in any one tabletop zone. To facilitate readability of the activity plots, the activity is mapped to six dot sizes. Figure 42 shows the dot sizes and their corresponding mappings, as well as the breakdown of the tabletop workspace. The absence of a dot in a tabletop zone corresponded to an absence of activity in that zone. To further assist interpretation of
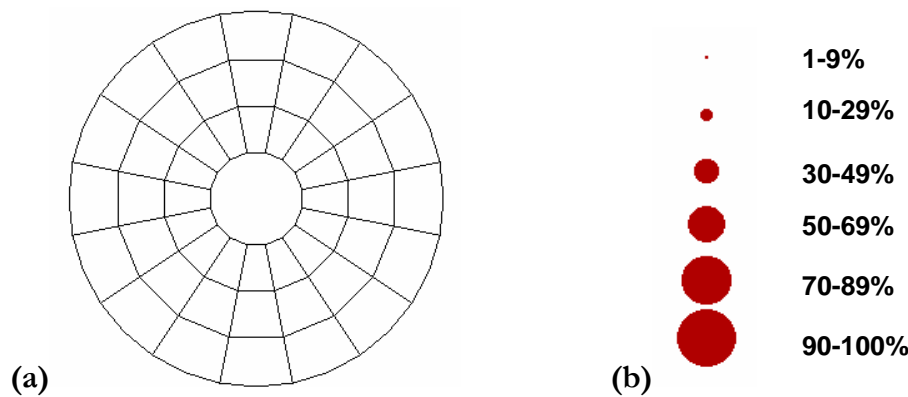
Figure 42. Activity plot details: (a) tabletop interaction zones, and (b) activity mappings. The percentages given in the activity mappings represent the percent of actions that occurred relative to the maximum amount of actions that occurred in any one tabletop zone.

the plots, the location of the participant who performed the action represented by the

plot is indicated beside the plot with a silhouette icon.

4.2.2 Results and Discussion

The results of the spatial action analysis confirm that participants made use of tabletop territories to help coordinate their actions during their construction of the furniture layouts. Similar to the observations made in Study 1, the video analysis reveals that participants in Study 2 also established personal, group, and storage territories during their collaborative sessions. The analysis also provided a more precise understanding of some of the characteristics of tabletop territories revealed by the analysis of Study 1. For example, the fine-grained observations enabled by the video data suggest that storage territories sit atop the group and personal territories in the workspace and are not separate partitions in the workspace. The results of the spatial action analysis in conjunction with the video transcripts clarify who interacted where on the table and what they were doing when interacting at those locations. This level of analysis provides further insight into how each tabletop territory contributes to the overall task and collaborative interactions, allowing us to better understand how to support this practice in a digital tabletop workspace.

4.2.2.1. Personal Territories

Participants' spatial interactions during their collaborative sessions are shown in the activity plots and tables in Figures 43-45. As described earlier, each plot shows the amount of activity one participant performed in each tabletop zone during the collaborative session. The activity tables detail the number of actions performed by each person in the indicated location (e.g. 'Midway Western' indicates WSW, W and WNW actions in the *midway* zones). The percentages show the relative amount of activity that each person performed in the indicated location. For example, in Figure 43, Participant W performed 11 actions in the central zone, which accounted for 55% of all the actions that were performed in that tabletop zone. The shaded cells in the activity tables indicate actions by each person in the zones nearest them.

Activity Plots

Activity Table

Participant	Central Actions	Western Actions				Eastern Actions			
		Midway	Floor Plan Edge	Table Edge	Half	Midway	Floor Plan Edge	Table Edge	Half
W	11 (55%)	7 (70%)	23 (77%)	36 (97%)	144 (83%)	5 (71%)	6 (20%)	0 (0%)	66 (36%)
E	9	3	7	1	30	2	24	38	115

Figure 43. Activity plots and tables for Group 1.

Activity Plots
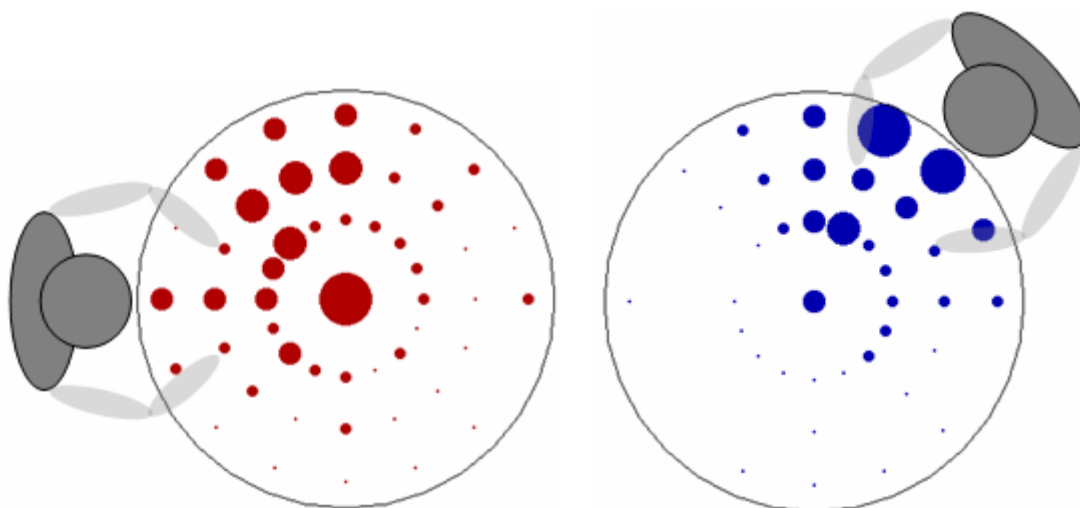
Activity Table

Participant	Central Actions	Western Actions				North-Eastern Actions			
		Midway	Floor Plan Edge	Table Edge	Half	Midway	Floor Plan Edge	Table Edge	Half
W	56 (64%)	44 (90%)	37 (100%)	29 (97%)	254 (83%)	36 (31%)	17 (18%)	26 (13%)	220 (35%)
NE†	32 (36%)	5 (10%)	0 (0%)	1 (3%)	53 (17%)	81 (69%)	76 (82%)	168 (87%)	412 (65%)

†This person spent 5 minutes at N then moved to NE.

Figure 44. Activity plots and tables for Group 2.

Activity Plots
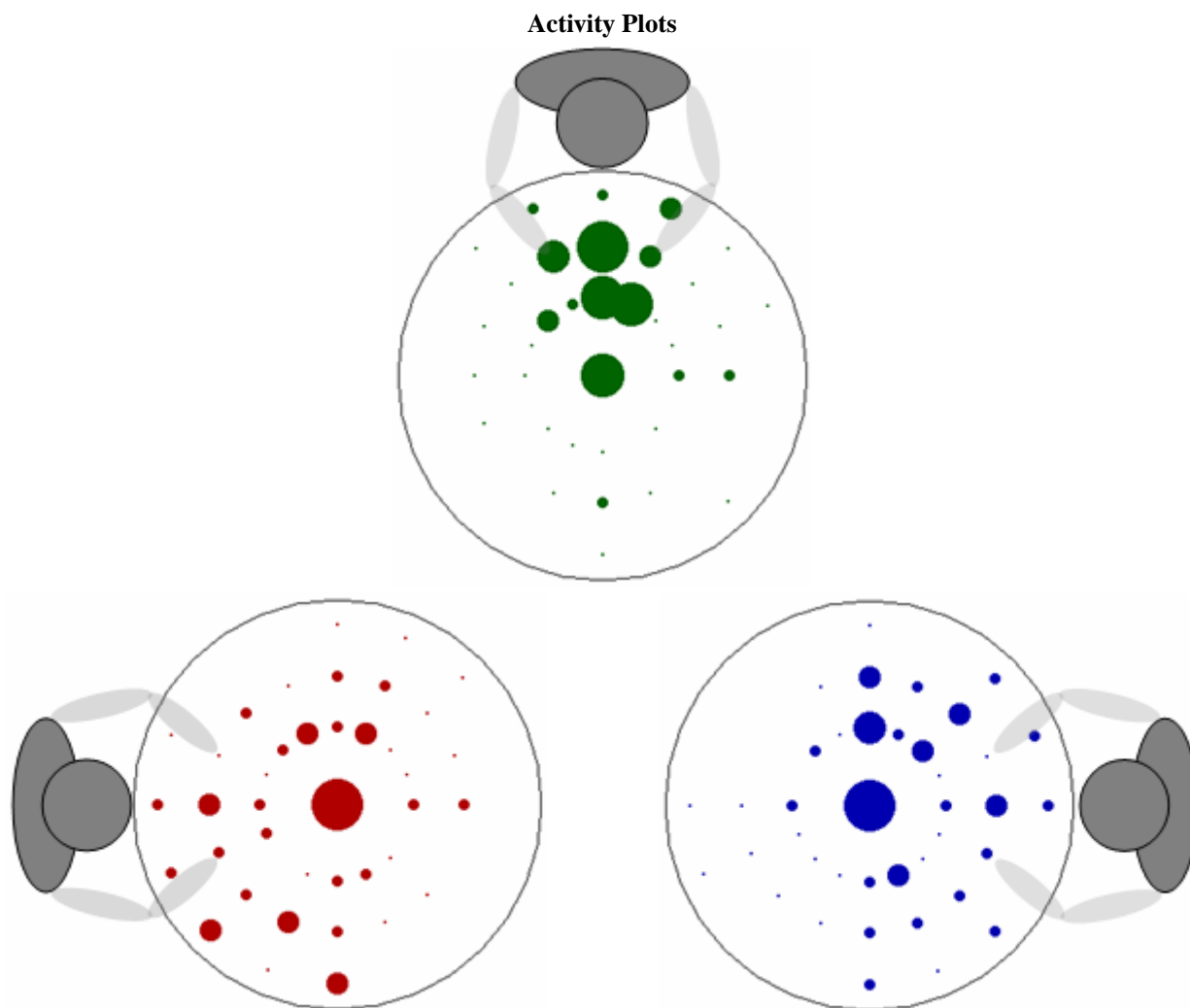
Activity Table

Participant	Central	Western Actions				Northern Actions				Eastern Actions			
		Midway	Floor Plan Edge	Table Edge	Half	Midway	Floor Plan Edge	Table Edge	Half	Midway	Floor Plan Edge	Table Edge	Half
W	43 (38%)	23 (68%)	25 (74%)	14 (88%)	135 (63%)	43 (34%)	12 (12%)	2 (6%)	82 (24%)	8 (40%)	6 (14%)	0 (0%)	52 (19%)
N	27 (24%)	3 (9%)	5 (15%)	0 (0%)	49 (23%)	51 (40%)	58 (60%)	29 (88%)	153 (45%)	5 (25%)	8 (19%)	1 (7%)	72 (27%)
E	42 (38%)	8 (24%)	4 (12%)	2 (13%)	30 (14%)	32 (25%)	27 (28%)	2 (6%)	107 (31%)	7 (35%)	29 (67%)	14 (93%)	146 (54%)

Figure 45. Activity plots and tables for Group 3.

These plots and tables demonstrate that tabletop activity was strongly influenced by the participants' seating positions. Across all three groups, participants dominated the activity in the *table edge* zones directly in front of them (87%-100% of the actions that occurred in these zones). Participants used the *table edge* zones nearest them for keeping furniture items they used frequently, for writing on Post-it™ notes, for reading instruction sheets, and for cutting items into custom shapes. Thus, it appears that participants used the *table edge* zones directly in front of them on the table as their personal territories.

Personal territories appeared to provide each person with dedicated space on the table for performing independent activities. When participants wanted to modify Floor Plan items they would typically remove the item from its position on the Floor Plan, modify it in their personal territories, and then replace it on the Floor Plan. This behaviour facilitated both the interactions of individual group members and of the group as a whole. Ergonomically, the proximity of the personal territory eased such tasks as reading, writing, and manipulating items. Also, by moving an item into their personal territory, the person implicitly communicated their intentions to use the item, effectively reserving it for their own use. Furthermore, while this person was interacting in their person territory, there was more space available in the group territory for their collaborators to work on other parts of the task. These benefits illustrate the importance of allowing people to easily move items between the group and personal territories in a digital tabletop workspace, as well as the importance of providing access to support tools, such as item editing and manipulation tools, within the personal territory.

Though no group explicitly discussed reserving these areas for anyone's personal use, participants performed very few, if any, actions in their collaborators' personal territories (0%-13% of any actions that occurred in these zones), even in the group of three participants where multiple participants could easily reach the area in front of other group members. It appears that social norms dictate that the tabletop area directly in front of someone should be reserved for use by that person.

In general, when a group member wanted an item that was located in someone else's person territory, they would ask that person to pass them the item. In the few cases where someone did interact in someone else's personal territory, they were always retrieving a task resource. These interactions occurred quickly and fluidly with little to no disruption to the actions of the 'owner' of the personal territory. Often, these actions were accompanied by changes in body language which appeared to signify the owner giving permission to the collaborator for interacting in that area. For example, the owner would often sit back a little when they noticed their partner reaching for something in their personal territory, and would often stay in that position until their partner was done (see Figure 46a). Alternatively, people would also just move their arms to the left or right as their partner accessed items in their personal territory, while the owner continued interacting with items on the table (see Figure 46b). Sometimes the owner would more actively accommodate their partner's interactions by helping them find a resource item (see Figure 46c), and then they would return to their previous activities once the desired resources were found.

Figure 46. Accommodating others in one's personal territory: (a) moving out of the way, (b) moving slightly while continuing to perform activities, and (c) assisting the other.

In summary, the spatial action analysis, in conjunction with the video data, extend our understanding of how personal territories are used within the context of the overall task and group interactions. These results have shown that personal territories serve to ease the task of reading, writing, and manipulating task items, while at the same time help reserve these items for someone's personal use and clears space in the group territory for other group members to work there. These results have also confirmed that reserving the area in front of

each person is a socially understood phenomenon. Even when others could easily reach this area, they typically did not interact there. This observed behaviour corroborates previous findings from the social-psychology literature that has shown that people have a strong respect for other people's personal space (e.g., Sommer, 1969; Hall, 1974; Aiello, 1987). 'Trespassing' in someone else's personal territory only occurred on rare occasions, and only when it was necessary to retrieve a task resource. However, these instances typically caused little to no disruption to the activities of the 'owner' of the personal territory and enabled other group members to quickly access necessary task resources. These results all reinforce the suggestions from the Study 1 analysis that tabletop systems should provide tools and interaction capabilities for item modification and manipulation in the personal territory, space for personal territories to be established in conjunction with the group territory, and unrestricted access by other group members to each person's personal territories.

4.2.2.2. Group Territories

Figures 43-45 show that personal territories were the only areas consistently avoided by other group members. Thus, it appears that the remaining tabletop workspace was generally considered available for all group members to use. To varying degrees, all participants utilized most of the Floor Plan and table edge locations between participants. It appears, then, that the group territory covered the entire table to the exclusion of the areas occupied by personal territories.

The group territory was primarily used for assembling furniture arrangements in the Floor Plan. It was also used for discussing layout ideas and for assisting others to create or modify particular furniture arrangements. Moreover, it served as a place to share task resources. Participants would often pass each other resource items via the group territory.

Partitioning in the Group Territory

All groups used a divide-and-conquor approach to perform the layout task, spending the majority of their time working independently on different furniture arrangements in

separate regions of the group territory, essentially partitioning up the group territory (see Figures 43-45). Typically, no area of the group territory was as exclusively used by any one member of the group as the personal territories were. This partitioning appeared to help group members avoid conflicts while sharing the workspace by clarifying who should work where. Partitioning of the group territory occurred with little to no verbal negotiation. Participants typically discussed what type of arrangements should be made in the workspace rather than who should be working where.

Generally, participants took the initiative for creating and maintaining arrangements in the Floor Plan directly in front of them, as illustrated by participants' dominance of the actions performed in the group territory nearest them. In the two pair groups, participants were responsible for well over half of the interactions in the group territory zones nearest them (70%-94% of the actions[10]). In the group of three, participants performed well over one third of the actions in the group territory nearest them (48%-70% of the actions[9]).

This implicit delegation of responsibility of the workspace areas in close proximity to each group member appeared to clarify each member's role in the collaborative task, helping them to coordinate their workspace activities. However, there appeared to be more ambiguity as to who was responsible for those areas farther away from any group member. In general, interaction in these areas was much less dominated by any particular person and involved more verbal negotiation. Similarly, the activity plots and video data revealed that there was also less exclusivity of use and more verbal negotiation in areas that were equally close to several people. For example, participants in Group 3 (who were seated closer together than participants in the other groups), spent less time working independently in the group territory and more time negotiating their furniture arrangements as compared to the other 2 groups. It appears, that the ease with which group members can divide up responsibility for the group territory partially

[10] This represents the activity in the three directional zones directly in front of each person. For example for participants at W, the *floor plan edge* and *midway* activity is reported in the WSW, W, and WNW zones.

depends on the amount of space each individual group member alone can easily reach: the more 'overlap' areas or 'out of reach' areas there are, the more explicit coordination will likely be needed. Thus, both the size of the table and the seating arrangement of tabletop collaborators can potentially impact the ease of coordinating in the workspace.

Rotation of the Floor Plan

An event that occurred during one layout session suggests that the proximity of items in the group territory influenced how responsible group members felt for those items. About 30 minutes into Group 2's session, the participants rotated the Floor Plan (see Figure 47). The rotation was initiated by the participant

Figure 47. Group 2 rotating the Floor Plan.

seated at West, who wanted to work on an area of the Floor Plan located across the table from her. Together, her and her partner carefully rotated the Floor Plan about 110° counter-clockwise on the table. The area she wanted to work on was then located closer to her (in the N direction) and another fairly unfinished area was in front of her. She spent the remainder of the session working mostly in these areas, as indicated by the concentration of actions in the NW to N directions in her activity plot (Figure 44). In contrast, after the rotation, the areas near her partner contained completed arrangements.

Rotating the Floor Plan appeared to affect the participants' sense of responsibility for certain furniture arrangements in the workspace. Before the rotation, the participant at NE expressed his concern that an arrangement his partner had created on the table in front of her was too cluttered. At the time, he made some minor adjustments to it, but his partner immediately readjusted the arrangement, almost back to its original state. After the rotation, this arrangement was located near him (in the E direction). He soon began removing items from the arrangement and readjusting it. His partner helped him a little, readjusting the arrangement while he removed items, but in the end, they agreed on a final arrangement that contained much fewer furniture items. His partner seemed

much more open to his input on 'her' arrangement once it had moved closer to him (or farther from her) on the table. He also appeared more comfortable taking charge of the arrangement in its new position. This participant appeared to be the less dominant team member. Throughout their session, his partner appeared more comfortable interacting on his 'side' of the table, as illustrated by the four times as many actions that she performed in his half of the workspace (220 actions) as he did in hers (53 actions).

This episode suggests that there may be positive benefits to enabling rotation of the main work area on a digital tabletop workspace. It may allow less dominant members of the group to more freely contribute their ideas to the workspace. Such functionality may be particularly appropriate for moderated collaborative settings where a facilitator (e.g., a teacher in a classroom) can initiate a workspace rotation, especially since a less dominant team member may not be assertive enough to initiate such a global action. However, caution should be taken in providing workspace rotation functionality in a digital workspace since such an action would likely affect all content in the workspace and, thus, may be highly disruptive to the group activity if other members are not expecting the action to occur.

In summary, the video analysis revealed that the group territory covered most of the table with the exception of areas occupied by group members' personal territories. The results also confirmed that group members used this area to perform the main task activities and to assist others with these activities. The activity plots revealed that group members tended to partition the group territory during their layout activities. The results also suggest that these partitions emerged because participants implicitly felt responsible for the areas of the group territory in close proximity to them. Implicitly delegating responsibility for certain areas of the group territory appeared to have both positive and negative impact on group interactions. Partitioning the group territory appeared to minimize the amount of explicit coordination needed to share the workspace and helped clarify each member's responsibilities in the group territory. On the other hand, partitioning may have constrained less dominant group members from contributing to the parts of the layout that were located in someone else's partition, potentially reducing

the quality of the overall group product. For technology to support effective partitioning, the results suggest that the tabletop workspace must be large enough for each group member to work in without being 'on top of' the person sitting next to them. Also, providing functionality that enables users to rotate the workspace may help people feel more comfortable contributing to all parts of the group product. However, such functionality should be designed with care since such a global action may be highly disruptive to other group members' interactions.

4.2.2.3. Storage Territories

Throughout their sessions, participants stored the task resources in storage territories at various locations on the table. These storage territories were relocated in the workspace at different stages of the task, depending on where participants were currently working and what task resources they currently needed. Storage territories often contained individual items, piles of items, or a mix of both, loosely arranged in the storage territory. Using storage territories to casually store workspace items appeared to help collaborators organize their task resources through the layout task.

At the beginning of each layout session, all of the furniture icons were contained in several piles located in the centre of the Floor Plan. By the end of each session, all spare furniture icons had been moved to the table edge. The migration of these resources from a large storage territory in the centre of the table to several storage territories along the table edge, however, depended on the working style of each group. Group 1 immediately moved all but one of their furniture piles to the table edge, establishing large storage territories between the seating positions of the group members. Then, for the next 13 minutes, they moved the remaining furniture pile around the Floor Plan as they were working, retrieving items from it until they finally incorporated it into one of the storage territories along the table edge. In contrast, Group 3 spent the majority of their session (30 out of 38 minutes) with most of the furniture icons still on the Floor Plan, loosely piled or grouped into several storage territories. As the task progressed, and groups needed access to items contained in a storage territory (or the region of workspace that the storage territory was covering) they simply moved the

storage territory to a different position on the Floor Plan. Group 2 gradually moved all of their furniture icons to the table edge over a 10 minute period, also moving their furniture resources around the Floor Plan as needed. The mobility of the storage territories enabled groups to access task resources where they needed them, when they needed them.

When participants needed items contained in a storage territory in someone else's personal territory, they would usually ask that person to pass them the item. As previously mentioned, in the few cases of a participant interacting directly in a collaborator's personal territory, they were always retrieving a resource item. These situations often resulted in the participant picking up a handful of items and then relocating those items to a storage territory closer to him or her (see Figure 48). Moving these stored items served a dual purpose: it provided the person who moved them easier access to the resource and it released the other collaborator's obligation to distribute the resource.

Casually organizing task resources provides task and collaborative benefits

Similar to the behaviour observed in Study 1, participants in this study appeared to maintain only loose organization of task resources within each storage territory. This loose organization often provided certain benefits to completing the layout task. It provided a cognitively lightweight mechanism for storing resource items. The process of searching through items in a loosely organized store of task resources also appeared to
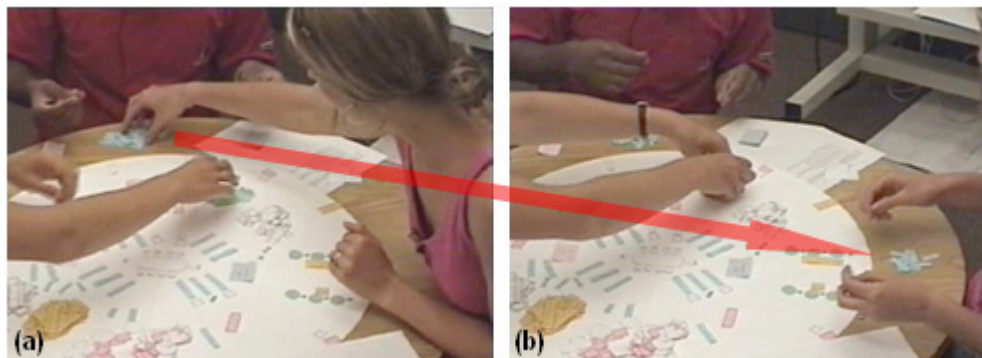
Figure 48. Replication of a pile of resource items that was originally contained in someone else's personal territory.

benefit the layout task by prompting discussions about the current state of furniture arrangements. For example, Excerpt 7 depicts a short discussion about what type of chair to use in the arrangement Group 3 was creating. The discussion was prompted by one participant (pN) asking the group the difference between two types of chairs he noticed while browsing through a pile of chairs on the Floor Plan. The group discussed the two types of chairs, eventually deciding to use the 'comfortable chairs.' They then continued working on the furniture arrangement.

Excerpt 7.

pN: [picks up several chairs from a pile and drops them on the Floor Plan (FP) at Midway-N] What is the difference between this chair [pointing to one of these chairs] and this chair [pointing to one of the other chairs]?

pE: [points to one of the chairs] That one is more comfortable.

pW: Do we want comfortable chairs for the people listening to the meeting?

pE: Sure.

pW: [slides a 'comfortable chair' from Midway-N to the Centre arrangement]

The location of a storage territory appeared to influence who utilized the resources contained within it. Stored resource items were often shared among participants, especially when the storage territory was located along the table edge between participants or in the *midway* or *central* zones. Participants often moved these storage territories around the group territory as they shared these resources. In contrast, when a storage territory was located in or near someone's personal territory, that person often became responsible for distributing those resources. For example, the participant at NE in Group 2 became responsible for creating and distributing customized items using the Post-it™ notes located on the table edge to his left (in the E-ENE direction). Relative to his activity on the rest of the workspace, he made frequent use of the table edge directly in front of and adjacent to him (44% of his total tabletop actions occurred on the table edge between N and E). Delegating responsibility for task resources appeared to facilitate the divide-and-conquer strategy used by all groups to perform the layout task, a strategy commonly used in collaborative activities (Cockburn and Greenberg, 1995; Scott et al., 2003). Similar to delegating partitions of the group

territory, having one group member responsible for distributing certain resources allowed the other group members to focus on other aspects of the group task.

In summary, these results confirm that storage territories were established in the tabletop workspace and appeared to help collaborators organize and share task resources during their layout activity. The video analysis also revealed that storage territories were often moved within the workspace. The mobility of storage territories appeared to facilitate sharing and reserving of task resources. The results revealed that when resources were located in or near someone's personal territory, that person became the main distributor of those resources. This behaviour appeared to help clarify group members' role during the collaborative task, reducing the need for explicit negotiation about who is working on what components of the task. Collaborative systems often provide each collaborator easy access to the same set of system tools, enabling anyone to access any task resource at any time (e.g. Vernier et al., 2002; Shen et al., 2002; Wu & Balakrishnan, 2003). While these tools likely support the interactions of each group member more easily than having to rely on someone else to relinquish a resource or having to reach in front of someone else to get it, the results of this analysis suggest that providing such easy access to all task resources may introduce ambiguity as to who is responsible for doing what in the workspace, increasing the need for explicit negotiation during the task.

4.2.2.4. Interaction between Territories

Each type of tabletop territory played an important role in helping participants share the tabletop workspace while performing their task. Based on the activity patterns discussed above, though, it appeared that all three tabletop territories did not exist as mutually exclusive partitions of the workspace. Personal and group territories appeared to be separate partitions, with associated accessibility properties, defined and controlled through social norms. For example, a personal territory was generally reserved for the use of the nearby person. Personal territories appeared to be extensions of group members' personal spaces (Sommer, 1969); thus, they existed in the tabletop workspace directly adjacent to each person. The group territory covered the remaining tabletop

workspace, including the areas in the centre and along the table edge between participants. In general, items in the group territory appeared to be available to all group members. However, responsibility for task items in areas of the group territory within close proximity to a particular group member appeared to be implicitly delegated to that person.

Storage territories, on the other hand, appeared to exist atop these other two territories and were mobile in the workspace. Furthermore, they took on the accessibility property of the territory on which they were currently located. For example, the activity plots and video data revealed that when a storage territory was located in the group territory, all participants tended to utilize the resources it contained. Whereas, when a storage territory was located on the table adjacent to someone, that person typically became the sole or dominant user of its resources. Simply moving a single resource item (or an entire group of resources) from the group territory to someone's personal territory and vice versa provided a lightweight mechanism for changing the availability of an item (or items), helping collaborators coordinate their use of the available resources.

4.2.3 Summary

The spatial action analysis performed on the video data from Study 2 confirmed that collaborators establish personal, group, and storage territories while sharing a tabletop workspace. Similar to the territoriality analysis performed on the data from Study 1, the spatial action analysis revealed that personal territories were indeed almost exclusively used by the 'owning' person. For the most part, though, the group territory was shared by various group members. Similar to the results of Study 1, these results revealed that the personal and group territories were used to perform the main task activities.

These results also revealed that people often worked in their personal territories at the same time as someone else was working in the group territory. Thus, tabletop systems should provide enough room in the workspace for personal and group territories to be used concurrently for performing main task activities. However, typically the personal territory will only be used for working on certain task items at any one time, as opposed to moving the entire group product into the personal territory. Therefore,

component parts of the group activity should be easily separable for temporarily relocating them into someone's personal territory.

The spatial action analysis also revealed that partitions emerged within the group territory. These partitions appeared to clarify the responsibilities of each group member in the workspace, helping group members coordinate their use of the workspace. However, the results also suggest that this partitioning may restrict the contributions of less dominant group members who have ideas for the portion of the group activity being performed in someone else's partition. The results suggest that rotating the workspace may help mediate this situation, yet such workspace actions should be done with caution because they might introduce ambiguity as to the responsibilities of each group member in the workspace, increasing the need for explicit coordination and verbal negotiation.

These results also revealed that storage territories appeared to sit atop the group and personal territories and were not actually separate partitions in the workspace. While personal and group territories have implied accessibility properties (i.e., who was allowed to interact there) that appeared to be governed by social protocol, and storage territories take on the accessibility property of whichever territory they are currently positioned over. Furthermore, the ability to move storage territories in the workspace provided an easy, commonly understood, way for collaborators to change the availability of resource items – either to reserve them for personal use or to make them available to other group members.

4.3 Chapter Summary

Similar to how *territories* in our physical environment (e.g., one sibling's 'side of a room') help to mediate social interaction (Altman, 1975; Fisher et al., 1984; Taylor, 1988), tabletop territories serve to coordinate tabletop interactions. The analyses presented in this chapter illustrated that tabletop territories were established and maintained during both casual and formal tabletop activities. The different tasks, group sizes, seating configurations, settings, and experimental methodologies used in Studies 1 and 2 provided the opportunity to observe various factors which influence how tabletop

territories are established and used during tabletop collaboration. In Study 1, people easily shared the tabletop workspace, fluidly expanding and contracting their personal territories as the activities and number of collaborators at the tabletop changed. In contrast, the spatial action analysis performed on Study 2 revealed that the size of participants' personal territories throughout the layout planning activity remained fairly static. Group membership remained stable during these sessions, likely playing a large role in the static nature of these personal territories; however, the prescribed 'work area' of the white cardboard Floor Plan may have also been a contributing factor. This factor and its potential impact on collaboration will be discussed in more detail in the following chapter.

The video data collected in Study 2 enabled more fine-grained investigation of collaborators' tabletop interactions. The spatial action analysis confirmed the exclusivity of use within each group member's personal territories and also revealed that participants tended to partition their interactions within the group territory. The Study 2 analysis also clarified the relationship between the three types of tabletop territories. Figure 49 shows a conceptual diagram of this relationship. In general, when group members arrive at a table, the table surface is available for sharing and, thus, forms the group territory. A personal territory is then established in front of each group member at the table, expanding and contracting as necessary. Storage territories, on the other hand, are established in a variety of locations on the table and appear to sit atop the personal and group territories. Storage territories are also moved around the tabletop workspace to suit the current task needs.
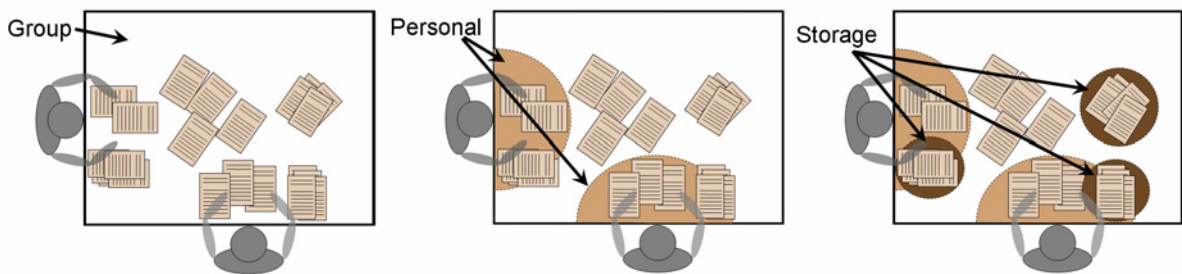
Figure 49. Conceptual diagram of the three types of tabletop territories.

The current location of tabletop items appears to indicate their availability. In general, items in the group territory are available for all group members to use and interact with, while items in someone's personal territory are typically reserved for use by that particular person. In contrast, the availability of items contained in a storage territory seems to depend whether the storage territory is currently located in the group territory or in someone's personal territory. The mobility of the storage territories allows group members to easily change the availability of stored items simply by moving them on the table. Relying on this social protocol to coordinate group members' access to tabletop items provides a lightweight mechanism by which people can easily change access privileges to these items throughout the course of the task. The analyses presented in this chapter also revealed several important issues for the design of digital tabletop workspaces, including the need for careful consideration of the tradeoffs between providing more power to individual group members and supporting the overall group process.

While the focused analyses of Studies 1 and 2 have provided many useful insights into how and why tabletop territories emerge during tabletop collaboration, the experimental tasks and settings used for these studies imposed certain limitations on the behaviours that could be observed. For instance, the use of a round table and a task that was fairly orientation independent in Study 2 provided little opportunity for observing people specifically rotating items for reading, writing, or sharing. Since digital tabletop systems may support a variety of typical tabletop activities, it is important to understand the variety of factors that influence the establishment and use of tabletop territories. In order to provide a more comprehensive understanding of tabletop territoriality, the following chapter presents a synthesis of the results presented in this chapter with previous research on collaborative tabletop workspaces and on human territoriality in general, as well as a set of design recommendations to illustrate how to apply the insights gained from this synthesis to the design of collaborative tabletop systems.

Chapter 5. Tabletop Territoriality: The Broader Picture

This chapter presents a process of innovation that builds on the deeper understanding of traditional tabletop work practices gained in Chapter 4 to create a digital tabletop workspace that supports these work practices (Chapter 6). This process consists of first integrating the findings presented in Chapter in 3 and Chapter 4 with territory-related findings from the literature discussed in Chapter 2, and summarizing the results in order to provide a knowledge base that can be used for future work. The second step is to use this knowledge base to develop design guidelines that provide a bridge between the deeper understanding of tabletop work practices and the development of digital tabletop technology.

5.1 Tabletop Territoriality Considerations

On a table, the practice of territoriality helps people share task resources by providing a commonly understood social mechanism that facilitates the reservation and sharing of task resources and the workspace itself. The social meaning attributed to regions of the tabletop workspace is derived from the context of the current tabletop activities and can change over time. The size, shape, and sometimes the location of tabletop territories often change as the tabletop activity evolves. Within the human territoriality literature it appears that a location, or partition of space, and a territory are considered equivalent. Yet, the results of Chapter 4 revealed that tabletop territories are not necessarily mutually exclusive partitions in the workspace (see Section 4.2.2.4). Considering a tabletop territory as a unique combination of its *spatial properties* (i.e. size, shape, and location), its *purpose,* and the *interactions* it supports provides a deeper understanding of how these

territories contribute to the collaborative process, as well as how designers can support the practice of tabletop territoriality in digital tabletop workspaces.

The remainder of this section summarizes these three aspects for each of the tabletop territories identified in Chapter 4: group territories (Section 5.1.1), personal territories (Section 5.1.2), and storage territories (Section 5.1.3). These sections incorporate results from the territorial analyses performed in Chapter 4 with related findings from the literature to provide a broader understanding of tabletop territoriality. Separate from the actual spatial properties themselves are a series of factors that influence how these spatial properties manifest. These factors are discussed in Section 5.1.4.

5.1.1 Group Territories

5.1.1.1. Spatial Properties

Collaborators typically establish one central group territory during tabletop collaboration (see Sections 4.1.2.2 and 4.2.2.2; Tang, 1991; Kruger et al., 2004). This territory occupies the areas on a table that are available for sharing. This usually includes areas within reach of group members, typically comprising the centre of the table and the table edge between group members' personal territories (see Sections 4.1.2.2 and 4.2.2.2). Sub-group territories are also sometimes established on the table between adjacent team members (see Section 4.1.2.2). The precise size and shape of the main group territory or sub-group territories tends to be flexible, changing in response to changes in the spatial properties of group members' personal territories (see Section 4.1.2.1; Kruger et al., 2004). The factors that can influence the spatial properties of personal territories and thus, in turn, influence the group territory are described below in Section 5.1.4.

5.1.1.2. Purpose

The main purpose of the group territory is to provide collaborators a space to perform their main task activities (see Sections 4.1.2.2 and 4.2.2.2; Tang, 1991; Kruger et al., 2004). These task activities include:

- working closely together on one component of the task (see Section 2.3.3),

- working independently on components of the task (see Section 4.2.2.; Gutwin et al., 1996),

- passing task resources to a collaborator (see Section 4.2.2.2; Gutwin et al., 1996), and

- discussing task-related ideas (see Section 4.2.2.2; Bly, 1988; Tang, 1991).

Another important purpose of the group territory is to provide a place for group members to assist each other during the task activities (see Sections 4.1.2.2 and 4.2.2.2; Bly, 1988).

5.1.1.3. Interactions

People often use a mix of tightly-coupled interactions (e.g., cooperatively sketching a product design) and loosely-coupled interactions (e.g., independently assembling different components of a layout plan) in the group territory (see Section 4.2.2.2; Bly, 1988; Tang, 1991). During tasks which afford a divide-and-conquer strategy, people tend to partition their interactions in the group territory, often implicitly taking on responsibility for those regions nearest to themselves (see Section 4.2.2.2; Ryall et al., 2004). The spatial properties of these partitions are influenced by the level of responsibility people feel for that region of the workspace (see Sections 2.2.3 and 4.2.2.2) and by the factors discussed below in Section 5.1.4. People also tend to use larger task objects (when available) to better enable sharing of objects when working in the group territory (see Section 2.3.3). People also use distinct orientations of task items in the group territory to facilitate communication (see Section 2.3.3) and to help coordinate access to shared items (Kruger et al., 2004).

5.1.2 Personal Territories

5.1.2.1. Spatial Properties

Personal territories are typically established on the table directly in front of each group member, within immediate reach (see Sections 4.1.2.1 and 4.2.2.1; Kruger et al., 2004). These territories are typically stationary while the person remains in the same tabletop

location (see Sections 4.1.2.1 and 4.2.2.1). In contrast, the size and shape of personal territories tend to be flexible, changing in response to several factors such as varying task needs, changes in group membership, and whether the person is currently working independently or in concert with other group members (see Sections 4.1.2.1 and 4.2.2.1). Additional factors that influence the spatial properties of personal territories are discussed below in Section 5.1.4.

5.1.2.2. Purpose

Personal territories provide a space for people to perform independent activities on the table, away from the main group interactions (see Sections 4.1.2.1 and 4.2.2.1; Tang, 1991; Kruger et al., 2004). These territories allow people to vary their level of participation in the group activity. For example, personal territories provide a place for group members to comfortably perform aspects of the group tasks, such as reading, writing on, and modifying task resources (see Sections 4.1.2.1 and 4.2.2.1; Kruger et al., 2004). In addition, personal territories can also serve as a 'semi-private' space for group members to independently explore alternate ideas that they may later integrate into the main group activity (see Section 4.1.2.1; Tang, 1991). The visibility of these spaces appears to be important, though, since other group members tend to monitor other people's activities in their personal territories, facilitating coordination of task interactions and enabling people to offer their collaborators assistance when it is warranted (see Sections 4.1.2.1 and 4.2.2.1).

5.1.2.3. Interactions

As mentioned above, people perform typical task interactions in their personal territories, such as reading, writing on, and manipulating task items. Items in these territories tend to be oriented toward the 'owner' of that territory (Kruger et al., 2004). Also, task items can be smaller in the personal territories because their proximity makes them easy for the 'owner' to see (Tang, 1991). Using smaller items in these territories also helps create the 'semi-private' space discussed in the previous section (Tang, 1991).

5.1.3 Storage Territories

5.1.3.1. Spatial Properties

Unlike group and personal territories, storage territories appear to sit atop the other two tabletop territories, and are mobile in the workspace (see Sections 4.1.2.3 and 4.2.2.3). People often establish several storage territories within the tabletop workspace. The size and shape of these storage territories depend on several factors, including their contents and the current activity (see Sections 4.1.2.3, 4.2.2.3, and 5.1.4). For example, a small storage territory might be established near the centre of the table to hold a pile of pictures that are being used to create a photo album layout, or a large storage territory might be established along the table edge to store several distinct piles of resources and individual items that are not currently being used (e.g., additional photos, paper supplies, stickers, glue, and scissors).

5.1.3.2. Purpose

The main purpose of storage territories is to provide a place to store task resources (e.g., tools, task resources, customized items, reference materials) (see Sections 4.1.2.3 and 4.2.2.3). People use storage territories to organize these items in the tabletop workspace (see Section 4.2.2.3). The ability to move storage territories around the group territory allows group members to easily obtain the resources they need *where* they need them, *when* they need them (see Sections 4.1.2.3 and 4.2.2.3). The ability to move a storage territory around the table also enables people to reserve resources for their own use or to share the resources with their collaborators (see Section 4.2.2.3).

5.1.3.3. Interactions

Storage territories typically contain a mix of individual items and piles of items. These contents tend to be quite loosely organized (see Sections 4.1.2.3 and 4.2.2.3). Most of the interactions that occur with stored items tend to be organizational, including activities such as rearranging and spreading out individual and piled items, searching these items, comparing stored items, tidying up the stored items, reorganizing the piles of stored items (e.g., moving items from one pile to another), and adding or removing items

(see Sections 4.2.2.3). Items are added to or removed from storage territories both one at a time and in handfuls of items at a time (see Section 4.2.2.3).

5.1.4 Factors Influencing the Spatial Properties of Tabletop Territories

All three types of tabletop territories tend to have flexible spatial boundaries, which dynamically change in response to the evolving task and group interactions throughout a collaborative activity (see Sections 4.1.2 and 4.2.2). The size and the shape of the tabletop territories that are established and maintained during collaboration are influenced by the amount of space available on the table (for the group and for each person), by the *perceived* amount of space available (for each person), and by the task process and task materials. These issues relate to five distinct factors which influence the spatial properties of tabletop territories: the group size and seating arrangement, the table size, the presence of any visible barriers on the table, the current task activities, and the task materials being used. These factor are detailed below.

Group size and seating arrangement. People easily accommodate others at the table, expanding and contracting their personal territories (and thus changing the size and shape of the group territory) based on the number of people at the table and how they are arranged (see Sections 4.1.2.1 and 4.1.2.2). When collaborators are seated close to each other, they generally restrict their personal activities to a small area directly in front of themselves; thus providing extra space for the group territory and for other people's personal territories (see Section 4.1.2.1).

Size of the table. The size of the table determines how much space is available for sharing, and thus influences the space available to establish personal, group, and storage territories on the table. Small tables force people to sit close together and, therefore, will generally restrict their personal activities to a small spaces directly in front of each individual. A very small table (relative to the size of the group) may prevent group members from simultaneously establishing personal and group territories, as well as prevent the establishment of any storage territories. This scenario may compromise the group's ability to share the table space. Larger tables are typically easier for a group to suitably adapt their activities because people can choose to sit close together at the table

and establish tabletop territories within their reach. However, a very large table which forces group members to sit quite far apart may make it difficult for everyone to see or interact with items in the group territory.

Visible barriers. The presence of visible barriers in a tabletop workspace may restrict the movement and expansion of territories across those barriers. A visible demarcation of tabletop regions is known to restrict people's perceived personal space (Fisher et al., 1984). For example, visible lines are often placed down the middle of food court tables to decrease the social discomfort of sitting in close proximity to others. The presence of such a visible barrier in the tabletop workspace can create a psychological barrier to expanding a tabletop territory across it. For instance, the boundary of the cardboard Floor Plan in the layout planning study appeared to restrict participants' personal territories to space between this boundary and the edge of the table (see Section 4.2.2.1).

Task activities. Tabletop territories often expand or contract based on the current task activities. For instance, when someone is searching for something in a storage territory, they typically enlarge the storage territory to spread out the items during this activity (see Section 4.2.2.3). Also, people expand and contract their personal territories based on whether they are currently working independently or in concert with the group and, thus, simultaneously contract or expand the group territory as the case may be.

Task materials. The size of task materials can also affect the spatial properties of tabletop territories. Larger task materials will necessarily need more space for manipulating and sharing than smaller task materials. For instance, a group sharing a large road map will need a much larger group territory than a group sharing several Post-it™ notes on the table. Also, having a large task item covering the table (e.g., a map or an architectural schematic) may restrict group members' abilities to establish personal territories on the table.

In general, people are very opportunistic in their use of table space: they use whatever space they can and will adapt their behaviour to whatever space is available. At the same time, social protocol requires people to accommodate others at the table. Therefore, people will restrict their personal activities to a 'socially appropriate' area,

generally refraining from using the table space directly in front of others and trying to accommodate their collaborators as well as they can given the available table space, size of the task materials, and the current activity.

This section has synthesized the insights revealed by the observational studies from Chapters 3 and 4 with the existing knowledge from the literature to provide a broader picture of the practice of tabletop territoriality. The following section describes how to apply this information to the design of a digital tabletop workspace that will effectively support collaborators' territorial behaviour and their group activities in general.

5.2 Recommendations for Collaborative Tabletop System Design

One of the most important findings revealed by this research is that, contrary to a current trend in tabletop groupware interfaces, providing fixed visible partitions in the workspace may in fact hinder natural territorial behaviour during tabletop collaboration. The previous sections illustrate that the size, shape, and location of tabletop territories typically fluctuate over the course of a collaborative activity. Moreover, partitioning the digital workspace into personal and group areas, as done in several existing collaborative tabletop systems (Shen et al., 2004; Omajola et al., 2000), may in fact present a visible barrier to collaborators that may hinder optimal usage of table space. Supporting the practice of tabletop territoriality in the design of collaborative digital tabletop workspace appears to need a more subtle approach. This section discusses how our new understanding of the spatial properties, purpose, and the interactions supported by each type of tabletop territory can be used to develop collaborative tabletop workspaces that support a variety of usage scenarios. These recommendations apply both to the physical (i.e. hardware) design of digital tabletop systems and to the design of tabletop groupware interfaces.

5.2.1 Provide Appropriate Table Space

As discussed above in Section 5.1.4, the size of the table can affect the establishment of personal territories on the table, and the space available for the group territory and for storing resource items. Thus, the size and display resolution of a digital tabletop workspace should suit the activities that will be performed on it and the users who will be using it. Furthermore, just as traditional tables often host a multitude of activities, a digital tabletop will likely be used for a variety of tasks by a variety of people. The size of the tabletop should be chosen so that it can support the most likely activities to be performed by the most likely users. Some factors to consider when determining an appropriate table size include:

- *Typical tabletop activities.* Both the type of task and the size of task materials should be considered when determining the appropriate table size. Tasks which afford periods of loosely-coupled collaboration will require enough space to establish personal territories and partitions in the group territory. For example, people tend to take personal notes during meetings and work on different parts of a group product during design activities. Performing such tasks on a small tabletop may hinder interactions because people may not have enough space to effectively disengage from the group activity or may require more explicit coordination to divide up the workspace. On the other hand, a small tabletop workspace may be well suited for activities involving tightly coupled collaboration, such as a cooperative learning task being performed by several school children.

- *Typical users.* The typical number of users and their typical age range should also be considered when determining how much table space should be provided. Large groups, especially those performing a great deal of independent activities such as note-taking during a meeting, will obviously need more space than a small group at a tabletop system. Moreover, the age of the typical users should also be considered. Groups of school children tend to need less space than groups of adults, both for ergonomic and for social reasons. For example, children cannot reach as far across a table as adults can, as illustrated in Figure 50. Also, children

tend to interact with others using a closer interpersonal distance than adults do (Aiello, 1987). Thus, a small table will likely be more appropriate for supporting collaboration involving children than collaboration involving adults.

Figure 50. Average reach distances for children and adults at a table.

Though any one table size will likely not be ideal for all possible tasks or users, incorporating flexibility into the design of the software interface will help accommodate non-ideal usage situations, as will be discussed in the following section.

5.2.2 Provide Workspace Content within Reach

Understanding the factors influencing the establishment of tabletop territories (see Section 5.1.4) can help us plan for variations in usage scenarios. These factors tell us that a flexible tabletop interface should accommodate various group sizes, seating arrangements, task activities, and task materials, and have minimal visible barriers. A fundamental requirement for providing such a flexible interface is ensuring that digital content is positioned within reach of tabletop collaborators.

Current interfaces are designed with the assumption that users can easily access content anywhere in the workspace. Yet on a digital tabletop, content that is automatically positioned in the workspace by the system may be unreachable by tabletop users. For example, Figure 51 shows a person having difficulty accessing a dialog box that was automatically placed
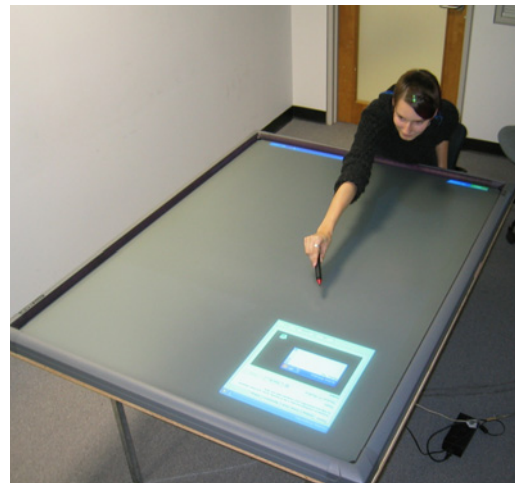
Figure 51. Items positioned by the system may be difficult to reach by a tabletop user.

across the workspace from where she is seated. Providing in-context functionality via interface components such as popup menus and then positioning any invoked content nearby would ensure that people could reach the items. Alternatively, context-aware sensors, such as motion detectors or touch sensors could be used by the system to inform applications of users' current positions. These approaches would provide users with easy access to task materials, support groups of various sizes, and allow people to choose a seating arrangement that best suits their task activities.

5.2.3 Provide System Functionality in the Appropriate Tabletop Location

Understanding the purpose of each tabletop territory during tabletop collaboration can help inform design decisions related to the placement of system functionality in the tabletop workspace (see Sections 5.1.1.2, 5.1.2.2, and 5.1.3.2). For example, personal territories provide space for collaborators to disengage from the group activity to perform independent activities. Thus, they provide the ideal place for people to access external programs when desired or to import external work into the current application. Providing space for group members to access work they have performed away from the table would facilitate transitions between work done at the table and work done externally (see Section 2.3.3). Also, providing space to access other applications, such as looking something up on a webpage or checking an email message, would facilitate transitions between individual and group work at the table.

One way to provide this space would be to provide a virtual 'personal tray' near each collaborator that could be expanded into the workspace when it is needed and collapsed when it is not. Figure 52 illustrates this personal tray concept. The personal tray could sit in a virtual layer atop the main workspace so any items currently in that location would remain undisturbed (Figure 52c), or it could shrink workspace items when the tray is expanded out against them and then restore them when it is collapsed (Figure 52b).
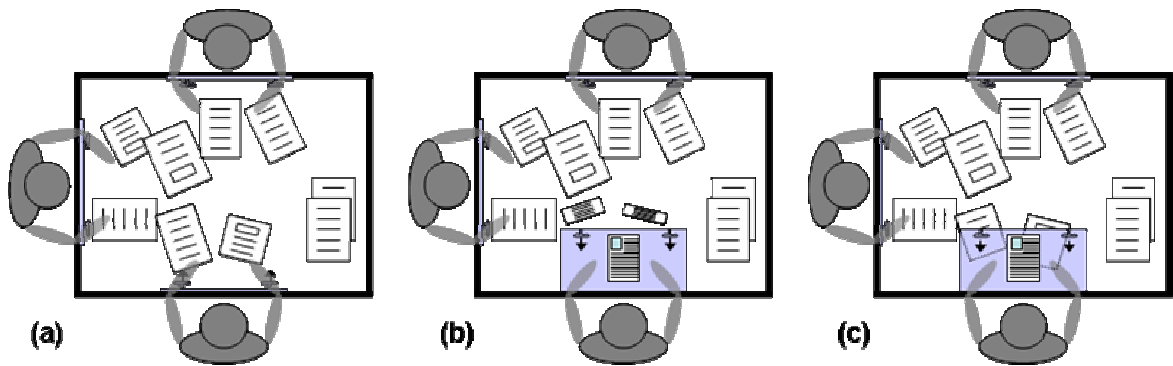
Figure 52. A personal tray: (a) the workspace when all trays are retracted; (b) a tray that shrinks workspace content when it opens; and (c) a tray that sits atop the workspace content.

Personal territories also help to ease activities such as reading and writing. Thus, it should be easy to move items to and from the area directly in front of each person and tools related to editing task items should be located nearby. A toolbar could be provided along the table edge in front of each collaborator, as discussed in Section 2.2.2 (see Figure 20).

One issue with personal toolbars, though, is that people are often surprised when one of their collaborators invokes a global action such as clearing the workspace or reorienting the contents of the workspace (Ringel-Morris et al., 2004). One solution that has been proposed to address this issue is to implement explicit access control protocols to guard against such situations. For example, collaborators could be required to vote on global actions or the system may disallow global actions until there is no interaction in the workspace (Ringel-Morris et al., 2004). Yet, such explicit protocols may still disrupt the collaboration. Requiring each member to respond to a voting dialog box for each global action may interrupt group members currently disengaged from the group activity. Also, assuming that it is 'safe' to perform a global action when no one is actively interacting in the workspace does not account for situations where someone may be reading a document or thinking about an arrangement of items. Further investigation is required to better understand how to guard against the coordination breakdowns associated with global actions.

People appear to monitor their collaborators' interactions in the group territory more closely than their collaborators' interactions in their personal territories (see Sections 4.1.2 and 4.2.2). Thus, locating any global functionality near the center of the table or along the table edge between collaborators may help people anticipate when someone intends to invoke any global functionality, giving them more opportunity to intervene when necessary.

5.2.4 Provide Visibility and Transparency of Action

Although group members appear to monitor interactions in the group territory more often than in other members' personal territories, people do tend to monitor activities occurring everywhere at the table (see Sections 4.1.2.1 and 4.1.2.2). Such monitoring behaviour is known to be an essential tool for maintaining workspace awareness during collaboration (Pinelle et al., 2003). On a traditional table, monitoring is possible because for every action performed on the table group members can see:

- when each action occurs, providing *visibility of action*, and

- exactly what action is occurring and which resources are being used, providing *transparency of action*.

Monitoring the actions of others can help people share task resources and the work surface. Moreover, monitoring helps people anticipate the actions of others, often resulting in unsolicited assistance in the workspace (see Sections 4.1.1.1 and 4.1.1.2).

To understand the importance of providing visibility and transparency of action, consider the meeting scenario depicted in Figure 53. When group member A makes a note on a paper in front of her the other group members can see: that *A is writing* on the paper, and *where* she writing on the paper, and, for those close to her, *what* she is writing and on *which paper* she is writing. Knowing which paper she is adding the note to and where she is adding the note can provide valuable context to her actions, perhaps informing others of how she is interpreting the current topic or that she means to raise a related point later in the discussion. In contrast, when participant B makes a note to a document on her laptop, group members can probably tell she is interacting to her

computer because they can see or hear her typing, but, with the exception of those directly beside her, they likely can not tell whether she is making a note or checking her email, unless she accompanies the action with a related verbal comment. Her actions do not provide the same context of action, decreasing the likelihood of others being able to anticipate future actions from her or to assess whether she is correctly interpreting the conversation.

This example suggests that systems designed to offload people's 'personal' interactions to a laptop at a digital tabletop system, like the configuration of the Augmented Surfaces workspace (Rekimoto

Figure 53. Transparency of action is reduced when group members interact with a laptop at a table as compared to when they interact with paper on the table surface.[11]

& Saitoh, 1999), may hinder workspace awareness. Monitoring exactly what actions are being performed by a person working on a laptop becomes difficult for any group member not located directly beside that person. If more space is needed than is available on the tabletop, providing each group member with a tablet-style computer instead of a laptop may provide greater visibility and transparency of action because people would be interacting directly with the tablet display surface, providing more opportunities for other group members to see the display. However, the limited viewing angle of some tablet computers may still reduce transparency of action compared to interactions occurring directly on the tabletop, potentially still compromising workspace awareness.

Providing each tabletop collaborator with a laptop may be more suitable for providing a *private* space in addition to space on the table to establish a personal territory,

[11] © NALS (National Association of Legal Secretaries) of Missouri, used with permission.

similar to the configuration used in UbiTable workspace (Shen et al., 2003). The importance of providing visibility and transparency of action in both the group and personal territories also applies to other types of co-located collaboration systems, such as walls and integrated mobile devices, as well as to distributed groupware systems. In many of these systems, all group members' interactions in the main workspace are shown on a shared group display, such as a large wall display, or are replicated across separate laptops or distributed computers. These systems often provide users with a work area that is not visible to other group members, similar to the private space provided by the UbiTable system. One advantage of providing group members with a private space is that people may feel less 'on display' when trying out new ideas or performing other personal interactions. However, the tradeoffs between the benefits gained by each group member using these private spaces and the possible loss of coordination due to the limited monitoring capabilities warrants further investigation.

5.2.5 Provide Lightweight Mechanisms for Accessing Workspace Content

The availability of workspace items is often implied by where those items are currently located (see Section 4.2.2.3). The simple act of moving an item from one's personal territory to the group territory is an easy, socially understood mechanism for a person to inform their collaborators that they are done with a task resource and that it is now available for others to use (see Section 4.2.2; Kruger et al., 2004). Similarly, the act of moving a resource from the group territory into one's personal territory appears to be a commonly understood action indicating that the resource is now reserved for use by that person (see Sections 4.2.2.3 and 4.2.2.4). Relying on this social protocol to coordinate group members' access to tabletop items provides a lightweight mechanism to manage changing access privileges to these items.

Enforcing strict 'ownership' of workspace items in a digital tabletop system through the use of access control techniques, such as Ringel et al.'s (2004) release, relocate, reorient, and resize access control methods (described in Section 2.2.3), may hinder normal cooperative behaviour. For example, people often work closely on the

same workspace items (see Sections 2.2.3 and 2.3.3). Requiring users to grant permission to their partners each time they are done with an object may hinder their ability to fluidly interact with the same object.

5.2.6 Allow Casual Grouping of Workspace Content

As described above in Section 5.1.3.3, items contained within the storage territories tend to be fairly casually organized. Storage territories often contain both loose piles of resource items as well as individual items loosely arranged in the storage territory region (see Sections 4.1.1.3 and 4.2.2.3). These casual grouping activities provide many task and collaborative benefits to tabletop collaborators (see Section 4.2.2.3). For example, being able to casually group resource items can help collaborators quickly organize the workspace and access task resources when they are needed (see Section 4.2.2.3). In a study of piling behaviour on office desks, Malone (1983) found that this type of casual workspace organization helps people organize their work, reminds people of work still to be done, and provides a cognitively lightweight mechanism for people to store items that are otherwise difficult to classify.

As discussed in Section 5.1.3, the ability to move storage territories around in the workspace provides several benefits for task interactions (e.g., easy access to resources) and for the collaboration process (e.g., allows people to easily reserve or share resources). The ease of moving storage territories around on the table to coordinate group members' access to tabletop resources is in stark contrast to the mechanisms typically used by groupware systems to manage access to shared items. These systems often assign 'ownership' of system resources to a group member, requiring that person to explicitly release control of an item before another group member can access it (e.g., Scott et al., 2003; Ringel et al., 2004). Such explicitness may hinder fluid group interactions since it appears to contradict the socially mitigated process used in traditional workspaces.

5.3 Chapter Summary

This chapter has shown that tabletop territoriality is a complex social practice that helps tabletop collaborators share task resources and the workspace with relative ease.

Enabling this practice in a digital tabletop workspace requires careful design that considers both the hardware and software of the system. This chapter has identified the spatial properties, purpose, and the interactions supported by the personal, group, and storage territories, as well as some factors that influence the establishment and use of these tabletop territories. Understanding the nuances of tabletop territories and how each contributes to the collaboration process can help designers create more appropriate collaborative tabletop systems. This chapter has also provided a set of design recommendations to illustrate how to apply this knowledge to tabletop system design. These recommendations advocate providing an appropriately sized tabletop (of suitable pixel resolution) for the most likely usage scenarios, as well as appropriately positioning digital content and functionality for the current users and task activities. Tabletop systems should also enable people to maintain workspace awareness by providing interaction areas that are visible to all group members. Finally, collaborative tabletop systems should allow people to create casual groups of workspace content to provide the collaborative and task benefits provided by casual organization of resource items.

Articulating how each tabletop territory contributes to the overall practice of tabletop territoriality, particularly how each facilitates the coordination of task and group interactions in the workspace, provides a strong theoretical foundation which can help tabletop designers predict the potential impact of prospective interface components and interaction techniques. To illustrate how this knowledge can be applied to the design of collaborative tabletop systems, the next chapter presents the design and evaluation of a new tabletop groupware interface component that facilitates organizing and sharing digital content in a collaborative tabletop workspace. This interface component facilitates tabletop territoriality by allowing collaborators access to casually stored workspace content anywhere on the workspace, enabling them to tailor their workspace to suit the requirements of the task and of the group interactions.

Chapter 6. Design and Evaluation of a Tabletop Groupware Interface Component

An important aspect of establishing storage territories on a traditional tabletop workspace is the ability to create casual groupings of workspace items (see Sections 4.1.1.3 and 4.2.2.3). Enabling this behaviour in a digital tabletop workspace may help people establish storage territories in this environment, as discussed in Section 5.2.6. The desire to enable casual grouping interactions in a digital workspace motivated the development of a new interface component, called a storage bin, which is the focus of this chapter. The storage bin interface component is a mobile, adjustable container widget that provides users with a lightweight interaction mechanism to store and retrieve workspace content anywhere in the workspace.

Before discussing the specific characteristics of the storage bin interface component, the chapter first discusses several problems related to the casual grouping of traditional resource items observed during the observational studies. Next, several existing interface solutions that can help minimize these problems in a digital workspace are described. The chapter then presents the basic design concept of the storage bin interface component. Finally, the methodology and findings from an exploratory user study that was performed to help evaluate the design of the storage bins are presented, along with some proposed design enhancements suggested from the study findings.

6.1 Problems with Casual Grouping using Traditional Media and Solutions for Digital Workspaces

Although the ability to casually group traditional media within storage territories on the table provides many collaborative and task benefits (see Sections 5.1.3.2 and 5.2.6), several issues associated with this practice were observed during participants' tabletop

Figure 54. Storage territories containing various casually grouped resource items.

interactions in Studies 1 and 2. Groups of stored items often occupied valuable working space on the table, especially if there were many items contained in the storage territory or if the stored materials were large. Furthermore, people often had difficulties searching for specific items within a storage territory because the stored items were often overlapped and haphazardly organized (see Figure 54, notice some of the 'messy' piles of items being stored in the workspace). Thus, the ease of being able to loosely organize stored items often hindered the later retrieval of those items.

Unlike the fixed size of workspace items in the physical world, the size of digital items can be adjusted. This property can be leveraged to help alleviate some of the problems that people encountered with casual organization of traditional media. Several existing interface techniques make use of item scaling for stored items to help create more display space for the main task activities. One approach is to 'squash' out-of-focus items against the workspace edge by pushing another item against it, creating more working area while at the same time minimizing overlap between items (e.g., Mynatt et

ZoomScape (Guimbretière et al., 2001)   Scalable Fabric (Robertson et al., 2004)
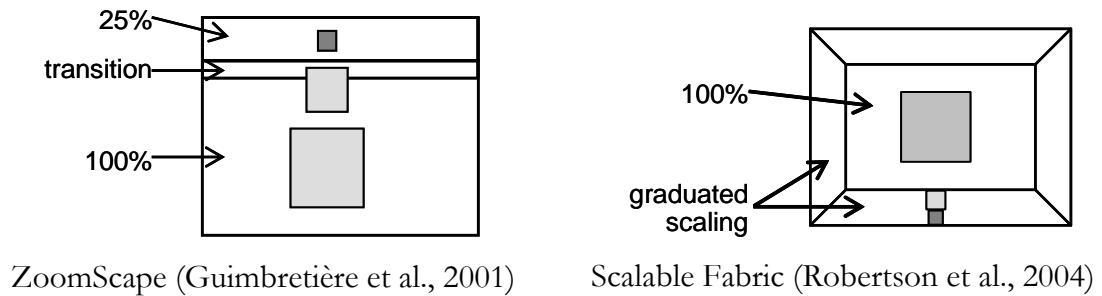
Figure 55. Examples of existing casual storage methods that shrink stored items.

al., 1999; Hutchings & Stasko, 2002). Another approach is to scale workspace items placed inside a visible 'storage' area along the periphery of the main workspace. For example, on Stanford's interactive wall, any workspace item moved into a storage area spanning the top edge of the display, called the ZoomScape, is scaled to 25% of its original size (Guimbretière et al., 2001). Similarly, any application window that is placed in the storage area surrounding the main workspace of the Scalable Fabric desktop system will also be reduced in size (Robertson et al., 2004). Figure 55 illustrates these two storage mechanisms. Reducing the size of stored items can also help minimize search issues because many small items can often be spread out in an available space before occlusion becomes an issue.

Providing storage areas along the periphery of the workspace only partially supports the storage behaviour observed in the observational studies (see Sections 4.1.2.3 and 4.2.2.3). Being able to store resource items anywhere in the workspace and to move them around can be critical for coordinating task and group interactions on a table (see Section 5.1.3.2). To facilitate this storage behaviour in a digital tabletop workspace, a mobile storage mechanism, called a *storage bin*, was developed which provides the space-preserving features of existing storage mechanisms, while also providing the capability to relocate stored items in the workspace.

6.2 Storage Bin Basics

Combining the design criteria discussed above and in Section 5.2 with participant responses during pilot studies, storage bins were designed with the following characteristics.

- *Container capabilities.* The contents of storage territories during tabletop collaboration often change over time. Piles of resource items are created, individual items are added and loosely arranged, items are removed individually or as a group (e.g., a handful of items may be removed at once) (see Section 4.2.2.3). Therefore, storage bins were designed to provide the capabilities of a container, allowing items to be added or removed as a group or individually. They were also designed to be resizable to easily accommodate varying amounts of stored items.

- *Mobility.* The location of stored items is strongly connected to their relationship to the main task (see Sections 4.1..3, 4.2.2.3, and 4.2.2.4). Moreover, storage territories are often moved when someone wants to have easier access to their contents or when they are in the way of the main task. Leveraging the container metaphor, all items in a storage bin can be readily relocated simply by moving the storage bin.

- *Visual characteristics.* Storing items and accessing stored items are typically peripheral activities. These activities should support the main task but not pull attention away from it. Therefore, transparency is used to make storage bins only slightly visually distinguishable from the background rather than being visually dominant. With physically-based media the shape of storage territories was always variant, loose, amorphous, and often changing. Similarly, storage bins have loose, curved and adjustable boundaries. Figure 56c shows a storage bin; note the casual shape and the minimal colour usage.

- *Storage.* Borrowing from the ZoomScape (Guimbretière et al., 2001) and Scalable Fabric (Robertson et al., 2004) storage techniques, the size of items placed in a
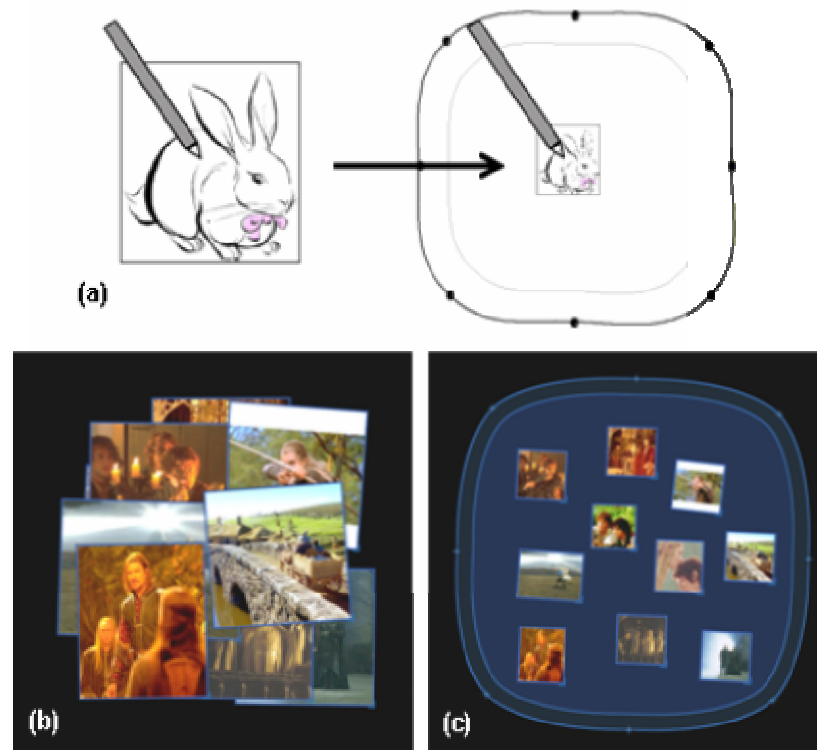
Figure 56. Storing an item in a storage bin (a). The same photos are shown at full-size in (b) and stored in a storage bin (c).

storage bin is reduced to help conserve screen real-estate in areas where the main task activity is being performed and to help minimize item occlusion among stored items.   Pilot tests involving several groups of participants previously unfamiliar with storage bins both confirmed the usefulness of this feature and refined it by indicating that while, in general, reduction in size proportional to the objects original size (to 35%) was most understandable, a minimum size (of 80x80 pixels) was necessary to maintain recognizability. Items are considered to have entered the storage bin when the current touch point (i.e. current location of the user's finger or pen) is within the storage bin. Figure 56a illustrates the act of storing an item in a storage bin and Figures 56b and 56c show two views of the same 10 images demonstrating how the size reduction can help with occlusion: the full-sized images (Figure 56b) have considerable overlap and scaled images in a storage bin (Figure 56c) are not occluded.

Scaling items as they enter and leave a storage bin requires consideration of how and when the scaling should occur. Pilot tests revealed that people found abrupt scaling to be jarring; thus, animated transitions were introduced. Scaling animations can be implemented spatially, as an item crosses a particular region, or temporally, during a short period of time upon entering the storage bin. Adding a rim to the storage bin, as shown in Figure 56c, provides a spatial transition zone. However, it is possible for a part of an item to be over the storage bin without the item being considered to be inside it, since an item is not stored unless the touch point enters the bin. If a subsequent touch occurs on a region of the item that is over the storage bin, a timed scaling animation is applied to produce a smooth scaling change since the touch point did not cross the transition zone.

In summary, a storage bin is a graphical user interface container component that can be used to hold other workspace items, such as images, documents, and thumbnails. Its mobility and adjustability in size and shape allow people to share resources and transition between resources. Moving a storage bin allows a person to bring a collection of stored items into and out of the current focus of activity. Being able to expand and collapse a storage bin allows people to dynamically customize their working area: when they are actively using a collection of stored items, the storage bin can be expanded to provide easier access those items; when they are finished with the collection, the storage bin can be collapsed to free up that area of the workspace. Enabling dynamic customizability of the tabletop workspace should also facilitate the practice of tabletop territoriality because collaborators will be free to adjust items in the workspace to help establish territories and flexibly adjust their boundaries.

6.3 Exploratory User Study

In order to investigate the usability of storage bins and to understand the advantages and disadvantages of both mobile and peripheral storage mechanisms, an exploratory user study was conducted. In this study, small groups performed a collaborative photo layout

task on a digital tabletop system containing either storage bins or a peripheral storage area that spanned the perimeter of the tabletop workspace.

6.3.1 Experimental Methodology

6.3.1.1. Participants

During the week of July 26, 2004, six pairs of university students (3 male groups and 3 female groups) were paid to participate in this study. All participants rated themselves as frequent desktop computer users, although only four were computer scientists. Only four participants had previously used a digital tabletop system. Participants all had previous experience collaborating at a table using traditional media and were familiar with the two popular shows (Friends and Lord of the Rings) used as the content for the experimental task (described below). Only one pair of participants knew each other prior to the study.

6.3.1.2. Apparatus

Participants performed the experimental activities while seated at a large (152.4cm x 121.9cm), high-resolution (2048x1024 pixels) tabletop display located in the Interactions Laboratory at the University of Calgary. Participants sat at adjacent sides of the table during the study and stood when it was necessary to reach something across the table. During one session, participants ended up standing on opposite sides of the table for the majority of the session. The tabletop system enabled multi-user touch interaction by using a 4-camera[12] SMARTBoard™ DViT 1810 interactive whiteboard that recognized up to two simultaneous touches on the board surface. The experimental software ran on a Xeon™ 2.80GHz Windows XP personal computer. Figure 57 shows this experimental setup and Figure 58 shows the schematics of the physical configuration of the digital tabletop workspace.

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[12] The DViT 1810 model comes in a 2-camera and a 4-camera version. Only the 4-camera version can robustly track two simultaneous touch points.
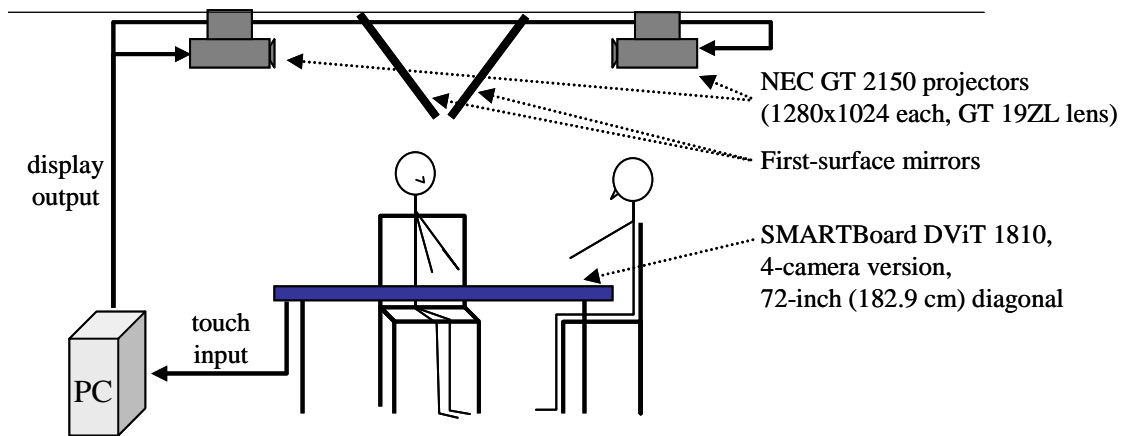
Figure 57. Experimental setup.
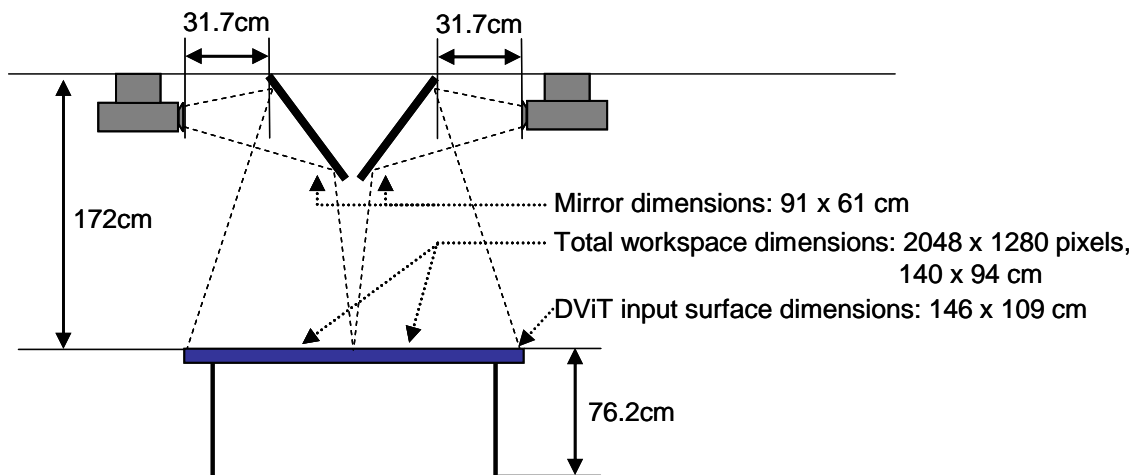
Figure 58. Schematic diagram of the digital tabletop setup.

A digital video camera was setup at one end of the table to record the participants' interactions with the tabletop surface and with each other. Small, clip-on microphones were also used to record participants' conversations during the sessions.

6.3.1.3. Experimental Design

Each pair completed the experimental task twice: once using storage bins and once using the peripheral storage area. The order of presentation of the storage mechanisms was counterbalanced. In addition, two sets of photo content were used in the study, one for the television show 'Friends' and one for movie trilogy 'Lord of the Rings'. Participants

used different photo content in each task trial. The order of presentation of the photo content was counterbalanced.

6.3.1.4. Experimental Task

The experimental task involved creating several photo collages on template layout pages in a tabletop workspace. During each task trial, participants were provided with four theme pages (512x512 pixels each) and 100 photos (125x125 or 256x256 pixels each) loosely

Figure 59. A photo layout created on the theme page for 'Romance'.

clustered in the middle of the tabletop workspace. The photos and layout themes used for each task trial related to a popular television show ('Friends') or movie ('Lord of the Rings' trilogy). The goal of each task trial was to create a photo layout for each of the four theme pages in the allotted time. Figure 59 shows a sample layout on the 'Romance' theme page from the 'Friends' TV show.

6.3.1.5. Collaborative Tabletop Workspaces

Participants performed the layout task using two different workspaces: one containing storage bins and one containing a peripheral storage area.

In the storage bin workspace, nine storage bins were provided: one in each corner and five clustered directly between the participants' initial seating positions. The latter five storage bins were intentionally positioned between collaborators, and likely 'in the way,' to create the opportunity to see if people would move them to a more 'suitable'
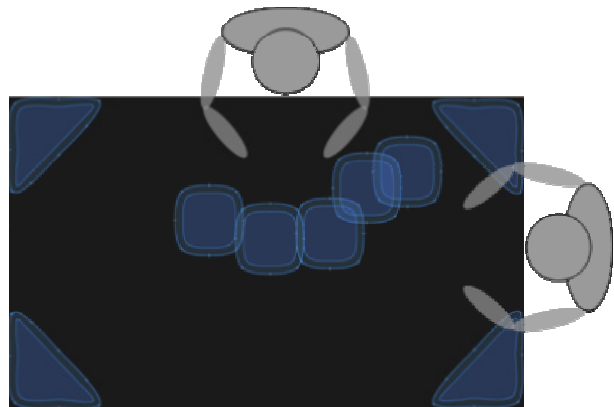
Figure 60. The initial configuration of storage bins in the workspace. Photos and theme pages were randomly placed near the centre of the workspace, atop the storage bins.

Figure 61. The peripheral storage area: with an empty workspace (left) and during the layout task (right).

location and, if so, where that would be. Figure 60 shows the storage bins used in this study and their initial configuration relative to the participants' seating positions.

Storing an item (or group) in the peripheral storage area was identical to storing an item (or group) in a storage bin. Unlike the storage bins, though, the peripheral storage area was permanently fixed to the workspace edge. A larger or smaller storage area could be created by resizing the peripheral storage area. Each side could be resized independently to allow different sized storage areas on each side of the table. Figure 61 shows the peripheral storage area used in this study, with and without task content.

The experiment software was implemented in Microsoft Visual C# and OpenGL, using the Tao.OpenGL library (www.taoframework.com), see Appendix C for further details on using Tao.OpenGL to create an interactive workspace. To provide software support for multiple users at the tabletop display, Tse's DViTtoolkit (an extension of the SDGToolkit (Tse & Greenberg, 2004)) was used.

Aside from the storage mechanisms described above, the tabletop groupware also contained several features useful for performing the layout task. The photos and theme pages could be easily resized via a resize handle on the lower right corner of each item. Groups of items could be created and selected by dragging a bounding box around several items. To facilitate reorientation of tabletop items on the table, touching and dragging an item (or group of items) in the workspace invoked an interaction mechanism called Rotate 'N Translate (RNT) (Kruger et al., 2004; Kruger et al., 2005). RNT allows

an object to be simultaneously rotated and translated in a single fluid motion using a single touch point. RNT also provides the ability to toss items across the workspace with a simple 'flick' action performed on an item, allowing items to be easily passed to someone else or discarded across the table.

6.3.1.6. Procedure

Each session began with a brief introduction from the experimenter. Participants then filled out a consent form and a background questionnaire which elicited information on general demographics, computer experience, and collaboration experience (see Appendix D for the consent form and questionnaire). Next, the experimenter gave an introduction to the tabletop system and participants were shown how to use the first storage mechanism. They were given 15 minutes to perform a practice layout session using one theme page and 45 photos. Once the practice session was complete, the group was given 20 minutes to create the four theme layouts in the actual task trial. After the task trial, participants completed a post-trial questionnaire that elicited their reactions to the storage mechanism and the interface in general. This procedure was then repeated for the remaining storage mechanism. Finally, participants completed a post-experiment questionnaire which asked them to compare the two storage mechanisms along a number of factors, including ease of use, task suitability, and overall preference. This questionnaire also contained a freeform section to allow participants to provide further comments on their opinions of the storage mechanisms and the overall interface. The post-trial and post-experiment questionnaires are provided in Appendix D. After completing the post-experiment questionnaires, participants were debriefed, paid, and thanked for their participation. Each session took roughly 90 minutes to complete.

6.3.1.7. Data Collection

Participants' interactions in the digital workspace were logged to a data file and their interactions with the tabletop and with each other were captured on audio- and videotape. Field notes were also recorded during the session to note any particularly interesting interaction behaviours or emerging patterns. Preference data was also collected on the post-trial and post-experiment questionnaires.

6.3.1.8. Data Analysis

To understand how the storage mechanisms were used during the layout task and how their designs impacted participants' interactions, as well as the overall collaboration – especially as it relates to the emergence of territorial behaviour – it was necessary to know what actions each person performed in the workspace. However, the SMARTBoard DViT touch surface does not distinguish between different users touching the surface; it only knows that one or two touches are currently on the surface and where each touch is. Therefore, the initiator of the workspace actions could not be recorded in the corresponding logfiles.

Thus, in order to interpret the interactions that occurred during the layout sessions, visualizations were produced from the actions recorded in the logfiles. Visualizing the actions that occurred across and on the storage mechanism (i.e. boundary interactions) was found to be useful for identifying interesting episodes and interaction trends during the sessions. These boundary interactions included:

- storage or retrieval actions (i.e., any instance of a item (or group) being moved inside or taken out of a storage mechanism), and

- resize, reshape, or move actions performed on the storage mechanism.

Figure 62 shows a sequence of visualizations which correspond to a series of interactions in one of the storage bin trials. Each image in the sequence shows the cumulative boundary activity (i.e. any storage or retrieval actions) between storage bin
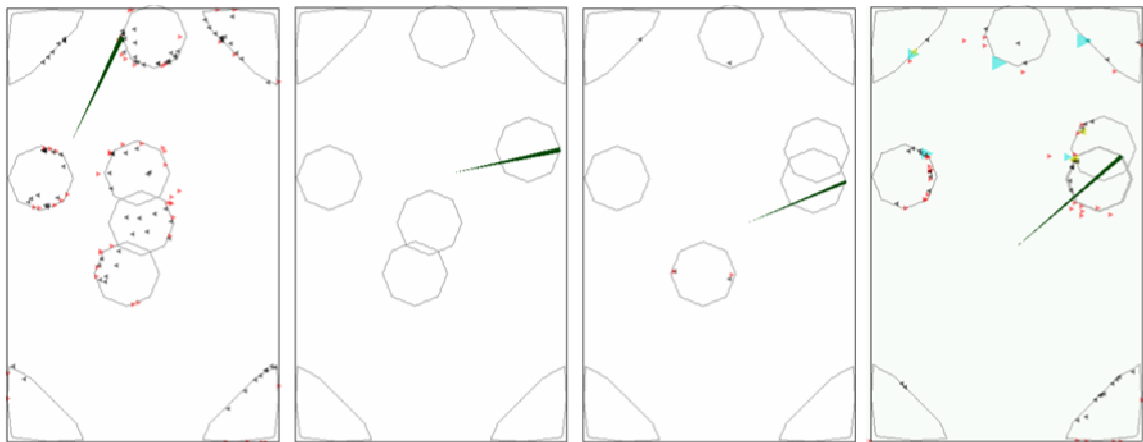
Figure 62. A sequence of workspace visualizations from one of the storage bin trials.

events (i.e., a move, resize, or reshape). The red and black triangles show storage and retrieval of individual items, while the aqua and yellow triangles show the storage and retrieval of a group of items (participants were seated to the left and top of each image). The rough outline of the current location, size, and shape of the storage bins are shown, along with all storage and retrieval actions associated with each storage bin while they were in the indicated positions. In the case of a move, the green line shows the path from the initial position to the new position of the re-located storage bin.

Figure 63 shows a series of visualizations for one of the peripheral storage area trials. Each image shows the cumulative storage and retrieval actions on the peripheral storage area during two phases of the task: sorting photos (left), and assembling theme layout pages (right) (again, the red and black triangles show storage and retrieval of individual items, while the aqua and yellow triangles show the storage and retrieval of a group of items, participants were seated to the left and top of each image). No manipulations were made to the storage mechanism during this trial.
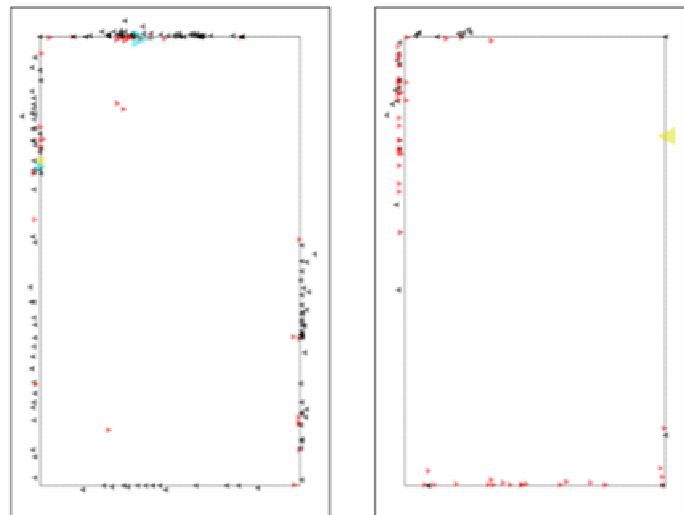
Figure 63. A sequence of workspace visualizations from one of the peripheral storage area trials.

These visualizations were then used in conjunction with the video data to help understand the tabletop interactions that occurred during the sessions. For each trial, the visualizations were reviewed for interesting interaction patterns related to storage and retrieval of workspace items, to manipulation of the storage mechanisms, and to

positioning of the storage bins. Once particular episodes were identified, the corresponding video segments were then reviewed to help further understand these interactions and to precisely identify which participants were performing which actions shown in the visualizations. The videos were also viewed in their entirety several times to gain a better overall understanding of the interactions in each trial, especially with respect to the different working styles used within and across groups and across storage mechanisms. The results of this analysis are presented below, along with snapshots from the video data to help illustrate the findings.

6.3.2 Findings

In general, participants reported finding the storage mechanisms helpful for performing the layout activity. Furthermore, both storage mechanisms were used extensively during the layout sessions. At least half of the 104 photos and layout pages were stored at some stage during the twelve layout sessions. In nine of twelve sessions at least 98% of the items were stored and in six sessions all 104 workspace items were stored.

Though both storage mechanisms were used frequently for storing and retrieving items, the storage bins were manipulated much more often than the peripheral storage area. Only one pair adjusted the peripheral storage area at all. This group enlarged the storage area in front of each person by about 25% (see Figure 64a) at the beginning of their trial and left it that way for their entire session. Conversely, the storage bins were manipulated by all six groups. The move feature was used most often: across all six trials, the storage bins were moved 75 times. How frequently they were moved varied widely between groups: some groups moved the storage bins only a few times, while other groups moved them over 20 times. The reshape and resize features were used much less often, but appeared to be helpful when used: the storage bins were reshaped twice and resized eleven times across all trials.

The field notes and video data revealed that two distinct types of activities emerged during the layout task: coarse-grained organization and fine-grained organization. Participants spent roughly the first half of each trial (~10 minutes) performing coarse-grained organization of the workspace, sorting the photos into four

theme groups. During the second half of the trial, participants then assembled the photo layouts. This stage of the trial involved more fine-grained organizational activities such as arranging the theme pages and candidate photos in the workspace, passing and sharing items, and manipulating the storage mechanisms to gain access to stored photos or to create more room in the workspace. Each storage mechanism provided different advantages and disadvantages for supporting these organizational activities. The following sections describe the interactions that occurred during each organizational phase and the extent to which each storage mechanism supported these interactions.

6.3.2.1. Coarse-grained Organization of the Workspace

All six groups made extensive use of the storage mechanisms while sorting the photos. Groups typically placed each theme page in a storage bin or in a separate region of the peripheral storage area. For each photo, if it related to one of the four themes, it was stored with the appropriate theme page. If not, it was discarded into a separate storage bin or in a separate region in the peripheral storage area.

In general, participants used fast, casual interactions during the coarse-grained organization of the workspace. People spent little time tidying up the theme groups. The ability to toss items beyond one's reach on the table was a widely used feature and often reported by participants to be one of their favourite features. This tossing interaction was used frequently during the sorting task: once a photo had been classified, it would be tossed quickly toward the appropriate group. While the item was still moving, participants would often be considering the next photo. Consequently, the large target area provided by the peripheral storage area was well suited to the sorting activity. The long, continuous boundary was easy to aim for and the table edge stopped items from going beyond the storage area. When using this storage mechanism, all of the groups established four separate theme groups in the peripheral storage area and one or more groups for discarded photos that could not be classified. Two theme groups were typically established near each participant, while the groups of discarded photos were typically established along the sides where neither participant was seated (see Figure 64).
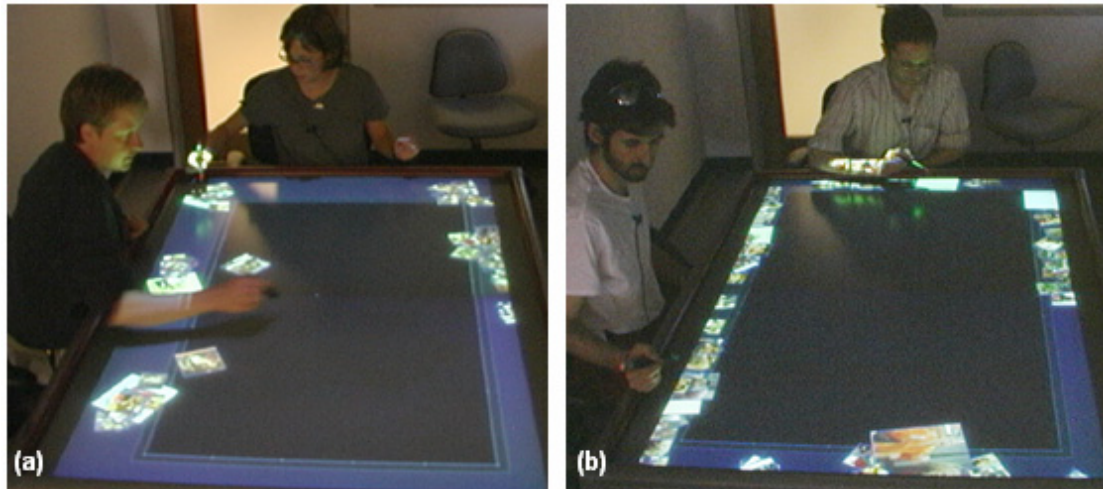
Figure 64. Teams sorting photos into theme groups in the peripheral storage area.

Sorting the photos using the storage bins required more accuracy because of their smaller size. Tossing items into a storage bin was difficult because people would often over or under shoot the storage bin, requiring people to be much more careful with the force and direction they applied to the toss gesture. When photos were tossed into the bins located in the corners, the photos would often pass through the container area and land on the transition areas, thus, growing in size again. Participants would often toss several items toward a storage bin – getting them close – and then later spend time placing items that had 'missed' their target into the storage bin. Each group used a separate storage bin per theme and one or more storage bins for the discarded photos (see Figure 65). Though the sorting process was typically slower because of the more

Figure 65. Teams sorting photos into theme groups in the storage bins.

careful interaction required, some people preferred this storage mechanism for organizing the workspace. Several participants reported that they "preferred the movable bins for organizing content and moving groups" and they felt that "having different storage spaces made grouping easier."

6.3.2.2. Fine-grained Organization of the Workspace

The next stage of the task involved creating the theme layouts. During this stage, photos were retrieved from the storage mechanisms and then arranged on the theme pages. When a theme layout was finished, the assembled layout and left-over photos were typically stored in order to create space for working on the next theme layout. Assembling the theme layouts involved a mix of careful manipulation of theme pages, photos, and storage mechanisms, and of casual discarding of photos that were not incorporated into the final layouts. In general, the storage bins supported this mix of activities more effectively than the peripheral storage area. The storage bins provided greater flexibility for supporting the variety of individual and collaborative working styles employed by participants while they were creating the theme layouts.

Organizing the candidate photos. To create a theme layout, participants had to choose several photos (typically 5-8) from the group of candidate photos (typically 15-20) that the participants had originally categorized into the corresponding theme. Participants used several methods to organize the candidate photos to facilitate this photo selection process: *traditional*, *previewing*, and *within-storage* (see Figure 66). The traditional method involved participants retrieving a group of candidate photos from storage and then choosing from the group of full-sized photos in the workspace. The previewing method involved participants retrieving one candidate photo at a time from storage for full-size viewing before deciding whether or not it was appropriate for the layout. If so, the photo was added to the layout. If not, it was re-stored and another candidate photo was retrieved until the layout was complete. The within-storage method involved participants choosing candidate photos directly from within the storage mechanism to add to the layout.
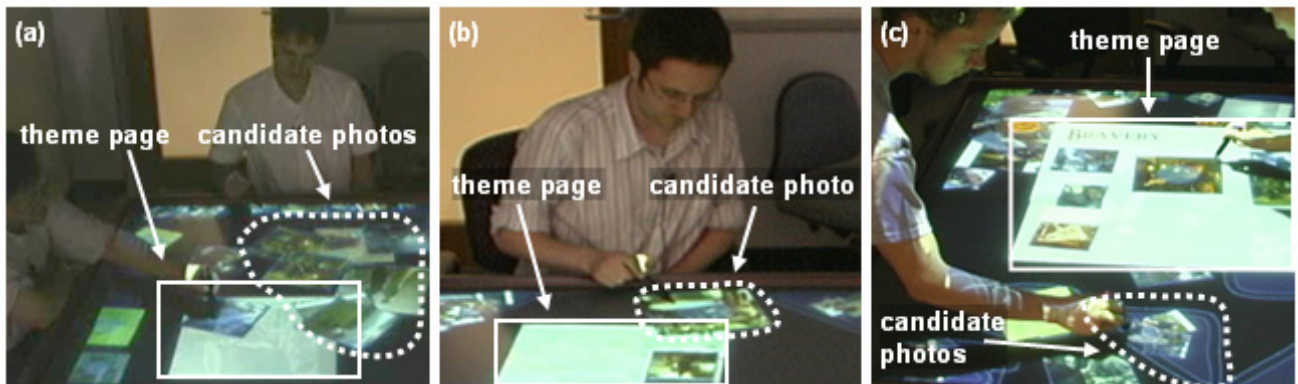
Figure 66. The three organizational methods: (a) traditional, (b) previewing, and (c) within-storage. In (a) and (b) the candidate photos are being viewed in the main workspace, but in (c) the candidate photos are inside a storage bin.

Participants tended to move candidate photos close to the theme page, often just beside it, allowing them to make easy visual comparisons between the current layout and the candidates. When items were stored in the peripheral storage area, participants typically used the traditional method to compare candidate photos with the current layout (see Figure 66a). Previewing was also used, but much less often. Participants rarely used the within-storage method when using the peripheral storage area. While the photos in the peripheral storage area were very close, and thus easily viewed, people tended to want to view the candidate photos directly to one side or the other of the theme page. Since the photos stored in the peripheral storage area were typically located at the bottom of the theme page, this may explain the more frequent use of the traditional and previewing methods for choosing photos.

In contrast, storage bins easily supported all three methods of organizing candidate photos. People could move a storage bin out of way if they needed more space for creating a group of full-sized photos or space to preview photos beside the layout. The storage bins could also be moved directly beside the theme page (see Figures 66c and 67a). Furthermore, the storage bins could be expanded to show more candidate photos at once. People often added photos directly to a photo layout from within a storage bin. Choosing photos from within a storage bin allowed people to minimize the space occupied by candidate photos; thus, reducing overlaps and facilitating the photo

selection process. In general, storage bins provided more support for customization of the workspace, allowing people to use the organizational method they preferred.

The style of collaboration used by each group also affected which method participants used for organizing candidate photos in the workspace. Half of the groups used a divide-and-conquer strategy (one male and two female groups), with each team member working independently to create a theme layout. The remaining groups worked together on a single layout at a time (two male and one female groups).

Participants working together on the same layout tended to use the traditional and previewing methods for choosing photos, regardless of which storage mechanism was currently being used. These methods facilitated group discussion of the candidate photos better than the within-storage method because full-sized photos were easier to share among group members than small, stored photos. Only one pair of participants working together on a layout selected photos directly from within storage (see Figure 66c). This pair was also the only pair that stood during their session, which may have increased the visibility of the smaller items in storage because the participants could easily lean over the workspace.

Participants working independently in the workspace used all three organizational methods. However, the method used during each trial appeared to be influenced by the storage mechanism they were currently using. They tended to use the traditional and previewing methods when using the peripheral storage area. On the other hand, they tended to use the within-storage method when they were using the storage bins. This difference likely resulted because the peripheral storage area provided limited access to stored items away from the table edge: as mentioned above, restricting the stored items to the periphery of the workspace did not suit everyone's working style, people often wanted to view the candidate photos beside the theme layout, not below it.

Supporting different collaboration styles. In general, the storage bins were more effective at supporting variations in collaboration styles than the peripheral storage area because the storage bins enabled localized storage interactions. The mobility of storage bins allowed participants working together on a layout to position a storage bin centrally so that both participants could access the stored items (see Figure 66c). Furthermore, the adjustability and mobility of storage bins allowed people to bring a group of stored photos into and out of the main focus of activity without interfering with their partners' activities. Several participants took advantage of these features to provide easier access to stored photos and to create more space when photos were no longer needed.

An example of this behaviour is shown in Figure 67. This figure shows a sequence of interactions where a participant (on the left) first selects photos from an expanded storage bin (Figure 67a), then he collapses the storage bin (Figure 67b), and finally he selects photos from a second expanded storage bin which he has repositioned from the opposite table edge to the table in front of him (Figure 67c). Notice that in Figure 67c he has moved the first storage bin (1) out of the way, about halfway to the far table edge. This episode illustrates that his interactions have not affected his partner's access to the stored photos in the upper left corner of the table. In contrast, if the first group of photos had been in a peripheral storage area in front of him, collapsing this group would have collapsed all photos being stored along that table edge, including the photos his partner was using in Figures 67b and 67c. The localized behaviour of the
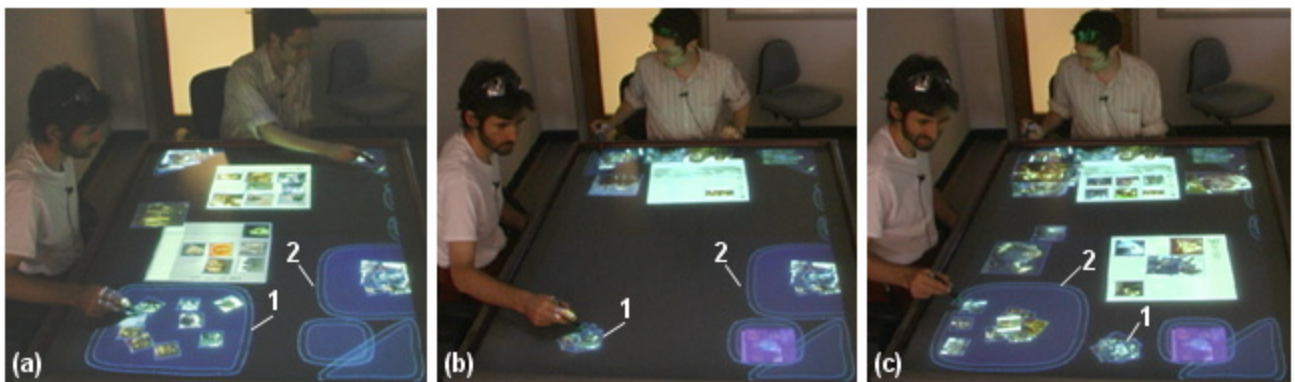
Figure 67. Localized use of the storage bins: (a) participants select photos from separate storage bins, (b) the participant on the left collapses a storage bin, and (c) then he selects photos from a different storage bin while his partner continues using the same storage bin.

storage bins frees each group member from worrying about interfering with their collaborators' interactions.

6.3.2.3. Supporting Tabletop Territoriality

In general, the ease of manipulating workspace content in the tabletop groupware interface supported the establishment of personal, group, and storage territories during the layout sessions. The localized interactions enabled by the storage bins, however, provided more flexibility for tailoring these tabletop territories to more precisely meet their task needs.

Personal territories. Establishing a personal territory on the table allows collaborators to perform independent task activities when desired and to reserve task resources. As discussed in the previous chapter, personal territories typically comprise the area on the table directly in front of each person. However, because the peripheral storage area occupied the entire table edge, this area was unavailable for working on the layout. When using this storage mechanism, participants working in parallel typically placed their theme page just above the peripheral storage area and arranged their candidate photos beside the theme page in the main workspace. They typically placed the theme page as close to the table edge as possible without moving it into storage.

On the other hand, when using the storage bins, group members working in
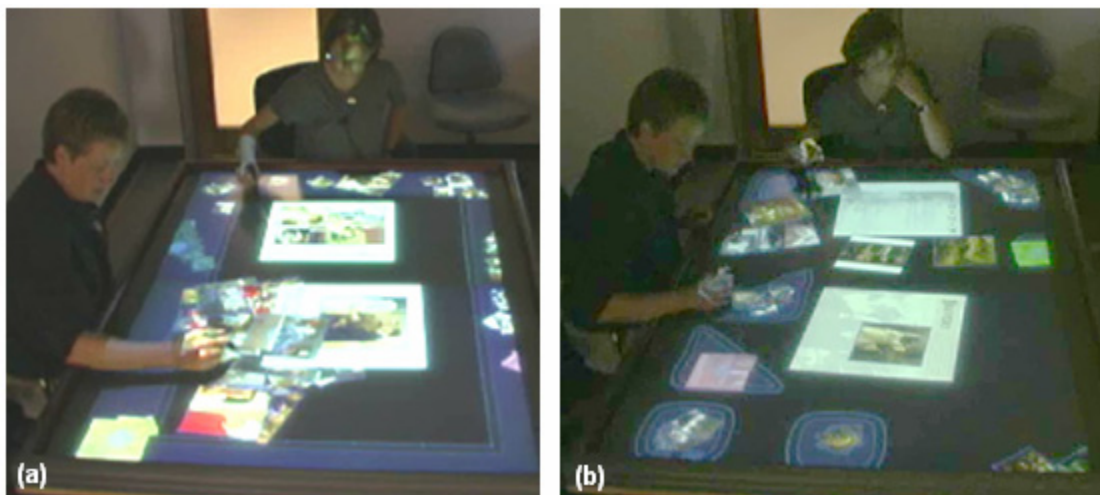
Figure 68. One group using the two storage mechanisms. Note how much closer the theme page is to the participant at the top of the scene when she is using the storage bins (right).

parallel typically placed either a theme page or a storage bin that was actively being used for choosing photos directly in front of them on the table, in close proximity to the table edge. For example, the upper participants in Figures 67c and 68b have placed their theme pages close to the table edge as they are working on them, while the side participants in the same figures have placed storage bins close to the table edge for choosing their candidate photos. Contrast this to Figure 68a, where both participants are forced to work with their theme pages quite far from the table edge.

Thus, it would seem that, when possible, people preferred to establish personal territories close to the table edge when working in parallel during the layout task on the tabletop. The mobility of the storage bins provided people with the choice to either have the theme page or the stored photos close to them in their personal territory. In contrast, the fixed nature of the peripheral storage area did not offer people the choice to work on their theme pages in this space, unless the entire storage area was collapsed; thus, preventing access to any stored items along that entire table edge.

The localized interaction enabled by storage bins has important implications for the establishment of personal territories. Enabling localized interactions allows people to effectively disengage from the group activity when desired without interfering with their collaborator's workspace actions. Simultaneously, storage bins still provide the visibility and transparency of action which enables people to monitor their collaborator's activities in their personal territories, which we saw in Chapter 4 can result in group members offering assistance when appropriate. Figure 69 shows a similar example from this study where one participant (at the top) suggests that her partner include a photo that was stored in a storage bin in her partner's personal territory. She points to the photo to clarify her suggestion and her partner then incorporates that photo into her layout.

The group territory. Both storage mechanisms enabled participants to use the central region of the table to perform the layout task, to share task resources, and to assist each other in performing the task. The storage bins, though, allowed participants to more precisely define the bounds of group territory, enabling participants to place shared resources within easy reach of where the participants where actually working, as opposed to having the group territory predefined by the physical perimeter of the tabletop workspace. For example, Figure 70 illustrates how one group has arranged the storage bins all along the bottom of the workspace, and away from the side edges to accommodate their layout activities in the group territory. This figure also provides an example of how storage bins can facilitate assistance in the group territory: the participant (on the left) is passing a storage bin to his partner to put the finished layout page in.

Storage territories. Both storage mechanisms supported the establishment of storage territories – both inside and outside of the actual storage mechanisms. Just as participants assembling the jigsaw puzzle in Study 1 stored items directly on the table surface as well as within the puzzle box lids (see Section 4.1.1.3) participants in this study created casual groupings of digital content both within the storage mechanisms and in the main workspace. Also, just as participants assembling the jigsaw puzzle assembly in Study 1 took advantage of the convenience of moving the box lids around the table in

Figure 69. A group member providing assistance in a storage bin located in her partner's personal territory.

Figure 70. Participants have rearranged the storage bins to accommodate their interactions in the group territory.

order to easily gain access to stored puzzle pieces, participants in this study leveraged the ability to move a group of items contained within a storage bin. Thus, storage bins allowed participants to easily move a group of photos into and out of the focus of activity as the task required. One group also took advantage of the mobility of storage bins to loosely arrange several storage bins together at one end of the table to establish a large storage territory (see Figure 70).

6.3.2.4. Usability Issues

While the storage bins were used extensively throughout the layout sessions, the visualization sequences and the observations made from the video data indicated that the move and resize features may have been used more often if the interaction mechanism had been more intuitive.

As discussed in Chapter 1, tabletop orientation issues make traditional menus problematic; thus, a radial marking-style menu was used to access the move, resize, and reshape functionalities for storage bins (Figure 71) and the resize functionality for the

Figure 71. The marking-style menu for the storage bin.

peripheral storage area. For example, moving a storage bin involved touching the control point to reveal the menu; dragging the touch-point to the move menu icon; and then moving the storage bin to the new location. This menu design was used because it offered an orientation-independent control and because similar marking-style menus have been shown to be useful on other touch-sensitive large displays (Guimbretière et al., 2000, Guimbretière et al., 2001).

However, the video data revealed that these menus did not seem intuitive to many participants. The questionnaire responses confirmed this: many participants reported finding these menus very difficult, and often frustrating, to use. The videos showed that several people repeatedly tried to move a storage bin by touching an empty area in the storage bin and dragging. This may be because the photos and theme pages could be moved by a touch and drag action. Several people also tried to resize the storage areas by dragging the control point itself instead of selecting the resize menu.

Providing direct-touch interactions that involve dragging on any empty area inside the storage bin to move it and dragging on a control point to resize would appear to provide a more intuitive interaction based on participants' behaviour. Few people attempted to reshape the storage bins, though, it is not clear whether this was due to the difficulty of using the menus or whether reshaping was an unnecessary feature for this task. Providing several pre-defined shapes might be helpful so that people could reshape the storage bin without the hassle of moving each control point. This issue needs further investigation.

The video data also revealed that the method for handling stored items during resizing operations needs to be reconsidered. Collapsing a storage bin currently uses a physical metaphor of collecting up the stored items as the boundary sweeps inward, pushing photos toward the center. However, when the storage bin is subsequently expanded, the photos remain clustered in the center (see Figure 72). This metaphor facilitates creating space for new items; however, it requires manually spreading out the clustered items if someone wants to later search the items.

One alternative to the current expand/collapse interaction is to use a 'stretchy fabric' metaphor, that would keep stored items at the same relative distance from each other and the storage bin center as the boundary moves. Another alternative is to return all displaced items to their original locations when a group is subsequently expanded after a collapse. These alternatives need further investigation.
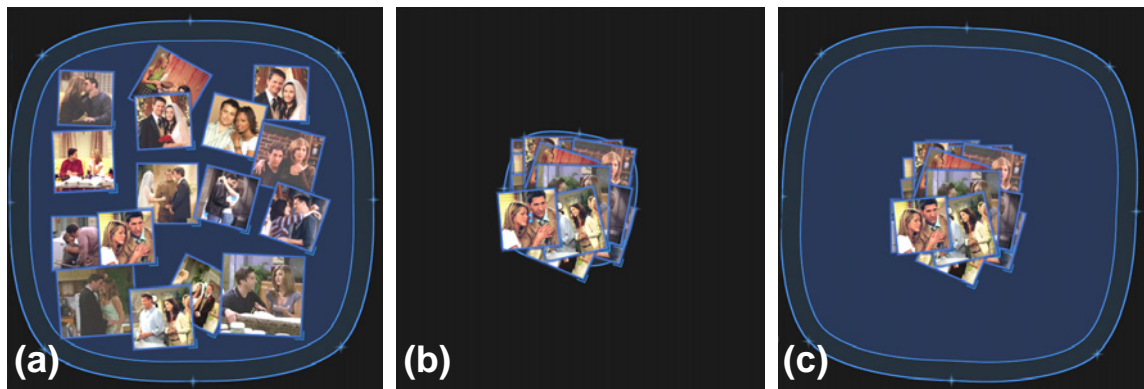
Figure 72. Collapsing and expanding storage bins: (a) the initial storage bin, (b) the collapsed storage bin, (c) the storage bin re-expanded.

The video data also revealed that including both spatial and temporal transitions for scaling may be unnecessary. Participants typically placed items either completely inside or completely outside of the storage bins, rarely leaving them in the transition zone. If a photo was tossed into a storage bin and it stopped in the transition zone, people typically pushed it fully inside. Thus, it appears that using only the timing mechanism for scaling transitions may be sufficient for boundary crossings. Timed scaling alone provides a smooth visual effect and eliminates the spatial transition zone, freeing up additional space.

Despite these usability issues, both storage mechanisms were used extensively through the experimental sessions. Both mechanisms appeared to support casual grouping interactions during the collaborative layout task. It appears, though, that the peripheral storage was better suited to the coarse-grained organizational activities that occurred during this task, while the storage bins was better suited to more fine-grained organizational activities. More specifically, the large, fixed nature of the peripheral storage area enabled the quick, inaccurate arranging common in the coarse-grained organizational activities. In contrast, the mobility and adjustability of the storage bins enabled localized interactions, supporting the variations of individual and collaborative working styles that occurred during the fine-grained organizational activities.

6.3.3 Design Enhancements

With the exception of the shrinking of stored items, the casual grouping capabilities of storage bins closely parallel the casual grouping behaviours that occurs in a storage territory on a traditional table. However, the digital realm offers many other possibilities that may increase the utility of storage bins for task and collaborative interactions. This section proposes several design enhancements which relate to the interface design of storage bins and to providing more automated support for organizing and searching stored items.

The results of the study revealed that both the mobile and peripheral storage mechanisms offer benefits for different task activities. Creating a hybrid storage mechanism that extends the mobile storage bin design to allow it to 'dock' to the
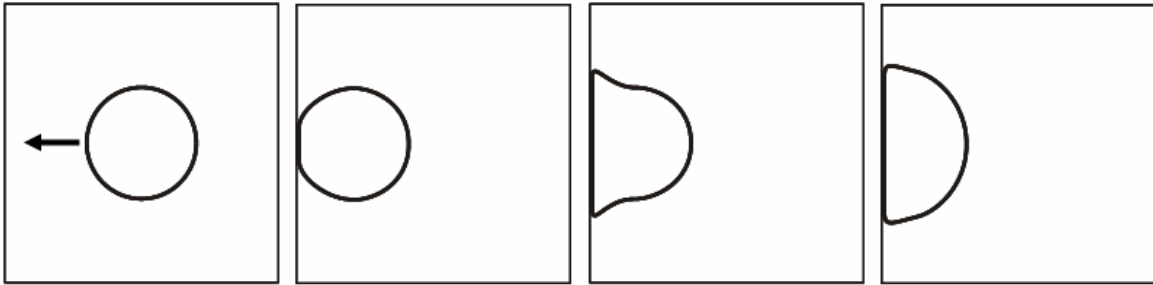
Figure 73. A dockable storage bin docking to the edge of the workspace.

workspace edge would provide the advantages of both types of storage mechanisms (see Figure 73). The concept of a dockable storage bin is similar to the toolbars that can float or be docked to a window edge that are seen in many popular development applications.

While participants found storage bins useful for selecting photos during the layout task, enhancing them with tools that provided automated layout features could provide further support for organizing and searching large collections of items. Several participants commented that they would have liked to be able to automatically arrange the stored photos so they did not overlap.

Automated layout techniques could also help users by automatically arranging the stored items for easier visual scanning. For example, stored items could be arranged in a grid formation, potentially ordered by some criteria, such as the date of a photo (Bauer et al., 2004) or by how recently an item was stored. Alternatively, an automatic spacing algorithm could be used to spread the group of items based on the size of the storage bin.

6.4 Chapter Summary

This chapter has introduced the storage bin, a tabletop groupware interface component that combines storage container capabilities with mobility and adjustability. The design of storage bins arose from the design recommendations presented in the previous chapter, as well as from the casual grouping behaviour with traditional media observed in Studies 1 and 2, reported in Chapter 3. Storage bins were designed to enable people to create and access casual groups of items anywhere in the workspace in order to support

the establishment of storage territories on the table. Storage bins were also designed to support tabletop territoriality in general by providing users with a mobile, adjustable interface component that allow users to move storage bins into and out of the current focus of activity as the task requires.

Since previous casual storage facilities have typically been fixed in a peripheral location in the workspace, the study presented in this chapter investigated the use of both mobile and peripheral storage interface components. This study revealed that participants frequently took advantage of the ability to move stored items in the workspace, and that the mobile storage bins better facilitated different individual and collaborative working styles. On the other hand, the peripheral storage mechanism appeared to facilitate task activities that required fairly loose spatial organization, such as the quick photo sorting that occurred at the beginning of each layout session. In general, storage bins appeared to provide tabletop collaborators more flexible support for performing task activities associated with fine-grained organization of the workspace, while peripheral storage mechanisms provided better support for more the casual interactions involved in coarse-grained organization of the workspace.

The study also revealed a number of usability issues with the current design of storage bins. Several design improvements were proposed that should address these issues, along with several design enhancements that could increase the utility of storage bins. One proposed enhancement that arose from the study results was to extend the design of storage bins to include a docking feature in order to provide the benefits of peripheral storage when appropriate for the current task activities.

Overall, this chapter has illustrated that the in-depth understanding of tabletop territoriality developed in the previous chapters can be a valuable tool for designers to use as a foundation for developing new interfaces and interaction techniques for digital tabletop workspaces. The interface component described in this chapter is only one step toward developing a full set of fundamental interface components upon which more complete tabletop groupware applications can be built.

The investigation presented in this chapter can help guide future work in this area. For example, this study has demonstrated that interface tools like storage bins must be flexible enough to support the evolving needs of a group task. Furthermore, tabletop groupware interface components must support the numerous individual and collaborative approaches used to complete a group task. The study revealed that storage bins were able to accommodate the variety of collaboration styles observed in the study, yet they were not flexible enough to accommodate some of the task interactions that occurred during the layout task. The study results also revealed the importance of enabling localized interactions in the workspace. Interface components that allow group members to interact independently in the workspace will facilitate tabletop territoriality because they allow group members to disengage from the group activity without interfering with their collaborators' interactions, as well as to easily redefine the actual working areas without being constrained to the physical boundaries of the tabletop workspace.

Chapter 7. Conclusion

This dissertation has identified and carefully examined the use of territorial behaviour during tabletop collaboration. This research was motivated by the general problem that collaboration is not well supported with current digital tabletop technology. The results of this research provide a knowledge base which can be used to inspire the design of new digital tabletop workspaces, as well as to help predict the impact of potential interface and interaction designs on collaborators' territorial behaviour and on their collaborative interactions in general.

This chapter summarizes the research contributions made by this dissertation and future directions that stem from this work. The chapter is organized into four parts. First, the research hypothesis and research goals originally presented in Chapter 1 are revisited and the progress that was made on these goals is discussed. Second, the contributions that this research has made to the fields of HCI and CSCW are discussed. Third, possible extensions of this work to other areas of research are described. Finally, directions for future research that could further the ideas developed in this dissertation are presented.

7.1 Research Goals and Summary

The central research hypothesis of this dissertation is that studying how people manipulate and share paper media on a table can be used to develop collaborative tabletop technology that enables dynamic interactions with digital media and facilitates effective co-located collaboration. This hypothesis was investigated through a four step process that involved the following goals:

Goal 1: to identify work practices that facilitate task and group interactions during traditional tabletop collaboration,

Goal 2: to select one specific work practice and investigate this practice in detail in order to inform digital tabletop workspace design,

Goal 3: to develop a set of design recommendations for digital tabletop workspaces that will support the investigated work practice, and

Goal 4: to apply the design recommendations to the development and evaluation of a digital tabletop workspace that supports the investigated work practice.

Each of these research goals was successfully reached and demonstrated in the previous chapters. Moreover, the cumulative activities undertaken to achieve these goals have lead to the successful innovation of collaborative tabletop technology that supports flexible, dynamic interactions with digital media and facilitates collaboration. This result supports the central research hypothesis and suggests that further innovations could arise from detailed investigation of additional traditional work practices.

7.2 Contributions

This research builds on previous research from the fields of CSCW and HCI and contributes additional knowledge and practices to these fields. There are four main contributions from this research, all of which deepen our understanding of tabletop collaboration which, in turn, helps us understand how to support this activity on a digital tabletop workspace.

7.2.1 Identifying Traditional Tabletop Work Practices

By reviewing the literature and by performing new observational studies, this research has identified important work practices that facilitate collaboration in traditional tabletop environments (Chapters 2 and 3). This research focused specifically on understanding these work practices in the context of the table environment, revealing several important aspects of previously identified work practices that have implications for the design of digital tabletop workspaces. For example, while pointing at tabletop objects during collaboration has been previously discussed in the literature (e.g., Bly, 1988; Tang, 1991),

the observational studies conducted in this dissertation revealed that people often touch objects on the table during these pointing gestures or while they are thinking about the task. This new observation implies that designers of digital tabletop systems should not assume that touching the tabletop surface will necessarily constitute a user's desire to actively 'interact' with the system.

Identifying traditional tabletop work practices is important for two reasons. First, it can help us better understand the beneficial qualities of traditional media and physical tables that enable people to successfully organize and share resources during tabletop collaboration so that we can design digital tabletop workspaces with similar beneficial qualities. Second, it can help us identify existing skills that people have developed for interacting with and sharing resources. Designing digital tabletop workspaces to allow people to transfer these existing skills in this new, yet familiar, interaction environment may assist with learnability and ease of use, allowing people to focus on the task at hand rather than on how to use the technology.

7.2.2 Defining Tabletop Territoriality

While previous research has reported that partitioning of a tabletop workspace is an important practice for coordinating task and group interactions, the careful investigation of tabletop workspace interaction performed in this dissertation has revealed that workspace partitioning is part of the more complex practice of tabletop territoriality. This work practice involves the establishment and maintenance of various tabletop territories on a shared tabletop workspace. Careful analysis of the observational studies presented in Chapter 3 and 4 led to the identification of three types of tabletop territories: personal, group, and storage territories. Previous work has mentioned the emergence of personal and group territories during tabletop collaboration (called 'spaces' in this earlier work (Tang, 1991; Kruger et al., 2004)), yet no one has previously discussed the use of storage territories nor has anyone previously investigated precisely how tabletop territories contribute to the collaboration process.

The focused investigation of tabletop territoriality presented in Chapter 4 revealed that the three types of tabletop territories have dynamic spatial properties that fluidly change

as the task activities evolve. This research also revealed that tabletop territoriality facilitates collaborative interactions on a table by providing commonly understood social protocols that help people:

- share the tabletop workspace by clarifying which regions should be used for joint task work and for assisting others (see Section 5.1.1.2) and for disengaging from the group activity (see Section 5.1.2.2),

- delegate task responsibilities (see Sections 5.1.1.3 and 5.1.3.2),

- easily coordinate access to task resources by providing lightweight mechanisms to reserve and share task resources (see Section 5.1.3.2.), and

- organize the task resources in the workspace (see Section 5.1.3.2).

The insights gained from this investigation provide a knowledge base which can be used to innovate new digital tabletop technology and to help assess the appropriateness of existing digital tabletop technology to support territorial behaviour and collaborative interactions in general.

7.2.3 Providing Design Recommendations

The knowledge provided by the previous two contributions led to the development of a set of design recommendations for digital tabletop workspaces (see Chapter 5). These recommendations apply both to the design of tabletop interfaces and interaction techniques and to the design of the physical characteristics of collaborative tabletop displays. These design recommendations suggest that digital tabletop workspaces should:

- provide appropriate table space,

- provide workspace content within reach,

- provide system functionality in the appropriate tabletop location,

- provide visibility and transparency of action,

- provide lightweight mechanisms for accessing workspace content, and

- allow casual grouping of workspace content.

These recommendations were specifically designed to produce a digital tabletop workspace that facilitates the coordination of task and group interactions in the workspace. They also provide advice for creating a flexible environment that can be easily appropriated by different groups for a variety of activities. These design recommendations are timely because they challenge emerging trends in the design of tabletop displays and it is hoped that they will spark renewed interest in the development of new digital tabletop technology that provides more comfortable and natural interactions than many of the existing tabletop systems can currently provide.

7.2.4 Developing Tabletop Groupware that Supports Tabletop Territoriality

This dissertation also demonstrates that tabletop groupware can be developed to support tabletop territoriality and collaboration in general (see Chapter 6). The design recommendations (see Section 5.2), together with the results of the observational studies (Chapters 3 and 4), led to the development and evaluation of a novel tabletop groupware interface component, called a storage bin, and a tabletop groupware test-bed environment (see Chapter 6). The experimental findings from Chapter 6 demonstrate that this tabletop groupware, which was designed to support the work practice of tabletop territoriality, provides collaborators with a flexible digital workspace that supports a variety of task activities and collaboration styles. These findings also show that the storage bin interface component and the workspace in general facilitate both individual and group interactions during collaboration.

7.2.5 Additional Contributions

This dissertation also provides several additional contributions to the fields of CSCW and HCI through novel analytic methodologies and the design of new software technology. First, an original analysis method, called a spatial action analysis, was

developed for investigating tabletop workspace interactions (see Section 4.2.1.1). This method could also be applied to investigations of other two-dimensional workspaces by using the same breakdown of the workspace (i.e., using radial and directional zones to define the interactions) or by applying a new breakdown of the workspace more appropriate for the workspace under investigation. Second, this dissertation contributes two methods for visually summarizing workspace interactions for the purposes of analyzing and reporting study findings. These visualization methods could be used to investigate other types of workspaces:

- the activity plots used for visualizing concentrations of interactions in the workspace, which were used to visualize the results of the spatial action analysis (see Section 4.2.1.2), and

- the activity plot sequences used for visualizing interactions with a specific interface component over the duration of a task, which were used to visualize the logfile data from the study in Chapter 6 (see Section 6.4.1.8).

Third, this dissertation contributes to our understanding of casual organization and storage of workspace items during task activities. This research contributes both a novel interface component for organizing and sharing objects in a digital workspace, the storage bin, as well as an initial comparison of storage bins to a peripheral storage mechanism similar to those found in the wall and desktop literature (e.g., Guimbretière et al., 2001; Robertson et al., 2004). The experimental findings from Chapter 6 show that storage bins are better at supporting variations in individual and collaborative task strategies than the peripheral storage mechanism, a finding that may also be relevant to wall and desktop interaction environments.

Finally, this dissertation contributes several potential design ideas for additional tabletop groupware interfaces that incorporate more complex workspace functionality to support many of the work practices that were identified (see Section 5.2).

7.3 Extending the Findings

While this dissertation investigated collaboration in a specific environment (i.e. a tabletop workspace) with specific tasks (i.e. games and layout planning) and specific users (i.e. peer collaborators), the results of this research also extend to other areas of research. These extensions relate both to the experimental findings from this dissertation and to the research process that was used.

7.3.1 Experiment Findings

7.3.1.1. Other Tabletop Collaboration

Because the practice of tabletop territoriality appears to stem from the general phenomenon of human territoriality we can look to the generalized theories of territoriality to help us predict whether territorial behaviour will be exhibited in other tabletop task and user settings. In general, territoriality theories predict that people exhibit territorial behaviour when they perceive a sense of ownership or responsibility for a space, item, or idea (see Section 2.4.1). According to this prediction, people will likely exhibit territorial behaviour while performing any task in which users can partition the task activities among group members (either spatially or semantically). Therefore, these tasks would likely benefit from a workspace that supports tabletop territoriality through application of the design recommendations from Chapter 5. Whether these findings extend to other types of users is not as clear. The groups studied in this dissertation had equal social status and equal stakes in the collaborative activities. The territorial behaviour observed in the studies appeared to be fairly balanced among participants. However, introducing social imbalances to the collaboration needs further investigation (as will be discussed below in Section 7.4.1.1). Thus, this research extends most directly to other peer collaboration tasks performed on a table.

7.3.1.2. Other Collaborative Settings

There are general findings from this research that can be extended to other collaborative settings, such as the co-located collaborative workspaces discussed in Section 2.1 and distributed groupware environments. In particular, many of the design

recommendations are aimed at providing support for coordinating task and group interactions, which is important in any shared collaborative workspace, whether it be physical or virtual (e.g., Gutwin et al., 1996). The most relevant recommendation for these collaborative settings is to provide visibility and transparency of action (see Section 5.2.4), even for 'personal' interactions. Distributed groupware applications and co-located systems where people have access to personal devices, often enable people to offload part of the task into a personal area, not visible to their collaborators. Not being able to monitor other group members' interactions in these areas may result in an overall loss of coordination during the collaborative activity (see Sections 4.1.2.1).

7.3.1.3. The Research Process

The research approach used in this dissertation emphasizes:

- identifying the skills and practices that people have developed to do work with traditional media,

- understanding the benefits of these ways of working, and

- providing these benefits in the technology design in a way that people can easily transfer the skills they know to help them interact in novel technology environments.

Thus, this approach could also be applied to other areas of technology research that would benefit from a deeper understanding of traditional work practices. For example, the four research goals discussed above could be applied directly to the study of collaboration at a whiteboard to be used to inform the design of interactive wall technology.

7.4 Future Work

The results from this dissertation suggest several directions that warrant further study. These directions relate both to collaborative tabletop technology and to other collaborative environments. These directions include further exploration of territoriality on tables and in other collaborative workspaces, further development of tabletop

groupware, and investigation of how to balance personal and group requirements during collaboration.

7.4.1 Further Explorations of Territoriality

7.4.1.1. Non-peer Tabletop Collaboration Contexts

Since territorial behaviour is exhibited as a result of the perception of ownership or responsibility for a space, item, or idea (see Section 2.4.1), introducing a social imbalance to a collaborative situation may alter collaborators' establishment of tabletop territories. For example, the groups under investigation in this research were peers and, thus, likely had a roughly equivalent perceived sense of ownership or responsibility for the tabletop workspace and the items they were interacting with (which were supplied by the experimenter). In contrast, a group comprised of a boss and a subordinate or a doctor and a patient may have different perceptions of the space and the items they are sharing. These differences may result in different usage patterns in the workspace that may have implications for system design.

7.4.1.2. Digital Tabletop Workspaces

The experimental findings from the study in Chapter 6 and findings from Ryall et al.'s (2004) investigation of collaboration in a digital tabletop workspace (see Section 2.2.3), both indicate that the practice of tabletop territoriality is also used in digital tabletop workspaces. We also know from the human territoriality literature that the level of territorial behaviour that is exhibited depends on the design of the space (or workspace) in which people are interacting (see Section 2.4.3). Digital tabletop workspaces provide new possibilities for interaction, which may affect the level of territorial behaviour that people exhibit in these environments.

7.4.1.3. Other Co-located Collaboration Workspaces

Given that territoriality is a general human strategy known to be used to mediate our social interactions in a variety of spaces (see Section 2.4.1), it is likely that territorial behaviour will also be exhibited in other workspaces where people are interacting in a shared physical space. Understanding how the properties of a space affects the level of

territorial behaviour that is exhibited and the precise role that territoriality plays in these workspaces may provide insights into further development of these other workspaces to better facilitate collaborators' task and group interactions. A recent study by Tse et al. (2004), which investigated a pair of co-located collaborators sharing a desktop computer that enabled concurrent interaction, indicates that territorial behavior might also be used in shared desktop workspaces. In their study, people strongly favored the side of the screen nearest them even though they were working with indirect input and, thus, were not restricted by physical interference. This result suggests that territorial behavior extends beyond our physical world and affects our virtual interactions as well.

7.4.1.4. Distributed Collaboration Workspaces

Since territorial behaviour tends to arise from a sense of responsibility for or ownership of a space, item, or idea (see Section 2.4.1), it is possible that people exhibit territorial behaviour (at least to some extent) whenever they delegate responsibilities for a shared task, which is a common occurrence in many collaborative activities. As this dissertation has shown, delegation of responsibility for a tabletop task often leads to partitioning of the workspace (see Section 4.2.2.2). How do people delegate task responsibilities in distributed groupware workspaces which may not have such obvious spatial mappings? In these environments, collaborators may exhibit territorial behaviour more semantically than spatially. For example, people may try to take on responsibility for certain information or task activities. Distributed groupware, which often suffers from coordination breakdowns (e.g., Dourish & Bellotti, 1992; Easterbrook, 1995), may benefit directly from exploring how to support people's natural tendencies to exhibit territorial behaviour because territoriality appears to help simplify the coordination of activities in a shared workspace Exploring this issue may extend our understanding of what it means to be 'territorial,' especially in workspaces without the obvious spatial mappings that appear to guide our territorial behaviour in the physical world.

7.4.2 Further Development of Tabletop Groupware

7.4.2.1. Iterating the Storage Bin Design

Chapter 6 introduced a new tabletop groupware interface component: the storage bin. The exploratory user study presented in that chapter was an initial step in iterating the design of this interface component. While the study indicated that storage bins were useful for supporting a variety of task activities and for supporting various collaboration styles, the results of the study also indicate several possible design improvements. Several usability problems were revealed related to controlling the size, shape, and location of the storage bins. While several of the proposed solutions for these problems have been implemented, further work in this area is needed, especially related to the question of whether flexible boundary shapes would be useful in practice.

Extensions of the current storage bin design were also suggested by the study. One possible extension is to provide a storage bin with a 'docking' feature, as discussed in Section 6.3.3. This enhancement would enable people to gain the benefits of peripheral storage when desired. Improving the organizational features of a storage bin also requires further investigation. While some participants expressed a desire to have sorting or spreading features inside the storage bins, the impact of such features on the traditional benefits of casual grouping behaviour is unclear. It is possible that some of these benefits may be related, in part, to the distinct shape of messy groups of items or from the fact that we have to manually manipulate these items. Finally, further investigation is required to understand how to integrate storage bins into more complex tabletop workspaces that include other types of interface components, tools, and resources.

7.4.2.2. Developing Complex Environments

Storage bins were designed to support collaborators' organizational and sharing needs during tabletop collaboration. The test-bed tabletop groupware environment in which storage bins were implemented currently only provides limited functionality (see Section 6.3.1.5). For example, this workspace does not allow people to import or export work to or from this collaboration environment. Chapter 5 provides several suggestions for

additional tabletop groupware interfaces that could help support more complex task activities on the table. For example, the 'personal trays' discussed in Section 5.2.3 would help to support group member's personal activities, without interfering with their collaborators' tabletop interactions.

7.4.2.3. Applying this Research to Current Designs

During the discussion of the design recommendations discussed in Chapter 5, several modifications of existing tabletop groupware interfaces and interaction techniques discussed in Section 2.2.2 were proposed to help provide better support for tabletop territoriality in these interfaces. For example, the replicated personal menus currently provided by the DiamondSpin tabletop toolkit (Shen et al., 2004) could be split semantically in order to spatially separate 'personal' functionality from 'global' functionality, as discussed in Section 5.2.3. This modification may reduce the coordination breakdowns that have been reported in studies involving replicated personal menus resulting from a group member surprising their collaborators by changing the workspace view or rotating the workspace (e.g., Ringel-Morris et al., 2004).

7.4.3 Balancing Personal and Group Requirements

An important question that arose during the in-depth analysis of workspace interactions in Chapter 4 was the possible tradeoff between supporting individual group member's interactions and supporting the overall group process. This analysis revealed that people often take on responsibility for resources within or near their personal territories (see Section 4.2.2.3). This delegation of responsibility for certain task items appeared to allow other group members to concentrate on other resources and activities in the workspace. The development of task roles (e.g., someone becoming responsible for making custom items because they have the scissors) has also been observed in other collaborative settings and appears to facilitate the collaborative process (Nardi & Muller, 1990). However, gaining access to task resources is often perceived to be a problem by individual group members. Consequently, digital environments are often designed to provide each group member easy access to all task resources (e.g., the replicated personal

menus discussed above). What impact does this design approach have on the group's ability to establish and maintain roles during the activity? If providing easy access to resources hinders group coordination, is it possible to compensate for this in design? What are the precise tradeoffs for coordination and individual gain? Answering these questions would help designers predict the impact of certain design choices for tabletop groupware.

7.5 Conclusion

This dissertation has shown that effectively supporting collaboration on a digital tabletop workspace requires subtle attention to detail in interface and interaction design. This research has provided a careful investigation of traditional tabletop collaboration, which has led to a deeper understanding of the nuances of collaborators' task and group interactions. In particular, this research has revealed the use of territorial behaviour during tabletop collaboration. This discovery has furthered our understanding of the mechanisms that people use to coordinate their activities during collaboration, leading to a better understanding of how to facilitate coordination in digital tabletop workspaces. This research has provided many contributions to the process of redesigning the tabletop interface, yet as discussed above, there is still much to be done before digital tabletop workspaces are as ubiquitous in our environment as traditional tables.

Chapter 8. References

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Appendix A. Observational Study 1 Materials

A.1 Posted Informed Consent Sign

SIMON FRASER UNIVERSITY & DALHOUSIE UNIVERSITY

<u>INFORMED CONSENT BY SUBJECTS TO PARTICIPATE IN A RESEARCH STUDY</u>

ATTENTION!
Research Study in Progress

Activity at these tables is being observed.

By participating in these activities, you are consenting to be observed.

You may withdraw your participation at any time.

Further information can be obtained from the *Information Sheet for Participants* (located at the Researcher Table). If you have any questions, please ask the researcher, Stacey Scott, at the Researcher Table.

The Universities and those conducting this project subscribe to the ethical conduct of research and to the protection at all times of the interests, comfort, and safety of subjects. This notice is for your own protection and full understanding of the procedures. Your participation in the research activities signifies that you voluntarily agree to participate in the project.

Any information that is obtained during this study will be kept confidential to the full extent permitted by law. Knowledge of your identity is not required. Materials will be held in a secure location. However, it is possible that, as a result of legal action, the researcher may be required to divulge information obtained in the course of this research to a court or other legal body.

You may register any complaint about the study with: Dr. Brian Lewis, Dean of the Faculty of Applied Science, Simon Fraser University, email: bslewis@sfu.ca, or Ms. Patricia Lindley, Human Research Ethics/Integrity Coordinator, Office of Research Ethics, Dalhousie University, email: patricia.lindley@dal.ca.

You may obtain copies of the results of this study, upon its completion, by contacting: Stacey Scott, School of Computing Science, Simon Fraser University, Burnaby, BC, V5A 1S6, or Dr. Kori Inkpen, Faculty of Computer Science, Dalhousie University, Halifax, NS, B3H 1W5.

A.2 Information Sheet for Participants

SIMON FRASER UNIVERSITY & DALHOUSIE UNIVERSITY

<u>INFORMATION SHEET FOR PARTICIPANTS</u>

This form describes the proposed tests involving physical, psychological, or any other invasive testing.

Title of Project: User Interfaces for Co-located Collaborative Tabletop Activities

Description of the procedures to be followed and a statement of the risks to the subject and benefits of the research.

Summary of the Project:
This project is investigating how to support face-to-face collaboration using tabletop computer systems. This phase of the project is focused on understanding how people use the space provided by a tabletop surface and how they use artifacts (e.g., pens, paper, game pieces, drink containers, etc.) on a table while collaborating. Through the observation of participants performing tabletop activities the researcher hopes to determine patterns of use of tabletop space and of artifacts used in collaboration. This information will be used to develop tabletop computer interfaces that support natural collaborative behaviour.

Procedure:
There are three activities in which you can participate. You are free to participate in one, two, or three of them for as little time or as much time as you would like. The three activities are: Puzzles, Pictionary, and Building a Community with Lego®. Each activity is described below.

Puzzles
There are several types of puzzles at the Puzzle table, including jigsaw puzzles, tangram puzzles, and word puzzles. Instructions for each puzzle are located on instruction cards at the Puzzle table. You can perform the puzzle activity alone or with other participants.

Pictionary®
In this activity, you will join other participants to create a team that will compete against other participant teams. The premise of the activity is that teams advance on a game board by guessing a clue word or phrase that one member of their team has drawn on paper. The complete instructions will be available on an instruction card at the Pictionary® table.

Building a Community with Lego®
In this activity, you will work with other participants to build and place Lego® structures which will contribute to a make-believe community. Examples of structures you could contribute include: roads, parks, houses, schools, playground, and so on. All Lego® structures are public once they have been contributed. Therefore you are allowed to modify other participants' contributions as well as your own, and they are allowed to modify your contributions as well.

During the session, the researcher will observe and take notes regarding your interactions with activity artifacts. You are allowed to withdraw your participation in the session at any time.

Risks and Benefits:
There are no risks involved and there are no direct benefits to you. However, the results of this research may contribute to the knowledge base of Human-Computer Interaction research and also may lead to the development of better user interfaces.

A.3 Subject Feedback Form

SIMON FRASER UNIVERSITY & DALHOUSIE UNIVERSITY
UNIVERSITY RESEARCH ETHICS REVIEW COMMITTEE

SUBJECT FEEDBACK FORM

Completion of this form is **OPTIONAL**, and is not a requirement of participation in the project. However, if you have served as a subject in a project and would care to comment on the procedures involved, you may complete the following form and send it to the Chair, University Research Ethics Review Committee at Simon Fraser University or to the Human Research Ethics/Integrity Coordinator, Research Ethics Office at Dalhousie University. All information received will be treated in a strictly confidential manner.

Name of Principal Investigator: Stacey Scott

Title of Project: User Interfaces for Co-located Collaborative Tabletop Activities – Phase 1

Dept./School/Faculty: School of Computing Science (SFU) / Faculty of Computer Science (Dalhousie)

Did you sign an Informed Consent Form before participating in the project? _____

Were there significant deviations from the originally stated procedures?   _____

I wish to comment on my involvement in the above project that took place:

_____
(Date)   (Place)   (Time)

Comments: _____

_____

_____

_____

_____

_____

Completion of this section is optional

Your name: _____

Address:_____

Telephone: (w)_____   (h)_____

This form should be sent to the Chair, University Research Ethics Review Committee, c/o Office of the Vice-President, Research, Simon Fraser University, Burnaby, BC, V5A 1S6, or to the Human Research Ethics/Integrity Coordinator, c/o Research Ethics Office, Dalhousie University, Halifax, NS, B3H 4H6.

A.4 Instructions for the Pictionary® Activity
Game Instructions
Pictionary®

THE OBJECT
To identify through sketched clues as many words as necessary to advance to the finish square, and correctly identify the final word. Sketches may NOT include letters, numbers or the # symbol.

PREPARATION
Place the timer and card box so all players have access to them. Divide equally into teams of two to four (see instructions on number of players). Provide each team with pad, pencil, category card and marker. Place marker in the start square on the board. Each team selects a picturist, one who will sketch clues for the first word. Roll the die to determine the order of play. The highest roller starts.

THE PLAY
All markers rest in the P square to start, so the word in the P category is in play. The die is NOT rolled to advance at the start.

P	Person/Place/Animal (or related characteristics)
O	Object (things that can be touched or seen)
A	Action (things that can be performed; events)
D	Difficult (challenging words)
AP	All Play (this can be any type of word)

SPECIAL NOTE: Any word preceded by a triangle (>) is designated as an All Play word. (Read the All Play section thoroughly.)

The starting picturist selects a word card from the front of the deck and has five seconds to examine the word to be played. The timer is then turned and the picturist begins sketching clues for the team. The picturist may not use verbal or physical communication to teammates during the round. Sketching and guessing continue until the word is identified or time is up. If a guess is correct, the team continues to play by rolling the die, advancing the number of squares indicated and selecting a new card and new picturist. Any number of markers may occupy the same square. THE PICTURIST ROLE MUST ROTATE EVERY TIME A TEAM SKETCHES!

If a word is not identified in the time limit, the die is passed to the left. The team receiving the die begins its turn by pulling a new card from the deck, NOT a roll of the die. The word corresponding to the square in which the marker lies is the word in play. The ONLY times the die is rolled to advance the marker is when a word is identified within the one-minute time limit, or a team is first to identify the word in any All Play situation. A TEAM MUST OCCUPY A SQUARE AS LONG AS IT DOES NOT IDENTIFY THE GIVEN WORD.

ALL PLAY
In the All Play category, the word card is shown to the picturist of each team. The All Play word is sketched simultaneously by picturists to their respective teams at the start of the timer. Regardless of whose All Play it was, the first team to identify the word earns control of the die and immediately rolls and advances the number of squares indicated. This team now continues its turn with a new word. If no team identifies the word in the time allotted, the die is passed to the left. However, this team does NOT roll the die, but begins its turn by pulling a new card and sketching the word corresponding to the square they currently occupy.

SPECIAL NOTE: The above rules apply when a triangle (P) designates a word as an All Play. Remember! Any team that first identifies an All Play word immediately receives the die and rolls, then moves the indicated number of squares and draws another card.

TO WIN
A team must reach the final All Play square for the chance to win. It must be the first team to identify the word in the same manner of play as in previous All Play categories. If it is, that team wins the game. If this is not accomplished, the die is passed to the left (in a round when a word is not identified by any team), or to the team that first identified the word. A team that reaches the final All Play square cannot win the game by winning a round controlled by another team. It must first regain control of the die to attempt a winning word. An exact roll of the die is not required to enter this square. Normal rules apply to teams not on the final All Play square.

NUMBER OF PLAYERS
The number of players per team may be uneven if an odd number of players wish to play. In the case of three players, two teams are formed. One person must act as the picturist for both teams. This person selects word cards and sketches throughout the entire game. THE PICTURIST MAY NEVER VARY. Normal game rules apply.

Play is quicker and more exciting when there are less teams, and more players per team. If more than 16 people wish to play, create a fifth team or add more players to each.

A.5 Instructions for the Tangram Activity
Game Instructions
TANGRAM – Ancient Chinese Puzzle

History

The tangram is an ancient Chinese puzzle made from a large square cut into seven pieces. Each individual piece or shape is called a tan. The tans can be arranged to make pictures.

Objective

The original objective was to fit all the pieces together to make a square, but there are also many different shapes that can be made from the seven pieces. There is a collection of shapes and patterns that can be constructed from these seven pieces presented in the game booklet of silhouettes. Try to see how many silhouettes you can recreate using the seven pieces – no more, no less – of the puzzle.

Alternative Tangram Activity

If you want to try something different, try the following challenges:
1. Construct squares using 1 piece, 2 pieces, 3 pieces, etc., all the way up to 7 pieces. Sketch you solutions. One arrangement is not possible - which is it?
2. If the original square has an edge length of 2, what are the edge lengths of each piece?
3. Construct a convex hexagon. There are only 13 possible convex shapes - how many can you find?

A.6 Instructions for LEGO® Activity

Game Instructions

Redesign the Faculty of Computer Science Building with Lego®

OBJECTIVE

Participants should work together to re-design the Faculty of Computer Science Building, including study spaces for undergraduate and graduate students, faculty offices, lunch areas, etc. The re-design can be done as 4 separate floor plans, one connected structure, or any other way participants would like to approach the re-design.

All Lego® structures are public once they have been contributed. Therefore you are allowed to modify other participants' contributions as well as your own, and others are allowed to modify your contributions as well.

The design site will be available in the Atrium over from 2-8pm August 9th, so you may spend as much or as little time as you want contributing to the construction.

A.7 Instructions for the Word Puzzle Activity
Game Instructions
Word Puzzles (Wordles)

GOAL

Solve all or part of the 36 word puzzles. The solutions are words or phrases represented by the word clues. The clues are composed of play on words, words jumbled up, inside out, backwards, transposed, and repositioned. Form and spelling can all give hints to the solution.

Sample Puzzles

DICE DICE → paradise (… from pair of dice)   HIM   → it's beneath him
                                                     IT

A.8 Instructions for the Jigsaw Puzzle Activity

No predators are allowed access to prey animals. For example, you must be sure that the tigers can't escape to get at the goats, and the bears can't attack the llama. Two animals of the same type can be connected (a tigress and her cubs, for example), but they must be kept separate from you and the rest of the wild animals. Animals that are not a threat, can share a cage (a chimp and a kangaroo could coexist).
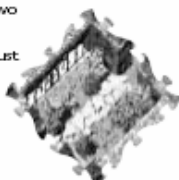
Predators cannot have access to your path.

You will start and finish in the same place.

Hints

There are distinct right, left, top and bottom edge scenes. It's easier if you group them together first.

All the nine piece scenes are identically shaped, but when the artwork is upright, there are effectively 2 diamond shapes. Group these to make things easier.

You can't climb over the walls and neither can any of the animals.

The predators are the lions, tigers, wolves, brown bears, polar bears, cougars, bobcats, and fox.
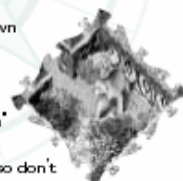
Each scene is viewed from the same perspective, so no animals will be "upside down".

You will travel all over the maze in this puzzle, so don't look for a quick, central solution.

LOST in a Jigsaw II

Instructions

Survival of the Fittest is a diabolical maze fraught with challenge and pitfall. When assembled correctly, a stone path will lead you on a tour of animals both docile and deadly, with all the creatures safely contained. If you're not careful, a lion may mistakenly have access to a peace loving kangaroo, or a polar bear may wind up face to face with you! You must discover the logic of the maze and follow its rules to correctly complete it.
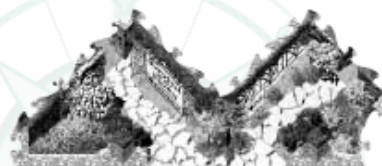
Entrance and Exit

Begin by assembling all the nine piece diamond shaped maze scenes and all the edge scenes. On one of the edge scenes you will find your starting point. This is where your safari adventure begins. You'll now have to connect the scenes to each other, arranging and rearranging them according to the rules of the maze, until everything is in order. When placing scenes together pay attention to the walls and any exits or pathways they contain. Each exit in a scene must match exactly with an entrance in another.

Remember, you're not trapped, you're on safari!

Rules:

You must form one contiguous stone path through the maze, from which you must be able to view all the animals in their habitats. To properly view an animal, a stone path scene must be adjacent to the animal scene, and a "wall" of wrought iron bars must separate the two.

Appendix B. Observational Study 2 Materials

Note: This dissertation reports on only one activity from this study (the collaborative tabletop activity discussed in the consent form). At the time of the study I was enrolled as a graduate student in the School of Computing Science at Simon Fraser University, Burnaby, BC, Canada and a visiting student at Dalhousie University, Halifax, NS, Canada.

B.1 Informed Consent Form

SIMON FRASER UNIVERSITY & DALHOUSIE UNIVERSITY

INFORMED CONSENT BY SUBJECTS TO PARTICIPATE IN A RESEARCH EXPERIMENT

Project: User Interfaces for Co-located Collaborative Tabletop Activities

The Universities and those conducting this project subscribe to the ethical conduct of research and to the protection at all times of the interests, comfort, and safety of subjects. This form and the information it contains are given to you for your own protection and full understanding of the procedures. Your signature on this form will signify that you have received a document, which describes the procedures, possible risks, and benefits of this research project, that you have received an adequate opportunity to consider the content in the attached Information Sheet for Participants, and that you voluntarily agree to participate in the project.

Any information that is obtained during this study will be kept confidential to the full extent permitted by law. Knowledge of your identity is not required. You will not be required to write your name or any other identifying information on the research materials. Materials will be held in a secure location. However, it is possible that, as a result of legal action, the researcher may be required to divulge information obtained in the course of this research to a court or other legal body.

Having been asked by Stacey Scott of the School of Computing Science at Simon Fraser University to participate in a research project experiment, I have read the procedures specified in the document.

I understand that I may withdraw my participation in this experiment at any time.

I have been informed that the research material will be held confidential, to the extent that I have indicated below, by the Principal Investigator, and the data will be coded accordingly.

I also understand that I may register any complaint I might have about the experiment with:

Dr. Brian Lewis		Ms. Patricia Lindley
Dean of the Faculty of Applied Science	or	Office of Research Ethics, Dalhousie University
Simon Fraser University		email: patricia.lindley@dal.ca
email: bslewis@sfu.ca		phone: 902-494-1464
phone: 604-291-4724		

I agree to participate by performing a collaborative tabletop activity and also by partaking in a participatory design task, both as described in the Information Sheet for Participants, during an approximately time period of 180 minutes, broken over two sessions, at the EDGE Lab (3rd Floor) in the Faculty of Computer Science building at Dalhousie University.

I may obtain copies of the results of this study, upon its completion, by contacting:

Stacey Scott   Dr. Kori Inkpen
School of Computing Science   Faculty of Computer Science
Simon Fraser University   or   Dalhousie University
Burnaby, BC   Halifax, NS
V5A 1S6   B3H 1W5

	Please Circle One		Please Initial Your Choice
I agree to participate in the activities explained above	YES	NO	____
I agree to be video-taped, photographed, and audio-taped	YES	NO	____
I agree to let my conversation during the study be directly quoted, anonymously, in presentation of the research results	YES	NO	____
I agree to let the Videotapes/Photographs/Audiotapes be used for presentation of the research results	YES	NO	____

NAME (please type or print legibly): _____

ADDRESS: _____

_____

SIGNATURE: _____ **WITNESS:** _____

DATE: _____   ONCE SIGNED, A COPY OF THIS CONSENT
                                                    FORM AND A SUBJECT FEEDBACK FORM
                                                    SHOULD BE PROVIDED TO THE SUBJECT.

B.2 Information Sheet for Participants
SIMON FRASER UNIVERSITY & DALHOUSIE UNIVERSITY
<u>INFORMATION SHEET FOR PARTICIPANTS</u>

This form describes the proposed tests involving physical, psychological, or any other invasive testing.

Title of Project: User Interfaces for Co-located Collaborative Tabletop Activities

Description of the procedures to be followed and a statement of the risks to the subject and benefits of the research.

Summary of the Project:
This project is investigating how to support face-to-face collaboration using tabletop computer systems. This phase of the project is investigating patterns of interactions with artifacts (e.g., pens, paper, drink containers, etc.) during tabletop collaboration that were observed during earlier investigations. Through observation of participants performing collaborative tabletop activities (e.g., a group design task) the researcher hopes to further understand patterns of use of tabletop space and of artifacts used in tabletop collaboration. This phase also involves a design activity that will help the researcher understand users' preferences for the design of tabletop technology. The information gathered in this phase will be used to develop tabletop computer interfaces that support natural collaborative behaviour.

Procedure:
Your task will be to perform two group activities at a table. A description of each activity follows.

The first activity will be to produce a plan to furnish a reading room. You will use paper supplies such as paper-cutout tables, chairs, and bookshelves to be arranged on a paper layout of the room. You will work with other participants to try to optimize the following requirements (they appear in no particular order):
- Accommodate as many people as possible in the room
- Provide space for individuals to read or do work quietly with minimal distraction as well as space for groups to work together on projects and to have discussions
- Make the space as attractive and inviting as possible
- Provide an area for current journals to be available
- There should be clear access to all entrances and exits for safety purposes
- The room should be inspiring

The second activity will take part over two hour-long sessions on separate days. This activity will be a participatory design activity that draws on your experience performing tabletop activities, such as the activity above, as well as any previous experience you have with technology. This will involve working with other participants and the researcher to design a room layout computer-aided design application for a tabletop computer system. The application design will be created using craft supplies such as paper, markers, post-it notes and stickers.

During the session, a researcher will observe and take notes regarding your interactions with the activity artifacts and the tabletop. You will also be videotaped and any artifacts produced during the session will remain with the researcher. You are allowed to withdraw your participation in the experiment at any time.

Risks and Benefits:
There are no risks involved. Beyond the $30 remuneration, there are no direct benefits to you. However, the results of this research may contribute to the knowledge base of Human-Computer Interaction research and also may lead to the development of better user interfaces.

B.3 Subject Feedback Form

SIMON FRASER UNIVERSITY & DALHOUSIE UNIVERSITY
UNIVERSITY RESEARCH ETHICS REVIEW COMMITTEE

SUBJECT FEEDBACK FORM

Completion of this form is **OPTIONAL**, and is not a requirement of participation in the project. However, if you have served as a subject in a project and would care to comment on the procedures involved, you may complete the following form and send it to the Chair, University Research Ethics Review Committee at Simon Fraser University or to the Human Research Ethics/Integrity Coordinator, Research Ethics Office at Dalhousie University. All information received will be treated in a strictly confidential manner.

Name of Principal Investigator: Stacey Scott

Title of Project: User Interfaces for Co-located Collaborative Tabletop Activities – Phase 2

Dept./School/Faculty: School of Computing Science (SFU) / Faculty of Computer Science (Dalhousie)

Did you sign an Informed Consent Form before participating in the project? _____

Were there significant deviations from the originally stated procedures?   _____

I wish to comment on my involvement in the above project that took place:

_____

(Date)   (Place)   (Time)

Comments: _____

_____

_____

_____

_____

_____

Completion of this section is optional

Your name: _____

Address:_____

Telephone: (w)_____   (h)_____

This form should be sent to the Chair, University Research Ethics Review Committee, c/o Office of the Vice-President, Research, Simon Fraser University, Burnaby, BC, V5A 1S6, or to the Human Research Ethics/Integrity Coordinator, c/o Research Ethics Office, Dalhousie University, Halifax, NS, B3H 4H6.

B.4 Task Instruction Sheet
Reading Room Task Instructions

The first activity will be to produce a plan to furnish a reading room. You will use paper supplies such as paper-cutout tables, chairs, and bookshelves to be arranged on a paper layout of the room. You will work with other participants to try to optimize the following requirements (they appear in no particular order):

- Accommodate as many people as possible in the room

- Provide space for individuals to read or do work quietly with minimal distraction as well as space for groups to work together on projects and to have discussions

- Make the space as attractive and inviting as possible

- Provide an area for current journals to be available

- There should be clear access to all entrances and exits for safety purposes

- The room should be inspiring

B.5 Summary of Participants' Workspace Activity

The following table summarized the activity all three participant groups. This table shows each person's actions in the indicated location (e.g. "North Midway" indicates WSW, W and WNW actions in the midway zones). The percentages show the relative amount of activity that each person performed in the indicated

location. For example, Participant @W in Group 1 performed 11 actions in the central zone, which accounted for 55% of all the actions that were performed in that tabletop zone. The shaded cells in the activity tables indicate actions by each person in the zones nearest them.
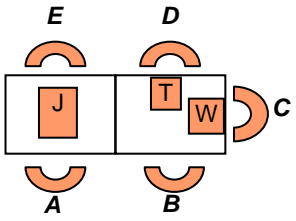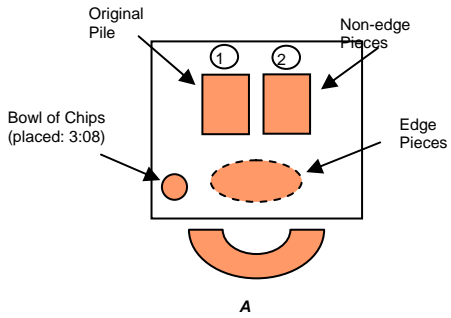
		Group 1		Group 2		Group 3		
		@ W	@ E	@ W	@N/NE†	@ W	@ N	@ E
Central	◉	11 (55%)	9 (45%)	56 (64%)	32 (36%)	43 (38%)	27 (24%)	42 (38%)
Midway	◎	27 (64%)	15 (36%)	183 (53%)	165 (47%)	89 (35%)	74 (29%)	91 (36%)
Floor Edge (FE)	◯	102 (60%)	68 (40%)	156 (54%)	133 (46%)	79 (33%)	80 (33%)	84 (35%)
Table Edge (TE)	◯	99 (57%)	75 (43%)	127 (39%)	197 (61%)	42 (38%)	37 (34%)	31 (28%)
North Half	◓	103 (67%)	50 (33%)	289 (44%)	**364 (56%)**	82 (24%)	**153 (45%)**	107 (31%)
Near	◓	65 (68%)	30 (32%)	149 (41%)	**211 (59%)**	56 (23%)	**128 (53%)**	58 (24%)
Midway	◓	10 (63%)	6 (38%)	39 (33%)	**78 (67%)**	43 (34%)	**51 (40%)**	32 (25%)
FE	◓	31 (72%)	12 (28%)	70 (54%)	**59 (46%)**	12 (12%)	**58 (60%)**	27 (28%)
TE	◯	21 (62%)	13 (38%)	49 (32%)	**104 (68%)**	2 (6%)	**29 (88%)**	2 (6%)
West Half	◐	**144 (83%)**	30 (17%)	**254 (83%)**	53 (17%)	**135 (63%)**	49 (23%)	30 (14%)
Near	◑	**62 (83%)**	13 (17%)	**86 (93%)**	6 (7%)	**64 (71%)**	10 (11%)	16 (18%)
Midway	◑	**7 (70%)**	3 (30%)	**44 (90%)**	5 (10%)	**23 (68%)**	3 (9%)	8 (24%)
FE	◑	**23 (77%)**	7 (23%)	**37 (100%)**	0 (0%)	**25 (74%)**	5 (15%)	4 (12%)
TE	◑	**36 (97%)**	1 (3%)	**29 (97%)**	1 (3%)	**14 (88%)**	0 (0%)	2 (13%)
South Half	◒	107 (55%)	87 (45%)	110 (68%)	52 (32%)	102 (51%)	13 (7%)	85 (43%)
Near	◒	61 (72%)	24 (28%)	41 (69%)	18 (31%)	56 (48%)	9 (8%)	52 (44%)
Midway	◒	9 (69%)	4 (31%)	19 (59%)	13 (41%)	19 (39%)	3 (6%)	27 (55%)
FE	◒	25 (66%)	13 (34%)	19 (95%)	1 (5%)	21 (47%)	5 (11%)	19 (42%)
TE	◒	25 (81%)	6 (19%)	4 (50%)	4 (50%)	18 (67%)	2 (7%)	7 (26%)
East Half	◑	66 (36%)	**115 (64%)**	131 (28%)	**345 (72%)**	52 (19%)	72 (27%)	**146 (54%)**
Near	◖	11 (16%)	**59 (84%)**	45 (28%)	**116 (72%)**	15 (18%)	14 (17%)	**53 (65%)**
Midway	◑	5 (71%)	2 (29%)	22 (32%)	47 (68%)	8 (40%)	5 (25%)	7 (35%)
FE	◑	6 (20%)	**24 (80%)**	9 (18%)	**40 (82%)**	6 (14%)	8 (19%)	**29 (67%)**
TE	◑	0 (0%)	**38 (100%)**	12 (20%)	**49 (80%)**	0 (0%)	1 (7%)	**14 (93%)**
Total	⬤	**251 (60%)**	**170 (40%)**	**482 (50%)**	**478 (50%)**	**265 (36%)**	**207 (28%)**	**271 (37%)**
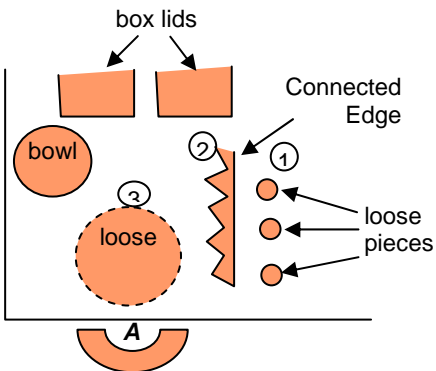
. †This person spent 5 minutes at N then moved to NE.

B.6 Study 1 Field Notes
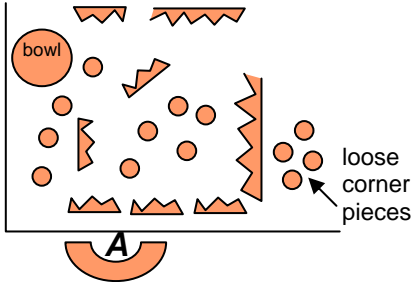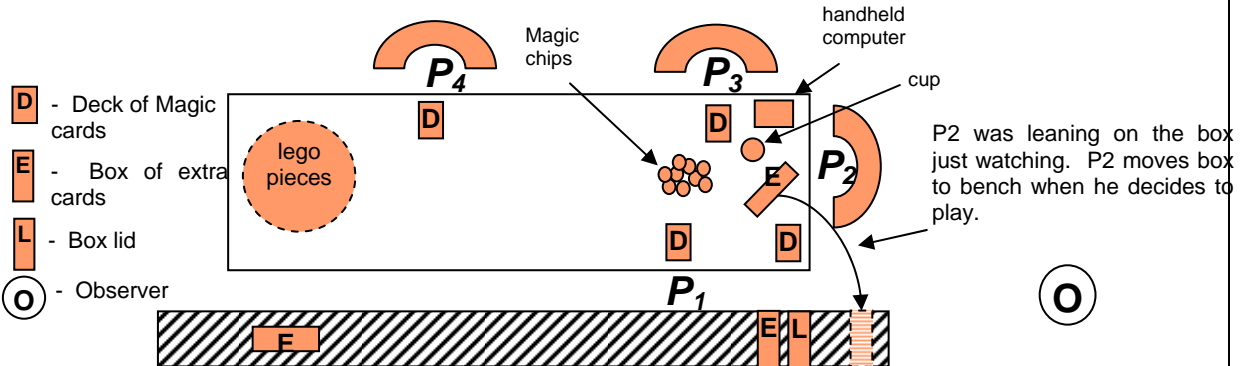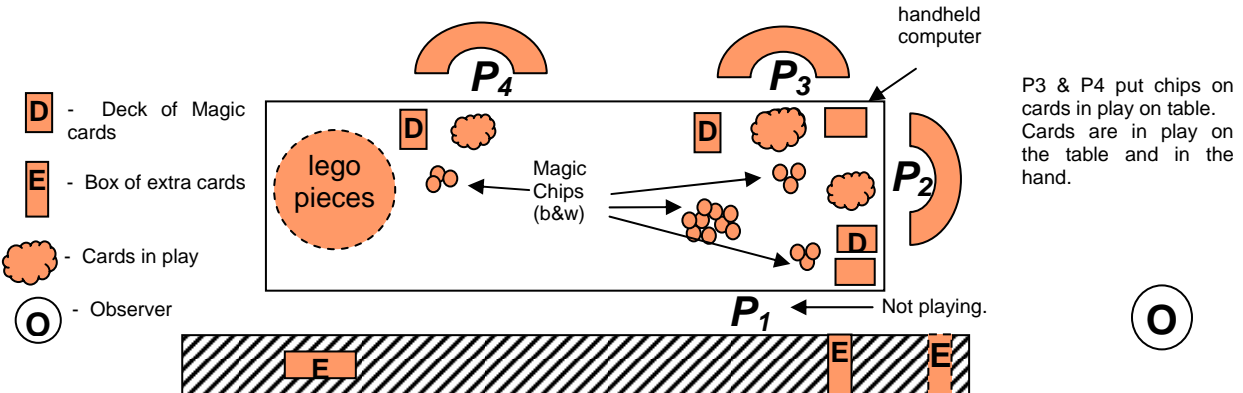
Time	Situation	Self
	Setting: Atrium, lower level, FCS building, Dalhousie University, Halifax, NS.	

Equipment Setup: There are three activity tables and one observer table setup behind the elevators in the Atrium. The three stations are:

- *Puzzle Table* (two adjoining square café tables, approximately 2.5'x2.5': one table with Lost in a Jigsaw *II* puzzle and one table with the tangram and wordlzes puzzles setup on it. Initially the jigsaw puzzle was still in the box on the table).

- *Pictionary Table* (one round table, approximately 3' diameter: the Pictionary board game was setup on the table, with 4 chairs around the table, grouped into 2 teams).

- *LEGO® Table* (one rectangular table, approximately 2'x5': instructions were taped onto each corner and random Lego blocks were piled on the far end of the table, with extra pieces in an open plastic storage container in the bench beside the table).

Time	Situation	Self
2:30	While I was getting ready to start the study, waiting for some people to drop by, a student dropped by the observer table to ask if he and his buddies could come and play the game Magic in my study area. He wanted to know if I would be interested in observing that. I said yes since there wasn't many people around and it might be the only opportunity to observe people doing things on the table. If it got busy with the other tasks, I would just ignore them.	

Time	Situation	Self
2:40	1st customer – male undergrad student asked about the study and started to play the tangram game. He's sitting in spot B. lifting, sliding pieces on the table moved tangram key to be just arms reach in front of him - he is working on one holding a tan – glancing back and forth between the piece in his hand and the key sliding tans, placing tans holding tan in hand, then drops it on the table after glancing at the key he's sitting with left arm folded in front of him, right arm leaning on table – he's sliding finger across the table [perhaps tracing tangram key out – trying to figure out pattern]	 J – Lost in a Jigsaw Puzzle T – Tangram Activity W – Wordzle Activity
2:46	He's sliding pieces on the table. He's leaning in looking at the key [seems confused] He moves to the Wordzles (seat C) "I think there's a piece missing." – He says he was kidding when I ask him about it. He asks me whether you're allowed to overlap the pieces. I tell him no.	
2:46	Another guy comes and sits in position B. He's trying the tangram game. Guy C says "try this one…I spent ten minutes on it" pointing to the silhouette he was working on in the tangram key. C then turns the key back a page and says "Here's the start". C suggests that I should used the game "Settler's of Cattan" for my study – he says it's a good multi-player board game with lots of components	This game sounds good for Regan's interests.
2:53	C moves to jigsaw puzzle: "I think I'll do something with a little more interaction with the table. He's reading the instructions, sitting with the box open on the table in front of him.	This is nice of him for my study.
2:55	He starts taking pieces out of the box in front of him – sorting them – putting edge pieces on the table in front of him and non-edge pieces in the box lid. He's putting the edge pieces face-up on the table. 	
3:00	Three guys come and set up Magic at the Lego table. I chatted with	

Time	Situation	Self
	them for a little while.	
3:02	Tangram guy (seat B) thinks he's done and tells me. I say that he should move on if he thinks he's done.	
	Guy A doing the jigsaw puzzle moved the box lids closer to him – box lid (2) is about 3 inches from edge of the table. As he's digging through the top lid to find all of the edge pieces he's sliding the box lid towards him – it's not a separate action – he's dragging the edge with his wrist as he's digging in the box. He leans over the box to look inside.	
	Guy B leaves.	
	Once he finishes pulling edge pieces out he pushes both lids to the center again – he still has non-edge pieces in both lids.	
	One guy stops by the observer table "Is this for real?" laughing…he stops and looks at the tangram puzzle for a little while and then leaves (he's a guy on the CS society…a building "regular").	
3:10	Guy A lifts and holds above his head one, then the other lid to look at the image/writing on the box cover. Then he sets it down. He's assembling the edge – he tries different pieces together.	
3:12	A holds each piece closer to examine them. He places it on the table. He's holding a piece just above other pieces – looking closely, comparing – he's building the right edge – find more and more pieces.	I think he's grouping potentially similar pieces.
	He tries to connect 2 pieces, he connects them, then disconnects them, then lifts them both with the same hand – he piles one on top of the other and picks them up. He sets them on the area (1), just right of the right edge pieces.	
	He picks up a piece, rotates it in his hand – sets it next to piece, picks up again, rotates it and connects it with the piece on the table – moves on to the next piece.	
	Holding piece in hand, rotating it, looks around, sets a piece back on the table without looking at it – into an empty spot.	
	He uses both hands [on a piece?] – with one finger each to rotate and slide them to near pieces on the table – moves on.	
	Holds piece, hovering about 2-3 inches above the table, looks around,	

Time	Situation	Self
	sets it near another piece – he's getting a few connected pieces in the area (3) (loose pieces centered in front of him on table).	
	Holds piece, taps it up and down on the table, looks around then drops it and looks at other pieces.	
3:21	He slides assembled right side edge up, away from him, with his finger and puts 2 connected pieces to the left and below it…the pieces seem to part of the right side of the bottom edge.	
	(He often moves pieces on the table, by sliding, lifting, etc., while he's holding a piece in one of his hands. E.g. He's holding a piece, uses a finger or thumb to slide or rotate a piece on the table and sets the piece in hand down on the table in the newly cleared spot.)	
3:24	More of the bottom is assembled.	
	Slides bottom edge to the left – just about 1-2 inches – He doesn't have the lower-right corner piece in place yet.	
	He's connecting 2 pieces – examines connection while piece still in hand, leans close – picks up a piece again and sets elsewhere on the table.	
	Picks a piece from area (1) (loose pieces to the right side of the assembled right edge – just a few pieces there), turns the piece in his hand and replaces it on the table.	
	Connects 2 pieces, 3 pieces – bottom edge pieces.	
	He slides a group of loose pieces in area (3) and slides 3 connected pieces down to be in line, but not attached to existing bottom edge pieces. He brought them close, examined them, then pushed them a little bit away.	
	He has about 30-35% of the edge assembled.	
3:29	He's scanning edge pieces – picks up box on the right – pushing through the pieces, replaces and does some with box lid on left.	I think he's looking for corner pieces or more edge pieces.
	He replaces the lid without removing any pieces.	
	Someone stopped by the observer desk to ask some questions about the study.	
3:31	Guy A: He's connected a few more pieces.	
	He's leaning his arm on the table while interacting with the pieces in right near spot on the table (in relation to him).	
	He's pressing his fingers quite hard into the table at an empty spot while he's scanning the table.	
	He's sliding pieces around. He says towards me: "I'm convinced that pieces are missing, even though I know they're not". There's a wolf's head somewhere…."	
	Mew guy joined the Magic table. He's sitting right in my line of sight for viewing the table surface.	
3:37	He found the wolf's head: "It doesn't look anything like a wolf's face.	
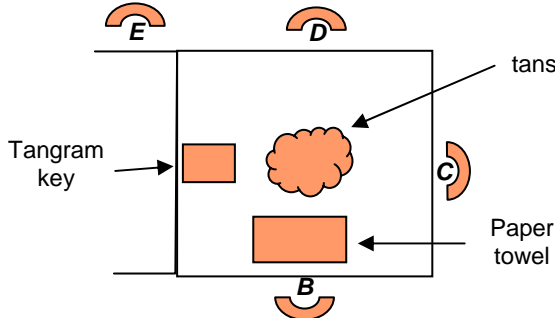
Time	Situation	Self
	It looks like a rock."	
	I walk over to the Magic Table to observe from the far side of the table by the exit door)	
	Current state of Magic table.	
3:45	P₁'s going through the cards on the table in front of him…looking at the deck in hand and placing cards on the table and then picking them up.

P₂ slides game chips towards him when he wins a hand – keeping them on the table, he slides them one by one with his fingers.

P₁ has a card with 2 white chips sitting on top of it.

During play: | He appears to be sorting the deck.

It's difficult to observe this because I don't understand the rules of Magic. |
| | | |
| 3:50 | P₃ reaches over, touches all P₄'s cards on the table while he counts outloud [points?]

P₄ rotates the cards on the table 90 degrees. | This game definitely has "ownership" of objects – each player owns his/her own deck – I'm not sure |

Time	Situation	Self
	P₁ is being dealt into the game.	who "owns" the game chips.
	After each turn they seem to turn the cards – swapping between upright and side ways.

P₃ and P₄ are playing each other

P₁ and P₂ are playing each other.

P₃ – "You're worms are dead…"

P₄ puts 2 cards that were face up on the table on top of the cards to the player's right of his deck. P₃ – "You have to put your graveyard face up" – P₄ flips the cards piles to the player's right of the deck over.

P₄ and P₁ leave the table.

P₂ moves to P₁'s spot.

P₁ returns to ask the guys if they are staying – he leaves his cards. | I spoke to one of the players afterwards and he said that this turn takes the particular cards "out-of-play" for the next turn. The position of the cards is how they keep track of the cards in play.

I think they had a meeting to go to.

This is a pretty good game to observe – except that it's competitive and I don't know the rules! |

P_3

P_2

handheld computer

D - Deck of Magic cards

E - Box of extra cards

- Cards in play

O - Observer

lego pieces

P3's cards

P1's cards

E

E

Magic chips

D

D
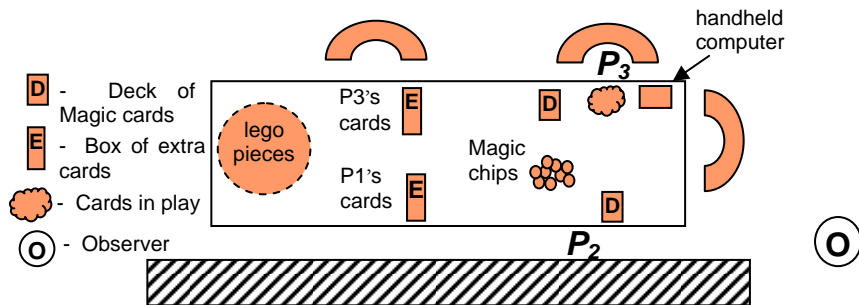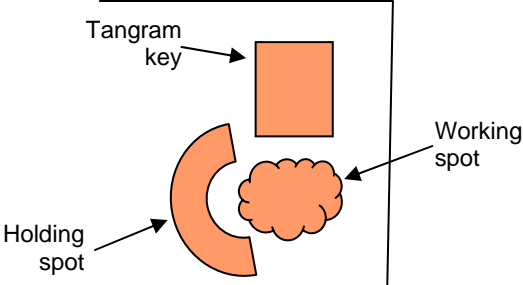
| 4:00 | Stopped watching Magic Table – back to observer table and watching jigsaw assembly. | |
| 4:02 | The same guy is still in position A working on the jigsaw puzzle. He's got quite a bit of the edge assembled. | |

Box lid   Box lid

Edge is almost done

A

Time	Situation	Self
	He's sliding the pieces around inside the finished edges.	
	He's finishing off the edges – He's rooting in the box again looking for missing edge pieces [he said this].	
	He found a piece that connects to an edge piece – he connects it on the table. He's holding the box lid in his left hand, leaning back in his chair, rooting through the pieces with his right hand. He sets the box lid back on the table and sighs.	
	He's trying to fit the connected pieces with the other edge pieces.	
4:08	His left hand is touching the connected left edge pieces. He's sliding them around slightly – glancing back and forth from where his hand is on the pieces to loose pieces on the table. He connects a piece to the edge.	
	He's about 95% done the edge. One loose piece and some of the bottom edge is not totally connected yet.	
4:10	He sighs and leans back – he's looking at the connections between the bottom edge pieces – he moves some to the left and reconnects – He pulls the whole left edge a bit away by sliding it along the table to the left. He created a gap in the top edge connected pieces. He places a loose piece – still seems to be a gap in the top edge. He's looking closely at the top edge. He's looking at the bottom edge now, and tapping his feet. He's looking forward at the top edge again. Tapping finger on the table – He leans back again with his hands in his lap. He leans in again.	
4:15	P₁ returns to the Magic Table.	
4:15	Karen sits down in position D to try some Tangram puzzles.	
	Another guy sits at C to do the wordlzes puzzles.	
	Guy whole had come by earlier and said "is this real?" just sat a the word puzzle table in spot D	
	I move to the far side of the word puzzle table (against the wall, near the table corner between positions C and D) to observe the tangram and word puzzles.	
	New guy comes to the table – he looks at the puzzle and lifts the box up to read the cover. He sits in position E – he lifts puzzle box up to read instructions.	
	E is watching C put tangram together	
	B gets paper towel and pen and tried to draw out the tans on a piece of paper towel to solve the tangram the group of them are working on.	
	D – "Lets try another one"	
	B – "Oh, come on…"	
	They switch the tangram key to a new silhouette.	
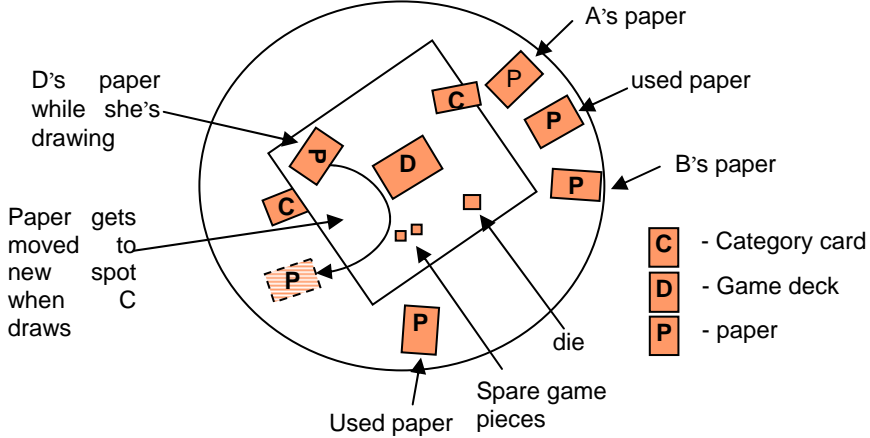
Time	Situation	Self
	  Both B and C are moving and sliding and picking up the tans and replacing. D is pointing and suggesting moves but not placing. D – "What about the small triangle?" B – "You had it the first time." Pointing to the tans with the pen. He starts drawing on the paper towel again. B – "You had the neck right before."	
4:30	D leaves E slides box lid a little out of his way so he can lean forward to see the tans on the table. E places pencil on the tangram key – B and E are discussing where the big and small pieces should go – C is moving the tans – B's hand is hovering near pieces – he's leaning close to the table. E moved the puzzle box lid to the far edge of the table so he could lean across the table – he slid his chair a bit closer. E or B points out that C is not using the square tan – C forgot about it (he said). C finishes the tangram puzzle.	This is interesting…the chair beside him, closer to the tangram is now empty (D left).
4:30	C – "It took 3 of us but we got one shape!" D returns – "Let's go back to the 1st one"	
4:32	A is now watching them do the tangram puzzle. He returns to the puzzle. He's holding the box lid in his left hand and taking pieces out of the box and putting on the table with similar pieces. Back to watching tangram puzzle Tangram key is facing C B is drawing on the paper towel – he moves 2 small tans together on the middle of the table– then returns to his paper towel. B – "Ok." He starts moving the tans around on the table. The other players are all looking at his paper. D – "Now you need to get that inside." E – "How many did you solve so far" [to the group]	I think he was seeing what shape they would make when the 2 pieces were joined.
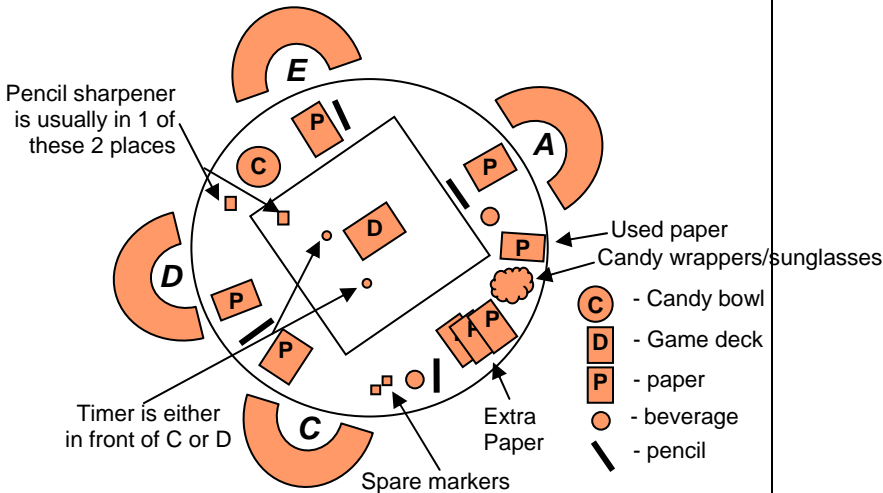
Time	Situation	Self
	D & C – "Only one, just when you came"	
	B is doing tangram on his own.	
	D & C are looking at the wordlzes	
	E is watching B solving the tangram – he's pointing and suggesting.	
4:37	B pushes pieces to center of table again and goes back to paper. He and E start discussing it. E is mostly looking at the tangram key and running his finger along the key silhouette.	
	D to B – "I think you're on to something….maybe not…."	
	B rotates the key towards him.	
	E – "I think the point is to figure out how to place these 2 big pieces"	
	B is tracing the key on the paper towel – then he puts the key back in the center of the table.	
	B takes the key back in front of him.	

Wordzle that C's done with (or will return to)

Current wordzle

Tangram key

tans

E

C

B

C seems to be joking.

A leaves – "I'll be back." He left the box lids piled on the far left corner from position A.

E is still moving the tangram tans around.

B & C are discussing a wordzle.

Some guy is standing at C's shoulder helping him with the wordlzes.

Another guy comes to stand directly behind C. C says: "You're far too close. You're invading my personal space man." They know each other. The other guy backs off a bit laughing and eventually leaves.

B left to get some food at the geek beer table.

A returned to the jigsaw puzzle.

E's moving the pieces around.

Shoulder guy is still helping C.

  Beside the study area, the CS society is setting up a ping-pong table.

E is still working on same tangram. He's reaching far across the table and hasn't moved either the tans or tangram key towards him. He's the only one working on the tangram puzzle – D has moved away. E is

E is an Asian male. Hall's proxemics observations have shown that there are cultural differences in seating arrangements. He specifically found that Asian (I'm not sure what region he did his observations) people (maybe students) were much more hesitate to rearrange their own seating pattern once it was set out by others. I need to look this up again though.
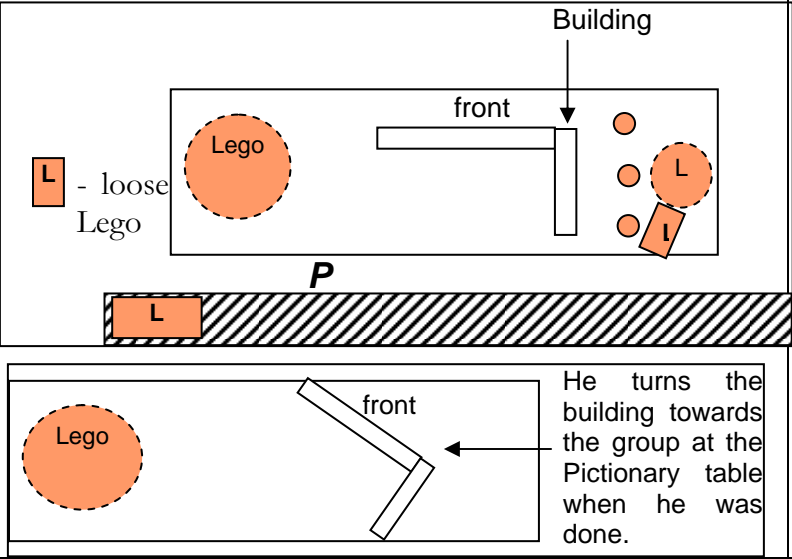
Time	Situation	Self
	really stretching to reach the tans.	
5:00	Geek Beer is starting outside of the study area.	
	I move back to the observer table.	
	A is still working on the puzzle. He's working on the middle now. There are only a few non-edge pieces on the table out of the box. The box lids are still piled at the NW corner of the table from A – by E.	
	C has left the table.	
	E is still working on the tangram from the same spot even though no one is sitting at the word puzzle table now.	
	[Ping pong comes across their table, it doesn't seem to interrupt either A or E]	
	A has a cup beside his bowl on the table along the left edge of the table.	
	A is holding the box lid – in his left hand – he tosses a piece from one lid to the other one that's still on the table. With his right hand, he puts the box that's on the table onto the empty chair beside him. He's still holding the other box lid in his left hand. He's sorting the puzzle pieces from the box lid. He's examining each piece and then putting them either on the table inside of the finished edge or to the left side (by cup and bowl).	
5:10	There are still 3 guys playing Magic at LEGO table (P_1, P_2, P_3 from before).	
	A's still sorting pieces.	
	He's got the stone wall pieces in one box lid and other miscellaneous loose pieces in the other box lid	
	All the pieces inside the finished edge are animal pieces, the pieces to the left outside of the edge seem to be related by colour or some other attribute.	
5:17	E is still working on the same tangram. There's a "working spot" and "holding spot" for the pieces.	
	Whenever he's trying a new combination of tan positions, he puts the pieces in the "working spot." When something doesn't work, he slides the pieces to the left or to the right of the working sport. When trying new tans into positions, he often holds the piece in his hand and turns it, or turns it on its "edge" against the table to "flip" the piece.	

Time	Situation	Self
	A new guy has joined E in position D to help with the tangram. E's explaining what he's doing. D's looking at the tans as E manipulates them on the table.	
	The tans are now more in front of D – E pushed them over and is working on them from the side.	
5:30	A's holding a piece and moving his hand all the way around the perimeter of the puzzle edge. Glancing between the piece in his hand and the edge pieces – he sets the piece back on the table.	
	D's now moving tans around the table. He attempts to move the pieces again, but E is moving the pieces. D keeps his hands on the table near the "work area." D & E both have their hands besides the work area, within 1-2 inches to the left (D) and right (E). D is just "resting" his left hand and E id manipulating the tans.	I'm starting to feel guilty that E's been working on this one for an hour now. I start to wonder whether it's doable with all of the pieces, but I remember that I only included ones that required all 7 pieces.
	Now E is leaning on his left hand, his right elbow and forearm is resting on the table in front of him.	
	E picks up the key and flips through the other silhouettes. They discuss moving to a new one.	These are definitely the most patient or stubborn people I've ever seen.
	E expresses that he thinks that the one they're working on is and "easy" one – I say that the silhouettes are not in the book in any particular order, so it isn't necessarily and easy one. I suggest they try a different one.	
5:40	I asked A what the pieces to the left of the finished edge pieces were. He says they're pieces that have some "distinguishing feature" [besides the animals and stone wall]. E.g. He has pieces that have a cast iron framing (a flower cart I think) and so on.	He seems determined to finish it.
	E continues with the tangram he's been working on.	
	D got a phone call and left the table.	
	E had shifted the tans back towards him – just a bit. It's still on the other table and he's still in the same seat. He's tilted the orientation of the working area towards him a bit.	
5:45	**I take a bit of a supper break.**	
6:00	D has returned.	
	A separates 2 pieces with one hand using his fingers.	
	Magic guys are eating at the LEGO table. They seemed to have packed their cards up.	
	I recruit some people to play Pictionary from the GeekBeer crowd.	
	A goes to join 3 people starting to play Pictionary.	
	They're reading the rules.	
6:20	Pictionary: It's an All Play. (C&D are partners, A&B are partners)	

Time	Situation	Self

Pictionary Board

timer

Extra Paper

C - Category card
D - Game deck
P - paper
○ - beverage
▬ - pencil

Time	Situation	Self
6:30	When C had finished with the paper she puts it behind the good paper in the stack of paper. C is turning the pad towards D as she draws. She's a left-handed writer and she's sitting to D's right, so as she draws D is craning her neck to see the drawing. New guy joins the table to be on the A&B team. He sits in spot E (between A and D). All Play: E&C are drawing. E has paper in front of him. C has paper in front of her. No one guessed the picture [it was Health]. E puts paper back in front of A when he is done. [he had taken it from there] A's drawing now and his paper is in front of him. They guess the answer.	
6:36	B and D are drawing. E's drawing – he uses A's paper. A takes paper back – he slides the paper back in front of himself when E's done. E leaves the table.	

Time	Situation	Self

Time	Situation	Self
6:38	All Play: C&A are drawing. C is using a pad of paper in front of her All play: B&D are drawing Each has their paper right in front of them.	
6:41	B's drawing – A's craning to see the drawing. B's right-handed and sitting to the left of A). A's drawing – he folds the paper as the clue – they dispute the legitimacy of the action and they make him retake it. They're making up the rules because the directions are not clear in this instance.	Interestingly, A looks to me to clarify the rules, I tell them it's their game. A little "open play"
6:45	A & B are on the last square on the board. All play for the win: C & D win the draw.	
6:50	D's drawing – they get it and roll the game die. All play: B&C drawing. E arrives again. D & C win the game. Someone is at the LEGO table playing.	
	Pictionary – New Game. E is still there, new person in A's spot. B has left. C&D remain. E&A against C&D. C&D sharing a pad of paper. E&A sharing a pad of paper. *	*This is interesting because A & B didn't share their paper and there're still lots of spare pads on the table. I wonder whether this has anything to do with the fact that E had been sharing with the former "A".
7:00	A drew 1st, then kept pad of paper in front of him. D's drawing – she took the pad from C. All play: C & E drawing. C took pad from D – slid and rotated it on the table to draw on. E drew – he took the paper from A	

Time	Situation	Self
	All play: A takes pad from E, turns it over and puts it down in front of him (there's a blank piece sheet of paper face up). D drawing – she takes the pad from C. Pencil sharpener is usually in 1 of these 2 places Used paper Candy wrappers/sunglasses C - Candy bowl D - Game deck P - paper ◯ - beverage ▬ - pencil Timer is either in front of C or D Extra Paper Spare markers	
7:04	Tangram Table E has finally moved tans in front of him – puzzle "A" guy is helping him (he only played Pictionary for the first game).	
7:07	Pictionary Table A keeps moving E's beer off of the game board (he places it beside the board), commenting each time that E shouldn't put his beverage on the board.	
7:10	D's paper is partially under the game board. C's paper is partially under the board. D pulls the paper out from the board to draw. C has the sheet of paper with the rules on it in her lap. A pulls the deck towards him a bit when D turns over the timer, moving the deck out of her way.	I wonder when they went back to separate pads of paper.
	I take a break.	
7:17	Pictionary Table. Rules are on the table, near the edge under used sheets and pads of paper between C & A.	
7:25	Lego Table There's a guy still working on constructing a re-designed CS building. He runs out of pieces that he wants to use for the building so he finishes. He stands up and walks around the table (on side near Pictionary group) and turns the structure so that the "front" is facing the Pictionary table and me.	

Time	Situation	Self

| 7:35 | They're still playing Pictionary so I walk around and take some pictures of the table arrangements. Then I pack up. | |

B.7 Study 2 Transcripts
Group 1

Group 1, Layout Task, Territory Observations

(0:04) Note: There are 2 people in this group - one female student (s1) and one male (s2), both Asian in origin. They are seated roughly opposite from each other, with the girl to the left of the scene (West) and the boy to the right (East). The initial layout of artefacts on the table: several piles of furniture cut-outs are in the centre area of the table (piles of plants, rectangular and square tables, round tables, chairs, couches, and book shelves), their instruction sheets are sitting on the edge of the table - to the left of each person.
(0:05) s1: begins moving the piles off of the floor plan area. She first slides the pile of plants to the edge of the table to a spot directly in front of her (West)
(0:10) s2: separates the cut-outs in the bookshelves pile from the chairs pile and then slides the chair pile to the edge of the table to his right (just East of North)
(0:17) s1: moves her instruction sheet off of the table to the floor to her left.
(0:24) s1 & s2: finish clearing the floor plan of the piles - s1 moves the pile of rectangular tables to the edge at the South of the scene, s2 moves a pen off the floor plan and puts it with a pile of post-it notes at South-East, then slides the pile of circular tables to the spot between it and the rectangular tables (South-South-East), s1 moves the pile of shelves to the edge at North-West and then s2 slides the pile of couches to the centre of the table
(0:28) s2: tries to lift the edge of the floor plan to slip the corner of his instruction sheet under it, but has difficulty lifting it from the table and instead places it back near the edge of the table, but still overlapping onto the floor plan area
(0:34) s2: takes a couch from the pile in the centre of the table and looks around at the floor plan as he's holding it. He then puts it down on the table, reads the instruction sheet and then starts discussing the design with s1.
(0:42) s1: quickly slides the pile of couches to the North of centre and starts discussing the plans for the middle of the room - pointing at the table in the centre location and gesturing circles on the table with her hand
(1:10) s1 & s2: start placing couches out of the pile of couches in a ring formation around the centre of the floor plan - the pile is still to the North of centre on the floor plan

(1:15) s1: reaches for the blue post-it notes and the pen (s2 - moves his instruction sheet closer to the edge of the table when s1 reaches for the post-it notes), s1 writes ("fountain") and places it in the centre of the floor plan, at the middle of the ring of couches, while s2 is still arranging the couches.

(1:27) s2: taps on the post-it note that s1 just placed on the table to make sure it's stuck to the table

(1:30) s1: places the blue post-it notes she was using and the pen to her right at the edge of the table (South-West)

(1:45) s1: starts placing plants from the pile in between the couches that they have arranged in the centre of the table. s2 helps her adjust the couches as she's placing the the plants and moving the couches to accommodate them

(2:42) s2: pushes his instruction sheet back on the table a bit, since it has slid quite close to the edge

(2:54) s2: points to the outer edge of the floor plan, starts discussing what to do next with s1. He picks up a couch from the pile North of centre, holds it while he discusses where to put it with s1

(3:10) s1: starts spreading out the couches in the pile

(3:10) s2: puts the couch on the table perpendicular to the wall of the library just to his right (North-East)

(3:10) s1: picks up a smaller couch than the one that s2 was holding and places it on floor plan close to the couch that s2 just put on the table (NNE)

(3:21) s2: placed another couch facing the first couch he put down, SE of the previous couch (leaving the couch that s1 placed where it is on the table)

(3:21) s1: picks up a table from the pile at South and places it between the two couches that s2 just positioned

(3:21) Note: couches are still spread all over in the floor plan

(3:26) s1: picks up a plant from the pile in front of her and places it on the table she just placed

(3:31) s2: places two more couches in the same formation as the previous two (perpendicular to the library wall, near the wall - floor plan edge - , and facing each other), directly in front of him (East)

(3:38) s2: places another couch to the South of the couch he just placed (ESE)

(3:38) s1: places a bookshelf from the pile at NNW parallel to the library wall, between the wall and the table at the first two-couch & table arrangement they positioned (NE). s2 helps her reposition the couches and table to accommodate the bookshelf

(3:45) s2: reads from the instruction sheet and then discusses with s1, pointing to the shelf they just placed - he was confused about where the wall and windows were on the floor plan, they decide to leave the shelf there

(4:08) s1: places another shelf next to the first shelf at NE

(4:13) s2: arranges the couches and table to accommodate the extra shelf

(4:22) s1: picks up 2 shelves from the pile at NNW and holds them out to s2, she drops them on the table near the couches positioned in from of him (NW) and he slides them into position near the couches directly in front of him (W)

(4:34) s1 & s2: they discuss...

(4:38) s2: continues creating a two-couch arrangement to the ESE, but picking up a couch from the spread out pile and positioning it facing the last couch he placed.

(4:38) s1: adjusts the arrangement of couches in the centre of the floor plan

(4:50) s1 & s2: they discuss an alternative arrangement of the couches - s2 slides the couches he has just positioned to explain that he's worried about the lighting conditions with the current arrangement, and proposes and alternative arrangement. s1 doesn't agree and suggests they add their own overhead lighting to solve s2's concerns. He agrees to that, and replaces the couches to their previous arrangement.

(5:24) s1: gathers the spread out pile of couches North of centre and slides the pile to an empty spot on the floor plan in front of her (West). She tosses the blue post-it notes that were sitting at SW on the floor plan at an empty spot on the floor plan (SE) in front of s2 and suggests that he can make some lighting

(5:24) s2: slides his instruction sheet under the edge of the FP so that the bottom edge of the sheet is just at the edge of the table. Most of words are covered up by the FP

(5:34) s1: places a table from the pile at South between the two-couch arrangement s2 just finished at ESE, and then she places a plant on the table from the pile at West

(5:34) s2: adjusts the positions of the two-couch & table arrangement

(5:40) s1: positions another table and plant between the two-couch arrangement at East

(5:42) s2: positions two more bookshelves at the two-couch & table arrangement at ESE

(5:46) s1: picks up a couch that was sitting on the table near the 3 couch arrangements (a couch that s2 had put on the table near the beginning of the session) and places it near off of the floor plan, at the edge of the table near the pile of plants (West). She also picks up the blue post-it notes that s2 didn't use and put it on near the edge of the floor plan to her right at SW. She then slides the pile of couches closer to the edge of the floor plan (some pieces are on the surrounding table surface), near the pile of plants (SSW)

(5:51) s1 & s2: discuss what to do next - s1 points and draws a circle with her finger on the North edge, which is currently clear

(6:12) s1: picks up the pink post-it notes from the pile at SSE, takes one off the top of stack and places the rest of the pink post-it notes at the table edge at North. She rips the post-it note in two and places one strip perpendicular to the floor plan edge at North and the other strip at the edge of the table to her left (NNW),

she then rips another strip off of the pink post-it notes stack, replaces the stack to North and the other strip on top of the stack, then places the strip in her hand perpendicular to the FP edge at NW.

(6:12) s2: is creating another two-couch arrangement South of the last one at SE

(6:15) s1: places the extra strip at the table edge at NW at the edge of the strip on the floor plan at NW to form a longer partition. Then she places the extra strip on the stack of post-it notes at North at the end of the strip at North to extend this partition as well.

(6:27) s1: asks experimentor if she can write on the floor plan ("No"), she then writes on the NW partition with the pen

(6:27) s2: places bookshelves besides the two-couch arrangement at SE

(6:41) s1: gets her instruction sheet off the floor and reads it. then they discuss what to do next. They decide that they only need 3 of the two-couch arrangements.

(7:21) s2: slides the last two-couch arrangement out of position, towards the centre of the table, s1 then continues to slide it towards her, off the edge of the FP (almost) at NW

(7:35) s2: moves a few chairs from the pile at NNE to the FP at North between the partitions that s1 created.

(7:35) s1: moves an oval table from the pile at SSE next to the chairs on the FP at North. They discuss how to arrange them

(7:47) s1: starts arranging the chairs and table

(7:47) s2: slides a overstuffed chair from pile of couches - he slides it across the table, south of the two-couch arrangements in front of him and slides it off the table towards him so that he can pick it off the table. He places it in the window alcove at the edge of FP in front of him (ENE). Then he picks another overstuffed chair from the pile and places in the next window alcove south of the previous one (at West)

(8:00) s2: places another overstuffed chairs from the pile into the window alcove south of the last (ESE)

(8:08) s1: finishes arranging the table and chairs and positions two shelves from the pile at NNW between the table & chairs and the partition at North

(8:08) s2: helps her arrange them

(8:15) s1: gets a round table from the pile at SSE and places it to the West of the last table arrangement (NNE)

(8:20) s2: positions some chairs around the round table and they both adjust the arrangement

(8:31) s1: moves some plants from the pile at West near the table arrangements she's working on (at North)

(8:40) s2: picks up the green post-it notes from the table edge at SW and peels a piece off, replacing the post-it notes to SW. He begins ripping up the post-it he has in his hands into small squares. He as he's ripping them up, he places the pieces on the instruction sheet, near the edge of the table at ESE.

(8:52) s2: places post-it squares on the wall area of the FP near the southern-most two-couch arrangement (ESE) and tells s1 that it's the light system in the wall.

(8:52) s1: passes him the marker (he didn't ask for it)

(8:52) s2: He places another green post-it square on the wall a little north of the first square.

(8:59) s1: picks up the pad of blue post-it notes on the table at SW and looks around the table. She asks if they can put pictures up, s2 says "Of course".

(9:08) s2: picks up the marker and writes on the two squares he just positioned

(9:11) s1: rips a post-it and replaces the pad at SW, partially on the FP and partially on the surrounding table. She rips off some small squares from the blue post-it in her hand and places them on the exterior wall of the FP, near the table arrangements at NW and North. She says aloud "picture" as she positions each one.

(9:19) s2: places the marker at the edge of the table at North when he's done writing and s1 immediately picks it up and starts writing on the squares she's just positioned.

(9:27) s2: looks at the pile of ripped post-it pieces he has in front of him, spreads them out a little but touching them, then picks up the pad of green post-it notes at SE, peels a piece off the top, then replaces the pad to SE. He rips up the post-it into pieces.

(9:29) s1: she picks up the pad of blue post-it notes at SW and picks up the marker, then puts the pad down, then picks up the pad of pink post-it notes at North, looks around, then puts it down near the pad of blue post-it notes at SW. She then reaches for the pad of green post-it notes at SE, saying "We're saying green is light, right?" and s2 confirms

(9:30) s1: takes a post-it from the green pad and then puts the pad down with the other pads of post-notes at SW

(9:47) s1: rips a square off of the post-it, places the excess at the table edge to her left (at NW) and places the green square on the FP in front of her and writes on it with the marker. She then positions it on the round table at NNW.

(10:04) s2: rips up some more green squares and positions them along the exterior wall in front of him at East and ENE

(10:08) s1: picks up the excess piece of green post-it from NW and rips another square off of it, replacing the excess again at NW. She writes on the square in front of her at West and then positions the square on the oval table on the FP at North

(10:22) s1 & s2: discuss adding a drink bar to the area on the FP at SSW. s1 proposes the idea and points

to the area, gesturing a circle on the table with the capped marker

(10:40) s1: takes several green post-it notes off of the pad at SW, replacing the pad at WSW and positioning three post-its side-by-side near the FP wall at South to SSW. She then writes on them with the marker.

(10:40) s2: puts his hand on the pile of chairs at NNE, picking up a few chairs and then replacing them and looking around the FP

(10:46) s1 & s2: discuss the drink bar further

(10:57) s1: gets her instruction sheet from a chair behind her and s2 pulls his out from under the FP, sweeping the loose pile of green squares away from the table edge, they both read the instructions again in silence

(11:04) s2: suggests they add more seating for people

(11:07) s1: agrees and asks if they need to put computers. s2 says they could, although it doesn't say so. He suggests they could just go on the tables they already have, pointing to the tables at North

(11:33) s1: touches the tables and they discuss it further. She proposes a specialized computer area

(11:48) s1: suggests an extension of the table area. She moves the pink wall at North to NNE and s2 suggests a big table, pointing to the pile of tables in the South. s1 picks up a large oval table from the pile, then drops it and peels off a large pink post-it from a pad at the NE edge of the table. She positions it parallel to the exterior wall at NNE

(11:53) s2: picks up some chairs from the pile at NNE and positions them around the pink post-it note/table

(11:55) s1: draws squares on the post-it note/table and says "computer" as she draws each

(12:07) s1: re-caps the marker and sets it down to her left at the edge of the table at NW

(12:16) s1: peels a post-it note from the blue pad of post-it notes at SW, rips squares off of it, placing them along the wall beside the new computer table at NNE, saying "picture" as she places each one

(12:24) s1: she tosses the excess piece near the pad at NW

(12:27) s1: slides the plants that were at the end of the wall, near the re-positioned wall and s2 adjusts them once she pulls her hand away

(12:47) s1 & s2: they discuss what to do next

(12:53) s1: adds some plants from the pile at West around the drink bar at South

(13:00) s1: suggests some columns near the entrance way (at SSW to the West of the drink bar)

(13:08) s1: rips 2 pieces off of the pad of pink post-it notes at SW and places each piece beside the entrance to the room (between SSW and SW) and then picks up the marker near the edge of the table at NW to write on each of the piece of post-it note, while saying "columns" and writing "column" on each one.

(13:14) s2: puts his hand on a pad of post-it notes near the edge of the table at SSE, pushing it closer to the edge. He then slides his instruction sheet a little more under the floor plan at that spot

(13:18) s1: finishes writing, slides some spare couches near the edge of the table at SSW. She then puts the marker back down near the edge of the table at NW

(13:23) s1 & s2: they discuss what to do next.

(13:16) s1: uses both hands to gather and slide a pile of spare couches on the floor plan in front of her off of the floor plan, near the edge in front of her (at W)

(13:28) s1: mentions she doesn't like the chairs in the pile at NNE (s2's hand's on the pile at the time) because they "don't look very comfortable", s2 says that they don't want people to fall asleep while they're studying so some of the chairs have to be hard-backed.

(13:39) s2: puts his hand on an empty area to his left on the floorplan (at SE) and asks what they should do with that area

(13:46) s1: says they already have a lot of seats. She rearranges the seats around a round table at NNW as she's speaking

(13:59) s1 & s2: they both look around the workspace in silence for a little while, thinking

(13:00) s1: picks up two loveseat chairs from a pile in front of her (at W) and suggests they use some 2-seaters for people to sit and drink. She arranges these at right angles in the space at SE.

(14:10) s1: picks through the pile of chairs at W, looking at different types of chairs

(14:10) s2: suggests that they put stools near the bar, pointing to the bar at S. He then picks through the pile of chairs near the edge of the table at NNE

(14:22) s1: picks 2 single chairs from the pile at W and places them near the couches that she just arranged at SE

(14:22) s2: picks two chairs from the pile at NNE and places them at S

(14:22) Note: they are crossing paths, but are not working in these opposing positions simultaneously - they are very good at timing their interactions so that they are not working in these opposite positions at the same time - as s1 was done and pulling her hand back, s2 was moving his hand to place the chairs

(14:33) s2: he's holding some chairs and picks a chair from his hand and places it at the bar at S. He then places the chairs in his hand back in the pile, and looks for different ones in the pile.

(14:36) s1: she starts talking about having a smoking area while s2 continues to place chairs from the pile at NNE to the bar at S

(14:59) s1: she's talking about creating an enclosed room for smokers in the room so that smokers won't bother other people in the library. s1 & s2 discuss where it should go and they decide that it should go on

the side of the room somewhere.
(15:05) s1: draws a space for the room with her finger on an empty space at SSE between the couches and chairs she just placed at SE and the bar area that s2 was just working on.
(15:26) s1: takes a post-it note off the blue pad at SW and tears it in strips and places these strips on the floorplan around the space she drew with her finger earlier (at SSW).
(15:26) s1: asks if s2 wants it that way and he confirms that it's great
(15:22) s2: slides some spare pieces off of the floor plan at ESE
(15:46) s2: he surveys the floor plan, checking the lighting and then reaches around s1's hands (which are at SE still placing the strips of "wall" for the smoking room) to pick up the blue pad of post-it notes at SW - causing s1 to retract and say "sorry" - s2 quickly says "no problem"
(15:48) s2: leans back with the pad of post-it notes
(15:48) s1: continues to place the strips. She's actually enclosing a larger area than she originally indicated. She's closing off the space from SSE to SE, enclosing the couches and chairs she had placed earlier.
(15:51) s2: peels off a piece of post-it note from the pad in his hand, saying "more pictures wouldn't hurt". He tosses the pad down on his instruction sheet, near the edge of the table at SE
(16:01) s1: starts rearranging the furniture in the smoking area at SSE
(16:06) s2: rips the post-it note into small pieces and places near the floor plan edge (on the "walls" of the library), at ESE
(16:06) s2: tosses the excess piece of post-it note with the pad at SE
(16:10) s2: places another piece at E and puts another excess near the post-it pad at SE
(16:10) s1: removes the 2 couches from the smoking area and puts them back in the pile at W
(16:13) s1: she picks up a larger couch from the pile at W and places it in the smoking area at SSE
(16:13) s2: picks up an excess piece of post-it note at SE and rips it into smaller pieces, placing a piece at ENE
(16:17) s1: picks up the plants beside the bar at S and puts one of the plants in the smoking area at SSE
(16:28) s1: she then picks up a bookshelf from the pile at NNE and places it in the smoking area at SSE
(16:45) s1: she asks s2 whether they should have more bookshelves. They decide to add some
(16:45) s1: picks up a bookshelf from the pile at NNW and sets it down in an empty area in front of her at NW. She picks up a bookshelf from between two tables at N and adjusts several pieces of furniture while holding the bookshelf in that hand.
(16:53) s1: she places the bookshelf near the round table at NNW and then gets another one from the pile and places it beside the one she just placed at NNW
(16:00) s2: s2 laughs and his breath blows one of the paper bookshelves out of place in front of him. He replaces it (at E)
(17:02) s1: picks another bookshelf from the pile at NNW and places it beside another table at NNE. She then picks up a second bookshelf that was between the two tables at N and places it beside the bookshelf she just placed at NNE.
(17:08) s1: picks up a few bookshelve from the pile at NNW and is holding them as she looks at the workspace.
(17:08) s2: asks if s1 wants lights all the way around the room - to be uniform. s1 agrees with that
(17:16) s2: first starts to pick up the blue post-it note pad at SSW, but then reaches across the table to pick up the pink post-it note pad in front of s1 at WSW. s1 was trying to reach across to the smoking area and pulled back, saying "whoops, sorry", when s2 was reaching for the post-it notes. s2 pulls back when he has the post-it notes and says "no problem"
(17:18) s1: places several bookshelves in the smoking room at SSW and SW
(17:22) s2: pulls a post-it note off of the pad in his hand and puts the pad down at SE
(17:28) s1: continues to place bookshelves in the smoking room, now at ESE from the pile at NNW
(17:28) s2: rips up the post-it note and put extra pieces near the edge at ESE. He places small bits of post-it notes around the FP against the outer wall [he's placing lights] in NNE area
(17:43) s1: picks up several chairs from a pile near the edge of the table in front of her at W, to place in the smoking room at ESE
(17:38) s2: continues to rip bits of post-it notes to place along th FP wall, now almost at N
(17:53) s1: picks up some plants from a pile in front of her at W to place in smoking room at ESE
(17:59) s1: picks up some couches from a pile in front of her at W to place in the smoking room at SE
(18:07) s1: picks up a table from a pile at table edge at S to put in smoking room at SE
(18:15) s1: adjusts the items in the smoking room at SE, saying "the plants are too big"
(18:25) s2: asks if there are smaller plants and s1 says they're either tiny or gigantic
(18:32) s2: thinks the large ones she has in the smoking room are ok
(18:35) s2: continues to rip and place post-it notes at N
(18:35) s1: asks "what do you think so far?", and she clears away some extra items sitting on the FP in front of her (at W) and moves them to their respective piles at NNW and W
(18:40) s2: thinks it's good so far
(18:41) s1: points to a post-it note that s2 had placed some time ago and says "oh, these are pictures?"

(18:41) s2: responds, that he's putting one picture between every two lights
(18:50) s2: puts down the extra bits of post-it notes in a pile near the table edge at ESE
(18:52) s1: says ok, then looks around and points to a picture at NNW and says, we need two more green things (s2: says "lights")
(18:56) s2: picks up the green pad of post-it notes at SE and peels a post-it note off of the pad, replacing the pad at SE
(18:58) s1: is trying to peel a postit note (picture) off of the FP and move it closer to a postit note at NNW, she succeeds with some difficulty because it was stuck to the FP
(19:02) s1: she moves the second post-it off of the FP and places it near table edge at NW
(19:04) s2: is ripping the postit in his hand into bits
(19:05) s2: places a bit of postit note (a light) in the place where s1 removed the other postit note at NNW
(19:10) s2: continues ripping the postit note into bits, placing an extra piece on the table in front of him at E
(19:16) s1: she says they should label the smoking room. She picks up the marker at NW and takes a pink postit note from a pad at WSW, then replaces it. She starts writing on a postit note that's forming the wall of the smoking section, saying "cigar and...library room", then puts the marker down at WSW
(19:16) s2: places another small postit note (a light) on the other side of the picture s1 had positioned at NNW
(19:23) s1: moves an extra couch on the FP in front of her (at WSW) to a pile at W, then tidies up the piles in front of her (W, WNW & NW)
(19:27) s2: places another bit of postit note (a light) along the FP wall at SE
(19:34) s2: and rips off a bit more, puts the extra pieces in a pile at ESE and then places another bit of postit note (a light) along the FP wall at SE
(19:33) s2: suggests putting a ventilator in the windown of the smoking room
(19:37) s2: picks up a blue postit note pad at SE, peels a piece off, and replaces the pad at SE
(19:40) s2: rips the postit note piece in half, placing the extra piece in a pile at ESE
(19:40) s1: picks up the marker at WSW and puts it on the FP in front of s2 at E, saying "here"
(19:49) s2: rips up the postit note piece further, sticks it to the FP in the smoking room at SE, puts the extra pieces on the table at ESE
(19:56) s2: picks up the marker and writes on the postit note at SE, then puts the marker down in front of him, off the FP at E
(20:00) s2: picks up some postit note pieces from the pile at ESE and places them along the wall of the FP at SE
(20:07) s1: touches the pink pad of postit notes at WSW, then picks up a table from the pile at SSW and places it in the empty FP area in front of her at W. She asks s2 if they should put some tables in that area some people can work. S2 agrees
(20:11) s1: places more tables from the pile at SSW in the FP near the Centre at W and SWS
(20:17) s2: is looking at the items in the smoking room at SE, he touches an item then takes he hand away
(20:20) s1: adds more tables from the pile at SSW around the Centre at S, SE, and E
(20:25) s1: she reconsiders and picks up the tables she's placed at SE and E, and the one at NNW. She accidentally moves some items in the FP with her arm, she adjusts them and s2 helps her put things back into place in the Centre
(20:29) s1: she folds one of the tables in her hand in half and places beside the other tables around the Centre at NNW, then folds another and places it beside the first small table
(20:35) s1: picks up the table at WSW and S and folds them in half, then places them in the place of the original large one at WSW. S2 mentions she's making them smaller, and s1 responds by saying she wants the people to be able to get into the chairs in the ring in the Centre.
(20:40) s1: she places another large table at S, from the pile at SSW
(20:40) s2: while s1's getting the table from the pile at SE, he adjusting the tables s1 had just placed on the FP at NNW and NW
(20:44) s1: picks up more tables from the pile at SSW, folds two of them, then places them around Centre at SE (she's alternating the tables - one long, two short, etc)
(20:58) s1: places a long table at E, two folded tables at NE, then a long one at N (after getting more from the pile).
(20:59) s2: is getting something off of the floor (little bits of postit notes which have fallen off the table)
(21:04) s1: "Yay! Our room is pink. It's really pink." (s2 laughs)
(21:07) s2: looks at his instruction sheet on the table and says "so..."
(21:07) s1: puts both hands on the table in front of her at W and says "Ok, and this area ..."
(21:15) s1 & s2: discuss what to do next, while s1's hands remain in the empty area, while craning her neck to read s2's instruction sheet across the table
(21:49) s1: suggests a jukebox in the empty area, with small speakers around
(21:51) s1: picks up a pink postit note from a pad at WSW
(21:55) s2: thinks its a good idea, but not in the quiet area (he points to the study area in the N section of the FP
(21:57) s2: fingers the chairs in the pile at N

(22:01) s1: rips a piece off of the postit note in her hand and hands it to s2, saying "do you mind just writing jukebox?"

(22:05) s2: agrees, taking the piece of postit note, and picks up the marker at E, puts the postit note down on the the table at E, and writes on it

(22:07) s1: puts the other piece of the postit note on the FP in front of her at WNW, and then suggests putting more chairs in that area

(22:13) s2: hands the postit note back to s1, saying "here's your jukebox", s1 takes it, then passes him the other postit note she had just placed in WNW, saying "and you need one for the smoking area", she points to the smoking room at SE

(22:13) s1: places the postit note jukebox at WNW

(22:28) s2: places the postit note in the smoking room at SSE, then writes on it with the marker

(22:28) s1: starts placing couches from the pile at W on the FP near the jukebox at WNW

(22:28) s2: adjusts the items in the FP around the smoking room at SSE

(22:32) s1: picks up some chairs from the pile at W to add to the FP at WNW

(22:39) s1: picks up several tables from the piles at S, then SSW, but replaces them in the piles

(22:46) s2: sorts through the pile of extra postit note pieces at ESE, then picks up a piece, then puts it back down in the pile

(22:48) s1: picks up some plants in a pile at WNW and puts some on the FP near the chairs she's just placed at WNW (s2's just watching her)

(23:00) s1: picks up some tables from the pile at SSW, folds them, then places them between the chairs and couches at WNW

(23:00) s2: puts the marker down on the table edge at SSE

(23:08) s2: adjusts some places at NNE

(23:16) s1: makes a circle with her finger on the FP at an empty spot at NNW, saying "maybe some more seating area here?"

(23:19) s1: picks up some chairs from a pile at W

(23:20) s2: agrees, and also suggests a ring of lights around the fountain in the Centre area (he makes a circle on the FP around the fountain postit note)

(23:24) s1: puts her finger on the fountain postit note and says, "maybe "Fountain and Big Chandalier"?"

(23:24) s2: agrees and picks up the marker at SSE

(23:25) s1: picks up the fountain postit note at Centre, and puts it on the FP in front of s2, saying "here"

(23:29) s2: picks up the postit note from the table and puts it on the table closer to him at ENE, and writes on it

(23:27) s1: adds chairs (from her hand) to the empty FP at NNW

(23:35) s1: gets more chairs from the pile at W and places them with the others at NNW

(23:41) s2: places the postit note he was writing on back in the Centre of the FP

(23:44) s1: starts to pick up a pink postit note at WSW, but then picks up a white round table from a pile at S and then places it at NW by the chairs at NNW, saying "a table like this, just to read or whatever"

(23:45) s2: puts the marker down on the table edge at SE

(23:51) s1: as she's getting more chairs from the pile at W, she asks "do you think?", as she places a chair by the table at NW, then says "oh and we need more lights and pictures", pointing to the FP wall at NW

(23:51) s2: "more lights all around...", he picks up another blue postit note piece from a pad at SE and the marker

(23:52) s1: places more chairs at NW from the pile at W

(24:02) s1: picks up more round tables from the pile at S and places them at NW

(24:03) s2: rips the postit note into bits, placing the extra bits at the pile at ESE, then puts the marker down in front of him at ENE (he didn't use it). He waits for s1 to finish placing her tables, then puts the postit note bit on the FP wall near the chairs/tables s1 has just placed at NW

(24:14) s2: drops the extra bit in his hand to the table edge in front of him (ENE) [probably because it's not sticky], then picks up several pieces from the pile at ESE, discarding some [probably non-sticky ones], then rips a piece and places it south of the other one he just placed at NW-WNW.

(24:24) s1: was looking at the pile of couches and chairs and asks " what else?"

(24:25) s2: moves an item in the smoking room at SSE to a nearby spot

(24:29) s2: picks up the blue postit note pad from SE and peels a postit note off, replacing the pad at SE, then ripping up the postit note

(24:29) s1: moves the wall of the smoking room at S a little west to expand the smoking room

(24:29) Note: they're both working quietly

(24:38) s2: moves the postit bit towards the NW-W side of the FP, but then changes his mind and places it on FP wall at SSE [can't tell if s1 was in his way or not - she's still moving the smoking room wall]

(24:48) s2: rips up some more bits, placing extras at pile at ESE

(24:50) s1: picks up another postit note strip from a pile at NW, rips some off of it, dropping the excess on the table edge at W, and places it at SSE to extend the smoking room wall.

(24:50) s2: moves the postit note bit towards S, but s1 was in the way (she was reaching over to place the smoking room wall piece), so he changes his movement and tries to places the bit on the FP wall at W by

going under s1's arm, but he can't reach it, so he goes between her arms to place the bit at W. s1 withdraws and says "whoops." When s2 has finished and has moved back to ENE, s1 leans forward again to arrange items in the Centre [I think she displaced them when she pulled back], then continued to arrange the smoking room walls at S-SSE.

(25:04) s2: places a postit note "picture" bit on the FP wall beside s1's hands at SSW - s1 shifts her hands to the north to give s2 some room.

(25:16) s2: reach across the table, in between s1's hands to place a postit note bit along the wall at WSW - as he's placing it, s1 backs away, stopping what she's doing, then she continues when s2 is finished and has leaned back and says "so I guess we have enough pictures of people"

(25:17) s2: picks up the green pad of postit notes from ESE, peels a piece off and returns the pad to E, and rips up the postit note into bits

(25:22) s1: picks up a white table from a pile at table edge at S-SSW, folds the table, then places it in the expanded smoking room at SSE

(25:33) s2: places a postit note ("light") on FP wall at NW, then rips another piece and places that piece beside the previously placed piece at NW

(25:34) s1: rearranges some items in the smoking room at SSE

(25:40) s1: picks up another table from the pile at S-SSW and asks the experimenter if the pieces are to-scale. Exp says yes and that it's a really big room

(25:41) s1: places another table in the smoking room at S-SSE

(25:52) s2: rips another postit note bit and places it at NW

(25:52) s1: looks around FP and says it's getting really clustered, s2 agrees saying it's getting really cosy

(26:01) s2: places another postit note bit at NW, then gestures over the empty space surrounding the Centre of the FP saying, "I guess it will be nice that we'll have a ring of walk space around it "

(26:14) s1: says that will be stupid to have to walk around the circle to get to the other side, but then she conceeds saying I guess that would be ok.

(26:19) s1: picks up an extra piece of postit note from the FP in front of her at W and rips it up and places the bits ("lights") around the pictures that s2 had placed on the FP near her at W-SW

(26:29) s1: she picks up extra postit note bits from the table edge at NW and continues placing ("lights") at SW-S

(26:30) s1: she looks around at the items on the table edge in front of her (NW-SW) and says "lights...where's the green?", then says to s2: "we need more green for this and that", pointing to a postit note picture at SSW and SSE

(26:32) s2: "one more green?" s1: "actually three more" (pointing to the places needing green postit notes at SSW-SSE), s2 rips ups a green postit note piece taken from a pile at ESE, then places bits at SSE, S and SSW, placing the excess bits back in the pile at SE

(26:40) s1: says "then over here, we'll continue with what we were doing", her hands are on the furniture in the FP at NW

(26:46) s1: "what about a phone?", s2 agrees that they should have a phone: "we should have more than one phone actually"

(27:12) s1 & s2: they discuss where the phone(s) should go. s1 suggests a phone booth at WSW (she taps the table in that spot), s2 suggests a phone beside the fountain in the Centre, but s1 convinces s2 that it might be too loud there, so they agree on making a soundproof phone booth with multiple phones at WSW

(27:14) s1: reaches across the table first putting her hand on the pink postit note pad at SSE, then picking up the blue postit note pad at SE, saying "excuse me" as she does this

(27:15) s2: picks up the marker in front of him at ENE and sets it on the FP in front of s1 at SSW

(27:25) s1: peels of several postit note pieces, then puts the pad on top of another postit note pad at SSW, then places several pieces near the wall of the FP at SSW, saying "phone booths"

(27:25) s1: picks up the marker from the FP, sets the extra postit note pieces in the pile of extra furniture at SW

(27:42) s1: writes on the postit notes at WSW, saying "phone booths with multiple phones"

(27:43) s1: adjusts the furniture in the FP at NW as s2 says "I guess we just have one more wall area to work with" [there's an empty spot in the FP near the wall at W]

(28:07) s1: suggests replicating the chair and table arrangement that's at NW-NNW (she points to them) - they discuss what that is, they decide it's a group area, and then decide they want more computers there

(28:10) s2: picks up the pink postit note pad at SSE, peels a piece off and replaces the pad at SSE

(28:12) s1: picks up a chair from the pile at N and sets the marker down on the FP near S of Centre

(28:18) s2: places the postit note on the FP at W

(28:18) s1: picks up more chairs from pile at N

(28:23) s1: places chairs around the postit note s2 just placed at W

(28:24) s2: picks up the marker from S of Centre and puts it down on the table near s1's hands at W

(28:33) s1: finishes putting down chairs on one side of the postit note at W and then picks up the marker s2 placed at W and draws computers on the postit note, then puts the marker down at N, as she picks up more chairs in the pile at N

(28:43) s1: drops a chair on the FP just below the pile at N and s2 picks it up and puts it back in the pile at

N, s1 sorts through the pile for the correct chairs
(28:49) s1: places the chairs around the postit note at W and says "I guess we're done" - s2 says "just in time"
(28:51) s1&s2: lean back from the table to show the experimenter their layout
(28:51) Note: END

Group 2

Group 2, Layout Task, Territory Observations

(0:00) Note: There are 2 people in this group - one female student (s1) and one male (s2), both Caucasian. They are seated roughly at West and North respectively. The initial layout of artefacts on the table: several piles of furniture cut-outs are in the centre area of the Floor Plan (FP), which is roughly centred on the 3-foot diameter round table, with about 6-inches of table showing all around the FP (piles of plants, rectangular and square tables, round tables, chairs, couches, and book shelves), their instruction sheets are sitting on the edge of the table - to the right of s1 (WSW) and to the left of s2 (NE). There are several pads of postit notes at the table edge (e.g., off of the FP, near the edge of the table) at SSE and one at NNW. There is a marker in front of s1 at NW and a pen in front of s2 at NNE.

(0:04) s1: picks up a bookshelf from a pile in the Centre of the FP and places it near the FP wall at ESE (across the table from her), then repeats this with two other shelves, lining them up along the FP wall
(0:13) s2: reads from his instruction sheet on the table edge at NE
(0:17) s2: moves his instruction sheet to the side a bit at TE-ENE
(0:20) s1: slides another bookshelf from a pile in the Centre beside the others at ESE, but then slides it back towards the Centre again (it was shorter than the other three shelves), then picks up another shelf from the pile at Centre and puts it beside the other three along the FP wall at SE
(0:21) s2: holds up instruction sheet with left hand and tidies up the pile of orange couches at C-NE with right hand
(0:24) s2: helps s1 place bookshelves by taking bs from pile at C and placing at FPE-E (still holding instruction sheet)
(0:28) s2: picks up bs from C pile, slides pen from FPE-NE towards C a bit and places bs at FPE-NE
(0:29) s2: puts instruction sheet down at TE-ENE
(0:31) s1: leans back and moves the marker to the table edge at NNW and picks up another shelf in the Centre, looks around, then places it beside a shelf that s2 had placed along the wall at NE
(0:32) s2: picks up bs from C pile and places at FPE-NNE
(0:38) s2: repeats 3 times at FPE-NNE
(0:39) s1: sorts through the tables in a pile NW of Centre and moves them towards the table edge at W
(0:41) s1: continues sorting through the tables in the pile NW of Centre, she's sorting the pink tables from the white tables, from the white chairs that are in that pile
(0:41) s1: slides a bookshelf near the pile of tables off of the FP at S to pick it up, then puts it in the pile of shelves at Centre
(0:56) s2: picks up plant from pile at C-NNW, looks around and puts back down at C-N
(0:58) Note: s2; slides items in chair pile at C-N West a bit
(01:00) s1: watches s2 place some items, then picks up a large white table from the pile NW of Centre, begins to place it near the shelves at SE, but then puts it down on the FP, at SSE
(01:01) s2: picks up couch from pile at C-NNE then drops in pile of plants at C-NNW
(01:04) s2: picks up bs from pile at C and places at FPE-N
(01:07) s1: slides the pile of bookshelves to the north a bit to make room for the tables she has displayed
(01:07) s1: sorts through the pile of tables NW of Centre, pulling out different sized and shaped tables and puts them on the FP near the other table at SSE
(01:10) s2: tidies pile of chairs at N and pile of couches at C-NE
(01:11) s2: moves pen from C-NE to TE-NNW
(01:14) s2: tidies up couch pile more at C-NE
(01:16) s1: sorts through the pile of tables NW of Centre to find other unique tables and slides the rest of the pile away (to the NW) from the layed out tables
(01:17) s2: asks s1, "do you want the whole layout to be circular?" gesturing in a circle with right hand over FP
(01:20) s2: "...in the middle a little plant environment?..." as he's saying this, he's moving plants from the pile at C-NNW to C
(01:31) s1 & s2: discuss the design of the layout. The decide to have a noisy/group area where s1 has just put all the tables (she gestures over that area). They decide to put a "plant environment" in the Centre, and a quiet area to the north of Centre (s1 gestures to the area in front of s2 (between Centre and NI)). Both s1 is arranging tables in the Centre as they're talking and moves some plants from a pile at NNW to the Centre.
(01:31) s2: moves couch from pile at C-NNE to S, then tidies up pile of bs's in C - moving it to C-ESE

(01:35) Note: as s1 is talking about the different areas she sees in the room, s2 is tidying up the piles, moving them around, making empty spaces for placing items

(01:35) s2: moves pile of white couches from C-NNE to NNE

(01:45) s1: asks s2 if he wants some tables, and then she picks up a table from the pile NNE of Centre and puts it in an empty spot on the FP NE of Centre, then she gestures over the pile at NW, saying "I've got a whole selection of sizes and colours"

(01:45) s2: rooting through couches in pile at NNE

(01:51) s2: picking up chairs and holding them loosely, with some dropping on FP in front of him as he reads from his instruction sheet at ENE

(01:53) s1: moving more tables from the pile at NW to empty spots at S-SW-W

(01:54) s2: "I think we should be inspiring...", picking up an orange couch from pile at C-ENE

(02:00) s2: talks to s1 about the instruction to "be inspiring", saying "the room should be inspiring..." then drops couch in pile of misc forming at C-NNW

(02:09) s2: roots through pile at C-NNW

(02:12) s1 & s2: read the instruction sheet (s1 picks up her sheet from the table edge at WSW) and they discuss how to make the room "inspiring", then she puts the sheet down on the table edge, tucked under the FP at SSW

(02:12) s1: adjusts the tables at S, saying "this area will inspire people to work in groups"

(02:19) s2: picks up bunch of bs's from pile at C-ESE and puts the bunch down in a pile in front of him at TE-NNE

(02:24) s2: places a bs from pile at TE-NNE at FPE-N, repeats at N

(02:28) s1: picks up a plant from a pile at NNW and puts it in the Centre

(02:28) s1: slides the smaller tables at WSW-W towards s2 and the "quiet" spot at N, saying "this area will inspire people towards solitude"

(02:32) s1: picks up several other large plants from the pile at NNW and while arranging them with the other plants at Centre, says "but I like the idea of a plant environment"

(02:33) s2: repeats twice at FPE-N

(02:35) s2: repeats at FPE-NE

(02:37) s1: slides several small plants from the pile at NNW towards the Centre plant arrangement

(02:44) s2: picks up a plant from pile at NNW as s1 is talking about the plant environment in C and places it in C, saying "then we'll have the skylight here" gesturing above the FP-C

(02:49) s1 & s2: they talk about what's above the plants (s2 suggests a skylight, s1 suggests the whole room be under a bubble)

(02:57) s1: picks up several more plants from the pile at NNW and places them together (in an entranceway path) from the library entrance towards the Centre, saying "I'm going to make a little promenade in, like a plant promenade, so you kind of come in in a hedged-in labrinth"

(02:59) s1: picks up more plants from the pile at NNW and puts them between Centre and SSW

(02:59) s2: tidies pens at TE-NW, then picks up bs from pile at TE-NNE and places at FPE-NNW

(03:02) s1: picks up more plants from pile at NNW to put between Centre and SSW. She slides extra tables out of her way with her fingers as she's doing this

(03:03) s2: repeats four times at FPE_NNW

(03:14) s1: slides an extra white chair away from a plant at SW of Centre to a pile at NNW of Centre

(03:14) s2: repeats bs placement, but as he's placing bs at FPE-NNW he hesitates until s1 moves her hand out of his way, then places the bs

(03:20) s1: picks up an extra couch and slides some tables to the NE of SE (out of the way), then reads the instruction sheet at S-SSW

(03:22) s2: touches some white couches in pile at NNE

(03:23) s2: picks up large plant from pile at NNW and places in C

(03:25) s1: puts the couch down near a pile of tables on the FP at W

(03:27) s1: moves some plants from the pile at NNW to NW of Centre saying, "maybe we need a hedge here to keep the noise down" (she tries to reach across s2's hand, which is over the pile, but he starts to move, so she withdraws and approaches the pile from the W side instead), she moves some of the extra items on the FP towards N, out of her way)

(03:28) s2: repeats with small plant in C

(03:29) s2: pushes items in misc pile from NNW to N-NNE, clearing space for s1's "hedge"

(03:32) s2: tidies pile of bs's at TE-NNE, pushing pile to TE-NNW, saying "put some shelves over there..."

(03:35) s1: arranges the plants at NNW with her left hand and picks up a plant at N with her right hand, then places it at NW (near the others)

(03:41) s1: "I think I'm going to put [pointing to the FP wall at S] some shelves over here for the new journals", she picks up a bookshelf from a pile at ESE of Centre and puts it along the FP wall at S

(03:46) s1: slides a bookshelf that was already placed in FP at SE beside the shelf she just placed at S

(03:49) s1: adjusts the row of plants at SSW to make room for the book shelves, then adjusts the row of plants facing that row at SW

(03:50) s2: picks up several items from white couch pile, examines them and replaces then in pile at NNE, then picks up some orange couches from pile at NNE looks at them and puts in pile at NNE [there's a lot of mixing of items in the piles]
(03:55) s1: adjusts the shelves at S
(04:00) s1: slides another shelf from ESE to S
(04:04) s1: slides another shelf from ESE to S
(04:05) s2: picks up pile of couches at NNE and moves it to the TE-NE "I'll just take all these....and put them here...."
(04:07) s1: slides another shelf from E to S
(04:14) s1: adjusts the shelves at S
(04:20) s1: slides another shelf from E to S
(04:22) s2: he leaves some tables from the pile and starts arranging them on FP at NNE
(04:28) s1: slides extra tables from the FP at SW to the Centre area
(04:28) s2: roots through piles at N and NNW on FP
(04:33) s1: rearranges the plants at the entrance (at SSW) to bring them closer together at the entrance
(04:33) s2: "I think we need a storage area..." with his hand on a pile on FP at NW
(04:43) s2: picks up tables from NW and puts them in a neat pile at TE-NE
(04:45) s2: suggests creating a storage area s1 agrees and starts sliding the pile of tables at W and WNW to the table edge at WSW-W
(04:54) s2: picks up chair from pile at FP-NNW and places it by a table at C-N
(04:57) s2: moves some tables around on the FP at C-N [appears he is looking through them]
(04:58) s1: comments on the different sized tables and suggests that based on the variety of different tables they should have "it kind of random", meanwhile she's arranging a few tables in an empty spot on the FP at WSW
(05:04) s1: "I want to make a little couchy area over here" (glancing towards the tables she just placed at SW), reaching across the table, she picks up a couch from a pile on the FP at ENE of Centre, slides the tables to the north a bit and places a couch at SW (along the FP wall)
(05:08) s2: moves his chair from N to NE
(05:10) s2: picks up an orange couch from pile at FP-C-ENE
(05:14) s2: places couch at FPE-ESE
(05:16) s2: quickly pushes white table at C-E a bit towards centre
(05:17) s1: picks up another couch from the pile at NE of Centre, then puts it along the FP wall at W
(05:19) s2: picks up bs from pile at C-SE and places at FPE-E
(05:24) s2: picks up a bunch of bs's from pile at C-SE and puts them in his other hand while he looks through them with free hand
(05:26) s2: places a bs from hand at FPE-E
(05:29) s1: with a bit of difficulty, she picks up a 2-seater couch from the extra items at NNE of Centre and places it beside the couch at SW
(05:29) s2: repeats at FPE-E
(05:32) s2: repeats at FPE-E and adjusts the bs's already there
(05:34) s2: repeats at FPE-ENE [the bs's are all different sizes]
(05:37) s2: repeats at FPE-ENE
(05:40) s1: she says she wants a "modern looking couch", she sorts through the pile of couches at NE of Centre and picks up another 2-seater to place at WSW, adjusting the couches already there
(05:41) s2: repeats at FPE-ENE
(05:41) s2: repeats at FPE-NE
(05:45) s1: places a chair by the couches at SW-WSW (from her hand), arranging the couches
(05:46) s2: moves a pile of white tables off from FPE-NE to TE-N
(05:47) s2: places another bs from hand at FPE-NE
(05:48) s2: repeats at FPE-NE - long bs
(05:51) s2: slides short bs he placed at FPE-ENE towards centre and replaces it with longer bs from hand - he's now created a pattern between ENE to NE of long bs, short, short, short, long bs
(05:56) s2: now picks up long bs he just placed and puts back in hand, sliding short bs he slid towards centre back into place at FPE-ENE
(06:00) s2: picks up long bs at FPE-NE and moves it beside long bs at FPE-E, adjusting other bs's around it
(06:04) s1: finishes arranging the couches at SW-WSW
(06:06) s1: sorts through the pile of tables at the table edge at W, picking a table to put in the middle of the couches she just finished arranging at SW-WSW
(06:06) s2: puts long bs from hand down at TE-NNE, he slides 2 short bs's from FPE-NNE onto TE and replaces them with the long bs from the TE-NNE
(06:07) s2: puts another long bs from hand at FPE-NNE
(06:10) s2: puts remaining bs[s?] from hand onto TE-NNE
(06:11) s1: the table doesn't fit, so she puts it back in the pile at W and gets another table from the pile to put in the middle of the couches at SW-WSW

(06:18) s2: touches bs pile at FPE-NNW, then picks up a bs from pile at C-ESE, slides orange couch at 222
FPE-ESE towards centre and begins to place bs there - then push couch back to FPE-ESE and places
bs at FPE-SE - pushing a table towards centre, out of the way
(06:23) s2: picks up another bs from pile at C-ESE and places at FPE-SE
(06:24) s2: repeats at FPE-SE
(06:31) s2: repeats at FPE-SE [he ended up using 2 hands to pick the bs since he was having difficulties
picking off the FP]
(06:32) s1: she puts her hand on the pile of tables at the table edge at W, then she tries to fold and rip a
pink postit note from the pad at the table edge at NNW, but has trouble ripping a piece off of the pad, so she
sets is back down at NNW and picks up another table from the pile at the table edge at WSW to put between
the couches at SW-WSW. She rearranges the couches and the tables at SW-WSW, by sliding them around
on the FP surface.
(06:36) s2: picks up another bs from pile at C-ESE, then puts it back in pile and picks up green post-it note
pad from TE-SE
(06:38) s2: peels off a note from pad and puts post-it note pad down at TE-E
(06:44) s1: picks up a table from the pile at table edge at W, and places it in the table/chair arrangement at
SW-WSW
(06:44) s2: picks up pen from TE-NNW, reads from instruction sheet at TE-ENE, then puts note down at
TE-N and writes on it
(06:48) s1: slides a couch on the FP at NW and a couch on the FP at W around the FP with her hands while
she's looking at the FP
(06:51) s1: she releases the couch at NW on the FP and slides the couch at W beside the chair/table
arrangement she has just created at SW
(06:55) s2: picks up note from TE-N, puts down pen at TE-N, puts note down at FP-S, near row of bs's,
saying "It's one of those ladders...you know... to get up high" - s1 says, "on wheels" and s2 nods and says,
"yeah"
(06:58) s1: points to a postit note at S that s2 just placed there as s2 tells her it's a bookshelf ladder, and
she asks if its on wheels and s2 confirms this. She gestures above the bookshelves saying these are really
high bookshelves that go all the way up to the skylights, and s2 agrees.
(07:03) s1 & s2: they discuss the bookshelves at FPE-S for a little while - s1 says, "these are really high
bookshelves, they go up to the sky?" gesturing high above the table - s2 confirms
(07:06) s1: slides the couch at NW to WSW of Centre, near the previously placed couch at SW. As she
does this, she slides some extra tables out of her way to the NW
(07:10) s1: picks up a table from a pile of extra pieces in the FP at NNW of Centre and places it between
the two couches at SW-WSW
(07:10) s2: tidies pile in front of him at TE-NNE, then touches pile at TE-N, then picks up a couch from pile
at TE-NNE
(07:13) s2: places couch in C, and moves a table out of the way a bit
(07:23) s2: picks up some of the orange couch pile at C-ENE and puts them at TE-E and s1 starts getting
some couches from the pile on the FP [s2 appears to abandon clean up once s1's using the pile]
(07:25) s1: sorts through a pile of items at NNW, then asks "where are the couches?", she then leans
across the table to sort through the couches in the pile at NE of Centre, then picks one up to place beside
the couch/table arrangement she just created at SSW
(07:29) s2: fingers orange couch in loose pile at C-ENE while he reads the instruction sheet at TE-ENE,
then removes hand
(07:31) s1: she adjusts the couch/table arrangement at SSW
(07:39) s2: picks up bs from TE-NNE, then puts it back
(07:40) s1: picks up a couch from the pile at NE of Centre and places it near the previous couch/table
arrangement at W of Centre
(07:43) s1: picks up a table from a pile at the table edge at W and places it by the couch at W
(07:47) s1: picks up a couch from the pile of misc items at NNW and places it near the table she just placed
at W
(07:57) s1: starts to move hand towards misc pile [no couches left], then reaches across table to pick up
couch from pile at table edge at E, then places it in couch/table arrangement at W
(07:59) s2: picks up remaining orange couches from FP-C-ENE, piles them first at TE-ENE, then moves
them to beside the pile of orange items at TE-E
(08:01) s1: puts extra couch in her hand back in pile of couches at table edge at E
(08:04) s1: slides extra tables off of the FP at WNW to the table edge at NW
(08:07) s2: tidies up a pile of bs's on the FP at C-NE and moves a white table beside other tables on the FP
at C-SE, and adjusts some small bs's at that spot too
(08:17) s1: picks up bookshelves from a pile near FP wall at NNW, and places WNW of Centre beside the
couch/table arrangement at W (she places 5 shelves from her hand)
(08:19) s2: picks up the pile of bs's from C-NE and moves it to the pile of misc items at TE-NNE (right in
front of him)

(08:26) s1: picks up another shelf from the pile at NNW and puts it with others at WNW
(08:27) s2: as he's picking up stray bs's from the pile at FP C-NE, he slides one to the row of bs's at FPE-NE
(08:30) s2: moves a bs from pile at TE-NNE to FPE-NE
(08:32) s1: picks up a book shelf at N (near pile of bookshelves) that s2 had placed in the FP and places it near others at WNW
(08:35) s2: slides 2 short bs's at FPE-N to TE-N and slides a long bs from pile at FPE-NNW to replace one of them at FPE-N
(08:39) s2: repeats at FPE-N
(08:41) s1: slides a round table from a group of misc items in the FP NNW of Centre to NW, beside the shelves she just placed (she slides it around until she finds the "right" position for it)
(08:48) s2: adjusts some of the items at C-NNW and some of the plants at C
(08:56) s2: moves more of the plants to the C from C-NNW, while reading instruction sheet at TE-ENE
(08:58) s1: she looks like she was going to pick up something from a pile in front of s2 at NNE, but then she picks up some couches from the pile at table edge at E and places them near the other couch/table arrangements at W-WSW and W-WNW
(09:03) s1: puts extra chair she was holding down on table edge in front of her at NW, then picks up a table from the pile at WSW, puts it near a couch at W, then slides it off the FP back into the pile at the table edge at W
(09:06) s1: adjusts a book shelf at WNW
(09:14) s2: continues to move plants from FP-C-NNW to C
(09:15) s1: picks up the chair at the table edge at NW, then slides the table on the FP at NW around the shelves closer to the Centre (WNW of Centre), and puts the chair back on the table edge at NW
(09:21) s1: slides some misc items out of her way on the FP (around NNW), picks up some chairs from a pile on the FP at NNW and puts them around the table at WNW
(09:24) s2: picks up items from pile at FP C-N and makes pile in his hand.
(09:28) s1: she slides chairs from the pile at NNW to the table at WNW a few times, as she's doing so, she says to s2 "I think we need more plants. What do you think?"
(09:30) s2: places a chair from his hand around a couch/study corral at C-ENE
(09:34) s2: repeats twice at C-ENE
(09:35) s2: moves bs from on top of the study corral at C-ENE to one side of it
(09:37) s1: arranges the chairs around the table at WNW and asks s2: "will you make some palm trees?"
(09:37) s2: adjusts plants in C as s1 is talking about needing more plants - she asks him to make some palm trees
(09:42) s2: adjusts chair/corral arrangement at C-ENE
(09:48) s1: slides several more chairs from the pile at NNW to the table at WNW, and suggests that they could have a water fountain, pointing to the Centre where all the plants are
(09:52) s1 & s2: discuss adding a water fountain, s1 wants one and s2 thinks it would be distracting - s2 adjusts plants in C as they are talking
(09:56) s1 & s2: discuss the fountain idea. s2 thinks it might be distracting, s1 thinks that the Centre is a "peaceful retreat" - as they're talking about it s2 is adjusting the plants in the Centre. s1 starts arranging the plants in the Centre as well, shortly afterwards, s2 pulls his hands away. s1 suggests making a labrinth with the plants, where "people could wonder around and get lost"
(10:08) s1: points to an area NNW of Centre and says "I wanted to make a little hedge over here" (there had been one there early on, but it has been dismantled somehow)
(10:11) s2: empties pile of items from his hand onto misc pile at TE-NNE
(10:14) s1: slides a white chair from a pile on the FP at NNW to an empty spot at NW with her left hand and picks up an orange chair from the table edge at WNW with her right hand and places it in the FP at NW beside the white chair. Then she slides the white chair back to the pile at NNW and continues moving the orange chair around at NW.
(10:18) s2: adjusts chair/corral arrangement at C-ENE
(10:25) s2: picks up chair from pile at TE-NNE and places at table at C-SE
(10:27) s1: picks up a chair from around a table arrangement on the FP at WNW, slides several tables from the pile on the FP at NNW into the space at NW until she decides on one table, then she positions the table and places the chair in her hand down beside it (at NW).
(10:28) s2: repeats at C-SE
(10:32) s2: repeats at different table at C-SSE
(10:34) s2: repeats at C-SSE
(10:38) s2: repeats at C-SSE
(10:41) s1: she sorts through the pile at NNW to find two more chairs, she then slides the table arrangement at NW towards her to end up near the FP wall. She then places the two chairs from the pile around the table.
(10:44) s2: repeats at different table at C-S
(10:48) s2: repeats at C-S

(10:54) s2: repeats twice at C-S

(10:56) s1: she slides the orange chair at NNW around the FP near the new table arrangement at NW. She slides it around quite a bit, rotating it, moving it, until she finally positions it near the FP wall at NW.

(11:02) s1: reaches across the table to pick up another orange chair from a pile on the table edge at E, then places the chair beside the one she just placed at NW.

(11:07) s2: picks up chair from pile at TE-NNE, adjusts a bunch of tables on FP at C-N and C-NNE

(11:09) s2: places chair in hand at table at C-NNE

(11:13) s2: repeats at C-NNE

(11:17) s1: she spends quite a bit of time sliding, moves the two orange chairs around on the FP in the NW area.

(11:17) s2: repeats at C-NNE - then adjusts some nearby furniture

(11:20) s1: slides the two orange chairs to the side of the area she's working in (towards the pile at NNW) and slides the table arrange at NW back towards the Centre a little bit. The orange chairs are near the table, but appear not to be precisely positioned.

(11:23) s2: picks up another chair from pile at TE-NNE and places it by table at FPE-NNE

(11:25) s2: adjusts some furniture at FP-N, then watches what s1 is doing for a little while

(11:29) s1: picks up a bookshelf from a pile on the table edge at NNW and places it near the table arrangement NW of Centre

(11:38) s1 & s2: both laugh [perhaps at the awkward silence]

(11:38) s2: picks up chair from FP-C-N and places it at table at C-NNE

(11:41) s1: after hovering her hand over the pile at NW without picking anything up, she reaches across the table to pick up another orange chair on the table edge at E and places it near the other two orange chairs at NW-NNW, once this chair is placed she adjusts the positions of the other chairs.

(11:41) s2: moves a table from C-NNE to C-NE

(11:45) s2: repeats and adjusts some of the table/chair arrangements at C-NNE

(11:50) s2: picks up chair from TE-NNE and places it at a table at C-NNE

(11:53) s1: reaches across table to get another chair from the pile at E and places the fourth orange chair at NW

(11:53) s2: repeats

(11:56) s2: watches s1 for a while

(11:59) s1: adjusts the table arrangement at NW of Centre

(12:03) s1: picks up another bookshelf from the pile on the table edge (actually the pile is covering half on the FP and half on the table edge) at NNW and places it by the table arrangement at NW

(12:04) s2: adjusts the couches at C-N and C-ENE

(12:08) s1: gets another shelf from the pile at NNW and places it at NW beside the other shelf

(12:11) s2: adjusts the chairs and tables at C-NNE

(12:17) s2: moves a chair from C-NNE to a table at C-NE

(12:22) s2: puts chair in hand at table at C-NE

(12:26) s2: laughs - "don't sneeze"

(12:27) s2: picks up couch from misc pile at TE-NNE, then puts it back in pile

(12:28) s1: she repeats this two more times (getting shelf from NNW and placing it at NW), the second time picking up several shelves and placing a couple in the row of shelves at NW

(12:35) s2: picks up chair from pile at TE-NNE and places it at table at C-NNE

(12:38) s2: adjusts other furniture at C-E - C-ENE & C-N

(12:41) s1: she's rearranging the orange chairs at NW, sliding, turning, moving them closer to the new row of book shelves.

(12:45) s2: picks up chair from pile at TE-NNE and places at table at C-N

(12:56) s1: reaches across the table to get another orange chair from the table edge at SE (this chair was sitting separately from the couches in the pile), then places the chair with the others at NW and adjusts them

(12:56) s2: picks up couch/corral at C-N and moves a table and chairs slightly to place it at C-NE - then he adjusts the items he moved over

(13:00) s2: adjusts items at C-NNE

(13:05) s2: rearranges some chairs and tables at C-N

(13:07) s1: reaches across the table to get another orange chair from the pile at E, places it with others at NW.

(13:08) s1: slides some small plants from the pile on the FP at NNW and starts arranging the plants among the orange chairs at NW

(13:13) s2: touches several loose items on FP at FPE-N, then slides a small plant from FPE-N to C, rearranging some of the plants at C

(13:17) s2: repeats

(13:23) s2: tidies up loose items at FPE-N into a pile in that spot

(13:32) s2: moves some items in the pile at FPE-N off of FP to TE-NNE

(13:35) s1: reaches across table to get another orange chair from pile at table edge at E, places it with others at NW and rearranges the cluster

(13:39) s1: slides a small plant from the cluster in the Centre to add to the chair arrangement at NW
(13:40) s2: picks up a few plants from pile at FPE-N and puts them in the table arrangements at C-NNE
(13:45) s1: spends more time rearranging/adjusting the chairs at NW
(13:48) s2: adjusts table arrangement at C-N
(13:49) s2: looks around FP [he's very quiet]
(14:02) s2: moves some chairs from C-N to table arrangements at C-NE
(14:03) s1: slides another small plant from Centre to the chair arrangement at NW, which is now covering and area near the FP wall from NW-NNW
(14:07) s1: pushes/slides a bookshelf and chair on the FP away from har chair arrangement towards a row of book shelves along the FP wall at N. She slides the chair back away from the shelves [it seems out of place right now, probably an artifact from the pile that was once there]
(14:08) s2: moves remaining items from pile at FPE-N to TE-NE (all except one chair)
(14:13) s2: slides remaining chair at FPE-N to nearby table at C-N
(14:14) s2: reads instruction sheet at TE-ENE
(14:23) s2: "it's pretty crowded"...they discuss the scale for a while
(14:25) s2: adjusts a corral arrangement at C-ENE while their talking
(14:29) s1: asks s2 how many book cases they need, she picks up her instruction sheet from SW and reads it then puts it back at SW tucked under the FP, s2 comments on how crowded the room is, s1 says the people are very small!
(14:31) s2: removes a small item [plant?] from C-N to TE-N, then adjusts the table arrangements at C-N - C-NNE
(14:34) s1: adjusts a table arrangement at S
(14:40) s1: picks up a table from a pile on the table edge at NW, looks around the FP, then puts the table back in the pile at table edge at NW, saying "I want more trees"
(14:42) s1: picks up a green postit note pad at table edge at SE, peels off a piece, then puts the pad down at table edge at NW-NNW
(14:42) s2: adjusts a bs at FPE-N
(14:44) s2: touches pile at TE-NNE, tidying the pile at both ends
(14:48) s1: shifts/slides some of the plants in the Centre to the north a bit and places the postit note in the now empty spot (it's mostly surrounded by plants)
(14:48) s2: watching s1 work in C
(14:55) s1: peels off another postit note from the green pad at NW, shifts some Centre plants to the E [moving some couches and chairs that s2 had positioned in the FP out of their positions a bit], puts the postit note on the FP, then rearranges the plants around it
(14:56) s2: laughs at s1's growing garden in C
(14:58) s1: peels another green postit note off of the pad at table edge at NW and places it just NNW of Centre and rearranges the plants around it.
(15:05) s2: adjusts a plant s1 moved in C, then adjust nearby tables at C-N
(15:12) s2: adjusts the tables at C-N when s1 asks, "are those individual seating areas [she points to C-N - C-NE area]"
(15:15) s1: asks s2 if the area he's working on is "individual seating areas"
(15:23) s1 & s2: discuss an unusual item at C-E- s2 says, "it looks like a computer"
(15:23) s1: picks up an item in the FP at SE and asks "what's this?", she puts it back down and s2 says "I don't know. It looks like a computer"
(15:26) s2: goes back to adjusting the table arrangements at C-NNE
(15:27) s1: picks up the "computer" item from SE and says "I'm going to put it on this computer here", placing it on a table on the FP at NW, then adjusts the table arrangement.
(15:39) s1: reaches toward the NE side of the table, then retracts her hand and then adjusts a table arrangement at SE
(15:40) s2: reachs underneath s1's arm to adjust some items at C-E - while she's working at C-SE
(15:45) s1: picks up some tables at the table edge at NW and places them across the table on the FP at ESE, adjusting all the furniture around them in the meantime.
(15:50) s2: picks up item from pile at TE-NNE, looks around, then puts it back in pile
(15:57) s1: picks up two bookshelves that at on the FP at SE
(15:59) s2: puts hand on couch/corral, saying "I think these look like enclosed spaces...you know...booths" s1 agrees
(16:02) s1 & s2: discuss an item in the FP at ENE, deciding it can be a "booth" for studying
(16:05) s2: adjusts bs's at FPE-NNE when s1 says "I don't think we need all these bookshelves [gesturing to the bs's around the FPE on s2's side] - s2 says, "we're supposed to have room for journals..."
(16:11) s1 & s2: discuss "more people or journals?" - s2 reads the instruction sheet at TE-ENE
(16:11) s2: adjusts the table arrangements again at C-NNE
(16:30) s2: moves some loose bs's from FP to TE-NNW, and adjusts the bs's at FPE-N as s1's talking about getting rid of them

(16:35) s1: thinks they have too many bookshelves, pointing to the shelves near s2 - they discuss this for a while. s1 adjusts the journal bookshelves at SSE. s1 wants to remove the shelves from N-ENE and make more room for people. s1 asks if she should put in some study carrels at NE, s2 agrees

(16:37) s2: agrees to s1's plan of putting "carols" along FPE by s2

(16:39) s1: slides the rows of bookshelves at N-NNE off the FP into a pile at NNW

(16:40) s2: starts to slide bs's from FPE-NNE, then let s1's take over

(16:43) s1: continues sliding shelves off of the FP from NNE-NE to the pile at NW

(16:44) s2: sorts through items in pile at TE-NNE

(16:45) s1: picks up a "study carrel" from the FP at NNE of Centre and put is along the FP wall at N

(16:49) s2: moves couch/carol from C-ENE to FPE NE

(16:50) s2: moves chair from C-NNE to carol at FPE-NE

(16:51) s1: picks up another carrel from the FP at ENE (leaving chairs on the FP that were arranged around it) and places it near the other carrel at N

(16:52) s2: slides chair from C-NE to FPE-NE

(16:54) s1: slides another carrel from a pile at the table edge at N onto the FP and arranges it with the others at N (she spends some time on this)

(16:56) s2: repeats - then adjusts the chairs

(17:13) s2: picks up couch/carol from pile at TE-NNE, adjusts the carol arrangement at FPE-NE, then places the carol in his hand on FPE-NNE, beside where s1 is working

(17:15) s2: slides loose chair from FPE-NNE to carol at FPE-NNE

(17:19) s2: picks up chair from misc pile at TE-NNE and puts at carol at FPE-NNE

(17:20) s1: slides some chairs from a table arrangement at N-NNE over to N to arrange around her carrels. She continues to do this, pulling lots of chairs away from table arrangements at NNE for her carrel arrangements at N. Once, she started to take a chair at NNE that s2 had just placed there in his own carrel arrangement that he was creating, but she stopped and took a chair from nearby.   She's arranging her study carrels perpendicular from the FP wall and s2 is arranging his tangential to the FP wall. They both spend quite a bit of time setting up these carrel arrangements.

(17:22) s2: repeats

(17:26) s2: pushes table arrangements at C-NNE - C-NE towards centre a bit

(17:31) s2: picks up carol from pile at TE-NNE and puts beside (just to centre of) carol at FPE-NE

(17:36) s2: picks up carol from pile at TE-NNE, pushes table arrangements at C-N - C-NNE towards the centre a bit, then places carol just to centre of carol at FPE-NNE

(17:46) s2: picks up chair from pile at TE-NNE, starts to place it at carol at FPE-NNE, then rotates the carol, then rotates the carol at FPE-NE, then places the chair in hand at C-NE (a carol)

(17:49) s1: pauses to look at her carrel arrangement and what s2 is doing.

(17:50) s1: begins adjusting her carrel arrangement at N again

(17:54) s2: picks up chair from pile at TE-NNE and places it at C-NE at carol

(17:57) s2: repeats

(18:04) s2: picks up chair from pile at TE-NNE, then moves hands away as s1 is getting something in the pile, then drops chair back in the pile when she's done

(18:09) s1: places the chairs in her carrel arrangement at N-NNW

(18:09) s1: reaches in front of s2 to pick up some chairs in a pile at NNE. s2 pulls his hands back a little from the table as she does this (actually putting one hand on his knee).

(18:15) s2: picks up plant from TE-NNE and places beside carols at FPE-NNE

(18:19) s1: she shifts the orange chair arrangement, by sliding the items on the FP, at NNW a little south, closer to NW, the spends a bit of time adjusting the arrangement

(18:20) s2: picks up chair at TE-NNE, places at carol at C-NNE

(18:24) s2: repeats twice

(18:31) s2: picks up bs from TE-NNE and places between carols at FPE-NNE

(18:35) s2: repeats at FPE-NE

(18:42) s2: places bs from TE-NNE behind carol at FPE-NNE

(18:46) s1: she's looking around the table edge for something "is there another one of those things", then she picks up another "carrel" from a pile of chairs/couches at the table edge in front of s2 at NNE (she reaches her hand just to the left of s2's hands, which are currently working on a carrel arrangement at NNE - he doesn't visibly react to her reaching for the "carrel")

(18:46) s2: repeats at FPE-NE

(18:47) s1: places the "carrel" at NNW, then places chairs at the carrel from her hand (she's been holding them for a while). She spends some time adjusting the carrel arrangement.

(18:52) s2: looks around FP

(19:03) s2: adjusts some table arrangements at C-NNE - C-NE - creating a little pile of tables at C-NE [not sure what he's doing, but he looks bored]

(19:21) s1: adjust the carrel arrangement at N

(19:22) s2: adjusts bs's at FPE-E

(19:26) s1: picks up a table from the FP at NE of Centre and puts it between the carrel arrangements at N

(19:32) s1: picks up some chairs from the FP at NNE of Centre and arranges them around the table at N

(19:34) s1: picks up another chair from the FP at NNE of Centre and looks over at what s2's doing in the workspace at WSW of Centre (he's adjusting her couch/table arrangements). She laughs.

(19:36) s2: picks up orange couch from C-E and puts it in s1's couch arrangement at C-W - she laughs [probably because it takes him awhile to figure out where it might fit]

(19:37) s1: places the chair at the table at N

(19:43) s2: looks around the room and out the door [there was a noise in the hallway]

(19:44) s1: picks up another table from NNE of Centre and places it between her carrel arrangement and s2's carrel arrangements near the FP wall at N, then arranges some chairs around it from a pile she's holding in her hand.

(19:45) s2: puts a chair which he had in his hand down at TE-NNE

(19:52) s1: looks at the FP, saying "it is pretty packed." She points to the E section of the FP, saying "there's all that room over there", she slides some of the furniture items in the NNE of Centre area (left over from things s2 has positioned and s1 taking some of the tables and chairs away to use in her carrel arrangement at N). s2 suggests putting a "big table" in the E area.

(19:56) s2: adjusts bs's at TE-E after s1 points out a big empty space at C-ENE

(20:05) s1: adjusts the position of a table in the NE area while s2 moves some items around as well (more to the E)

(20:06) s2: says, "...put a big table there or something..." he picks up a table from the pile at TE-NNE and places it at C-E

(20:09) s1: gathers a whole row of bookshelves along the FP wall at NE-E in one sweep of her hand, saying "we can get rid of these shelves" and puts them on the table edge in a pile of bookshelves at NNW

(20:10) s2: rearranges some tables and chairs at FE-NE-ENE

(20:13) s2: picks up a table at C-NNE and holds it as s1 is working at TE-NE-E

(20:17) s2: puts table down at C-N

(20:19) s1: picks up two stray shelves from E and puts them in the pile at NNW, while she's doing this she points to a carrel arrangement that s2 made at NNE and says"you can't put a bookshelf in there" s2: ["it's a little one"] s1: "It'll block people in..."

(20:20) s2: touches several items at TE-NE as he's talking to s1

(20:27) s1: she's holding a chair in her hand, fiddling with it looking around at the FP

(20:29) s1: puts down the chair on the table edge at NW and peels a green postit note off a pad at NW-NNW

(20:31) s1: puts the postit note down on the FP at N-NNW, just beside the edge of the plant arrangement

(20:34) s2: "what the hell is that?" referring to the plant area s1 is working on

(20:36) s1: adjusts some chairs beside the plant arrangement at N

(20:36) s2: watches s1 arranging the plants/chairs and says "what the hell is that?", s1: "this is a garden area" (gesturing her hand above the plant arrangement)

(20:41) s1: "I'm going to have a little pond in it", she reaches across the table and peels a blue postit note off a pad at the table edge at SSE, then places the postit note near the Centre and adjusts the plants/green postit notes around it

(20:54) s2: picks up a blue postit note pad from TE-SSE and looks around the FP

(20:58) s2: peals a piece off the postit pad, puts the pad down at TE-NE (in front of him), picks up the marker at TE-N, puts piece down in front of him at TE-NE and writes on it

(20:59) s1: as she's adjusting the plant arrangement she says: "now it's going to need places to sit"

(21:09) s1: still arranging the plant area in Centre/NE of Centre, and says "this is the inspiring portion"

(21:13) s2: after writing on the postit notes, he examines the writing on the marker, then sets it back down at TE-N

(21:14) s1: picks up a chair from the FP at NNE and places it in the plant arrangment N of Centre, adjusting the plants again

(21:23) s1: picks up another chair from NNE of Centre and places it N of Centre, then adjusts arrangment again

(21:29) s1: picks up another chair from E of Centre and puts it in the plant arrangement at Centre

(21:36) s2: picks up the postit piece at TE-NE, rips bits off, placing the extra bits at TE-NE, then puts the smaller piece at FE-SE

(21:40) s2: sits back and surveys the FP

(21:43) s1: picks up another chair from ENE of Centre and then a plant from the arrangement at E of Centre and puts the plant down in the carrel arrangement at NNE and then the chair down in the plant arrangement at Centre

(21:48) s1: rearranges a bunch of plants/chairs/tables in the area just NNE of Centre (on the edge of the plant arrangement) and slides a table not in her arrangement a little to the E

(21:52) s2: picks up a table from TE-NNE, then moves his hand out of the way as s1 is picking up an item in TE in front of him at TE-NE

(21:53) s1: picks up some chairs from a pile in front of s2 at the table edge at NNE, s2 leans back a little

(21:54) s2: puts table in hand down at FE-E
(21:55) s1: she adds the chairs to the plant arrangement at Centre, adjusts the items nearby and slides some chairs/tables not in the arrangement a little to the E
(21:57) s2: picks up another table at TE-NNE and places it at FE-ENE
(22:01) s2: adjusts some items at TE-NNE
(22:05) s1: leans back an surveys the FP
(22:11) s2: picks up a study coral from TE-NNE, adjusts the table he just placed at FE-ENE, sets the study coral down at FE-ENE and pushes aside the table a bit, so it is a little randomly placed [it seems like he's still trying to figure out a plan for the furniture in this area]
(22:14) s2: picks up a chair from TE-NE and places it at the study coral at FE-ENE
(22:16) s1: adjusts the plant arrangement, picks up a table from the miscellaneous items to the E of Centre and adds it to the plant arrangement at Centre/N of Centre
(22:19) s2: repeats once
(22:23) s1: picks up a chair from the misc items to the E of Centre and adds it to the plant arrangement at Centre/N of Centre, adjusts arrangement
(22:24) s2: looks across table at orange and pink couch and table arrangement s1 made. He picks up a pink table from one of the sets at C-W and puts the table down at TE-N
(22:27) s1: pulls a plant that's sitting on the FP E of Centre into the arrangement at Centre
(22:29) s2: picks up another chair at TE-NE and places it at the study coral at FE-ENE
(22:31) s1: leans back and looks at FP
(22:36) s1: adjusts a couch arrangement at WSW that s2 has been adjusting
(22:36) s2: reaches across the table to pick up an orange couch from C-WSW and places it with the table he removed at TE-N
(22:40) s2: he's looking at the orange couch arrangement across the table
(22:48) s1: picks up a couch from a pile in front of s2 at the table edge at NNE and puts into the couch arrangements at WSW and adjusts them
(22:49) s2: "what else do we need?"
(22:52) s2: asks what else they need, s1: "I don't know, what do we have?"
(22:54) s1: picks up a table from a pile at table edge at W and places it on FP at W in a couch arrangement, then picks it up again, gets another table from the pile at W (smaller) and places it in the couch arrangement at W, adjusts the couch arrangements
(22:55) s2: reads instruction sheet at TE-ENE
(23:04) s1: picks up another table from the pile at W and puts it in the couch arrangement at W
(23:08) s1: looks around at the FP
(23:15) s1: reaches across table to re-arrange some cubicle arrangements in front of s2, near the edge of FP at NE (they where cubicle's)s2 had originally positioned)
(23:18) s2: picks up another study coral from TE-NE and places at FE-ENE
(23:21) s2: picks up a chair from TE-NE and places it at the coral at FE-ENE
(23:24) s1: picks up plant from unfinished FP area at C-NE and puts it in area she was just arranging at NE - she creates a table and chair arrangement out of the furniture that was there.
(23:29) s2: repeats twice
(23:30) s1: adjusts some more furniture of the cubicles that s2 created. She's working directly in front of him, near the FP edge at NE, he's working off to his left (near E), but he's watching what she's doing.
(23:35) s1: more adjusting of furniture in the area in front of s2, still in NE
(23:42) s1: sliding tables and "cubicles" around on the FP at NE, then leans back (s2 is working at NE now, adjusting the furniture that s1 was just working on)
(23:44) s1: leans around s2's hands (he leans back) and adjusts what he was just working on - she adjusted his work, then he adjusted hers, then she adjusted his
(23:44) s2: adjusts several items at FE-NNE
(23:47) s1: points to a green post-it note in the "garden" area in C-NNW asks s2 something "Did you ..." [can't make out the rest]
(23:48) s2: points to the windows along the FP edge saying something [can't hear it]
(23:49) s1: "those are windows"
(23:49) s2: points to FE wall at FE-NNE to FE-NNW asking "what are these?" - s1 says "those are windows"
(23:53) s2: looks around FP, watches s1 arrange furniture across from him
(23:54) s1: adjusts the seats and plants directly in front of her near FP edge at NW for quite some time (until 24:14)
(24:07) s2: picks up a round table from TE-NE and places it at FE-NE
(24:09) s2: picks up a chair at TE-NNE, adjusts the items around the table he just placed at FE-NE to make room for the new table arrangement, then places a chair at the table
(24:16) s1: starts to adjust bs's at W, puts her hand over them, then takes hand away, looking at them
(24:18) s1: adjusts table on FP at C-WNW
(24:20) s1: picks up table from pile on table edge at WSW and puts it on table near table she was just adjusting at C-WNW

(24:26) s2: picks up another chair from TE-NNE and places it at the table at FE-NE
(24:28) s1: looks around table for chairs, hesitates to reach towards s2, then reaches under s2's hand to get chairs from a pile in front of him at NNE
(24:36) s1: puts the chairs around the table at C-WNW, saying something about the garden area [can't make it out]
(24:42) s2: adjusts the items at FE-NE, then picks up a chair at TE-NE and places it at round table at FE-ENE
(24:44) s1: adjusts chairs around the other table at C-WNW
(24:44) s2: repeats once
(24:46) s1: puts spare chair in her hand down on table edge at NNW, then reaches across to get another chair from the pile in front of s2 at NNE
(24:49) s2: picks up another chair at TE-NE and places it at a round table at C-ENE
(24:53) s2: repeats once
(24:54) s1: places chair around table at C-WNW
(24:55) s1: reaches across table to get another chair from pile at NNE, asks s2 what the item is that she just picked up....he laughs, saying "I don't know"
(24:58) s2: picks up another chair at TE-NE, holds it as s1 is rooting through the pile at TE-NE in front of him
(25:03) s1: "I'll put it on the table here" she puts item on table at C-WNW, saying "this will be our alien section"
(25:04) s2: adjusts the pile in front of him at TE-NE
(25:08) s1: looks around table edge, then reaches across again to get chair from pile at NNE, in front of s2
(25:14) s2: looks at the chair in his hand when s1 comments "I'm missing a rolling chair" as she's rooting through his pile at TE-NE, he offers her the chair by holding it towards her, but she's already found one, so he puts his back down at TE-NE
(25:16) s1: she searches through the pile of items, saying "I just need one more chair" - s2 offers her the chair in his hand, then puts it down in the pile when she doesn't take it (she has one in her hand). s1 places the chair in her hand at the table at C-WNW
(25:20) s1: adjusts the chair/table arrangement she just created at C-WNW, then adjusts some chairs around a table beside it.
(25:25) s2: he picks up a couple chairs from TE-NE and looks at the FP [possibly waiting from s1 to move her arm since she's reaching across the table for something]
(25:27) s1: reaches across table to get a couch from the table edge at SE
(25:27) s2: he places one of the chairs at a table at C
(25:30) s2: places another chair from his hand at another table at C
(25:31) s1: looks around table, reaches across again and picks up another couch from pile at SE
(25:32) s1: puts couch near couch/table arrangement at C-SW and adjusts it in the FP
(25:38) s2: picks up more chairs from TE-NE and places it at a table at C-SSE [he's just placed a lone chair at 3 different tables]
(25:40) s1: removes couch she just placed at C-SW
(25:40) s2: places a chair from his hand at the same table at C-SSE
(25:43) s1: picks up little table from pile at table edge at SW and places it in FP where she just removed the couch from at C-SW
(25:45) s1: picks up another table from pile at SW and places it at SW on FP
(25:46) s2: picks up another chair from TE-NE and places it with the other 2 at the table at C-SSE
(25:49) s1: adjusts some of the couches at SW
(25:54) s1: places a couch from her hand in the FP at SW and adjusts it
(25:56) s1: picks up the couch she just placed again from SW
(25:58) s2: picks up more chairs from TE-NE, looks at the FP
(25:59) s1: places other (smaller) couch from her hand in the place she just removed a couch from at SW
(26:12) s2: places the chairs at a table at C-SE and adjusts several table arrangements in that area and in FE-E
(26:13) s1: adjusts 2 chairs at W, then slides it right off FP to table edge, and also puts down the couches in her hand on table edge at NW
(26:15) s1: picks up one of couches she just placed on table edge at NW and puts it in spot she just removed chairs from at W on FP, slides it off FP, then puts the chairs from the table edge at W back onto the FP at W
(26:23) s1: looks around table, reaches across table to pile of couches at N, touches the pile, then picks up couch on table edge at W and places it becide the two chairs on FP at W, adjusting the arrangement
(26:27) s2: roots through pile of items (all mixed together) at TE-NNE to find more chairs
(26:28) s2: adjusts a table arrangement at C
(26:30) s2: adjusts the plant/chair arrangement in the C, saying "I don't know about this area here ... it seems random"
(26:31) s1: watches s2 adjust furniture in the C. s2 says something

(26:35) s2: he adjusts some items at C-NE
(26:38) s1: readjusts the furniture in the C, saying "it's supposed to be like....hidden reading nooks, in the park"
(26:42) s2: places two chairs from his hand at a table at C-ESE
(26:46) s1: adjusts the C furniture some more, saying "it's supposed to be for deep reading"...s2: "ok"
(26:51) s2: places a chair from his hand at a table at C-E
(26:57) s1: explains her design to s2...."I tried to use the plant life to buffer the human contact", s2 nods and laughs
(27:05) s1: points to the couch/table arrangements at W to SW, saying "over here it's a little a maze"
(27:05) s1: tidies the pile of tables on the table edge at W
(27:07) s1: reaches towards a furniture arrangement at SW, then leans back and laughs and points to it, saying "what's that?"
(27:16) s2: places another chair from his hand at a table at C-E
(27:18) s2: puts the remaining chair in his hand down at TE-NNE and picks up another chair at TE-NE and places it at a table at C-E
(27:21) s1: adjusts plants at C, saying something about the plants buffering the noise [she waves her hands over the group arrangements at C-NW], s2 agrees, the trees are like a canopy [he waves hands over C], s1 agrees indicating with her hands that she wants big trees in the garden
(27:27) s2: he talks with s1 about the center area and then he adjusts a pile at TE-NNE
(27:29) s1: picks up marker at table edge at NNW and draws/writes on one of the postit notes in the garden
(27:40) s1: hands marker to s2, saying "can you make some trees?", s2 takes marker, s1 puts marker cap down at TE-N
(27:41) s2: takes the marker that s1 is handing him as she asks him to make some trees
(27:43) s1: starts to reach across table, then starts adjusting table arrangement at C-S - she adjusts the table location and the chairs around it - sliding them on the FP
(27:44) s2: draws a tree on a postit note placed at C
(27:54) s1: looks around the TE at N, then goes back to working on table arrangement at C-S - commenting to s2 on plants he drew "...those are pretty..."
(28:00) s1: adjusts plants near the table arrangement at C/C-SSE then continues to adjust the table arrangement at C/C-S, sliding some chairs from the table arrangement made by s2 at C-SSE
(28:00) s2: moves out of s1's way as she's adjusting plants in C
(28:07) s2: draws on a postit note at C-NNW
(28:12) s2: says there "should be an observation deck" and gestures around the tree area in the center
(28:14) s1 & s2: discuss an observation deck around "the rim" of the room
(28:19) s1: starts to reach towards the table arrangement at C-SSE, then picks up some chairs from the pile in front of s2 at TE-NNE [s2 leans back in his chair while she's doing this]
(28:25) s1: hands s2 a pad of post-it notes (he takes it) from TE-NNW in response to s2 saying something about the centre area. She says, "...there's more here..." as she hands him the pad
(28:26) s1: places the chairs in hand at the table arrangement s2 made at C-S - she slides another table arrangement at C-SSE away (to SSE) from the one she's working on
(28:27) s2: reaches for the postit note in the C that he drew on, then s1 hands him a pad of green postit notes and he takes it from her
(28:28) s2: draws on a postit note at C-NNW as s1's working across the table from herself
(28:33) s1: reaches over s2's arm to pick up more chairs from the pile in front of him at TE-NNE [for a while he continues what he's going and does not seem visibly affected by this - even when at one point she had both hands in the pile, then he pulls his arm back and watches her, then he starts reading the instruction sheet]
(28:35) s2: continues to draw at C-NNW as s1 reaches over him to get some items from the pile in front of s2
(28:41) s2: stops drawing and leans back as s1's still rooting through the pile at TE-NNE [I think he's done drawing]
(28:46) s1: places the chairs in hand at the table arrangement at C-S
(28:59) s2: adjusts an item at FE-NE
(29:06) s1: "can we rotate the ... the thing?" [referring to the FP] they start turning the FP on the table, using their fingertips, then s1 points to the table arrangements that were at SE (the area furthest away from either of their positions) saying "so we can do that side"
(29:11) s2: moves his information sheet and a postit note pad from the table at TE-ENE (he holds the sheet and puts the pad down at TE-NNE) and then helps s1 rotate the FP with his free hand
(29:26) s2: puts the sheet down on the chair seat to his left and uses both hands to rotate the table
(29:29) s1 & s2: they laugh as they are rotating the FP and move some of the item on the TE away from the FP as its rotating so they don't get caught - s2 moves the instruction sheets to a chair beside him - they rotate the FP about 100 degrees counter-clockwise - the area that was in front of s1 is now at the far side between s1 and s2 at ~SSE, the area that was in front of s2 is just to the right of s1 and the table area that s1 indicated she wanted to work on is now at ~N, between them

(29:34) s2: picks up s1's information sheet from the TE-SSW as s1's rotating the FP and puts it on the seat beside him with his info sheet

(29:37) s2: adjusts the items on the TE-N to TE-NNE that were disturbed by the rotation of the FP

(29:41) s1: "I guess there's no real path here...maybe there should be a path right through the middle - she removes a post-it note from C (a "tree") - she puts it down at C-E, then picks it up again, looking at the centre arrangement

(29:45) s1: puts the post-it down at TE-WNW and adjusts a table arrangement at C-SE

(29:47) s2: agrees there should be a path

(29:49) s2: discusses the flow of the room with s1 and he adjusts some items at FE-NNE and C-NNE

(29:50) s1: takes some plants out of the C and puts them with the plants forming the entrance path at C-ENE

(29:51) s2: removes a table from C-NNE and puts it in the pile in front of him at TE-NNE

(29:52) s1: "...I think that's why we needed to rotate the..."

(29:52) s2: "I know what you mean..."

(29:56) s1: puts the post-it at TE-WNW back on the FP at C/C-N "I still think there should be a tree right here..."

(29:57) s2: removes a table from C-N and puts it down at TE-NNE

(30:02) s1: adjusts the plants around the postit at C-N, then adjusting the plants at the entranceway (sliding a plant from C-N to add to the plant row at C-ENE)

(30:03) s2: sits back and looks at FP, and comments to s1 with a directional gesure down the path between an isle of plants at FE-E to C-E

(30:06) s1: "yeah, this is how you get to the individual..." gesturing over the centre area and adjusting the table arrangement at C/C-W

(30:06) s2: "that's nice" gesturing down the entranceway path across the centre

(30:10) s2: starts adjusting the furniture in the orange couch arrangement that is now on his side of the table at FE-E/ESE to C-E/ESE, saying this "looks pretty packed in"

(30:16) s2: removes an orange couch from C-ESE and puts it on the pile of orange couches at TE-E, explaining that "they need room to move around and wave their hands"

(30:19) s2: adjusts some more of the orange couch arrangement at FE-E/C-E

(30:23) s1: adjusts a couch arrangement at C-E [where s2 is making changes]..."I think that they're very small..." [refering to the people]

(30:27) s1: adjusts some more at C-E, saying "maybe the tables could be a little smaller and that would help"

(30:27) s2: removes another couch from FE-E and puts it on the pile at TE-E

(30:40) s1: after adjusting more and saying "the tables are dining-room size...", she asks "do you think that's better?" - s2 agrees

(30:45) s1: adjusts the table arrangement at C-SE and the plants at C-ENE (both just beside the couch area)

(30:47) s2: adjusts a chair at a table s1 just adjusted at C-E

(30:55) s1: she's describing the area at SE to S to s2 (she created that area)

(31:01) s1: adjusting plants in C

(31:06) s1: picks up marker from TE-N - "...and maybe a little bridge here..." she draws on a post-it note in C

(31:12) s2: "I think we need reading lamps"

(31:16) s1: "yeah can you make those green reading lamps like they have in the movies?...at those serious European libraries..." (she's still drawing the bridge in the Centre)

(31:19) s2: suggests they need reading lamps, picks up a blue pad of postit notes from the table at TE-NNE, puts it back down at TE-NNE to draw some lamps - s1 requests "green European reading lamps"

(31:32) s1: adjusts some plants at C

(31:40) s1: adjusts table arrangements at C-W

(31:43) s1: laughs at s2's "big" reading lamp

(31:44) s2: peels off the piece he's drawn on from the pad at TE-NNE and holds the postit over the FP around C-E, then tosses it on the table at C-S

(31:45) s2: picks the postit lamp up again from C-S, laughs and says "it's too big" he puts it down at C-SW, s1 says "maybe it can just be a concept", then s2 picks up the postit note again

(31:51) s1: "maybe it can just be a concept"

(31:57) s2: he hovers over the table with the postit note, then the exp asks if he wants a pair of scissors, he says yes

(32:05) e: gives them a pair of scissors

(32:05) s1: "maybe we can trim the coffee tables too..." pointing to the couch arrangement at C-SE

(32:06) s2: picks up the scissors from C-E, where the exp placed them - s1 suggests the trim the coffee tables too

(32:17) s1: puts the marker down at TE-NW and adjusts a post-it note at FPE-NE

(32:24) s1: adjust plants and post-it note tree at C-N

(32:29) s1: places the lamp that s2 put on the FP on a table at C-NW

(32:29) s2: trims the postit note in his hand, placing the excess paper at TE-NE, then places the lamp on the table at C-W near a table, s1 places it on that table

(32:34) s2: puts the scissors down at TE-N, picks up the marker at TE-N, then picks up the green pad of postit notes from TE-NE, he clears some items out of his way at TE-NE, then puts the postit note pad down there and draws another lamp

(32:39) s1: removes a bs from the study correl arrangement in front of her at FPE-NW (s2 created these arrangements), saying "maybe these booths have lights built into them like at the King's library..." and puts the bs in the pile of bs's at TE-NNW

(32:43) s1: adjusts the correl arrangements at FPE-NW/NNW - sliding furniture around until she's satisfied - totally rearranging parts of it at FPE-NNW

(32:44) s2: draws two lamps on one piece of postit note on the pad at TE-NE

(32:44) s2: peels the piece with the lamp on it off the pad at TE-NE and places the piece aside just to the left of where's he's working (at TE-ENE)

(33:00) s1: she sneezes and then takes the 2 bs's out of the arrangement again, sliding them off the FP to TE-W

(33:17) s2: peels the postit off the pad at TE-NE, sets the marker down at TE-NE, picks up the scissors at TE-N, cuts out one lamp, placing beside the previous lamp at TE-ENE, then trims out the other lamp on the piece in his hand

(33:26) s2: he places the excess paper from the trimming in the pile at TE-NE and places the 2nd lamp at TE-ENE

(33:32) s1: removes another bs from a correl arrangement at FPE-W (still s2's original arrangements I think), saying "do we need these bookcases?"

(33:38) s1: removes another bs from FPW-W, she put the bs's at TE-W and readjusted the correl arrangements at W

(33:40) s2: he picks up the 1st lamp he set down at TE-ENE and trims off the excess paper, letting the trimmings fall again at TE-NE, and placing the cutout lamp beside the others at TE-ENE

(33:42) s2: puts down the scissors at TE-E

(33:52) s1: picks up one of the bs's at TE-W and repositions it in the correl arrangement at FPE-W

(33:54) s1: picks up the other bs at TE-W and repositions it at FPE-W as well

(33:57) s2: picks up the marker at TE-NE, moves some of the excess trimmings off the postit note pad, putting them just to the side at TE-NE, then draws more lamps on the postit note pad at TE-NE

(34:01) s2: peels the piece of postit note off the pad and sticks it to the table at TE-ENE

(34:03) s2: draws more lamps on the postit note at TE-NE

(34:07) s1: adjusts plants in C

(34:10) s1: removes 2 plants from C

(34:14) s1: adjusts a post-it note in C

(34:17) s1: tries one of the plants in hand at C-WSW, then picks it up again and slides a chair from C-W to C-WSW

(34:20) s2: peels the piece of postit note off the pad at TE-NEand sticks it to the table at TE-ENE

(34:22) s1: now adds a plant to C-WSW from her hand and adjusts that whole plant/chair area

(34:26) s2: picks up the scissors at TE-E, sets down the marker at TE-NNW

(34:37) s2: picks up a piece of postit from TE-ENE and trims out the lamps, placing the cutout lamps at TE-ENE and the trimmings at TE-NE (he's just letting them fall under where he's working)

(34:41) s2: stops cutting to listen to s1 talk about the area at C-SW that she's working on

(34:42) s1: adjusts a chair near the Centre - beside the bridge and says "well that's like the best seat in the whole place..." and s2 looks over at what she's doing

(34:45) s1: in response to s2's query about the bridge she created, "it's a bridge over the pond...so that people can go through this way" gestures over the bridge

(34:46) s2: points to an item at C with the scissors and says "what's that" s1 explains it's a bridge over a pond

(34:47) s2: continues cutting out his lamp, letting the trimmings fall at TE-NE, and placing the lamp at TE-ENE

(34:49) s1: adjust the C-W area again, moving plants and tables around

(35:01) s2: picks up the other piece of postit note at TE-ENE and trims out the 2 lamps

(35:12) s2: places one lamp at TE-ENE, continues cutting

(35:18) s1: still adjusting C-W - she adds the 2nd plant from her hand into the area

(35:21) s2: places the 2nd lamp at TE-ENE

(35:23) s2: sets the scissors down at TE-E

(35:25) s1: picks up small plant from C-SW

(35:30) s2: picks up several lamps from the pile at TE-ENE, holding them over the FP, saying "where should we put the lamps?"

(35:34) s1: adjusts plants in C-SW,C-W area

(35:35) s1: points to a few tables at C-NE and C-ESE

(35:37) s1: points to tables at NE and SE in response to s2 asking where to put the lamps he's made
(35:40) s2: places a lamp on a table at C-ESE
(35:43) s1: "...there's a skylight, but I guess it gets dark at night everywhere..." adjusts a table arrangement at C-NW
(35:45) s2: places a lamp on a table at FE-N
(35:49) s2: places a lamp on a table at C-NW
(35:50) s2: places a lamp on a table at C-N
(35:53) s2: repeats at C-NE
(35:56) s1: adjusts another table arrangement at WNW, adding chairs from her hand around the table - pushing the tables and other furniture on the FP nearby out of the way a little
(35:59) s2: repeats at FE-NW and C-NNW
(36:03) s1: picks up an item from the FP at WNW - "...here's another one of those inexplicable objects..." she places it on a table at C-S, beside the other one she had placed earlier in session
(36:16) s1: adjust furniture at C-NW, then asks s2: "do you want to put yourself in here?"
(36:18) s2: sits back and watches s1 continue adjusting items
(36:22) s1: picks up lamp item s2 placed at C-NNW - "...are these [clampy?] lamps, oh these are those green, European lamps..." she places it on a table at C-W
(36:26) s1: adjust furniture nearby at C-W, C-NW - spends sometime moving furniture around - loose tables and chairs
(36:34) s2: picks up the marker at TE-NNW and writes something on a postit note at C-SSW
(36:45) s2: "...it's charming...", s1: points to plant arrangement at C to SW, "this area?" - s2 nods
(36:50) s1: adjusts arrangment at FPE-N
(37:03) s2: sets the marker down at TE-N [he's looking very bored]
(37:07) s1: picks up items from FP-NW and puts them into a pile at TE-NNW
(37:10) s1: spreads table arrangements at C-NW into the empty FP space she just made at NW - she spends some time adjusting these
(37:14) s2: moves some small plants from the C area to the orange couch arrangement at C-E/FE-ESE
(37:30) s1: leans back and looks a the arrangement she just made at NW
(37:38) s1: adjusts a chair at NW, then a plant at C
(37:43) s1: adjusts the plant at C again
(37:47) s1: looks for something at pile at TE-NNW, then leans across the table to pick up a green post-it note from the pad in front of s2 at TE-NNE
(37:53) s1: places the green postit note at C-NNW, beside one that's already there, and puts the other postit note she picked up [which has been cut up by s2] down at TE-N
(37:53) s1: reaches across to TE-NNE to pick up another green postit note, places it at C-NW, repeats once
(37:53) s2: picks up a postit note at FE-NE, picks up the scissors at TE-E and trims the postit note, placing the trimmings near the others at TE-NE and the cut out item back at FE-NE
(37:59) s2: replaces the scissors at TE-E
(38:04) s2: picks up the marker from TE-N and a postit note pad from TE-NE, peels a piece of the pad, replaces the pad at TE-NE, places the piece down at TE-NNE and starts writing on it, saying ..."maybe this should be ah...a washer [???]..."
(38:06) s1: picks up chair from pile at TE-N, places it in middle of postit notes at C to C-NW
(38:17) s1: picks up another chair from pile at TE-N and places it at C-NW among the postit notes - spends some time adjusting this arrangement
(38:19) s1: "....like a water cooler?..."
(38:32) s2: finishes drawing, sets the marker down at TE-NNE, picks up the postit piece, picks up the scissors at TE-E, and trims the piece
(38:39) s1: adjusts table arrangement at NW
(38:46) s1: watches s2 hover over FP with item, points to FP-door at E, "...maybe put the door...or maybe in the oasis...[pointing to the plant arrangement at SW]..."
(38:46) s2: lets the trimmings fall to TE-NE, then places the water cooler with the isle of plants at C-E
(38:50) s1: picks up chair from pile at TE-N and places it in plant arrangement at C-SSW, then adjusts this new arrangement, then neighbouring arrangement at C-NW
(38:55) s2: adjusts some items at FE-E
(39:09) s1: picks up another chair from pile at TE-N and places it at C-NW
(39:12) s1: repeats
(39:12) s2: picks up the marker from TE-N and writes on a postit note at C-NW
(39:16) s1: watches s2 write on the green postit notes at C-NW, "...this is the reading jungle..."
(39:23) s1: picks up another postit note from TE-NNE and places it C-W
(39:28) s1: picks up chair from TE-NE [right in front of s2], places it at C-NW
(39:32) s1: repeats at C-N
(39:34) s2: crumples up the trimmings at TE-NE and puts it across the table at TE-SE
(39:36) s1: adjusts table arrangement at NW

(39:51) s1: picks up round table at C-N, looks at FP in front of her at NW which holding chair, adjusts table arrangement again - she begins to rotate, drops the table in her hand at TE-NW, then uses both hands to rotate the arrangements

(39:58) s2: looks around [looks very bored]

(40:00) s1: adjusts items at FPE-N, then reaches across the table in front of s2 to pick up some items from a pile at TE-NE, saying "...steal some of these..." - s2 tries to help her get things from the pile

(40:02) s2: picks up a small plant from TE-N and places it in the orange couch arrangement at C-E

(40:03) s1: leans back from table to look at FP

(40:06) s1: adjusts table arrangements at FPE-N

(40:06) s2: repeats at C-SW

(40:29) e: asks if they think they are done

(40:29) s2: "I think so..."

(40:34) s1: "...yeah sure....well I'm not really done..." (she's still rearranging the table arrangement at FPE-N)

(40:40) s1: pushes unwanted tables off the FP into the pile of misc items at TE-N

(40:49) s2: cleans up the area right in front of him on the FP because a bunch of extra stuff has gotten pushed into the bs's along the FE at FE-NNE

(40:50) s1: touches items at FPE-N, "well, these area here is kind of chaotic..." s2 agrees

(40:52) s1: moves a table off of the FP to TE-NNW

(41:08) s2: moves a postit note pad out of the way from TE-NNE to TE-E and pushes a bunch of items from TE-NE to TE-ENE

(41:10) s1: makes a new table arrangement with the existing table and chairs on FP at FPE-N and new chairs in her hand

(41:22) s1: picks up chairs from pile at TE-N and adds to the table arrangement at FPE-N

(41:25) s2: watches s1 make a new arrangement at TE-N, pushes some items back onto the table at TE-E, then slides the FP more towards the center, away from the table edge

(41:28) s1: adjusts table arrangement nearby at N

(41:35) s2: puts down marker at TE-NE

(41:37) s1: picks up chair from pile at TE-N and adds to table arrangement at N

(41:43) s1: reaches across table to TE-E to pick up green pad of postit notes (s2 moved it here)

(41:49) s1: rips off part of a postit note and places it at N beside table arrangement

(41:49) s2: adjusts some items at FE-NNE

(41:55) s1: repeats at FPE-N, then moves first ripped note adjacent to this second note, forming a line with the two, perpendicular to the FPE

(41:57) s1: adds a third ripped note, extending the line towards the C

(41:57) s1: moves the table arrangements to W of this line at FPE-NNW a smidge more W away from the line of trees - "...it'll be very humid in here...perhaps the books will [wilt?]..."

(42:03) s2: adjusts a postit note pad at TE-NNE, then picks up a bs from the pile of items at TE-N and places it in the bs's he's arranging at FE-NNE

(42:08) s1: roots through piles at TE-NW and TE-N, asking "is there any little mini couches left?"

(42:18) s1: reaches across table to pick up a couch at TE-E, places it at FPE-N

(42:23) s1: picks up pick table from TE-SW and places it with the couch at FPE-N

(42:30) s1: adjusts table arrangement at NNE (she's reaching across table to work in this area)

(42:41) s1: replaces a table item at NNE with a chair from TE-N

(42:47) s1: asks s2..."what about that?"

(42:48) s2: "looks good"

(42:51) s1: laughs, "...you were done a long time ago..."

(42:54) Note: END

Group 3

(0:02) Note: Group 3 - Aug 21, 2002, 2-3:30pm. 3 Participants, 2 female architecture students, 1 male computer science student. Seating arrangement from camera view (from left to right) is brown-haired girl (s1) (1), black-haired boy (s2) (2), then blond-haired girl (s3) (3). They are seated at the table, with the side of the round table closest to the camera open. The 2 girls are essentially seated across from each other. They are sitting at a round 3-feet in diameter wooden table with a pedastal leg. The participants are reading their task instruction sheets, s2 has his sitting on the table, and s1 & s3 are holding theirs, leaning back from the table.

The table is setup as follows: There's a 2-foot diameter circular white floor plan in the centre of the 3-foot table. There are 6 piles of paper cut-outs of furniture in the centre of the table. There are orange overstuffed (e.g., casual) chairs and couches, white and pink tables (round, rectangular, and square), white office chairs, green plants, blue bookshelves, and white armchairs. There's a spare instruction sheet sitting

on the table oriented towards the camera hanging over the edge of the table near the camera. There's also a pair of scissors, post-it notes and a marker on the table edge (outside of the floor plan edge) near the camera side. For the purposes of this transcription, the table will be divided roughly into 4 sections, North, South, East, West, with the "bottom" of the camera view being South and the other sections named relative to that. s1 is sitting at West, s2 is sitting at North, s3 is sitting at East, and the "extra stuff" (e.g., scissors, post-it notes, etc.) is at South.   Experimentor (Exp) is sitting beside the camera, out of view.

(0:34) Note: Both girls are out of the camera view, but s2 is looking around at the contents of the table as he is reading the task instructions
(0:53) Note: s3 sets the instructions on the table in front of her, oriented towards her
(0:57) Note: s3 sets a pen on the table beside the instruction sheet
(1:09) Note: s2 moves his instruction sheet to the edge of the table, outside of the floor plan, sightly oriented towards him, but with the long side of the paper parallel to the edge of the table
(1:14) Note: s2's paper won't stay there without falling off of the table, so he sets it further in on the table, with it now covering some of the edge of the floor plan
(1:16) s2: Can I talk to you (to Exp)
(1:17) Exp: What was that?
(1:21) s2: No, I have a question for you.
(1:24) Exp: Ok [Exp walks around s3 over to s2]
(1:30) s2: [pointing to the instruction sheet, which he's pulled in front of him again and is holding to his left - towards the Exp] What do you mean by "fit as many people in the room"? Where is the room?
(1:32) Note: Using his left hand and his right hand to support, s2 folds the paper away from the table, exposing the edge of the floorplan
(1:45) Exp: [with both hands on the edge of the floor plan] This whole space is a round room. This is the exterior wall [gesturing to the edge of the floor plan]. These are the windows [gesturing to a window]. Where's the door? [looking at the floor plan]. The door is [lifting s3's instruction sheet - s3 takes it and holds it in her lap]...right here [pointing to the floor plan right in front of s3]
(1:00) Exp: So by accomodating as many people, what I mean is like, whether they're sitting or working or whatever, however you arrange them, the first goal is to try to have as many people allowed in the room, or comfortable in the room as possible. That's one of the goals
(1:57) s2: - So...so, in the room [points in a circular motion over the floor plan], means the whole thing, right?
(1:57) Exp: Yep, exactly, exactly.
(2:14) s1: Hmm. So is there any particular reason why you chose a round room [gesturing over the table surface]...[s2 laughs] or maybe we shouldn't know that.
(2:16) Exp: Ahh...you shouldn't know that...
(2:16) s1: Oh ok.
(2:33) Exp: But actually, I mean I chose it because MIT has a round reading room and I love that so that was sort of why I chose that....one of the reasons why I chose that. But so there is actually a round reading room in the world.
(2:33) s1: Ok
(2:34) s2: So we have to work together right? That's what you mean?
(2:35) Exp: Yep
(2:53) Exp: So you guys have to decide how to um ... sort of ... ah... how to negotiate all the points on that list, because, I mean, some of them are conflicting, so you have to figure out what the best way to do that is.
(3:04) s2: So how can , how can you figure out the impact of human... [he's reading and pointing to the the information sheet that he's holding in his hand] because we are working together right?
(3:04) Exp: um-hmm
(3:07) s2: How can you find out the individual impact...on the human activity...is that what you mean? [he's reading the information sheet]
.
.   There's a bunch of stuff where I'm explaining the study to s2...he's confused about the motivation behind the study. I explain that I'm interested in understanding how people use computers in a collaborative way...
.
(3:31) s2: That makes sense
(3:34) Note: General confirmation/agreement from the 3 participants
(3:38) s3: [pointing to the paper artifacts on the table] and it's at our discretion of how much of each to use?
(3:38) Exp: Exactly, these are just things that I cut out that you might want to use AND if there's thing-- if you want something that's not here, you can draw it on a post-it note and you can cut it out if you want it smaller or something
(3:55) Exp: [pointing to the blue cut-outs] These are bookcases. [pointing to the green cut-outs] These are large plants and little plants. [pointing to the pile of white chairs] These are random kind of chairs. [pointing and pushing stray tables back into the pile] These are all tables. [pointing to and pushing stray chairs back

into the pile] These are small chairs, and couches and loveseats.....[pointing at the white couches]...and these are ...they could be couches, they've been used for study carrols...whatever, their kind of this miscelleous visual representation of something...so you can do whatever you want with them.

(4:17) s2: So how long will we do...
(4:20) Exp: So you're going to do this task for about a half and hour...
(4:20) s2: ok
(4:20) Exp:...and then you'll get into to the second task
(4:26) All: ok
(4:26) Exp: ... So half hour, if you think you're done...but it's flexible...so
(4:26) All: ok
(4:26) Exp: So is everyone set?
(4:31) s2: Is everyone ready?
(4:31) All: yep
(4:31) Note: s2 has put his instruction sheet back on the edge of the table, s3 has hers facing her half on the table, half on her lap
(4:40) s1: [pointing to the blue cut-outs] so desks [pting to green] plants, [pting to white chairs]...and ah...
(4:36) Exp: [Exp lays hand on pile of blue cut-outs and s3 points to it] these are bookcases
(4:36) s3: bookcases
(4:39) s1: [pointing again to the blue cut-outs] bookcase?
(4:39) Exp: so...shelves...
(4:47) s1: [pting to green pile] plants...[pting to white pile] and chairs... [pting to pink and white pile] and ...ah...---
(4:47) s2: --- {it's a mat} ? [picking a few paper pieces up and then dropping them back in the pile]
(4:47) s1: --- tables...
(4:46) s2: Oh these are tables...
(5:03) s1: [pting to orange pile] and these are couches and loveseats and chairs...[pting to and picking up pieces from the pile of white couches] and these are [she looks at Exp]...well they look like couches, but...
(5:03) Exp: they, they....
(5:03) s3: she said they are study carrols....
(5:03) Exp: they are couches in the program I used, but, ah, people used them for multiple things...like people have used them for study booths before.... so they can be whatever you want them to be...
(5:08) All: ok...
(5:12) Exp: That's why I kind of separated them...
(5:12) All: oh, ok
(5:25) s1: [reading from instructions] So accomodate as many people as possible, provide space for individuals to read and and work quietly, ---
(5:26) Exp: ---- So, ok, I'm just going to let you guys go off and do that...I'm going to go photocopy that [pting to the consent forms] and come back
(5:26) s3: ok
(5:26) All: ok [general shuffling of their instruction sheets, s3's sheet is on the table and she's reading from it, s1's is in her hands as she leans her forearms on the table, and s2 puts his excess forms on the floor beside him and tucks the instruction sheet on the table, with a corner under the floor plan.
(5:45) s1: So this is a reading room, it's quiet, people want to have their own individual space....
(5:49) Note: [They're all reading their own instruction sheets quietly]
(6:09) s3: [she slides the paper back from the floor plan and looks at the contents of the room
(6:11) s2: ...entrance...first we need the entrance....
(6:11) s1 & s3: umm-hmm
(6:12) s1: [she holds the sheet in right hand away from table and looks at the table]
(6:12) s3: that's here [tapping the floor plan at the location of the room entrance]
(6:16) s2: [points and touches the floor plan at the entrance location] right here?
(6:16) s3: yep
(6:16) s1: [pts to several locations on the periphery of the floor plan] ... and she said these were windows?
(6:17) s3: Yep
(6:17) s1 & s2: ok
(6:17) s1: and these are like walls [running finger along edge of floor plan]?
(6:17) s3: walls...yeah
(6:23) s1: [first she sets the instruction sheet on the edge of the table, outside the floor plan, but the edge isn't wide enough...she then sets instruction sheet on the floor beside her]
(6:26) s2: So we can put some plants at the entrance...[pting above the entrance]
(6:26) s1: [touching and slightly moving some of the orange couches]
(6:30) s1: some plants?
(6:30) s2: picking up some plant pieces and holding them]
(6:30) s3: [laughs]
(6:34) s3 & s1: that's a good idea...

(6:30) s1: [touching and moving some of the pieces in the table pile and pulling the whole pile towards her, away from the entrance, the floor plan shifts position on the table, and s2 shifts it back a little with the hand that's holding the plant piece (right hand)]

(6:36) s2: ... people like green things uh... [s1 picks up a plant piece from the pile and places it inside the entrance to oneside]

(6:36) s1: yeah...

(6:38) s3: should we... [holds up her hand towards the group], should we wait 'till she gets back to start? [s2 drops the plant piece in his hand back to the pile on the table]

(6:38) s2: Yeah,

(6:40) s3: ...actually doing this?

(6:42) s1: Oh, oh really?

(6:42) s3: I just wondered because I think she wants to ... [she gestures towards the camera]....

(6:43) s1: [she reaches over and starts to pick up the plant piece that she had placed, then leaves it there]

(6:43) s2: No, no, she said we should start right now...

(6:45) s3: oh, ok

(6:45) s2: yeah, we don't have to wait for her

(6:48) s1: Is she recording right now then?

(6:52) s2: ah...

(6:52) s1: I don't know... [they're all laughing]

(6:57) s2: [blows into mike...] I think you can hear it....

(6:59) s1: I guess it's rolling...

(6:59) s3: ok....

(6:59) s2: [bends over to pick up sheet on the floor...] so should we go ahead?

(7:05) s1: yeah we can go ahead...

(7:05) s3: ok

(7:14) s2: [talking into mike] Hello, Stacey we are starting, we are starting....

(7:14) s1 & s3: She can't hear us...

(7:17) s2: Alright we should start...

(7:20) s1: Ok, so plants...[pointing and touching the drawing surface beside were she put the first plant object, in front of 3]

(7:20) s2: [his hand is over the pile of plant objects and he's picking some up]

(7:22) s3: ok, plants always [look inviting] (she's hard to hear)

(7:22) s1: um-hm

(7:22) s2: [picks up plant objects from pile and places one on the table in front of 3, about where s1 indicated, places a 2nd plant object near the one he just placed. He then places a 3rd beside the plant object that s1 placed forming a "row" on the other side of the entranceway towards the interior of the room. He then drops the extra plant objects in his hand back in the pile]

(7:22) s1: So this is the entrance and the exit? [pointing to the entrance and making a sweeping gesture around the room back to the entrance]

(7:25) s3: [she slides the 2nd plant object that s2 placed beside the 1st plant object s2 placed to form a "row" facing the "row" s2 made on the other side of the entranceway]

(7:30) s3: I guess so, there's no other way...

(7:33) s1: That's not really safe.

(7:33) s3: No...that's not...up to code [they laugh, and s3 drums her fingers on the table near the edge]

(7:42) s1: We can tape an exit on the other side [she pulls a post-it note off a pad at the south of the table]

(7:42) s2: Yeah...

(7:42) s3: That's a good idea...

(7:45) s1: [first picks up a marker on the south side of table, and then reaches across the table] I think I'll use a pen [and picks up a pen sitting on the table between s2 and s3]

(7:48) s1: Where should it be? [she runs the pen tip along the edge of the room layout directly opposite from the entrance (at the west side of the table)] Right here? [she places the post-it note down at that spot]

(7:48) s3: Yeah, I guess so.

(7:57) s2: [pointing to the edge of the room to the right of the entrance (about NNE) and holding his finger at that spot and to then pointing with the other hand to a corresponding spot to the left of the entrance (SSE)] We'll need a couple of exits here and there. Some people enter, right, [sweeping his hand into the room from the entrance] and then they find some problems [he circles his hand in the middle of the table] then they can leave right here [he sweeps his hand out the indicated exit where his finger is still resting] [he laughs]

(8:00) s1: Maybe that can be entrance and exit [she points to the East entrance] and this can be an entrance and exit [she gestures towards the West door]

(8:00) s2: That's a good idea

(8:03) s3: yeah

(8:03) s1: It of course depends on what's outside of the circle [she gestures to the edges of the circle - she still has the pen in her left hand]

(8:03) s3: Yeah...
(8:03) s2: [points to the middle of the table, while s1 is writing on the post-it note for the West Door] Because if anything goes wrong here [touching down on the table], this guy has to some this way [gestures a path from the East door by the spot he's pointing to and to the West door]
(8:16) Note: s1 is still writing/drawing on the post-it note and s2 is picking up plant objects from their pile and dropping them near the other plants by the East door
(8:16) s2: (mumbling something as he's placing small plants by the door, near the large plants he has placed) [s3 moves some of the plants, reorganizing them in the same area]
(8:32) s1: [she puts the pen down in the pile of supplied in the South] So we're thinking right away about about entrance and exit first. Ah...Should we be doing that?
(8:36) s1: [to Exp] You're recording this as we go?
(8:36) Exp: Yes

2:08:35 Note: Beginning transcription where last transcript left off (8:36), with a lot less detail, and a focus on interactions and spatial relationships, less emphasis on exact dialogue.
2:08:39 s1: is discussing what they should be doing - what the "feel" of the room will be, while moving an orange chair around the FP at C-WSW [appears she's just fidgeting while she's talking]
2:08:40 s3: is adjusting the plants near entrance in front of her at E
2:08:40 s3: adjusting plant rows at ENE and E
2:08:46 s1: points with her hand towards the entrance at E, then does sweeping hand gesture towards exit at W, saying "where people enter and leave..."
2:08:50 s1: gestures to the Centre of the table "need a place to sit, in case they're waiting for something..."
2:08:56 s1: puts hand over orange couch at C-WSW, "ok...should it be comfortable?" s2 agrees, "ok...", she starts sorting through the pile of couches in front of her at C-W
2:08:57 s2: points to the entranceway at E, saying "...so, put some chairs over there"
2:08:57 s3: adjusting plant rows at E
2:09:00 s2: adjusts his instruction sheet on table edge at NNE
2:09:01 s1: picks up couch from C-WSW and puts it down on the FP at ENE
2:09:02 s3: helps s1 move the pile of chair away from the FP edge to C-NNE
2:09:04 s1: puts hand over pile of chairs on FP at NE and slides the pile out of the way to a spot at C-N
2:09:04 s3: adjusts couch at ENE that s1 just placed
2:09:06 s1: picks up an orange chair from pile on FP at C-W and puts it on FP at C-ENE, beside couch she just placed
2:09:08 s3: adjusts row of plants at ENE
2:09:10 s1: gestures over the couch and chair, saying "as long as we know [?], maybe we can put more chairs over there once we know"
2:09:11 s2: moves the couch s1 put at ENE a little
2:09:12 s2: picks up large plant from pile at NNE and puts it beside row of plants at E, sliding the couch out of the way a little
2:09:13 s1: tidies up pile of couches at C-W, sliding them over a bit to C-WSW
2:09:14 s2: slides the row of plants N a smidge, then slides the couch and positions it along the row of plants at ENE
2:09:18 s3: positions chair s1 placed at E beside row of plant at E, opposite couch s2 just positioned, and adjusts plants
2:09:19 s2: slides a little plant from pile at NNE to the row of plants at ENE
2:09:20 s1: sweeping hand gesture over the FP in front of her (from C to NW to SW), "if we think about the working area..."
2:09:32 s1: "where the books should be kept" - sweeping hand gesture over FP and then deliberate claw pointing on FP at NNW and SSW and a gesture towards NE ...."we should plot them out with our hands"
2:09:38 s2: points to entranceway at E as s1 is talking, then points again during a pause, "because some people are waiting over there" [referring to the couches they just placed]
2:09:45 s2: points to the FP, touching the table at C-E, keeping his finger here while s3 is talking about where to put seating
2:09:55 s3: points with opened handed claw, with both hands over C, saying "I guess we should establish what we'd like in the central area"
2:10:00 s3: "or if we prefer to do the periphery"...gestures around the edge of the FP
2:10:14 s1: "...perhaps the periphery" - sweeping circular hand gesture around the FP edge....."you have this whole long area", she makes slow deliberate sweeping hand gesture along the FP edge, "in the centre everything will be clustered...." [gestures with open hands hovering above C]
2:10:26 s1: points finger and moves hand around FP edge (close to her) again...."this provides and edge...."

2:10:32   s1:   open claw hand gesture, she puts both hands down on FP C, "perhaps the axis for the books should be in the centre..."

2:10:37   s1:   makes sweeping hand gestures from FP edge to C at various places around FP to indicate a flow inward "then we can reach it..."

2:10:41   s2:   points to the C, discussing having the books in the C and having a sign that tells people that the books are there, points to C again with one hand and makes a motioning gesture from the entranceway to the C to explain the sign could direct people into the C for books

2:10:58   s2:   points to the end of the row of plants at entranceway at C-E, "put a sign here, to say the books are there" [points to C again]

2:11:19   s1:   picks up pen and pink postit note from table edge at SSW, puts down on table in front of her (W), writes sign, speaking outloud as she's writing "sign to show location of books", then places sign at C-ENE

2:11:22   s1:   puts pen back down near postit notes at SW

2:11:23   s2:   pats down postit note that s1 just placed at C-E

2:11:33   s3:   points to a window area at S, suggesting using them as study carrells, "it's quiet and enclosed slightly", she points to other windows around the FP

2:11:46   s2:   reads (silently) from his instruction sheet at NNE

2:11:50   s3:   picks up "big" orange chair from pile on FP at WSW and puts it in window spot at S

2:11:52   s1:   adjusts postiit note at WNW

2:11:56   s3:   touches pile of couches at NW, looking for something, then picks up big chair from pile of chairs at C-N, then places it at window area in front of s2 at N

2:11:59   s1:   picks up chair from pile at WSW and puts it in window spot at SW sliding the pen off of the FP edge with her hand]

2:12:02   s2:   picks up chairs from a pile at C-NNE

2:12:03   s1:   repeats with loveseat at W

2:12:03   s3:   picks up another big chair from pile at C-N

2:12:06   s1:   repeats with loveseat at WNW

2:12:08   s3:   places chair in hand at window at ESE

2:12:10   s2:   slides the big chair s3 just placed at N, away from the FP edge, just a bit and puts a small, office chair by it [set up like a desk and chair]

2:12:11   s3:   moves chair out a little from edge, picks up a small table from pile on FP at SSE, then puts the table between the window and the chair, making a chair & table/desk arrangement

2:12:12   s1:   repeats with chair at NW

2:12:12   s2:   puts another office chair down near FP edge at NNW

2:12:14   s2:   reads outloud from his instruction sheet at NNE, "...put as many people as possible..."

2:12:17   s3:   picks up another small table from pile at SSE, places the table at a window at NNE [I think she was heading for N, but s2 already made a chair/desk arrangement]

2:12:19   s1:   touches pile of chairs at WSW, then points the the chair she just placed at NW, saying "do you think we should use the comfortable chairs for reading though?" - s2 disagrees, saying "no, no, no"

2:12:23   s3:   picks up big chair from pile at C-N and puts chair with table at NNE window

2:12:24   s2:   disagrees with s1 about putting comfortable chairs for readying - "if the chair are comfortable...some people might take advantage...."

2:12:45   s3:   begins to pick up a chair from pile at C-N, then laughs at s2's suggesting more signs and takes her hand away

2:12:49   s1: & s2: & s3: they discuss comfortable chairs or not, they decide to do both

2:12:49   s2:   suggests posting a message telling people not to stay more than one hour

2:12:58   s2:   places another "big" chair by the office chair at NNW, in the "desk & chair" arrangement, saying "we shouldn't block the window, maybe we should have a little space..."

2:13:00   s3:   adjusts the "chair/desk" arrangement at N back towards window (s2 had shifted it), [I think she then says, "is that alright?".....because he responds with "yeah"]

2:13:06   s3:   picks up a chair from pile at NNE, then puts it down and adjusts the chair at the S and SW windows

2:13:07   s2:   places another "big" chair from hand on FP at NNW, then moves it to NW, saying something I can't make out, then places an office chair with it at NNW in another "desk & chair" arrangement, adjusts this arrangement, then the last one he placed at NNW too

2:13:14   s1:   laughs, saying "oh another sign?", then picks up pen and pink postit note from table edge at SW, puts it down in front of her at W and writes a note silently, puts the pen down at SW, then places the sign along FP edge at W

2:13:16   s3:   picks up big chair from pile at NNE and puts it in window at WSW

2:13:19   s1:   picks up the pen and adds something to the sign at W

2:13:20   s3:   shifts pile of couches at NW, looking for something, then picks up table from pile at SSE, then puts the table with chair at WSW for a "chair/table" arrangement

2:13:22   s2:   picks up chairs from pile at C-NNE, and puts one beside a loveseat that s1 placed at WNW, adjusting it for a little while

2:13:24 s1: puts pen back down at SW
2:13:30 s2: drops unused chairs back into piles at C-NNE and at NW
2:13:31 s3: picks up orange loveseat from pile at WSW and puts it at window at NE
2:13:36 s1: gestures around FP edge, saying "...these work areas around the periphery, perhaps we should try one area first [pointing with both hands open to blank FP area at NE] and try to arrange that..."
2:13:39 s1: makes sweeping hand gesture around FP edge, "I don't know if we want to keep it the same all the way around...or jumble it with some that are [?] spaces and some that aren't [open hand claw pointing to various spots on table], I don't know..."
2:13:50 s2: asks for clarification of what s1 said: "so you mean design one just one side" pointing with turned hand to the empty FP at NE
2:14:02 s1: sweeping hand gesture around FP, "...unless you want to get down everything we're certain about..."
2:14:08 s1: tidies up pile of couches at C-WSW
2:14:12 s2: tidies up pile of plants at N
2:14:14 s3: check instruction sheet at SE
2:14:16 s1: points to item at WNW, "these are lights then?", s2 corrects her saying their chairs
2:14:17 s2: clarifies to s1 about the chairs he was placing: "no they're chairs"
2:14:25 s1: tidies up pile of tables at C-NW, sliding it a bit south to C-W
2:14:28 s2: points to a "desk & chair" arrangement at N (that s3 just adjusted) and mumbles something about "chairs..."
2:14:29 s3: helps s1 move the pile of chairs at C-N to NNE (away from centre)
2:14:30 s1: "so we were saying that books are going in the middle?" - she slides pile og chairs at C-NNE towards the FP edge at NNE, then slides the pile of bs's at N towards centre and her a bit to C-NNW
2:14:38 s1: picks up bs from pile at C-NNW and puts it at C-E, repeating twice, randomly placing bs's in this area
2:14:39 s3: suggests the centre area be a "gathering area for books and ...   large tables" pointing and gesturing around C
2:14:51 s1: & s3:   discuss how to arrange the bs's
2:14:55 s3: shifts a bs that s1 placed in C
2:14:56 s1: picks out other bs's from the pile at C-NNW and slides them into the C area, adjusts them a bit, saying "I don't know how they should be arranged..."
2:14:57 s3: shifts another bs that s1 placed to line up with the one she just positioned, forming a N-S row
2:15:01 s2: reaches for bs in pile at NNW, then hesitates
2:15:03 s1: moves more bs's from pile at C-NNW to C
2:15:03 s2: picks up bs from pile at NNW, looks at it, places it on the table in front of him, reading the text on it
2:15:09 s1: picks up a table from the pile at C-SSE and puts it down near the bs's at C-N, saying "perhaps we should get the location of our tables..."
2:15:10 s3: shifts the table s1 just placed at C a bit north to C-N
2:15:11 s1: picks up another table from pile at C-SSE and puts it down in C , then slides the table back into the pile at C-SSE
2:15:15 s2: picks it up again, then asks: "does it mean one book, or a whole bunch of books?" s3 says "....bunch, they're shelves", s2: "ok", s1 & s3 laugh
2:15:16 s1: slides the pile of bs's at C-NNW towards the FP edge at bit
2:15:18 s3: slides a pile of tables at C-S a little closer to the FP edge - now at SSE
2:15:18 s3: slides a large table out of the pile at SSE into the C, adjusting it together with other big table at C-N
2:15:24 s1: sorts through pile of tables at C-SSE, sliding it a bit W to C-S, picks out a table, then puts it back in pile and adjusts the table s3 just placed at C
2:15:25 s2: puts bs down on FP at NNW (where he was looking at it), reaches for table in C, then pulls away
2:15:27 s1: slides a bs at C between the two tables, asking "do you think it should go like this?", s2 & s3 agree
2:15:37 s3: begins to pick up another table in pile at SSE, then puts it back in the pile - she's watching what s1 is doing
2:15:40 s1: sorts through the pile of tables at C-S and picks out one to slide over to C-N
2:15:45 s1: picks up another table from pile at C-S and slides it to C-E, then adjusts table at C
2:15:46 s1: "I'm just putting things, you can move them if you like..."
2:15:47 s3: begins to pick up round table from pile at SSE, then puts it down, then picks up bs that s2 had put down on FP at NNW
2:15:49 s3: places bs beside other two in C to extend N-S row, keeping her hand on the bs as s1 is talking about the space
2:15:50 s2: begins to pick up a bs, then pulls hand away as s1 starts to talk about the Centre

arrangement

2:16:05   s1:   discusses how to arrange the tables, based on casual vs. formal meetings, pointing to the tables in C as she's talking

2:16:16   s1:   slides table at C-N to C-NNW, then adjusts a bs to separate the table from another table that's still at C-S

2:16:21   s2:   says people shouldn't have important meetings in the reading place [pointing to the C], "...they should go some other place..."

2:16:24   s3:   adjusts plant row at entranceway, E, she pushes some small plants off to the side of the row (a bit west) and replaces them with a large plant from the pile at N

2:16:29   s3:   adjusts chair/table arrangement at ESE, that her hand displaced, then continues adjusting the row of plants at E

2:16:36   s2:   suggests they could just ignore that, "they don't have much important things to talk about here [points to C with open hand], they'll do some reading and stuff...gossiping..."

2:16:37   s3:   adjusts the row of plants at ENE and the couch beside it

2:16:49   s3:   reads silently from the instruction sheet at SE (she puts her finger on the text as she's reading it)

2:16:53   s2:   adjusts instruction sheet at NNE

2:17:26   s2:   says "important meeting cannot be here" - pointing to C, explaining that people will be reading quietly around there, "it has to be some other place", pointing with open hand to C-SW, they discuss this for awhile, s2 does lots of pointing to WS

2:17:45   s2:   "or we can put another sign..." pointing to entranceway at E

2:17:48   s3:   replaces displaced plants at C-NE to the pile at NNE

2:17:50   s1:   moves a plant that has blown across FP, from C back to pile at NNE

2:17:56   s2:   reaches across table, picking up the blue pad of postit notes on table edge at S, then listens to s1 talking

2:17:57   s1:   holds up two white couches, then replaces them, "maybe it has to be blocked off with glass walls or something"

2:18:02   s2:   peals a postit note off of the pad, which he puts on table edge at NNE (on top of his instruction sheet), then puts the postit note on the table edge in front of him at N

2:18:06   s1:   open-handed claw point to the C, "it would get a lot of attention in the centre"

2:18:11   s2:   leans across the table to get the marker on table edge at SE, takes cap off while he's listening to s1 talk

2:18:16   s1:   open-handed claw point on FP at C-NNW, "perhaps it should be off-centre"

2:18:28   s1:   picks up two white couches again from the pile at C-W, then slides two tables around the C area, moving one out of the way to C and one to C-NNE to demonstrate this "off-centred" setup

2:18:31   s2:   puts cap back on marker, and holds it in his hand

2:18:32   s1:   puts one of the white couches down beside the table, at C-N, saying "...if theses were walls...", then places the other white couch from her hand adjacent to the first at C-N to form a corner

2:18:38   s2:   suggests an information desk instead of using all the signs - he first points to a sign at C-E, then he holds up the blue postit note from table edge at N as he says "information desk"

2:18:39   s1:   picks up another white couch from C-W and places it beside other "wall" at C-N to extend the wall, then adjusts the table inside the walls at C-NNW

2:18:39   s2:   is talking about replacing the signs with an information desk

2:18:46   s2:   he puts the blue postit note down beside the pink postit note "sign" at C-E, then picks up the "sign", points to the "information desk", saying "people should get all kinds of information from here..."

2:18:54   s2:   puts pink postit note down on table edge at NNW

2:18:58   s3:   picks up the "information desk" postit note at C-E from where s2 put it, saying "it can be somewhere where's it's readily available...", she lines it up with the entranceway and positions it closer to the C at C-E, holding onto it as she demonstrates with her hand that it's on the "axis coming in"

2:19:01   s1:   picks up pen from SW

2:19:06   s1:   writes on postit note that s3 has just positioned, for the "information desk"

2:19:11   s1:   replaces the pen at SW

2:19:15   s2:   puts marker down on table edge at NW

2:19:17   s3:   points to the C area and asks, "so do you want to establish some program for how the bookstacks will go?", she makes incremental gestures along the centre axis with the heel of her hand

2:19:29   s3:   slides a table at C-SE into the pile of tables at SSE

2:19:34   s3:   adjusts the bs's in the N-S row at C

2:19:39   s1:   points, in claw action gesture to C as she's talking about "meeting space"

2:19:39   s1:, s2:, & s3:   they discuss how to arrange the centre area

2:19:48   s2:   keeps moving his hands like he has something to say (like the beginning of a gesture), but then he keeps stopping, because s3 and s1 keep talking

2:19:53   s1:   "well we can begin arranging the books", picks up a bs from a pile at NNW and puts it in C, beside a N-S line of bs's, then adjusts it

2:19:56   s3:   pushes the pile of tables out of s1's way, to SSW

2:20:07   s1:   repeats bs placement
2:20:08   s2:   picks up a bs from pile at NW, then slides a white couch "wall" at C-N over a little, then returns it, saying "is this couch? right?", s3 responses with "yeah it can be a couch or a study carrell, or..."
2:20:08   s2:   places bs adjacent to N-S row of bs's, making a corner.
2:20:02 s2: places some bs's in the C, forming a corner with bs's in a N-S row
2:20:06 s1: places bs in hand at end of N-S row near C-SE
2:20:07 s3: pick up bookshelf from pile in Centre-NW
2:20:09 s1: picks up bs from pile at C-NW
2:20:13 s1: places bs in hand near the bs she just placed in N-S row, but closer to C. this bs is smaller
2:20:15 s2: helps s3 rearrange the bs's he's just placed to allow space between the shelves
2:20:15 s3: adjusts a bs in Centre-N
2:20:19 s1: reaches towards the bs she just placed at C-SE, then retracts hand
2:20:19 s3: more adjusting of bs's
2:20:21 s1: picks up bs from pile at C-NW, places it in C-S, making a corner with the large bs she placed in the N-S row. This corner mirrors the bs's closer to s2 surrounding the C
 2:20:27 s1: picks up bs from pile at C-NW
2:20:27 s3: places bs from hand inside "walls of bs's" in Centre-N
2:20:30 s3: picks up bs from pile at C-NW
2:20:31 s1: places bs from hand in row with last bs she placed at C-S
2:20:33 s3: places bs from hand in C
2:20:36 s1: gestures an open-handed hovering with two hands near her, over the WS as she's talking about how it might be easy to get lost in the room
2:20:37 s3: adjusts bs's she's just placed
2:20:40 s1: makes sweeping circular hand motion over the WS as she's talking about getting lost, pointing to the WS
2:20:45 s1: makes angled, sweeping motion with her hand down the centre of the WS talking about if it's "easily itentifiable what direction you're in"
2:20:47 s1: points with both hands to the WS as she makes a circular sweeping motion around the edge of the WS [encompassing the whole room]
2:20:49 s1: more hand gestures, waving in air in front of her as she says "it's hard to tell where's north, where's south...east...west"
2:20:55 s1: sweeping hand gesture over the centre area describing the need for a "bearing point" in the layout, she points her hand down at the WS as she's talking
2:21:05 s1: she's explaining the bearing point more, and moving her hands side to side over the WS as she's saying people need to be able to tell "which way, which way is what"
2:21:07 s1: she repeats her hand movements for N, S, E, W as she reiterates the need to be able to tell "north, south, east, west"
2:21:09 s1: points to the Info Booth postit note and makes a circle gesture on it as she says the information desk gives "you bearings"
2:21:17 s1: sweeping angled, directional hand motion down the centre of the WS as she's demonstrating the arrangement of the books
2:21:21 s1: points with finger tips on the Info Booth as she says "re-inforce this is where you came in"
2:21:27 s1: re-arranges the bs's in the C to demonstrate a possible arrangement of the bs's to reinforce the "bearings" she was talking about. "perhaps they could be like, like this....I don't know" [she's looking for confirmation from the others]
 2:21:40 s1: she rearranges some more bs's in the C to show rows of bs's for an "axis" in the C
 2:21:45 s1: "where they'd be sort of all be pointing in a direction", as she says this she's making a sweeping hand motion with both hands back and forth along the C axis she's created.
2:21:53 s3: hand gesture, directional sweep from C to C-S
2:21:53 s3: pointing to C, where s1 just positioned some shelves
2:21:55 s3: positions some bs's and tables at C-SE to C-S to illustrate a point about flow of the room
2:22:02 s3: makes two-handed illustrative directional hand sweeps in an "enclosing" manner
2:22:03 s3: points at the bs's s1 placed again at C
2:22:07 s2: makes sweeping, circular motion over WS - "so this one is just one room?"
2:22:10 s3: small nod to s2
2:22:11 s2: "we don't know how big it is? [gesturing with his hands wide apart]"
2:22:13 s1: points and gestures in a circular sweeping hand motion over WS as she explains to s2 that they can tell the size of the room by getting a "sense of scale from the size of the furniture"
2:22:15 s2: "we can assume it's a huge room [gesturing with his hands wide again], because it has a lot of windows [pointing to several windows around the WS edge]"
2:22:16 s3: small hand gesture towards s1 to agree with the point s1 is making to s2
2:22:18 s2: "because we have a lot of windows [pointing to the windows in front of him], lot of books [pointing to the pile of bs's], lot of things [pointing to the items in the C of WS], so we can consider this

[sweeping/hovering gesture above the WS] like the computer science building [making big gesture to encompass the whole table, high above the table]"

2:22:25 s2: "it's a huge room" - making two-handed wide hand movements again as he's speaking

2:22:31 s2: "so there's a little [makes "small" action with index finger and thumb] that people might get lost"

2:22:39 s1: points to the C where s1 and s3 have been arranging bs's, explaining that they've been trying to help people from getting lost by arranging the furniture in an intuitive way

2:22:39 s3: points towards the C where s1 had positioned all of the bs's to make point to s2

2:22:42 s1: "provide bearings within the room", waves right hand over and towards the room, above the table.

2:22:45 s1: sweeping circular motion over the WS, explaining a sense of bearing is necessary "since it is round"

2:22:47 s2: makes multiple pointing movements with both hands to indicate different directions when s1 is mentioning having "bearings" in the room

2:22:52 s2: "it's a minor concern because it's just one room [makes sweeping hand movement over the WS], because it's just one room you can find your way here and there [making jerking motions around the WS]"

2:22:57 s1: expands and contracts fingers in a "finger wave" as her hand is still on the table edge as she says "if you're in a rush"

2:23:00 s3: places the bs in hand to start a new row (where the other row was that s1 had made) in C

2:23:03 s1: points in a sweeping circular hand motion around the WS - explaing "you'd have to go all the way around the building" if you exited through the wrong exit

2:23:07 s1: makes upward pointing gesture with her arm on the table - "would help to remember which way you came in"

2:23:11 s1: makes a gesture away from the table, over her shoulder - "to know the opposite of that to ..."

2:23:15 s2: points to the bs's in C - "if these bookshelves...." points to edge of WS "...then people should know ... to get out [pointing again out of the bookstacks]"

2:23:25 s2: quick gesture towards C bs's - "so it's ok, you were right..."

2:23:31 s1: "I don't know how..." - she slides a bs in the middle as she's talking, not really positioning it, just moving it around slightly.

2:23:33 s2: in response to s1's "I don't know how...", quick gesture towards C "put some signs", points to C, then gestures towards the exit "that's exit".....

2:23:35) s1 & s3: laughs when s2 mentions "puts some signs" - s2 immediately says "it's a bad idea?"

2:23:35 s2: he sits back "...that's a bad idea?"

2:23:38 s3: moves a couch that is in the C, beside the central bs's, to a pile at C-W

2:23:40 s3: moves a 2nd couch from the C to the pile at C-W

2:23:41 s3: moves a 3rd couch from the C to the pile at C-W

2:23:42 s2: moved the pile of couches at C-W further W to help s3 clear the centre area.

2:23:43 s1: snaps her fingers as she's explaining to s2 that signs aren't as "fast as intuition"

2:23:46 s3: adjusting the bs's placed by s1 in the C

2:23:48 s3: moving a bs in C to a new position in C

2:23:50 s1: waves her hands around, rolling them in circular motions in front of her, then points towards the opposite side of the WS - the problem with signs is that "you have to look for the sign, you can't like feel .. well already, I've got to go this way [pointing]"

2:23:50 s3: adds another bs to the row in C by sliding a nearby bs into the row, then pushes the bs towards the pile of couches at W [prob because it's smaller than the other bs's]

2:23:50 s3: moves another bs in C - she's making one row of slanted bs's instead of the 2 rows that s1 had made

2:23:53 s3: gets another bs from the pile of bs's at C-NW

2:23:56 s3: nods at what s1 is saying to s2

2:23:56 s3: places the bs in hand in the row at C

2:23:57 s1: makes gripping gesture with both hands - "you're told in words, you're hanging on that sign" [emphasis]

2:23:59 s3: picks up a bs from a place in the WS nearby

2:24:00 s2: picks up bs from pile at C-NW

2:24:01 s1: touches/adjusts some bs's that s3 has placed in the C as she's still talking to s2 about not using too many signs.

2:24:02 s3: picks up a bs from place in WS nearby and places bs in the 2nd row she's making at C

2:24:08 s3: starts to pickup a bs from WS nearby, has difficulty picking up, then slides it into the 2nd row at C

2:24:09 s1: makes opening sweeping gesture with hand - "use the arrangement of the furniture"

2:24:11 s3: slides another bs from nearby across WS, moves a table out of the way with finger, then slides the bs into the 2nd row in C

2:24:13 s3: adjusts the bs's in the 2nd row

2:24:15 s2: makes bunch of pointing gestures in different directions - "the Killiam library has signs...go here,

go there..."
2:24:17 s2: points to s3 nodding when she says "that's 'cuz its hard to get around"
2:24:18 s3: picks up another bs from pile at C-NW and puts in into the 2nd row in C, while agreeing with something s1 has said to s2 and adds a points [she's still paying attention to the conversation]
2:24:20 s2: puts a bs in hand into the 2nd row s3 is creating in C
2:24:20 s1: points at s2 with little finger as he's making a point about signs - "and sometimes it's to code as well, like bathrooms..."
2:24:24 s3: pushes extra bs's and pile of couches at W further W out of the way of the bs rows
2:24:25 s1: gathers/tidies up the pile of couches at C-W, right after s3 put a couch in it, and moves it a little further W and closer to the pile of orange couches [out of the way]
2:24:25 s3: adjusts the bs s2 placed in the 2nd row
2:24:25 s3: touches/adjusts a bs in another row at C-S
2:24:29 s3: picks up a table in the bs row at C-S
2:24:30 s3: puts the table in hand in the pile of tables at S
2:24:31 s1: picks up small bs from pile at C-NW, puts it down on WS beside the pile and slides it near some other small bs's near C rows, moving another small bs near the one she just placed
2:24:36 s3: picks up bs from row at C-S
2:24:37 s3: slides small bs from 1st row in C near other extra bs's at C-SW, then places bs in hand into the 1st row of bs's at C
2:24:39 s3: makes a small "whatever" movement with her hands on the table to s1, saying "this is just to illustrate" [I think referring to the bs arrangement in the centre s3 has created]
2:24:43 s1: adjusts the bs's that s3's just placed, saying "so I guess..."
2:24:43 s3: picks up two bs's from row at C-S and places them near other discarded bs's at C-W
2:24:44 s2: reaches towards plant pile, then retracts hand
2:24:48 s1: turns over a bs on the WS
2:24:48 s2: "yeah I like this ok" gestures towards C
2:24:51 s2: moves spare bookshelves off of the workspace to pile in front of him on table edge - "I'll take something out"
2:24:56 s1: makes sweeping directional hand gesture along the axis of the bs's "so if it's like this, you'll probably feel like you're... [points to the entrance near s3] do you think you'd feel like you're going against the grain [she points/gestures down the axis from the entrance]?"
2:25:06 s1: "or if it was [she rotates her hands to illustrate the bs's in the opposite direction] this way, then maybe you'd feel like you were going with the grain"
2:25:10 s3: simultaneously turns four bs's in the 2 rows at C using both hands, she slides 2 bs's with each hand - to rotate them to another position as she's illustrating an alternative to s1's suggestion
2:25:13 s3: adjusts the bs's she's just positioned
2:25:15 s1: "yeah" as s3 is changing the bs's, then points to the entranceway near s3 then sweeps her hand down the WS axis again - "what would you feel like ahhhhh, going out [she gestures right off the table]?"
2:25:15 s2: rotates a bs in 2nd row to match the angle of the bs s3 just placed, then rotates one in 1st row in C
2:25:18 s2: points to the C of all the bs's - "this is the middle", then he adjusts the other bs's around the middle
2:25:22 s1: touches the bookshelves that s3 has just positioned..."or...because this way..."
2:25:24 s1: makes a directional pointing along the first bs in the row "...you see the books, then you just see a little bit" points to the end of the second bookself. "then you have to turn all the way around [illustrates this turning with a finger/hand motion around the bs] to see what is down it [gesturing up and down the second bs]
2:25:32 s1: "...but then if it's this way" rotates the bs's s3 just moved to illustrate her point - she laughs and makes a hand motion towards s3, saying "I keep changing this around..." adjusts the bs's "then you can see all this row by barely cranking your head" [she illustrates the sightline with her finger along the bs's]
2:25:41 s2: points on table between the first bs's of the 1st and 2nd row, right next to where s1 is gesturing [he says something but I can't here it, and s1 does not stop talking]
2:25:49 s2: makes a "giving" gesture with his hands in a sweeping movement towards the C telling s1 "not to worry about this"
2:25:56 s1: moves another bs to the new position in C as she's telling s2 that they should worry about the arrangement because "it doesn't cost any more or less money"
2:26:02 s2: "you were saying this way is good?" - pointing/gesturing towards the bs that s3 changed.
2:26:06 s3: "this way is good...but.." she holds a finger up in a "wait a sec" motion, then she repositions two of the bs's in C simultaneously with her two hands and explains that the bs's would be more inviting if they were turned the way she's illustrating.
2:26:06 s3: she points to with her two hands to the bs's s1 has just re-positioned
2:26:10   s3   " pointing to the rotated bs's in centre with both hands and then sweeping gesture from the entrance at E towards the bs's ""...this seems very welcoming..."", then hovering hands over the ""info desk"" at C-E"

2:26:11   s2   adjusts a bs in the north row in C placed by s3
2:26:13   s2   rotates a bs in the south row in C to the same angle as the fist bs s3 placed in that row
2:26:16   s2   repeats on bs beside the one he just rotated in C
2:26:21   s2   " moves a bs in north row in C to be at same angle as the others to the east, but then slides it back to it's original spot and angle, to create a symmetrical angle on the west side of the row and adjusts a bs in the south row in C"
2:26:23   s3   " adjusts the bs's she has positioned at C, pulling them a little away from the C and open-handed claw pointing gesture on the table at C, ""...can open up to a space in the middle..."" "
2:26:25   s2   " picks up plant from a pile on FP at N and puts it in the C, between all the bs's - in response to s3's comment about having a space in the middle, saying ""put a plant there."""
2:26:27   s1   nodding at s3's suggestion of something in the middle of the bs arrangement
2:26:31   s2   " tidies pile of bs's in front of him on the table at N, then picks up a little plant from the pile at FP-N, then quickly puts it back as s3 is talking about a table in the centre"
2:26:35   s3   " picks up a large table on the FP at C-N then picks up the plant that s2 placed in the middle and puts the table in the C, ""....a big meeting table..."""
2:26:36   s2   agrees with s3's idea about putting a table in the centre instead of the plant
2:26:37   s3   " puts the plant in her hand in the pile at C-N and adjusts the bs's around the table, spends some time adjusting these bs's on the E side of the arrangement, while s1 and s2 also adjust some on the W side"
2:26:44   s1   adjusts a bs in the second row in the C
2:26:46   s1   repeats on another bs
2:26:47   s2   slides bs's in the north row in C to the north a little to make room for the table s3 has placed in C
2:26:51   s3   adjusts a bs on the NW side of C
2:26:57   s1   " ""what would we put here?"" points with open claw gesture to spot opposite to Info Desk, at C-WNW"
2:26:59   s1   adjusts bs's with both hands in C
2:27:02   s3   " touches the ""info desk"" at C-E as s1 is talking about what to put at the other side (West side) of the bs arrangement"
2:27:04   s1   " gestures over C area...""it's difficult to get your bearings..."""
2:27:08   s3   " points on the table to the info desk at C-E, then points to the other spot that s1 is talking about at C-W, then gestures back and forth to these two spots, saying ""can this be and information desk, and that be an information desk, as almost a mirror..."""
2:27:13   s3   " touch-points to the entrance at W, then touch-points to the entrance at E, ""are we pointing an precedence on one entrance over the other?"""
2:27:15   s2   " puts finger on pink postit note ""entrance"" at FP-W then points to entrance at E, then back at the entrance at W, saying, ""oh, two entrances right?"" as s3 is talking about these entrances"
2:27:15   s3   " holding right hand on E entrance, waves here left hand back and forth between the W & E entrance, ""or is it going to be..."" (s2 starts talking about needing two information desks now)"
2:27:21   s2   " ""...then we need two information desks, because two entrance [he points to each as he's talking]"""
2:27:23   s2   moves pad of postit notes at table edge at NNE a little towards the FP (farther from the table edge)
2:27:30   s1   discusses whether to put another info desk....she puts her hand down on the FP at E and WNW in an open claw gesture as she's talking about the two sides of the room and points to E and W again as she continues
2:27:44   s1   " puts heel of her hand down on FP at C-E, pointing to the information desk as she's talking about it"
2:27:52   s1   " points with open hands at C-E and C-WNW ""whatever staff was there would have to be split up"""
2:27:57   s3   adjusts the bs's in C (on E side) as s1 is talking about the info desk at W
2:28:10   " s1, s2, s3"   " discuss the how many info desks they need...s1 thinks they need only one, s2 thinks they need something both entrances - they talk for quite a while on this topic"
2:28:36   s1   " suggests another type of desk for the C-WNW spot [she puts her hand back there as she's talking] ""...maybe a drop-off, or sign-off desk...."""
2:28:42   s1   " ""...ok...."", she peels a postit note off of a pink pad at table edge at SSW"
2:28:42   s3   " agrees with s1 to make the W desk a sign-out desk. Asks the experimenter ""is this a library or a place to read?"" - the reply is ""whatever you want it to be."""
2:28:46   s1   " picks up pen from table edge at SW, puts postit note down on table edge in front of her (W) and writes something on it"
2:28:52   s2   " points in a circular gesture on the FP at C-N, ""...we can put a computer lab there... for people to check email"""
2:29:06   s3   " taps on instruction sheet at SE, ""what we should do first is just make sure we establish all of these...."""

2:29:10   s1   moves a bs at C-WNW out of the way with right hand and positions the postit note with both hands at C-WNW

2:29:11   s2   holding onto his instruction sheet on the table edge at NNE as he's reading the requirements - using his finger to follow words

2:29:14   s1   puts pen back at table edge at SSW

2:29:17   s2   " points and touches the postit note ""sign-out desk"" s1 just placed at C-WNW, ""alright..."", then goes back to the requirements list"

2:29:23   s3   " taps and holds left finger on window chair/table arrangement at ESE as she taps on the different window chair/table arrangements around the FP edge at NE, NNE, N, NNW, W, saying ""so that's what these things are that we established..."" (in response to s2's comment about needing individual work spaces)"

2:29:24   s2   touches a chair/desk window arrangement at NNW as s3 is talking about them

2:29:24   s3   " adjusts the window chair/table arrangement at NNW, pushing it closer to the FP edge (s2 had moved it towards the centre before)"

2:29:26   s1   " points around FP edge at S to E, saying ""there's not very many"" [individual study spaces...]"

2:29:28   s2   touches the same chair/desk window arrangement at NNW just after s3 adjusted its position

2:29:36   s3   " makes pulling in gesture towards herself, then points to and taps on the window chair/table arrangement at SE, saying ""so this, around the periphery, becomes the most private spaces..."""

2:29:38   s3   " circles finger around the window chair/table arrangement at SE saying, ""...because you've got these walls..."""

2:29:43   s3   " moves hands over empty FP spaces N and S of the Centre table, saying ""is it possible that we should have individual spaces within the books?"""

2:29:52   s2   " picks up chair from the pile at FP-NE, hovers his hand around C area [appears to be looking for a place to put the chair down], then places it at C-NNE, just outside the bs in C"

2:29:54   s1   " slides two bs's in C away from the table in C with both hands (moves one a bit N and one a bit S), ""we need space for chairs"" [pointing with fingers on both hands around the table at C"

2:29:57   s1   " reaches across table to pick up chair from pile at C-NNE, places it at table in C (on S side of table)"

2:29:59   s2   " picks up another chair from pile at FP-NNE, begins to move hand toward the last chair he just placed at C-NNE, s1's hand is currently there, he puts it down on FP at C by other bs's"

2:30:01   s2   repeats moving chair from pile (FP-NNE) to C [he's placed the two chairs - one large and one small like a chair/desk arrangement]

2:30:01   s3   " picks up chair from the pile at C-NE and places it on N side of the Centre table, hesitating above the table [possibly because s2's or s1's hand's in the way - hard to see from camera angle, but all hands are near the same location for a little while]"

2:30:02   s1   repeats placing chair at C from pile at C-NNE (on S side of table)

2:30:06   s3   repeats from C-NE pile to N of C table

2:30:13   s3   repeats from C-NE pile to N of C table

2:30:14   s1   " switches hands and get chair from pile at C-NNE with left hand - first pulling a couple chairs beside the pile at C-N then picks an ""office chair"" from the two, and places it on S side of table at C"

2:30:16   s2   " mentions parking, s1 & s3 laughs, determine that parking will be outside"

2:30:18   s3   repeats from C-NE pile to N of C table

2:30:19   s1   reaches over s3's hand (in Centre) to get a chair from pile at NNE with left hand

2:30:22   s1   puts chair in right hand then places it on S side of table in C

2:30:23   s2   " ""....so this is just one room?"""

2:30:23   s3   adjusts all chairs on N side of C table

2:30:30   s1   " reaches across table again, intersects with s3's hand, moves around it and picks up a chair from the pile at NNE, with right hand"

2:30:32   s3   picks up chair from C-NE pile and puts at E side of C table

2:30:35   s1   switches hands and places the chair at W side of table in C with left hand

2:30:39   s3   adjusts bs at SW of C table

2:30:40   s2   " picks up a bunch of chairs from pile at FP-NNE, drops them on empty spot in FP at C-N, spreads them out, looking at them, then asks ""what is the difference between this chair and this chair?"" Pointing to one of the chairs at C-N and a chair he placed at C, s3 points to the one at C-N and says, ""that one is more comfortable"""

2:30:42   s3   " puts hand on bs at C-S as says to s2 ""that one's more comfortable"", pointing to the chair he was referring to at C-N, continues to hold onto the bs for a while, while watching s2 place some chair in C"

2:30:46   s2   " picks up chair from C-N, then drops it on the FP again"

2:30:47   s2   " picks up a chair at C-NNE, just outside the chair pile at NNE (s1 dropped these chairs there), points to the Centre table arrangement saying these should be comfortable chairs, s1 suggests putting comfortable chairs for the people listening to the meeting"

2:30:52   s1   " slides a ""comfortable chair"" to C from loose chairs sitting in FP at C-N"

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2:30:58   s2   drops the comfortable chair he's holding at C-N and picks up another office chair to put beside the chair s1 just placed at C
2:31:01   s2   pushes loose chairs at C-N back into the pile at NNE
2:31:01   s3   " picks up chair from pile at C-NE, puts it at end of bs at C-SSE"
2:31:05   s2   " makes circular motion on FP at C-N, saying ""let me design a computer room here...""""
2:31:07   s3   repeats from C-NE pile to C-SSE
2:31:09   s2   " points to the pile of orange couches on FP at WSW, ""what are these for?"" - s1 explains they are couches"
2:31:11   s1   " picks up a couch from pile at WSW, saying ""these are couches?"" in response to s2's question about them"
2:31:11   s3   " touches the chairs in the pile C-NE [appears to pick up chair, but may not] moves chair that she just placed at C-SSE to another spot beside the bs's at C-SSE [does not place a new chair, so probably didn't pick one up from the pile], then adjusts a bs where she's working"
2:31:15   s1   " touches furniture in the pile of tables at SSW, saying ""ah...so...computers...maybe these would be computer desks."" - she picks one up and shows it to s2. They discuss the computer desk arrangement. She holds onto the table in her hand while s2's placing tables in the ""computer room"" area - she suggests ""circular computer desks...""""
2:31:15   s2   reaches across table to pick up several tables from the pile at SSW-S
2:31:19   s2   " puts first a round table on the FP at N, then picks it up and puts down a pink rectangular table."
2:31:21   s2   reaches across table to pick up more pink tables from pile at FP-S
2:31:24   s1   tidies the postit note pads on the table edge at SW
2:31:25   s2   puts two pink tables down at N and arranges them together with the one that's already there
2:31:30   s1   " watches s2 arrange desks then puts table in her hand down on the FP at C-NNW, near where s2 is arranging the computer desks"
2:31:33   s1   picks up another table from the pile at SSW and holds on to it for a while
2:31:33   s3   picks up a small plant from pile at NNE and puts it in between the two chairs she just placed at C-SSE
2:31:37   s3   repeats from NNE pile to C-SSE
2:31:40   s2   " puts extra tables (white) down on table edge at NE and reaches across to pick up more pink tables from the pile at FP-S, while joking about being commercial-minded and putting as many computers in the room as they can"
2:31:42   s3   adjusts bs's in C-NE
2:31:47   s1   " puts the table down beside the one she already placed on the FP at C-NNW, near where s2 is working"
2:31:49   s2   puts 4th pink table down and arranges it with the others at FP-N
2:31:54   s1   " picks up another table from the pile at SSW with right hand, then holds the table in left, then searches through the pile at SSW with her right hand, but doesn't pick anything up"
2:31:57   s1   puts the table on the FP at C-SSE [don't know why she put it here]
2:31:57   s2   " moves one pink table at FP-N around a bit, then places another pink table from his hand down into the arrangement"
2:32:00   s1   " picks up another table from the pile at SSW with right hand, moves it to left hand and holds it"
2:32:00   s2   slides 2 loose chairs to NNW - out of the way of his table arrangement
2:32:07   s1   " begins discussing the layout, ""...so our computer spaces are going to be over here, here, here and here, right?"" - she puts hand down one table in open-handed claw pointing gesture in first location, then almost touching table at other spots [so far only one computer space has been started...]"
2:32:07   s2   " picks up the loose chairs at NNW, s3 reaches across to get some bs's from pile in front of him, he says ""sure"" to her"
2:32:07   s3   " drags some small plants in the FP at C-SE across FP to C-NE, stopping as s1 is talking about where the computer terminals are going to be located"
2:32:08   s1   puts table down on FP at C-WNW
2:32:08   s3   picks up a bunch of bs's from the pile in front of s2 - he moves his hands out of the way for her - at table edge at N and puts them down in a pile in front of her at the table edge at E
2:32:13   s2   " drops extra chairs in hand back into the pile at FP-NNE, the puts the extra pink tables on the table edge at N"
2:32:17   s1   moves the whole pile of plants at NNE with both hands off of the FP to the table edge at WSW (just to her right)
2:32:17   s3   " she puts a bs from the pile at E in the FP perpendicular to the bs's in the C-SE - she places it at C-SSE, moving it around at bit [probably trying to decide where to put it]"
2:32:18   s2   " reaches across table to pick up more pink tables at FP-S, meanwhile s1 is reaching over his arm to pick up plants on the other side of the FP"
2:32:20   s2   " puts pink table in table arrangement at N, adjusts the arrangement"
2:32:25   s3   " picks up another bs from pile at E, carries it towards the bs she just placed, then picks up

another bs [probably switching sizes] from the pile at E, and places it beside the previous bs at C-SSE"
2:32:32   s1   " picks up some leftover plants from the pile, still on the FP at NNE and puts them in the pile at WSW, repeats (the small one's are hard to pick up off of the FP...she has a bit of difficulty getting them in her hand)"
2:32:34   s3   " after trying to arrange the bs's at C-SSE she picks up the last bs she just placed, moves her instruction sheet off the FP at SE and puts the bs along FP edge at SE"
2:32:35   s2   " drops a small pink table from his hand by the arrangement, then slides it out of the way a little and slides a larger pink table on the FP at C-NW (one that s1 put there) into the arrangment, and pushes the small pink table to C-NW, but the other tables s1 put there"
2:32:35   s3   " slides the other bs at C-SSE to the FP edge at S, sliding a table nearby a little towards the C (still at S)"
2:32:36   s1   " adjusts a ""window chair"" at FP edge at SW, then moves postit note pads away from FP a bit closer to the table edge at SW"
2:32:40   s3   " puts a bs back in the pile at E from her hand [it appears so anyways] and then slides her instruction sheet under the FP at SE - out of the way of the FP, adjusting a table at FP edge at SE"
2:32:43   s2   he's formed a square with the pink tables at N - C-N
2:32:44   s1   " picks up pile of orange couches on FP at WSW with both hands and moves it to the table edge in front of her at W, picks up a couple loose pieces at WSW and moves them to the pile at WSW"
2:32:47   s3   picks up bs from her pile at E and puts it along FP edge at NE - holds her hand on it for a while as she looks around the FP - she's looking at s2 creating the computer lab
2:32:51   s2   " sits back from table, looking at FP"
2:32:57   s2   " picks up chair from pile at NNE and drops it inside the tables at N, saying ""need some chairs..."", arranges the chair"
2:33:00   s2   " repeats with another chair from NNE pile to tables at N, then picks up chair in his hand"
2:33:01   s1   " adjusts window chair at SW again, then gathers up the pile of tables from the FP at SSW and starts to move it, but then stops and picks up the pile of white couches at W and moves that to the table edge at W, beside the pile of orange couches. "
2:33:11   s2   " adjusts the tables as s3 is talking about the arrangement he's created - s3 thinks the room is becoming ""fragmented"""
2:33:15   s3   " points to the table arrangement that s2 has created at N, saying ""this arrangement ... makes me think that the room is becoming kind of fragmented..."" - she makes enclosing gesture with her two hands"
2:33:22   s3   " tries to explain to s2 that making ""caverns in certain areas....segments off the room"", she makes enclosing hand gestures over the computer area at N and cross gestures with her over the FP as she's talking, then a opening gesture as she says ""makes appear less kind of open..."""
2:33:23   s2   " starts separating the tables at N as s3 is talking about how ""caverns in certain areas"" can ""segment off"" a room"
2:33:31   s3   " points and gestures along the centre axis from the entrance at E to the centre space towards W, ""...what we're trying to acheive here seems alot more open....than this one"" - pointing to the computer area at N"
2:33:37   s3   " ""...maybe we can work with some to, you know, have a few desks..."" she starts adjusting some of the tables at N"
2:33:41   s2   " adjusts the tables again at N as s3 is still talking about the arrangement - she suggests a more open arrangement that does ""block people off"""
2:33:44   s3   " ""so it's not blocking people off..."""
2:33:46   s1   " picks a table out of the pile on FP at SSW, and puts it on the FP beside the pile, watches s2 & s3 talk about the arrangement of the computer desks that s2 was creating"
2:33:50   s1   " points to the computer desk arrangment at N and says, ""...I think I'd feel, maybe, intimidated to come in..."""
2:33:54   s2   " [the arrangement is more open now] traces his finger along the FP simulating a pathway through the desks, saying ""people can come this way"""
2:33:57   s2   " rotates a table, then sweeps his finger out the other side of the arrangement, saying ""they go out this way"""
2:33:59   s2   slides two of the tables off of the FP on to the table edge at NNW - they s1 says she liked that arrangement
2:34:00   s2   " picks up other chairs from NNE pile, discards one on table edge at N and places one in table arrangement at NNW"
2:34:01   s1   " [in response to s2 moving some table out of his arrangement] ""oh...I kind of liked that actually"" and she slides one of tables in the arrangement to a spot s2 just cleared tables from at NNW - it formed a corner with another table that s2 had placed there."
2:34:11   s1   " she explains why she likes the arrangement she just created, pointing with her fingers illustrating ""these people are focused that way [pointing], and these are focused that way [pointing]..."""
2:34:17   s1   " adjusts the arrangement at NNW a little more to show that ""there you have the light of the window [pointing to the nearby window]"""

2:34:25　s2　" picks up an office chair from pile at FP-NNE and puts it in the arrangement s3 just made in the ""computer area"" at NNW"

2:34:26　s3　arranges a pink table and white oval table on the FP at C-SSE to create a computer area like s1 has just suggested

2:34:28　s1　" moves that table that she put on the FP at SW a bit, saying ""perhaps we should echo that in other areas..."", she reaches for the 2 pink tables that she placed at NW, picks them up, slides the piles of tables at SSW to the E a bit to S, clearing a spot near the SW window"

2:34:29　s1　pushes a pile of tables to S and it runs into the oval table s3 just positioned

2:34:29　s3　keeps her hand on the pink table at SSE while she reads the instruction sheet again

2:34:32　s2　repeats with another chair from pile at NNE to arrangement at NNW (this chair is a big chair)

2:34:37　s1　" uses the white table on the FP at SW, sliding it over a bit, places one of the pink tables in her hand beside it to create a corner desk formation, like the one at NNW"

2:34:37　s2　repeats with two office chairs from pile at NNE now at N part of table arrangement

2:34:38　s1　" replaces the white table with the other pink table in her hand at SW, spends some time adjusting the tables"

2:34:42　s2　repeats with another office chair from NNE pile to N arrangement

2:34:46　s2　repeats with office chair from NNE pile to N arrangement

2:34:52　s1　" picks up pink table from pile at S, puts down white table in her hand on edge of FP at W"

2:34:54　s2　" picks up another office chair from NNE pile, slides big chair at NNW away from arrangement on to table edge at NNW and replaces it with the office chair in his hand"

2:34:56　Note　" everyone's working very quietly and independently on areas (fairly) near themselves [i.e., the working area is closer to the one working on it than to anyone else] "

2:34:57　s3　takes her hand off of the table at SSE - digs through the pile of tables at S and picks up a pink table to arrange with the other pink table at SSE

2:35:02　s1　" looks around, moving pink table around in her hand [appears to be searching for a place to put it], she moves towards S, then puts the table down on the pile of tables at S, moves scissors off of the table edge onto the floor, moves pen and postit note pads over a little to the W (the pile's spanning the table edge SW-SSW), clearing a spot on the table edge"

2:35:04　s3　" looks around table, then picks up a little square pink table and chair from the pile of miscellaneous items in front of s2 at N"

2:35:04　s3　places the table and chair at the window at SSE

2:35:05　s2　moves discarded chair at NNW to the pile of other discarded chairs at N

2:35:08　s3　" swaps the pink table and white chair at SSE with the orange chair at S, saying ""...make that one orange..."" to create and alternating pink table/white chair and orange chair arrangement around the south edge of the FP at the windows"

2:35:09　s2　" picks up another office chair from NNE pile and places it in arrangement at N, then adjusts the tables in the arrangement"

2:35:10　s1　" gathers up all the tables in the pile at S with both hands, separating a bs that's touching the pile, moves the pile to table edge at S, moving right over s3's hand at FP edge at S"

2:35:13　s1　" moves loose tables at FP S to pile at table edge S, again moving right over s3's hands at FP edge at S"

2:35:15　s3　pushes her instruction sheet at SE under the FP a little more

2:35:16　s1　moves last loose table piece at SSW to pile at table edge at S

2:35:16　s2　picks up the chair he just placed at N and slides the table he was adjusting off of the FP to the table edge into the pile of misc discards at N

2:35:18　s3　tidies the pile of bs's right in front of her at E

2:35:22　s2　slides a white square chair [or possibly table] from the NNW arrangement off of the FP to table edge at NNW - as he does this he hold the FP down with his other hand because it was moving as he was sliding the piece of furniture

2:35:25　s2　" moves a table in the arrangement away from the other tables a little - spacing them out a little (at N), still holding the chair in his hand"

2:35:26　s1　picks up pink table from pile at S and looks around the FP

2:35:29　s3　" reaches across table to grab a bunch of plants from the pile in front of s1 and puts them down in a pile in front of her on the table edge at ENE - s1 comments as s3 picks up the plants ""yeah we need plants..."""

2:35:38　s2　" adjusts table at N again, the puts chair down in arrangement and adjusts the chairs at N"

2:35:48　s1　" holding table, listening to s3 explain that she's like to arrange the periphery to focus on the centre area. s1 watches s2 put rows of plants in the WS"

2:35:50　s3　" ""...well I was just thinking that ... this is kind of funnelling [gesturing with both hands towards the centre]....it seems kind of nice to arrange something like [she puts a plant from the pile at ENE down at FP edge at SE]...so everything is really focusing....I'm just throwing things on... [picks up more plants from the pile at ENE and puts a plant at SSE and then another plant beside this one, to form a row perpendicular to the FP edge, then slides the two pink tables out of the way to a nearby FP location and puts

another plant beside the plant at SE to form another row towards the centre - she gestures in towards
the centre] everything is kind of focusing..."" "
2:35:50   s3   puts another plant from her hand down on the FP edge at NE
2:35:55   s3   " picks up another plant from pile at ENE and puts it beside the plant at NE - it's touching the
pile of chairs at C-NE - she points to a chair/table arrangement by the window nearby, saying ""that makes
this space more private"""
2:35:57   s3   " picks up two plants from NE pile, slides the pile of chairs towards the centre a tad and
places the plants on the other side of the window from the first plant row at NNE, ""what do you guys
think?"" - she adjusts the plants"
2:36:07   s1   drops table on FP and makes several gathering gestures towards the Centre area -
agreeing with s3 about having a focus on the middle area
2:36:13   s1 & s3 " discuss the idea of arranging plants around the outside to hightlight the central area and
to establish private spaces on the outside - s2 listens and watches - he tries to say something at one point,
but s1 cuts him off while she's talking to s3 - s2 appears to be playing a very secondary role in the decision
making compared to s1 & s3 - he seems to get overridden often because s1 & s3 tend to usually agree on
things"
2:36:16   s1   pushes extra plants on the FP edge at WSW onto the table edge
2:36:19   s3   " picks up a small round table at table edge at S and puts it in between two rows of plants at
SE, saying ""...and that makes a space for a little bit more private .... [she picks up chairs from the pile of
tables at S (there were some chairs on top of it) and places them around the table at SE] ... like not that
private, but a semi-private space..."""
2:36:26   s2   reads instruction sheet again...reading outloud (quietly) and using his finger on the paper at
NNE
2:36:31   s1   adjusts the table arrangement at SW
2:36:34   s3   slides a bs from FP edge at NE off the FP to the table edge at NE
2:36:35   s1   " picks up table from pile at table edge at S and puts it at SSW in the FP, beside the table
arrangement at SW"
2:36:37   s2   " picks up a plant from pile at table edge at NE, saying ""so we can put one plant in every
window..."", he drop plant on FP at NNW by the window"
2:36:39   s1   " reaches across table to pile up some ""office"" chairs from pile at C-NNE on FP"
2:36:40   s3   picks up table from pile at S and puts it on FP edge at ESE
2:36:41   s1   places chairs around table at SSW
2:36:41   s2   " repeats from NE pile to NW window, saying ""one for every window"""
2:36:45   s2   " sits back & s3 says ""wants some plants?"" pointing to to the W side of the FP - she puts
the 2 plants in her hands down on the FP at N and pushes them towards s2"
2:36:45   s3   " picks up plants at her pile at table edge at ENE and says to s2 ""want some plants?"" and
points to NW-W side of the table, she puts some plants down on the FP at NNE and pushes them towards
s2"
2:36:46   s1   " reaches across table again to get more chairs from the pile at C-NNE, hesitating a little
until s3's moved her hand out of the way, picks up some with right hand, then some more with left hand"
2:36:46   s3   picks up some more plants from ENE pile and tosses them on FP at N
2:36:47   s2   " picks up plants at N and puts it at a window at another window at WNW-NW, saying ""one
for every window"""
2:36:52   s3   picks up small plants from ENE pile and puts one between the two large plants at SE
2:36:53   s1   " slides the ""office chairs"" away from the table at SSW, towards the Centre to C-SSW, and
places the new chairs around the table - these are ""comfortable chairs"""
2:36:53   s2   " picks up another plant on FP at N and reaches across table [intersects with s1's hand]
drops plant at C-S, and pushes it to window at S"
2:36:56   s2   picks up plant at N and places at window at W
2:36:56   s3   puts the other small plant in hand between the two large plants at SSE
2:36:59   s1   " reaches across to get another ""comfortable chair"" from the pile at C-NNE on FP, saying
""those would be kind of like where people would gossip..."""
2:37:01   s2   " sits back, then reaches towards NE, then sits back again"
2:37:02   s1   puts the chair around the table at SSW
2:37:06   s1   tidies the postit note pads on the table edge at SW
2:37:06   s2   reads instructions again
2:37:08   s3   " moves one large plant from SSE right beside the other large plant along the FP edge (also
at SSE), then picks up a small plant from the table edge pile at ENE and puts it beside the newly place large
plant at SSE"
2:37:09   s1   " reaches across to get another ""comfortable chair"" from pile at C-NNE and puts it at table
at SSW"
2:37:18   s3   picks up table at table edge at S and places it at FP edge at NE
2:37:22   s2   " ""so if people want to work on project they should come here [points to table in C], or
maybe we need some other table..."", he reads instructions outloud about the project space"

2:37:25   s3   digs through table pile at S and picks up chair and places it at table at FP edge NE

2:37:28   s3   picks up chair from pile of chairs in FP at C-NE and places it at table at NE

2:37:31   s2   " sweeping hand gesture over C table, ""this one is more public"""

2:37:31   s3   adjusts the table/chairs at NE

2:37:33   s2   " ""maybe we can put some place right there"", open-handed, claw pointing on table to empty space at NNE, beside pile of chairs"

2:37:38   s1   " points to the table/chair arrangement at SSW as she's talking to s2, saying ""like these spaces?"""

2:37:40   s3   " picks up two chairs at pile at C-NE and puts them at table at NE, then pushes the edge of the chair pile out of the way (tidying up the pile at C-NE)"

2:37:47   s3   adjusting table chair arrangement at NE

2:37:49   s1   " points with open-handed, claw gesture, above the WS to the table/chair arrangement at SSW (she made) and the table/chair arrangement at SE (s3 made), saying ""I can see these spaces as discussion spaces..."""

2:37:54   s1   " points with open-handed, claw gesture to computer desk area at N-NNW, saying ""...and these areas as project areas...but not necessarily working together..."""

2:37:59   s1   " ""maybe we should set up a couple tables where people can work together..."", pointing to computer desk at N as she's speaking, s3 says ""with the computers?"", s1 says ""yah"", s2 says ""...basically computers everywhere?"""

2:38:11   s2   " points to ""computer area"" at N, saying ""so basically there's no computer lab, there's just computer everwhere, scattered?"" gesturing around the FP"

2:38:11   s3   " puts hand on table beside computer area at N, ""...well not necessarily..."", she leaves hand there for quite a while as s2 is talking (more about 1.5 minutes - she doesn't move it until after s2 points to that location at around 39:40)"

2:38:27   s2   " does not want discussion allowed in the computer lab - he says, ""some people might be programming"" [he's a CS major]"

2:39:08   s2   " points to empty spot on FP at C-NW, saying ""...I think separate room is good, separate table..."" regarding the discussion about a group computer work area"

2:39:19   s2   " makes circular pointing gesture over computer area at N, ""this one can be separate...computer labs..."""

2:39:35   s2   " points with open hand over computer area at N, ""this one is good..."" (for a separate working area, computer lab)"

2:39:40   s2   " reads instructions, ""for this one, I'd say put some separate tables, here [points to empty spot at C-NW he previously pointed to], here [points to spot at C-NNE, right beside s3's hand which is pointing and touching a spot at C-NNE], here [points to spot at C-S]"""

2:39:47   s3   " ""right, so I think that's what we're trying to do here..."" she touch-points to the table/chair arrangement at NE"

2:39:51   s3   " ""here you have a little...ah....space defined by these plants really....we don't have to do it with walls"" she makes an enclosure gesture with her hands and then points to the plants at NE"

2:39:54 " s1, s2, s3   " they have long discussion about what to do with the computers...do they have a ""lab"" or do they have computers ""everywhere""? There's lots of pointing, but no manipulation of the objects"

2:40:01   s2   " in response to s3's comment about the group spaces they've already set up, he says, ""ok, so you've got one [points to arrangement at NE], two [points to arrangement at SE]..."""

2:40:04   s1   gathers up couches in the pile (tidying) at table edge at W as the discussion continues and s3 picks up plant from table edge at WSW

2:40:06   s3   " she touches the table at ESE, then says ""...so this can be universal..."" she picks up some plants at the pile across the table at the WSW table edge and places then on the FP edge at NNE"

2:40:08   s1   picks up white table from FP edge at W and puts it on table edge at WNW

2:40:08   s3   " slides a large plant from FP edge at N to another spot at NNE, on the other side of the FP window from the plant she's just placed at NNE, then she places some small plants from her hand beside these two large plants at NNE to form two rows beside the window"

2:40:10   s1   moves white table from table edge at WNW to pile of tables at table edge at S

2:40:13   s2   " reads the instruction sheet again, then watches s3 rearrange some of the plants in front of him"

2:40:17   s1   " picks up round white table from pile at table edge at S, slides pink table at SW closer to the FP edge and puts round table down at WSW"

2:40:22   s3   " she slides a large plant at N over a bit E so it is beside the window at N, then looks around"

2:40:24   s2   adjusts table at C-N

2:40:26   s2   picks up marker from table edge at NNW as s1 and s3 are rearranging different areas of the FP

2:40:26   s3   she places some small plants in her hand beside this large plant at N to form a row

2:40:27   s1   " she adjusts the four tables, playing around to figure out an arrangement, she moves the round table close to W in the FP"

2:40:29   s3   picks up a table from pile at table edge S

2:40:30   s1   " picks up a larger round table from the pile at S and replaces it with the smaller round table at W, sliding a loveseat [or small white table?] out of the way towards the centre to C-WSW, puts the smaller round table back in the pile at S"

2:40:32   s2   " reads FP again, then writes something on a blue postit note on a pad at the table edge at N"

2:40:35   s3   places table between two plant rows at N

2:40:42   s3   " then picks up table from N, picks up a smaller table at FP edge at E and places the larger table between two plant rows at E instead, then puts the smaller table back in the pile at table edge S"

2:40:43   s1   " picks up some chairs with both hands from pile at C-NNE, and puts them around the table at W"

2:40:45   s2   " peels postit note off of pad at N, looks around then places it in the table arrangement at NNW, saying ""...quiet place...""

2:40:49   s1   repeats with another chair from C-NNE to W

2:40:52   s2   pushes postit note at NNW down on table as he reads the instructions about quiet study place

2:40:52   s3   picks up chairs from pile at C-NNE and places them at the table at E

2:40:56   s1   " moves a blue postit note on FP at C-NNW to inside the ""computer room"" at N"

2:40:57   s2   checks off that requirement on the instruction sheet at NNE with the marker

2:41:01   s1   picks up another table from pile at S

2:41:03   s1   " puts table on FP at NW, between two plants that are there"

2:41:03   s3   picks up more chairs from pile at C-NNE and places them at the table at E

2:41:08   s1   " reaches across table to get chairs from the pile at C-NNE, with both hands"

2:41:08   s2   reads the instructions again

2:41:12   s3   " adjusts the new chairs at E, then removes them and moves the table closer to the FP edge, holding the chairs in her hand"

2:41:18   s1   puts chairs at table at NW

2:41:20   s2   " points to centre area, then points one of the requirements on the sheet at NNE, saying ""I think this one is this....provides a space for current...also make the space as attractive and inviting as possible..."" he points again, wiht sweeping, circular pointing motion to C arrangement, s1 and s3 agree with him, and also say that it applies to the whole room"

2:41:23   s1   " agrees with s2, gesturing a sweeping hand motion around FP, saying ""yeah, but also these little areas too...""

2:41:27   s3   " leans back and gestures around the room, saying ""...it's also a thing that applies to the entire room..."" (in reference to s2's comment about making the space as attractive and inviting as possible)"

2:41:30   s3   " ""...that's what I think is really nice about this arrangement..."" pointing to the entrance at E with index and pinky fingers and gesturing down the centre room axis"

2:41:31   s1   " touches the pile of tables at S, then reaches across table to get chairs from pile at C-NNE"

2:41:36   s1   puts one chair back in the pile at C-NNE

2:41:37   s1   " places chairs at table at NW, sliding the plant a little out of the way"

2:41:38   s2   reads instructions again

2:41:38   s3   puts the chairs in her hand back in the pile of chairs at C-NNE

2:41:42   s3   " slides some small plants around that are on the FP near the pile of chairs at C-NNE, then leaves them and adjusts the row of plants at ENE"

2:41:46   s2   " ""so current journal section means this one?"" he makes circular pointing motion over C bs arrangement, they discuss this for a bit, then decide that that's a good journal area, then s1 asks about needing more journals"

2:42:01   s3   picks up a bs at table edge at NE as s2 and s1 are talking about journals

2:42:03   s1   " picks up loose bs at C-W as they're talking about the journals, ""...but do we need more journals?...""

2:42:08   s2   " picks up bs from pile in front of him (at N) on the table edge, holds it while s1 & s3 discuss putting more journals and where to put them"

2:42:09   s3   " points to the journals she's placed along the FP edge at S to SE because s1 has just noticed them, s3 says ""oh I just put those in there, they don't have to go there...I was just playing around"""

2:42:13   s1   " touches a bs at S, saying ""oh, this gives you more books...."" s3 says, ""yeah I just put those in there...they don't have to go there...""

2:42:21   s3   " picks up the bs at SE, ""but if we're going to put these spots here [points to the table arrangement at SE] then it might be kind of difficult to access these..."" and moves the bs to C-SSE beside another bs that's loosely positioned there, ""it's better to probably keep them in the centre...""

2:42:26   s3   " drops the bs in her hand on the FP at C-ENE and picks up part of the pile of chairs with both hands on the FP at C-NNE, saying ""let's move these things...""

2:42:27   s1   " puts the bs in her hand down on FP at C-S, ""how should more of them be arranged?"""

2:42:27   s2   " puts the bs in hand down at C-N, near the bs's in the C, prompting s3 to move the pile of chairs out of the way"

2:42:30 s3 " she puts the chairs down in a pile on the table edge at NE, then picks up the rest of the pile at C-NNE and adds them to the pile at NE"

2:42:31 s2 tidies the pile of bs's at table edge at N

2:42:35 s2 " picks up another bs from pile at N, and puts it on FP beside the one he just placed at C-N"

2:42:38 s1 " reaches in front of s2 to get some bs's, ""oh you've got some over there...."" - she takes a bunch"

2:42:38 s3 picks up a pink table at C-SE with left hand and puts it in the pile of tables at table edge S

2:42:40 s2 " picks up bs from pile at N, then hesitates while s1 is picking up bs's from the pile, then goes underneath her arm to place the bs at C-NNW, in line with a bs in the north centre row"

2:42:40 s3 picks up pink table at C-SSE and move it to the pile at table edge S

2:42:44 s2 " picks up bs from N pile, then s1 reminds them they need to put in as many people as possible, he says, ""oh, that's very important..."", he drop the bs back in N pile and picks up some chairs from the NE pile on table edge"

2:42:45 s2 " picks up another bs from N pile, puts it down at C-NNW beside one he just placed"

2:42:50 s3 " picks up bs's at C-SSE and C-E and holds on to them as s1 talks about putting in ""as many people as possible.."""

2:42:52 s1 puts some extra bs's down on the table in front of her (C-W on the FP) and sorts through the ones she has

2:42:52 s1 " says ""we also have to remember to put in as many people as possible..."" as she's holding the bs's"

2:42:54 s1 puts a bs beside the one she just placed at C-S - adjusting them

2:42:55 s2 " with chair in hand, he moves his hand around over the FP [appears to be trying to find a place to put more chairs down]"

2:42:59 exp " ""you have about 2 more minutes...you don't have to be totally done"""

2:43:01 s2 adjusts a chair in the FP at N-NNW

2:43:02 s1 " picks up bs's from little pile at C-W, holds them"

2:43:04 s2 " ""let's put as many people as possible"", he puts a chair down at NNE, near a chair/deck window arrangement"

2:43:06 s1 picks up another bs from C-W and places it beside others she's put at C-S

2:43:11 s3 " ""of these things, we can't do everything"", pointing to her instruction sheet at SE"

2:43:13 s2 picks up the chair he just placed at NNE

2:43:19 s1 " they discuss ""is it more important to have as many books as possible or as many people as possible?"""

2:43:21 s2 " picks up chair from table edge at N and reaches across the table to put the chair at C-SW, near the bs arrangement at C - just as s1 & s3 are discussing which requirement they want to optimize ""is it more important to have as many books as possible or more important to have as many people as possible?...probably people"""

2:43:24 s2 " picks up the chair he just placed at C-SW, holds onto it as he looks around FP"

2:43:24 s3 reads from instruction sheet as she and s1 discuss whether to books or people are a priority

2:43:31 s2 " points to empty spot at C-NNE, mumbles something that sounds like ""here's a spot..."""

2:43:34 s3 " starts to pick up a table from small pile of tables at NE table edge, then leaves it and picks up table from pile at table edge S, and puts it on FP edge at NNE, between two plant rows"

2:43:39 s1 " picks up bs from C-W, moves hand with bs's in it towards C a few times, but retracts each time [seems to be trying to figure out where to put the bs's in her hand - they're smaller than the other one's she's placed already]"

2:43:39 s2 " moves hand towards E, hesitates as s3 puts something at NNE, then when she moves he puts the chair down at NE"

2:43:39 s3 picks up a chair from the pile at table edge NE and puts it at the table at FP edge NNE

2:43:40 s3 repeats from TE-NE to FPE-NNE

2:43:41 s1 " reaches across table to pick up large bs from table edge in front of s3 at E, and places it at C-NNW beside some bs's s2 has placed - she's still holding the smaller bs's in her hand"

2:43:41 s2 puts another chair from hand down at table s3 just placed at NNE

2:43:43 s2 repeats at NNE

2:43:44 s3 picks up chair that s2 just placed at FPE-NE and drops it on the pile of chairs at TE-NE

2:43:44 s3 puts another chair (from hand) and adjusts the chairs around the table at FPE-NNE (just after s2 put a chair there)

2:43:47 s1 adjusts bs's at C-NW

2:43:51 s3 puts a table from hand at FPE-N between two plant rows

2:43:54 s1 " holds her hand over the bs's she's placed at C-S, ""ummm..."", looking at the arrangement N of C - it's different than the one she has created S of C, she slides them around a bit"

2:43:55 s2 " puts chair down at C table, then picks it up again"

2:43:56 s2 " puts a different chair, one that matches the current chairs, at C table"

2:43:57 s3 picks up chairs from pile at TE-NE and puts around table at FPE-N

2:44:03 s2 repeats at C

2:44:03   s3   picks up more chairs from TE-NE pile and puts around table at FPE-N

2:44:06   s1   picks up 2 large bs's on FP at C-SSE and places them at C-SE in a similar arrangement to the N of C bs arrangement

2:44:08   s2   adjusts C table

2:44:13   s1   " puts two small bs's from her hand at C-SSE, beside the larger bs's she's just placed [using 2 small to be like one large]"

2:44:17   s2   picks up more chairs at pile at NE

2:44:18   s2   " points to table arrangement at SW saying something about more chairs - s1 responds - ""yeah we need more chairs"" (the arrangement currently has no chairs)"

2:44:24   s3   " watches s1 place bs's at C-SE and says ""I like that....maybe....maybe"" she picks up two bs's that s1 just arranged and puts them in the pile of bs's at TE-ENE"

2:44:25   s2   drops chairs in his hand in pile of misc items at N and picks up chairs from chair pile at NE

2:44:27   s2   " still holding chairs in left hand, picks up chair from pile at N with right hand and drops it by the table arrangement at SW"

2:44:27   s3   picks up smaller bs's from the pile at TE-ENE and replaces them where she just removed the larger bs's at C-SE

2:44:29   s2   picks up a chair from his hand and drops it at arrangement at SW

2:44:31   s2   puts last chair in his hand at SW arrangement [they seem fairly randomly placed]

2:44:32   s3   she replaces the third bs s1 placed at C-SE with one in her hand and puts the removed bs in the pile at TE-ENE

2:44:33   s1   " touches an item on the table edge at WNW, then reaches across table to pick up a chair from pile at table edge at NE - she picks up a bunch in her hand"

2:44:33   s2   " picks up more chairs from NE pile, hesitates while s1 is reaching across table in his way, then starts to reach over to SW again, but stops as s1 starts arranging the table/chair arrangement at SW"

2:44:38   s3   picks up more bs's from the pile at TE-ENE and adds them to the end of bs's at C-NNE

2:44:40   s1   " using her hand as a tray holding a bunch of chairs, she places a chair around tables at SW"

2:44:40   s3   picks up two larger bs's sitting on the FP at C-N and puts them on the pile of chairs at TE-NE

2:44:42   s3   " picks up another small bs to add to a third long bs at C-NNE - it's slightly smaller than the other ""small"" bs's she's already placed"

2:44:46   s1   repeats at SW

2:45:00   s1   " points to group table at SSW, saying ""...the problem is that they'll be having a discussion here, but they'll be working here [pointing to the desk arrangments at SW]"""

2:45:01   s3   " picks up another bs from the pile at TE-ENE (also shorter than the original two), and puts it at C-NNE [her hand is obsuring the camera angle, so it's hard to see what she's doing exactly, but I think she tried to put the two short ones together , but they were longer than the other ones - when she moves her hands, she's lined up the four short bs's beside each other, with the two onger ones on the outside and two shorted ones on the inside]"

2:45:02   s2   puts chairs in hand down on N pile

2:45:04   s3   " taps on the FP at C-N, saying ""it might just be good to have this computer station here"" - keeping her fingertips on the table as she's talking to s1 - until s2 puts a table on the FP beside her table, then she moves it"

2:45:07   s1   " picks up chairs at SW and puts them back in her hand, as s3 suggests that maybe they just have a computer station at N (s3 points on table with open, claw hand to N)"

2:45:08   s2   " picks up pink table from N pile and puts it right beside s3's hand at C-N (just east of current computer lab) as she suggests putting a computer station there, when she moves her hand he pushes the table to where her hand was touching"

2:45:09   s1   " waves hand over desk arrangement at SW, ""what would we put here?"""

2:45:11   s2   " puts another table from N pile at C-N, meanwhile s1 & s3 are discussing where the computer desks should go"

2:45:15   s2   picks up chair from NNE and places it with the new table arrangement at C-N

2:45:17   s2   picks up another chair at NE pile and puts it at C-N

2:45:23   s2   repeats from NE pile to C-N

2:45:23   s3   " talks to s1 about continuing the small casual workspaces around the periphery, she points and taps on the table around the SE area as she's talking"

2:45:25   s1   " ""I like this idea of the plants and the people all the way around"" - sweeping hand gesture around the FP edge"

2:45:25   s2   sits back from table

2:45:29   s1   puts chairs from hand into new pile on table edge at NW

2:45:31   s2   " picks up chair from NE pile, adjusts tables at C-N and then puts chair in the arrangement"

2:45:32   s1   picks up tables from SW and puts them on table edge beside chairs at NW

2:45:33   s3   " reaches across table and picks up plants from TE-WSW, and places the plants at FPE-S, beside a plant that already there, sliding the chair/table arrangement at SSW a little west and drops puts one

plant on each side of it at SSW and SW (at FPE)"

2:45:36   s1   picks up another table from SW and puts it on other side of chairs at table edge at WNW

2:45:37   s2   sits back from table again

2:45:37   s3   picks up some small plants at TE-WSW and puts at FPE-SW

2:45:38   s2   " makes gathering gesture over N pile at table edge, then sits back again"

2:45:38   s3   " picks up large plant from FP at SE from a row of two large plants and one small plant, and puts in at FPE-WSW"

2:45:39   s1   " touches chair at SW, then adjusts plant at WSW s3 just placed "

2:45:39   s3   adjusts a large plant at FPE-W

2:45:41   s1   adjusts plant s3 just placed at W

2:45:46   s3   " picks up large plant from row of two large plants at FPE-NE, then reaches across table to get a small plant from TE-WSW and put it with the one large plant left at FPE-NE"

2:45:47   s1   " tidies up pile of couchs at table edge at W, making sure they don't spill onto the FP, picks up a little orange chair from pile and puts it in a window at WSW"

2:45:48   s2   " picks up another chair from NE pile, looks around the FP, then says ""I think we are up?"", dropping chair on table edge at N [exp's getting up]"

2:45:50   s3   slides another small plant from C-NE to FPE-NE

2:45:50   s3   picks up the other small plants at C-NE and puts them on the table in the pile at TE-NE

2:45:50   Note   END

Appendix C. Creating the Tabletop Groupware from Chapter 6

This appendix provides further details on the implementation of the test-bed environment that was used in the study in Chapter 6 and details on how to implement storage bins and the peripheral storage area.

C.1 The OpenGL Workspace

The visible test-bed workspace was created by stretching a Tao OpenGL .NET container control widget (available for download at www.taoframework.com) across the entire Windows Form in Visual Studio .NET and maximizing the window at runtime so that only the OpenGL container pane is visible. This container widget allows the developer to send OpenGL draw commands to this window to produce the visual components in the workspace. By mapping the OpenGL viewport to the window's pixel dimensions and using the orthographic projection, the developer can deal with straight pixel values throughout the rest of the drawing and interaction code. This is done using the following code, where `ClientSize` is the size of the OpenGL control:

```
/* Initialize the OpenGLWorkSpace */
Gl.glViewport(0, 0, this.ClientSize.Width, this.ClientSize.Height);
Gl.glMatrixMode(Gl.GL_PROJECTION);
Gl.glLoadIdentity();
Glu.gluOrtho2D(0.0, (double) this.ClientSize.Width,
               this.ClientSize.Height, 0.0);
```

This approach simplifies computations related to workspace interactions because all touch coordinates are provided in pixel values. Our test-bed environment was a strictly 2-dimensional workspace. Thus, this viewport and perspective provided a one-to-one mapping of possible touch points in the workspace to the OpenGL workspace. However, if more complex visuals or interactions are desired (e.g., 3-dimensional workspace), a different viewport or projection could be used.

All interaction items (e.g., images, layout pages, etc.) are currently being created by drawing bitmap textures from stored bitmap image files. A straight forward application of this technique creates images that are square and are of 2^i x 2^i ($i = 0, 1, …, n$) dimensions. For our study we accepted these limitations on the variety of image sizes

and shapes that were used. For the simple layout task performed in the study described in Chapter 6 this approach was sufficient since participants could manipulate the size and shape of the items using a resize icon. For more complex interactions, though, an alternative approach would be needed, especially to allow the use of non-image content such as documents.

Since all workspace items are basic OpenGL primitives, an underlying method had to be developed to provide a way to interact with these objects. This is done using a combination of two methods, to provide real-time interaction performance. The first method uses an underlying workspace grid structure, which stores all interface objects and interface components and their current ordering in the workspace. It also facilitates interaction between components (i.e. storing an image in a storage bin). The second method provides faster detection of storage mechanisms (or other interface components) under the current touch point. The OpenGL *selection buffer* is used to determine if the current touch point is over a storage mechanism (and whether it is over the transition zone or the main container area). Once it has been determined that the touch point is over a storage mechanism, the precise storage mechanism is obtained from the grid structure.

C.2 The Storage Mechanisms

The storage mechanisms (i.e. the storage bins and the peripheral storage area) are created with OpenGL drawing primitives, using a 0.3 alpha level in OpenGL to produce a subtle visual look. For each storage mechanism, a set of control points are calculated and used to draw the storage mechanism. These control points are recalculated whenever someone modifies the storage mechanism. An example of the drawing procedure used to create the storage bin is given below, where the `this.vertexArray_BorderInside` is the array of control points for the inside border of the storage bin and the `this.vertexArray_BorderOutside` is the array of control points for the outside border of the storage bin:

```
/* Draw Container Area */
Gl.glColor4f(0.2f, 0.4f, 0.8f, 0.3f);
Gl.glVertexPointer(2, Gl.GL_FLOAT, 0, this.vertexArray_BorderInside);
Gl.glDrawArrays(Gl.GL_TRIANGLE_FAN, 0, nodeList.Length+2);
```

```
/* Draw Transition Zone */
Gl.glColor4f(0.3f, 0.6f, 0.9f, 0.15f);
Gl.glVertexPointer(2, Gl.GL_FLOAT, 0, this.vertexArray_TriangleStrip);
Gl.glDrawArrays(Gl.GL_TRIANGLE_STRIP, 0, nodeList.Length*2+2);

/* Draw Inside Border */
Gl.glLineWidth(1.5f);
Gl.glColor4f(0.2f, 0.5f, 0.9f, 1.0f);
Gl.glVertexPointer(2, Gl.GL_FLOAT, 0, this.vertexArray_BorderInside);
Gl.glDrawArrays(Gl.GL_LINE_LOOP, 1, nodeList.Length);

/* Draw Outside Border */
Gl.glLineWidth(2.0f);
Gl.glColor4f(0.2f, 0.5f, 0.9f, 1.0f);
Gl.glVertexPointer(2, Gl.GL_FLOAT, 0, this.vertexArray_BorderOutside);
Gl.glDrawArrays(Gl.GL_LINE_LOOP, 0, nodeList.Length);
```

The control points used for the storage bins are calculated using a Dyn-Levin-Gregory (Dyn et al., 1987) interpolating subdivision curve, since this approach produces a smooth curve with control point actually on the curve. This approach was first used on a related project, called Interface Currents[13], and was then adapted for the purposes of the Storage Bin project. The peripheral storage area uses a similar drawing method, but with control points along a rectilinear boundary.

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[13] For more details see:

Hinrichs, U., Carpendale, S., & Scott, S.D. (2005). Interface Currents: Supporting Co-Located Collaborative Work on Tabletop Displays. Technical Report 2005-773-04. Department of Computer Science, University of Calgary. Calgary, AB, Canada.

Appendix D. Storage Mechanism Study Materials

D.1 Informed Consent Form

[University of Calgary Logo]
Department of Computer Science
Consent Form

Title of Investigation: Interfaces for organizing and sharing information
Investigators: Stacey Scott, Sheelagh Carpendale

This consent form, a copy of which has been given to you, is only part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. If you would like more detail about something mentioned here, or information not included here, please ask. Please take the time to read this form carefully and to understand any accompanying information.

Description of Research Project:
We are currently investigating how software can support interactions between people as they organize and share information. In particular, we are interested in investigating how various software interfaces affect the organization and sharing of digital media, such as documents and images, during collaboration on large-screen displays. To this end, you will be asked to use two large-screen interfaces that offer a variety of support for organizing and sharing information while you perform a layout activity. This activity will involve working with a partner to create picture collages from a set of digital images.

During the session, a researcher will observe and take notes regarding your workspace interactions and you will be videotaped. Your interactions with the software will also be programmatically captured. Videotaping is optional and you can still participate if you choose not to be videotaped. You will also be asked to complete four brief questionnaires to further our investigation: one for background information, one after each of the two interface trials, and one at the end of the experiment. It is estimated that your involvement will take approximately one hour, and you will be remunerated for your time.

There are no known harms associated with your participation in this research. No information that discloses your identity will be released or published without your specific consent to disclosure. All data received from this study will be stored in a locked cabinet and such information that will be stored on a computer will only be accessible through the use of a password. All data will be stored for a period of time no longer than five years. Information will be carefully disposed of (shredding for hard copies and deleting for electronic copies) when this investigation is complete.

You will be able to withdraw from this study at any point. If this occurs, any data collected up to that point about you will be discarded. You are also able to refuse to answer whatever questions you prefer to omit.

Informed Consent: Your signature on this form indicates that you have understood to your satisfaction the information regarding participation in this research project and agree to participate as a participant. In no way does this waive your legal rights nor release the investigators, sponsors, or involved institutions from their legal professional responsibilities. You are free to not answer specific items or questions in interviews or on questionnaires. You are free to withdraw from the study at any time without penalty. Your continued participation should be as informed as your initial consent, so you should feel free to ask for clarification or new information throughout your participation. If you have further questions concerning matters related to this research, contact:

Stacey Scott, Department of Computer Science, University of Calgary
Phone: (403) 210-9501, sdscott@cpsc.ucalgary.ca

Sheelagh Carpendale, Department of Computer Science, University of Calgary
Phone: (403) 220-6055, sheelagh@cpsc.ucalgary.ca

If you have any questions not satisfactorily answered by the primary researchers concerning your participation in this project, you may contact the Office of the Vice-President (Research), University of Calgary, and ask for Pat Evans, (403) 220-3782.

	Please Circle One		**Please Initial Your Choice**
I agree to participate in the activities explained above	YES	NO	____
I agree to be videotaped, photographed, and audiotaped	YES	NO	____
I agree to let my conversation during the study be directly quoted, anonymously, in presentation of the research results	YES	NO	____
I agree to let the videotapes/photographs/audiotapes be used for presentation of the research results	YES	NO	____

_____   _____
Participant Name (please print legibly)   Participant Signature

_____   _____
Investigator/Witness   Date

A copy of this consent form will be given to you to keep for your records if you request it. This research has the ethical approval of the Department of Computer Science and the University of Calgary.

D.2 Pre-Experiment Questionnaire

Instructions: For each of the following questions, please circle one and only one number in each scale to indicate your response. For questions with more than one scale, please circle one and only one number in each scale. Your responses are confidential; please do not discuss them with your partner.

1. COMPUTER EXPERIENCE:

How long have you been using computers?

no experience	less than 1 month	less than 1 year	1-5 years	more than 5 years
1	2	3	4	5

How often do you use a computer?

never	0-5 hrs per week	5-15 hrs per week	15-35 hrs per week	over 35 hrs per week
1	2	3	4	5

How often have you used a digital tabletop display?

never	once	2-5 times	6-20 times	over 20 times
1	2	3	4	5

2. COLLABORATIVE EXPERIENCE:

How often do you work in small groups (2-5 people) at a table (e.g., have meetings at a table, work on a group project at a table, do homework with others at a table)?

never	1-5 times a year	1-5 times a month	1-5 times a week	at least once a day
1	2	3	4	5

Please state your reactions to working in small groups (2-5 people) at a table:

dull				stimulating
1	2	3	4	5

frustrating				satisfying
1	2	3	4	5

3. DEMOGRAPHICS:

Are you currently a student, or were you during the Sept 2003-Aug 2004 academic year?

_____ Yes   _____ No

If yes, please indicate your program information:

Which degree are you currently enrolled (e.g., B.Sc., BA, M.A., Ph.D., etc.)
_____

What is your major (e.g., Chemistry, Fine Arts, Computer Science, etc.)
_____

What year are you completing relative to your current degree (Sept 2003-Aug 2004) (please circle one)?

1st year	2nd year	3rd year	4th year	5th year or higher
1	**2**	**3**	**4**	**5**

If no, what is your profession? _____

Are you **primarily** right- or left-handed?

_____ Right-handed   _____ Left-handed

4. EXPERIENCE WITH EXPERIMENTAL TASK CONTENT:

How often have you watched the NBC Friends TV show (please circle one)?

never	1-5 times	6-15 times	16-25 times	more than 25 times
1	**2**	**3**	**4**	**5**

Which of Peter Jackson's The Lord of the Rings movies have you seen (please select all that apply)?

_____ **None**
_____ **Part I: The Fellowship of the Rings**
_____ **Part II: The Two Towers**
_____ **Part III: The Return of the King**

Thank you! Your responses are confidential; please do not discuss them with your partner. Please inform the experimenter when you have completed this questionnaire.

D.3 Post-Trial Questionnaire

Instructions: For each of the following questions, please circle one and only one number in each scale to indicate your response. For questions with more than one scale, please circle one and only one number in each scale. Your responses are confidential; please do not discuss them with your partner.

1. REACTIONS TO THE SOFTWARE WORKSPACE:

Placing content in and retrieving content from the storage areas was:

difficult				easy
1	**2**	**3**	**4**	**5**

Manipulating the storage areas (i.e., resizing, relocating, reshaping, (whichever apply)) was:

difficult				easy
1	**2**	**3**	**4**	**5**

For the purposes of performing the layout activity, the storage territories in this workspace were:

unhelpful				helpful
1	**2**	**3**	**4**	**5**

frustrating				satisfying
1	**2**	**3**	**4**	**5**

2. COLLABORATION:

Sharing the digital content (i.e. pictures, layouts) was:

difficult				easy
1	**2**	**3**	**4**	**5**

Giving your partner digital content (i.e. pictures, layouts) was:

difficult				easy
1	**2**	**3**	**4**	**5**

Receiving digital content (i.e. pictures, layouts) from your partner was:

difficult				easy
1	**2**	**3**	**4**	**5**

Coordinating with your partner was:

difficult				easy
1	**2**	**3**	**4**	**5**

3. WORKSPACE AWARENESS:

How often were you aware of where your partner was working?

<div align="center">

never   always

1   **2**   **3**   **4**   **5**

</div>

How often were you aware of what your partner was doing?

<div align="center">

never   always

1   **2**   **3**   **4**   **5**

</div>

How often were you aware of what your partner intended to do?

<div align="center">

never   always

1   **2**   **3**   **4**   **5**

</div>

4. WORKSPACE INTERACTION AND ORGANIZATION:

Finding digital content (i.e. pictures, layouts) when you needed it was:

<div align="center">

difficult   easy

1   **2**   **3**   **4**   **5**

</div>

Organizing digital content (i.e. pictures, layouts) in the workspace was:

<div align="center">

difficult   easy

1   **2**   **3**   **4**   **5**

</div>

Retrieving a single content item (i.e. a single picture or layout) when you needed it was:

<div align="center">

difficult   easy

1   **2**   **3**   **4**   **5**

</div>

Retrieving a group of content items (i.e. a group of pictures or layouts) when you needed them was:

<div align="center">

difficult   easy

1   **2**   **3**   **4**   **5**

</div>

5. ANY FURTHER COMMENTS:

_____

_____

_____

_____

**Thank you! Your responses are confidential; please do not discuss them with your partner.
Please inform the experimenter when you have completed this questionnaire.**

D.4 Summary of Post-Trial Questionnaire Results

Ratings (Questions 1-15 correspond to the first to last questions on the questionnaire, in order):

Cond..	Subject	Question														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Peripheral	1	5	3	4	3	5	4	5	4	3	4	5	2	5	2	5
	2	5	2	4	2	5	4	5	4	3	4	5	2	5	2	5
	3	5	5	4	3	5	5	5	5	3	2	5	2	5	5	5
	4	5	2	4	2	5	5	5	5	3	3	5	5	5	5	5
	5	5		4	4	5	4	5	4	3	2	5	3	5	3	5
	6	5	2	4	2	5	4	5	4	3	2	5	4	5	4	5
	7	5	2	4	3	5	5	5	4	3	3	5	2	5	2	5
	8	5	5	4	5	5	5	5	5	3	2	5	4	5	4	5
	9	4	4	4	3	3	4	4	4	2	3	5	3	3	3	4
	10	5	5	4	5	5	5	5	4	3	4	5	5	5	4	5
	11	3	2	4	4	5	3	2	1	4	4	4	3	3	2	2
	12	5	4	4	4	5	5	5	5	3	5	5	5	5	4	5
Storage Bins	1	4	5	5	4	3	5	5	4	4	3	5	3	5	2	4
	2	5	3	4	3	5	4	5	5	3	3	5	4	5	4	5
	3	4	3	5	5	3	4	4	4	5	5	3	5	4	2	5
	4	5	5	4	5	5	4	5	4	3	4	5	5	5	4	5
	5	5	4	4	4	5	3	5	3	3	2	5	3	5	2	5
	6	4	3	4	3	2	4	4	2	4	2	3	3	4	2	3
	7	5	5	4	5	5	4	5	5	3	4	5	4	5	3	5
	8	4	2	2	2	4	5	4	4	4	4	4	4	3	4	4
	9	3	3	3	2	4	4	4	4	3	3	2	2	3	4	3
	10	5	4	4	5	5	4	5	4	3	4	5	4	5	4	5
	11	4	1	4	2	4	5	5	5	3	3	2	2	4	2	1
	12	5	5	4	5	5	5	5	5	3	4	5	5	5	5	5

Freeform question:

Cond.	Subject	Q16: Any further comments?
Peripheral	1	
	2	At times it was hard to select things in the storage place to do a group retrieval.
	3	Not being able to "lock down" the layout page was frustrating. I'd also liked to have been able to "glue" the pictures to the page so I could move it without worrying about disrupting the layout. Resizing with only one corner was somewhat frustrating.
	4	(1) Sizing borders with two points is odd. (2) Not being able to lock objects in place makes work difficult (3) snap for rotation and (4) sizing corners would help (5) storing objects in storage area still clutters too much (6) extending storage border should move objects stored [inside]
	5	
	6	
	7	I preferred the movable bins for organizing content and moving groups, but finding individual items this way may have been easier because I didn't pile them up as much.
	8	The "stealing" of pictures by partner was only surprise. I did like this border layout better.
	9	Main problem was pictures moving across the table or disappearing under other photos.
	10	
	11	Conceptually the boarder was easier to work with. The work area was better defined.
	12	Easier because of the boarder and the experience from the previous on with LOTR.
Storage Bins	1	It would be nice if it was possible to tidy up a group of pictures with a simple action (for example, organize the pictures in a grid facing the same way).
	2	Having the different storage placed all over the workspace was annoying.
	3	I'm not sure if I liked the new storage areas. They behave very much unlike any "real" storage area, and didn't respond in the same way as other items. They worked well for grouping items, but the "shrinking" was distracting and often unexpected. I also often wished for a way to discard the extra storage areas.
	4	(1) Resizing storage areas to very small can hide all control points. (2) Working @ 90 degrees to your partner means pictures need 90 degree rotation frequently in a quick rotation of some sort would be nice.
	5	
	6	Very finicky - very minor movements did not cause intended results.
	7	Stealing items from my partner was the biggest problem, as well as selecting the wrong item when close to boundaries. The storage areas worked really well.
	8	Hard to find all pictures when started due to the piling -> once all uncovered; easy.
	9	Put the "move storage" button in the centre, that way you only have to remember what the function of 2 arrows could be instead of 3. Start with all the bins at the edge of the table, have an "undo" feature.
	10	
	11	The pictures were all in one lump and required a lot of initial sorting. A clearer starting point would have made all aspects easier.
	12	Need more space (higher resolution, smaller objects) and the ability to lock pics down. And when moving pics, be able to do it transparently so that you can see what is underneath.

D.5 Post-Experiment Questionnaire
Your responses are confidential; please do not discuss them with your partner.

1. COMPARISON OF STORAGE AREAS

Fixed

Mobile

Please circle one and only one type of storage area for each question.

	Fixed	Mobile
Which type of storage territory was more **helpful** for performing the layout activity?	●	●
Which type of storage territory did you find more **enjoyable** to use during the layout activity?	●	●
Which type of storage territory better supported **sharing** digital content?	●	●
Which type of storage territory better supported **finding** digital content?	●	●
Which type of storage territory better supported **organizing** digital content?	●	●
Which type of storage territory better supported **retrieving** digital content?	●	●
Which type of storage territory better supported your **awareness of your partner's activities** in the workspace?	●	●
Which type of storage territory did you **prefer**?	●	●

3. SYSTEM FEATURES:

Which features did you find helpful for the layout activity?

Which features did you find frustrating or annoying for the layout activity?

Can you suggest any other types of activities for which you feel that Fixed or Mobile Storage territories might be beneficial?

Any further comments?

Thank you! Your responses are confidential; please do not discuss them with your partner. Please inform the experimenter when you have completed this questionnaire.

D.6 Summary of Post-Experiment Questionnaire[269] Results

Storage Mechanism Preference Ratings (Questions 1-8 correspond to the first to last preference questions in Part 1, in order). P corresponds to the Peripheral (or Fixed) storage mechanism. SB corresponds to the Storage Bin (or Mobile) storage mechanism.

Subject	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
1	P	P	SB	P	P	SB	P	P
2	SB	SB	SB	SB	SB	SB	SB	SB
3	P	P	SB	P	P	SB	P	P
4	SB	SB	SB	SB	SB	SB	P	SB
5	P	P	P	P	P	P	P	P
6	P	P	P	P	P	P	P	P
7	SB	SB	P	P	SB	SB	SB	SB
8	P	P	SB	SB	SB	P	P	P
9	SB	P	SB	SB	SB	SB	SB	SB
10	P	P	SB	P	SB	P	SB	P
11	P	P	P	P	P	P	P	P
12	P	P	P	P	P	P	P	P

Subject	Q9: Which features did you find helpful for the layout activity?
1	"Sliding" pictures to a corner of the table. Making pictures smaller in the storage thingies to get them out of the way.
2	Having different storage spaces made grouping easier.
3	The moving and rotation behaviour was excellent; very natural. The "fixed" storage area was also very natural and worked much like I'd expect to use a real tabletop.
4	Grouping of images in mobile storage areas
5	Fixed storage areas. Comfortable with pen.
6	Box items as a group and moving item. Organizing pictures. Flinging discarded pictures.
7	The spinning aspect of grabbing. Grouping. Movable, resizable bins. Tossing!
8	The grouping and the ability to toss pictures didn't want away, or for passing to partner.
9	The bin, but I don't think we needed so many…maybe if you could copy of delete some, rotating and resizing.
10	The storage bins, so you could put things away to clear your workspace. The resizing was helpful too. Being able to throw/pass the pictures good. Being able to pick up a group of pics.
11	Being able to move large groups of pictures and discarding useless ones.
12	It is very quick to manipulate pictures. Easy interaction with partner.

| Subject	Q10: Which features did you find frustrating or annoying for the layout activity?
1	Mobile storage was hard to control. Sometimes the control points were all hidden.
2	The ungrouping of group item. Also the moving of the page with my pictures on it.
3	The "bring to front" (i.e. not being able to "lock") was annoying. The "shrinking" behaviour on the mobile storage areas was unexpected and distracting. I also didn't like to select the whole page to move my collage when a "glue" feature would have worked.
4	No snap for motion or rotation. Not enough sizing corners [on images/layout pages]. The dot (pionter highlight) is counter intuitive on sizing because all MS products use round corners for rotation. Handling of mobile storage resizing.
5	Mobile storage. Partner gets picture if you're both using.
6	Layout screen (the 4 topic screens) moving. Pictures would not affix to where you intended to go. Laying a picture and then the topic screen moves. Losing 1 picture that you were working with at the bottom of the pile.
7	Layering -> it was hard to keep layers in order. STEALING OBJECTS!!. Grouping could be difficult.
8	Stealing of pictures, changing of what was in the forefront and background when unintended.
9	Frustrating - the fact that there wasn't a way to glue down the photos to the background and it kept covering the pics, that and "jumping" pictures.
10	When the picture transferred to the other person. Resizing the mobile bins. When the picture disappeared under the layout.
11	"Running into" mobile storage spaces with a selected layout.
12	Missing or double-tapping pics sometimes resulting in different/unexpected challenges.

Subject	Q11: Can you suggest any other types of activities for which you feel that Fixed or Mobile Storage territories might be beneficial?
1	Composing music by combining (dragging) tracks.
2	Activities that require grouping. For example, in learning of course matter, where students could [group] what they have covered with the course objective.
3	Not really, but I'm sure there are other uses. Just for moving things not in use to the side.
4	I don't think the flexible shape is very important. I would see them as "windows" or "multiple desktops" so they could be used to store program windows, etc. by context.
5	Storing files if you are multi-tasking.
6	Any type of media application. Organizing digital clips. Organizing transportation signage.
7	Organizing extra groups of code - programming (I'm terrible at it). Organizing photos.
8	Gaming -> reminds me of when group troops to fight.
9	
10	Mobile storage bins may be useful for things that are not rectangular. Mobile mile be better if you have more than one person (or group of people) moving around the table. Mobile might be better for things that need to be put in categories.
11	
12	Nope

Subject	Q12: Any further comments?
1	
2	
3	Was a lot of fun to use! Aside a few bugs, it felt very natural.
4	How much does one of these setups cost? I want one! If there were done on a REALLY BIG screen a means would be needed for long distance transport….numbered portals?
5	What a great piece of equipment. Hopefully you can get all the glitches fixed.
6	Thanks and Good luck!
7	Very fun system, allows one to really be creative.
8	
9	It would be helpful if you could toss the storage bins and if you could name them ex using the pen to write "kinship" "trash" etc. so everyone knows what's what. Could you somehow crop pictures?
10	
11	That was fun.
12	Nope

D.7 Activity Plots from Storage Mechanism Study

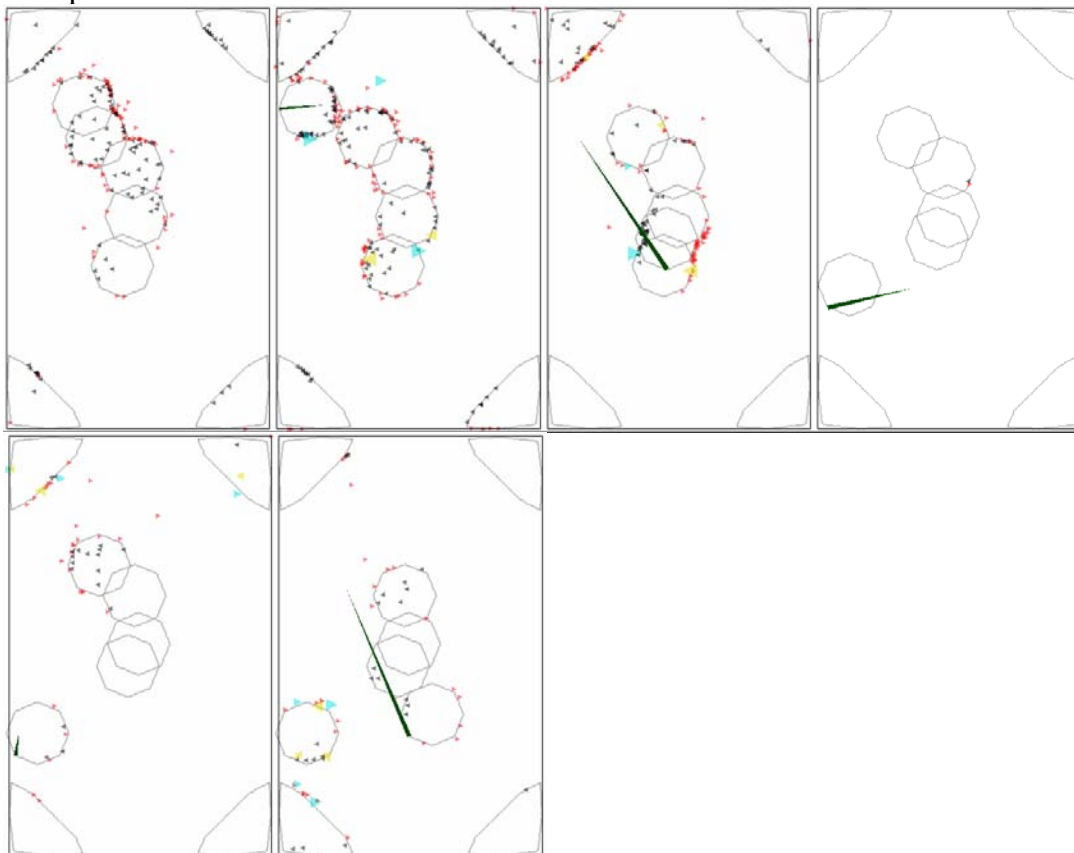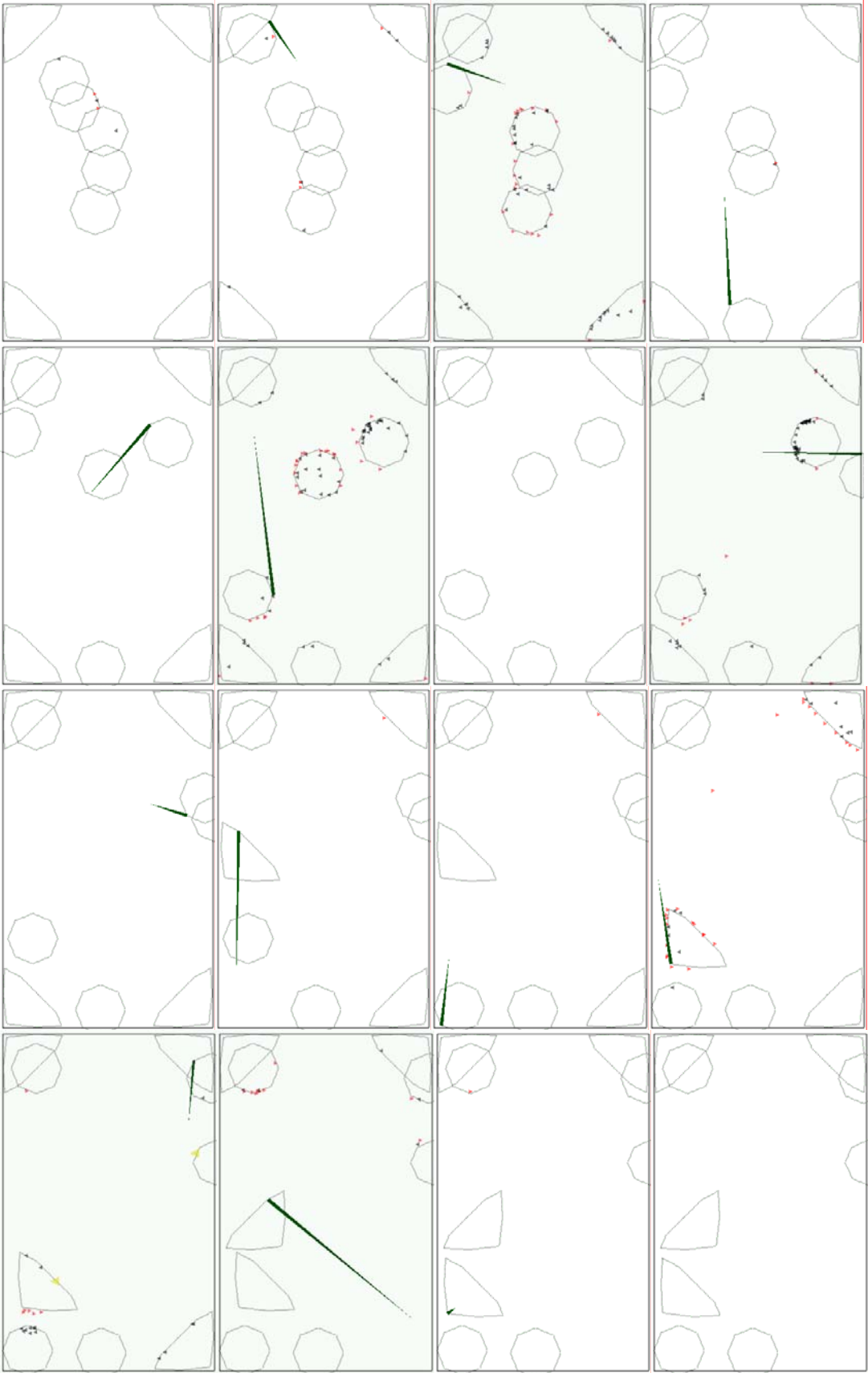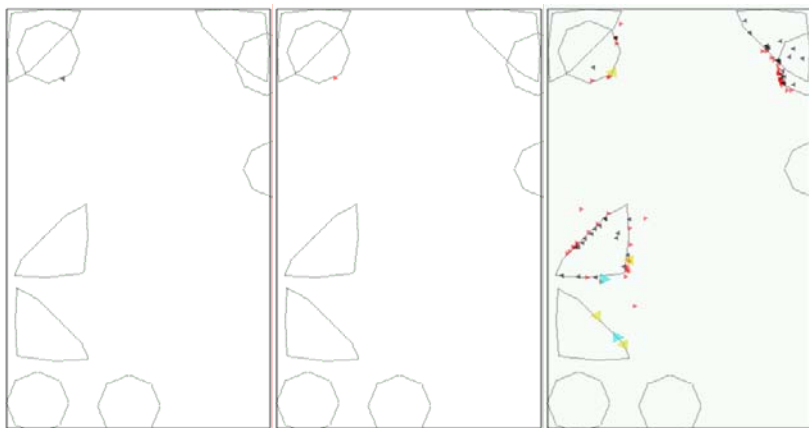**Storage Bins: Boundary Activity (users are seated to the top and left of the images).**
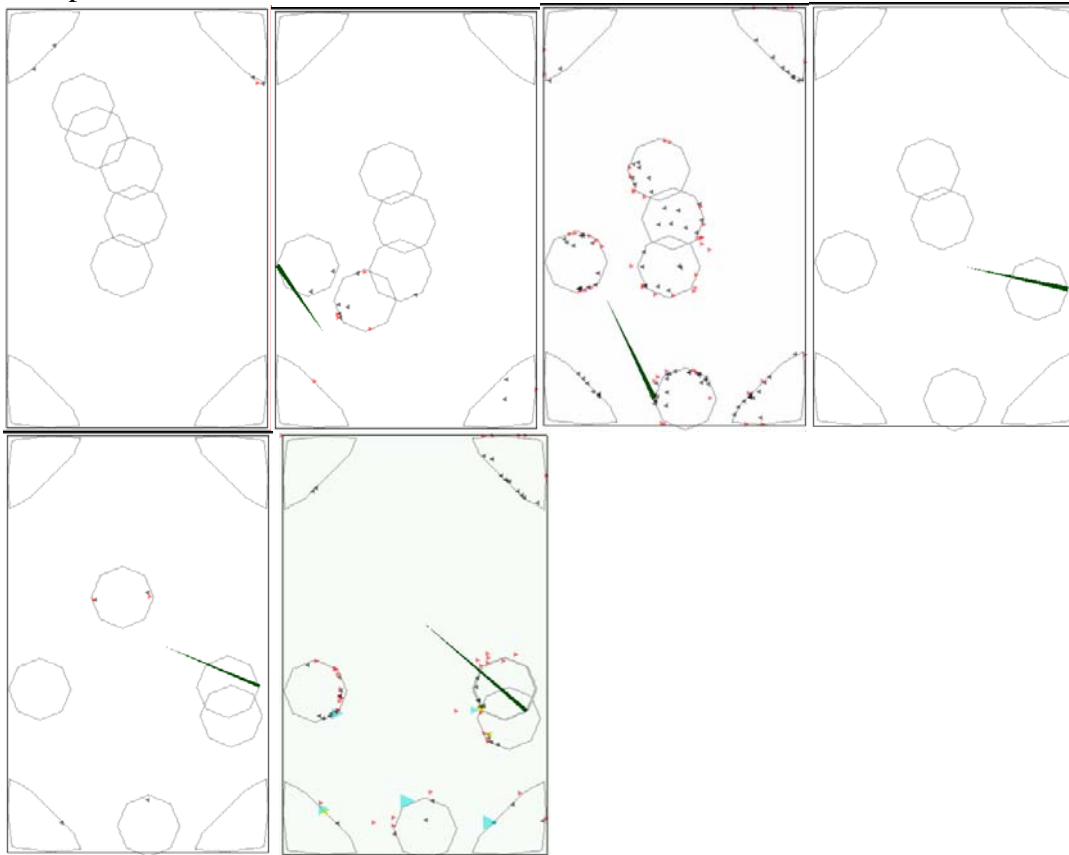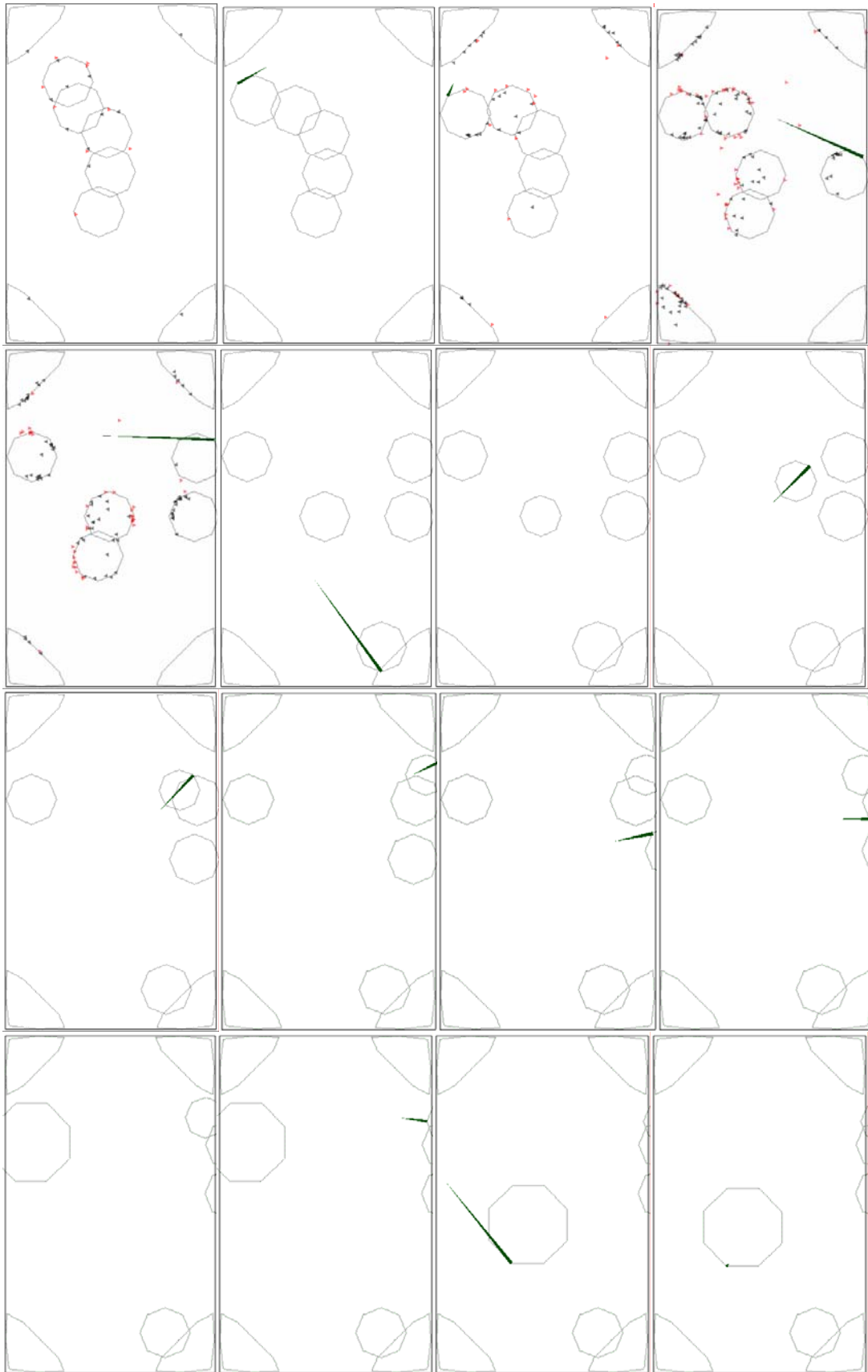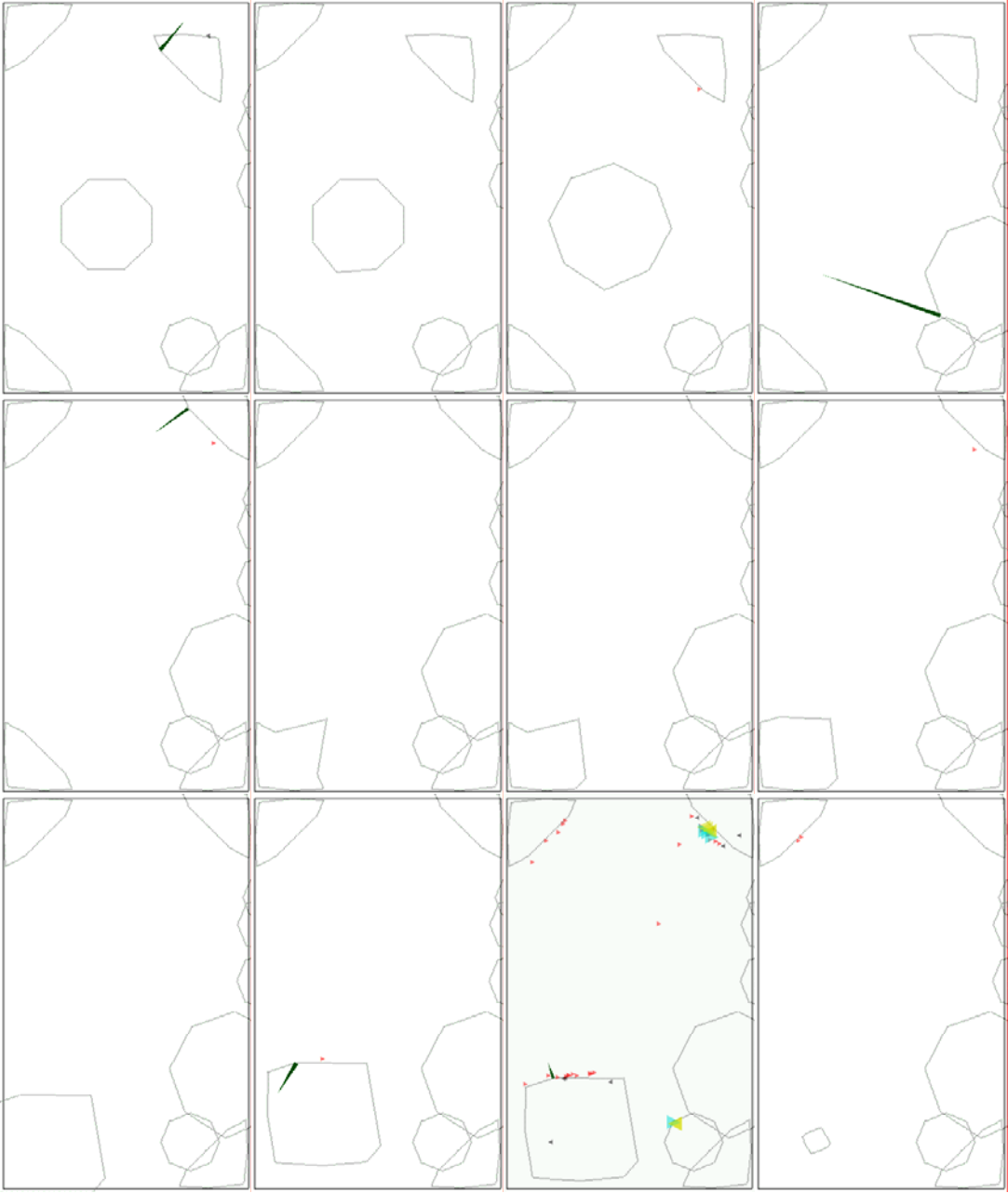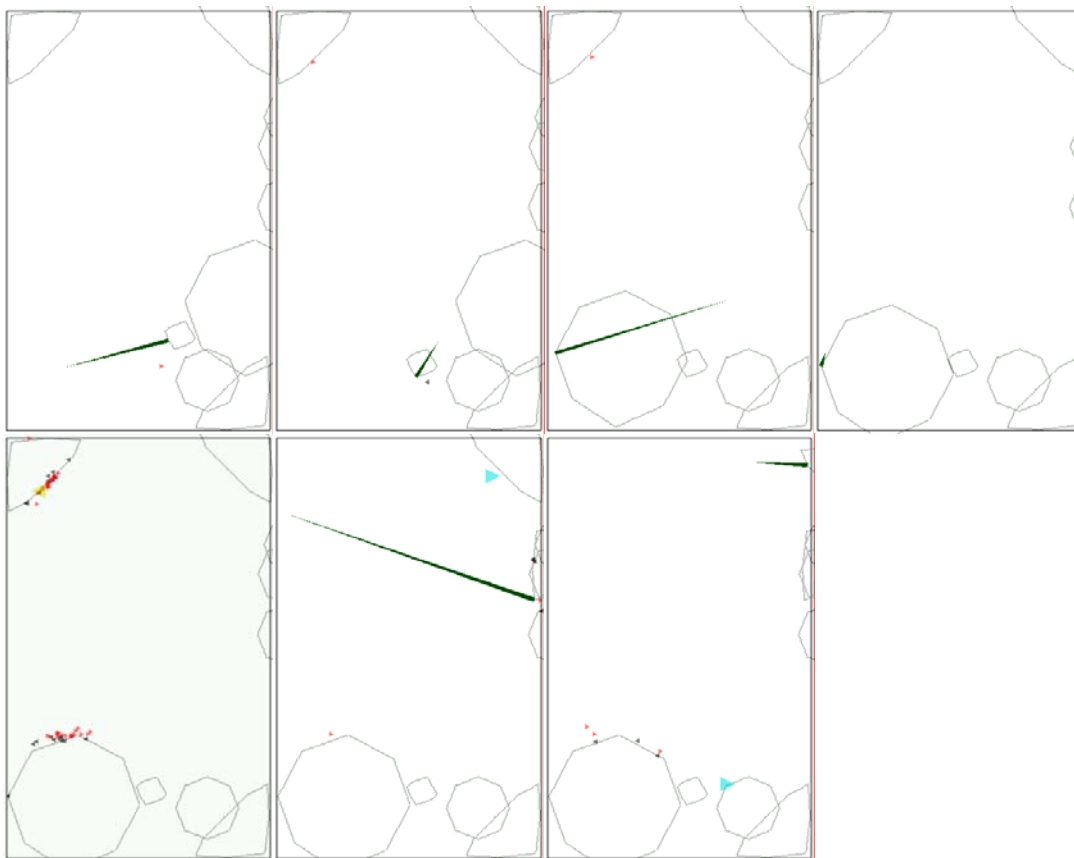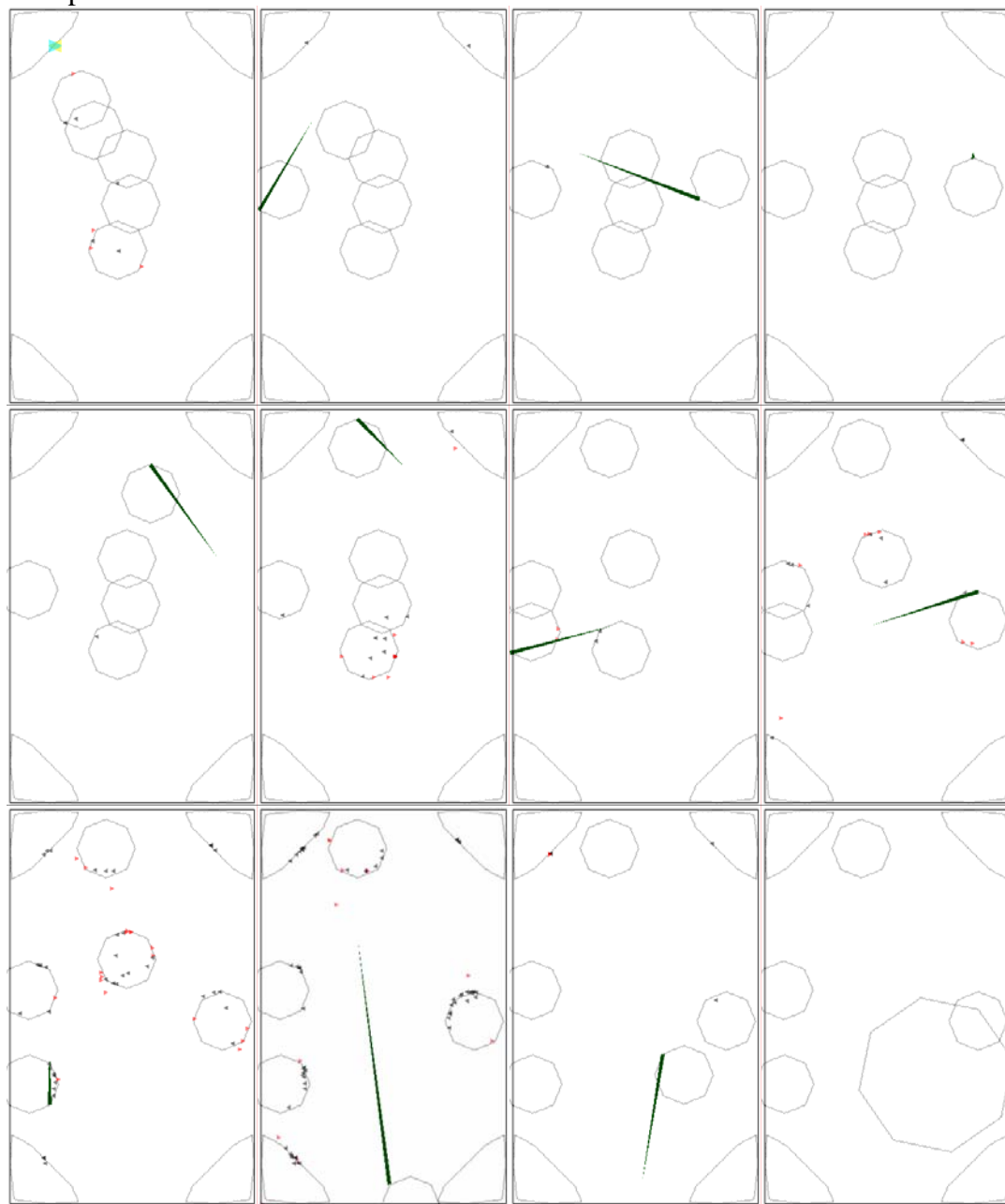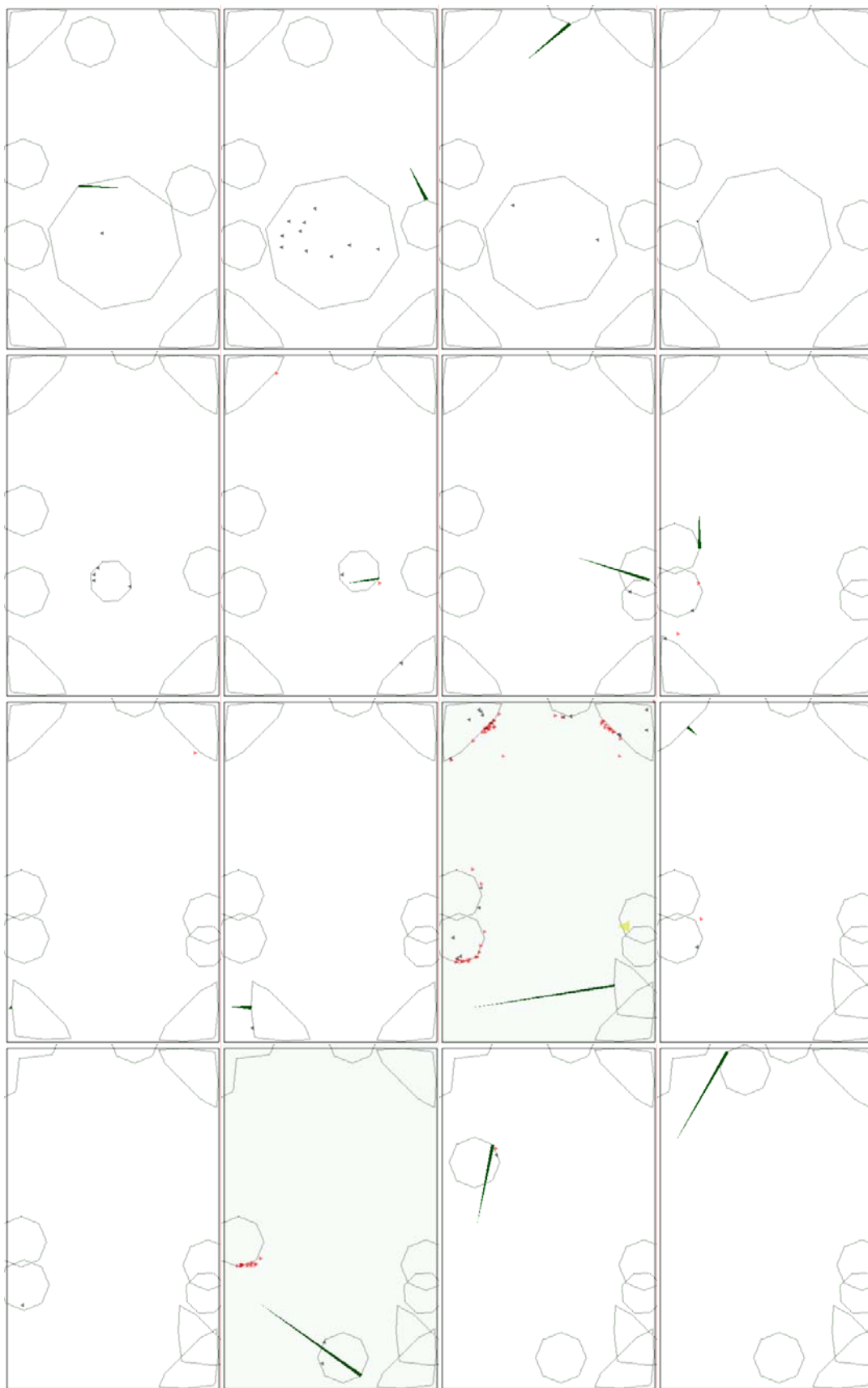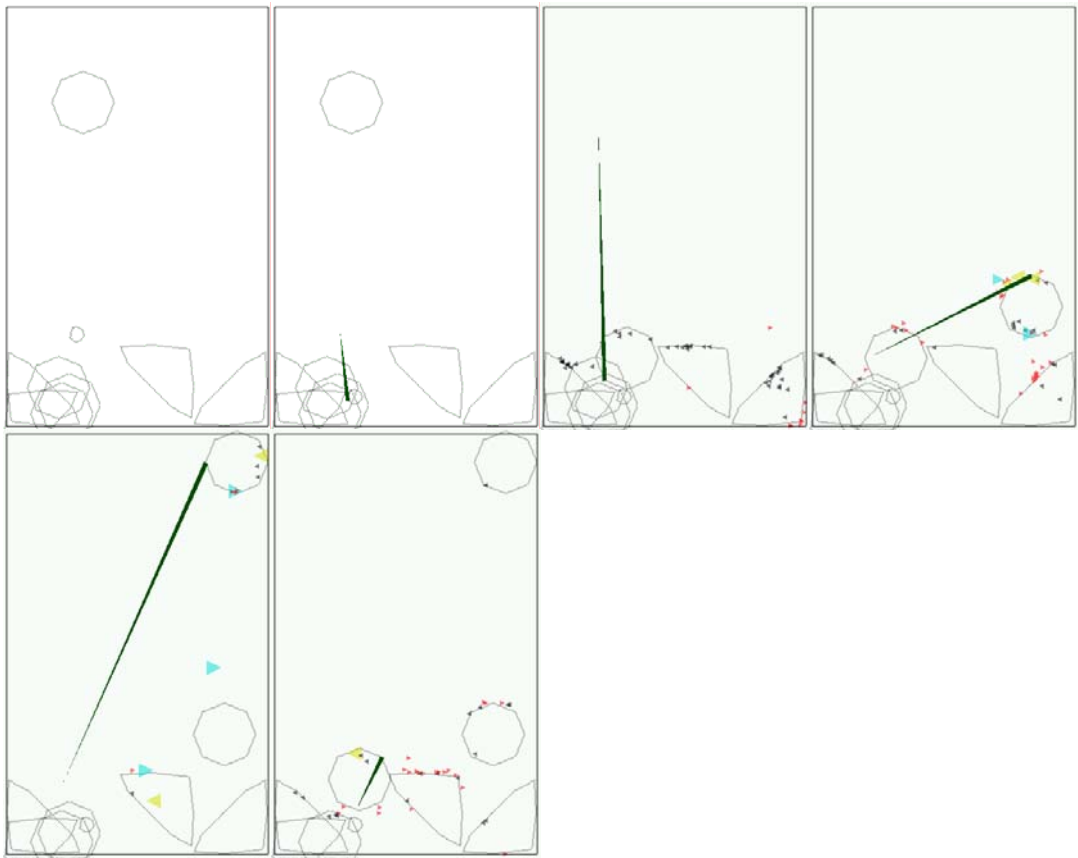
Group 3

Group 5

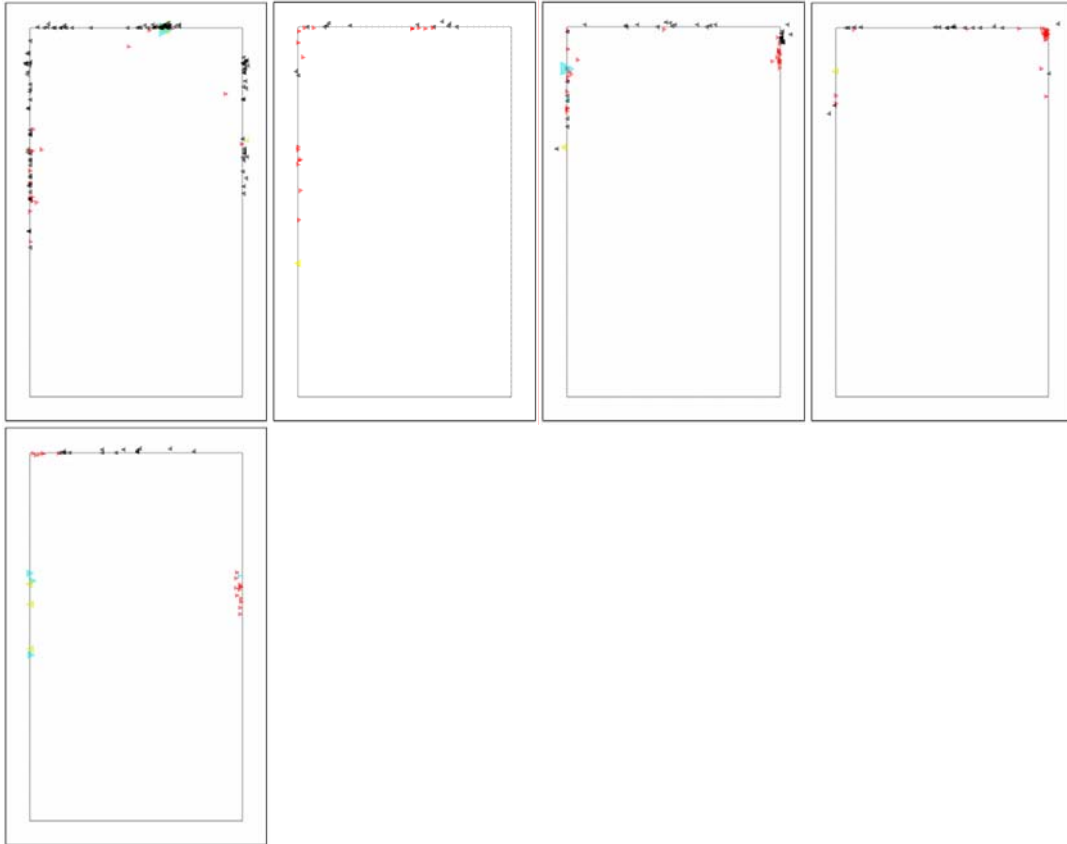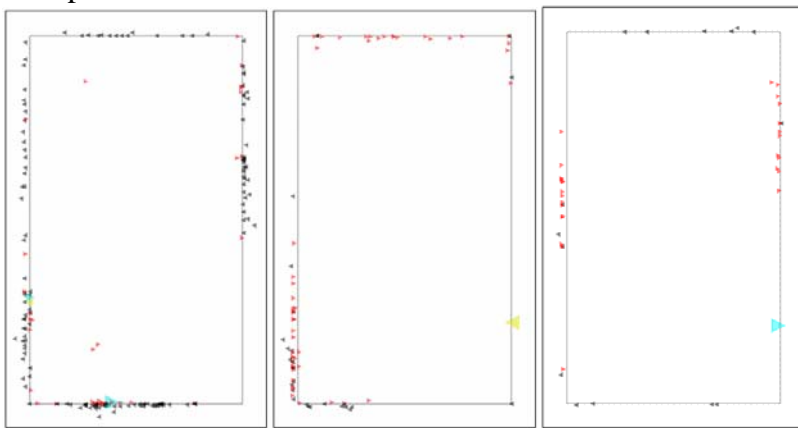Group 6

Group 7

Group 8

**Peripheral Storage Areas: Boundary Activity (users are seated to the top and
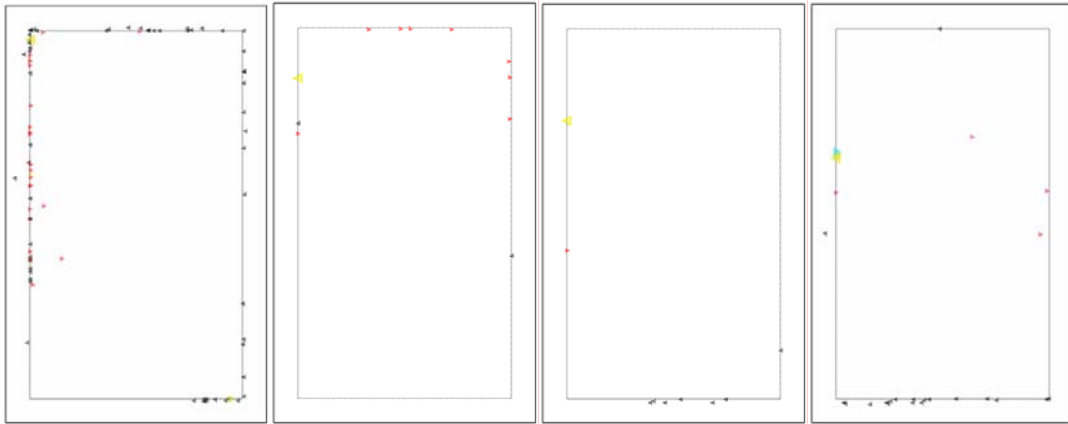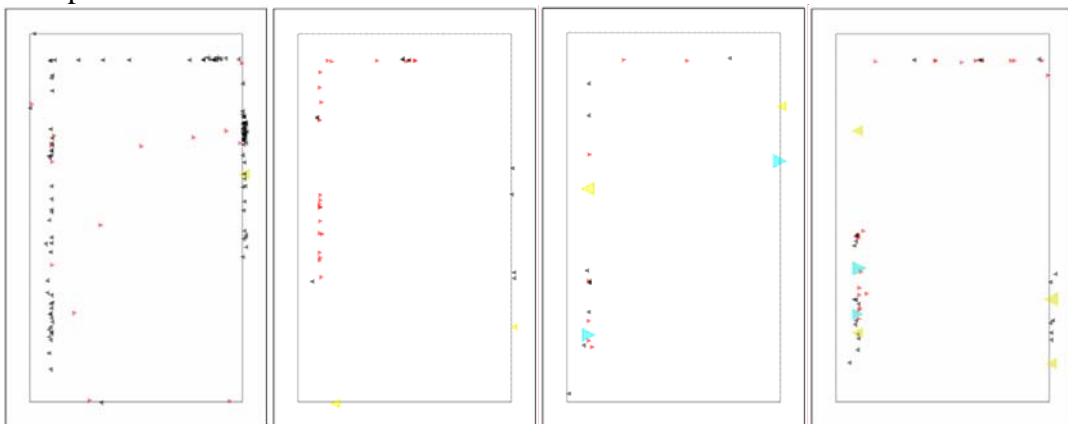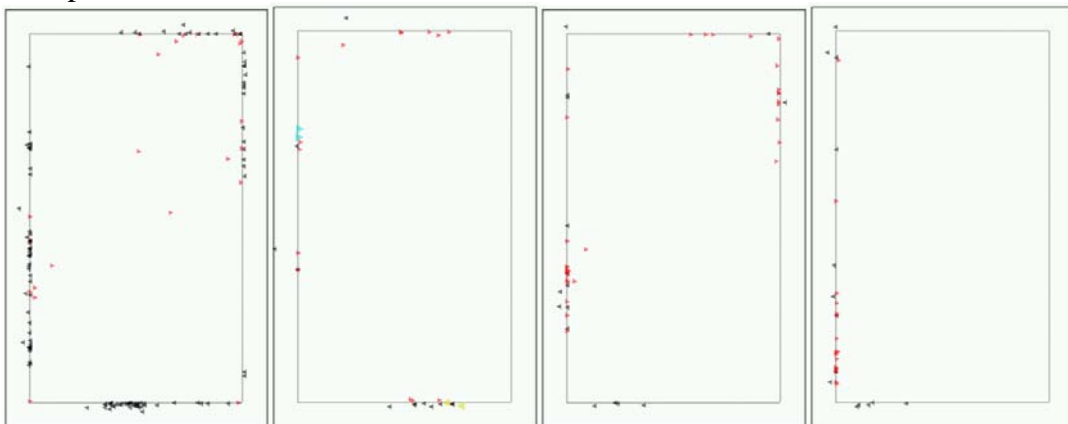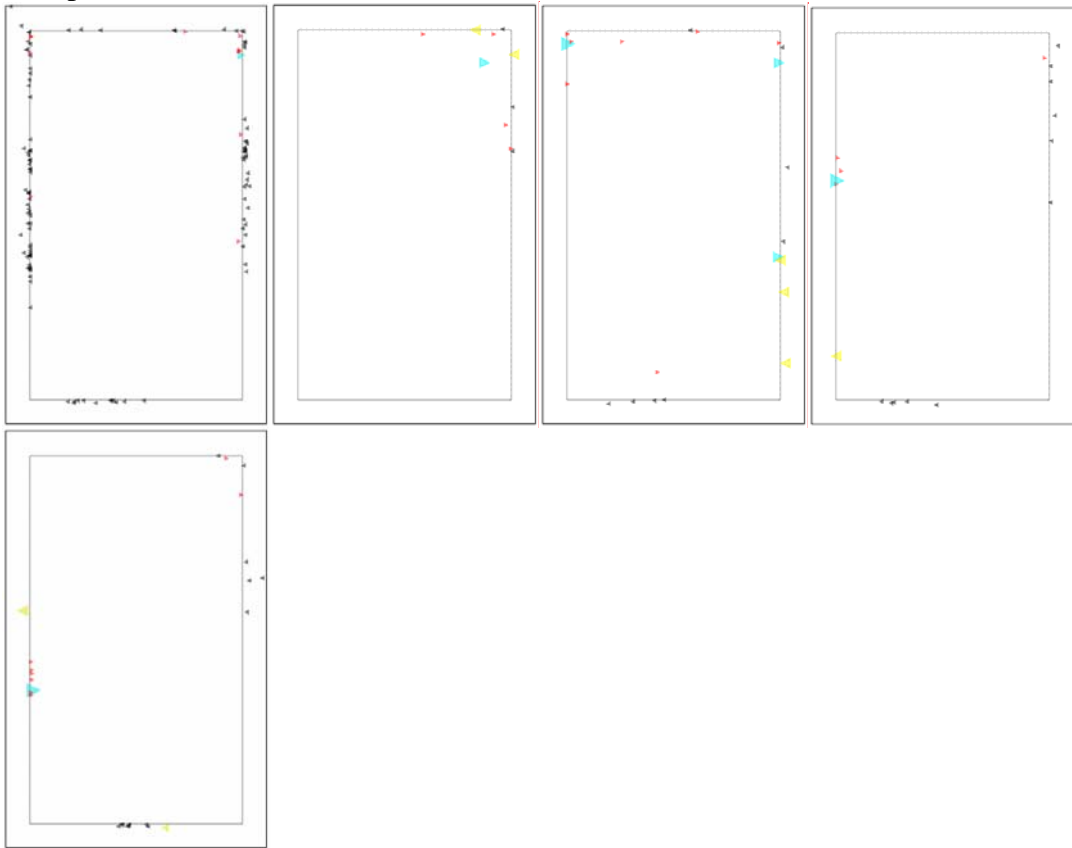x
282 left of the images).**

Group 3

Group4

Group 6

Group 7

Appendix E. Permission from Co-authors to Use Shared Intellectual Property

February 27, 2005

Stefan Habelski
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Subject: Computational Visualistics
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Germany

I, Stefan Habelski, give Stacey Scott permission to use co-authored work from our paper:

Scott, S.D., Carpendale, M.S.T, Habelski, S. (submitted). Storage Bins: Mobile Storage for Collaborative Tabletop Displays. Submitted to *IEEE Computer Graphics and Applications: Special Issue on Large Displays* (submitted December 10, 2004).

for Chapter 6 of her Ph.D. dissertation and to have this work microfilmed.

Sincerely,

Stefan Habelski

Stefan Habelski

Simon Fraser University

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February 25, 2005

I, Regan Mandryk, give Stacey Scott permission to use co-authored work from our papers:

Scott, S.D., Grant, K.D., & Mandryk, R.L. (2003). System Guidelines for Co-located, Collaborative Work on a Tabletop Display. In *Proceedings of European Conference Computer-Supported Cooperative Work (ECSCW)'03*, September 2003, pp. 159-178.

for Chapter 2 of her Ph.D. dissertation and to have this work microfilmed.

Sincerely,

R. Mandryk

Regan Mandryk
Ph.D. Student

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February 25, 2005

I, Kori Inkpen, give Stacey Scott permission to use co-authored work from our papers:

Scott, S.D., Carpendale, M.S.T., & Inkpen, K.M. (2004). Territoriality in Collaborative Tabletop Workspaces. In *Proceedings of CSCW'04: ACM Conference on Computer-Supported Cooperative Work*, November 6-10, 2004, Chicago, IL, USA, pp. 294-303.

Scott, S.D., Carpendale, M.S.T., & Inkpen, K.M. (2004). Exploring Casual Tabletop Interactions. Technical Report 2004-742-07. Department of Computer Science, University of Calgary.

for Chapters 3, 4, and 5 of her Ph.D. dissertation and to have this work microfilmed.

Sincerely,

Kori Inkpen

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I, Karen Grant, give Stacey Scott permission to use co-authored work from our paper:

Scott, S.D., Grant, K.D., & Mandryk, R.L. (2003). System Guidelines for Co-located, Collaborative Work on a Tabletop Display. In *Proceedings of European Conference Computer-Supported Cooperative Work (ECSCW)'03*, September 2003, pp. 159-178.

for Chapter 2 of her Ph.D. dissertation and to have this work microfilmed.

Sincerely,

Karen Grant

Karen Grant

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I, M. Sheelagh Carpendale, give Stacey Scott permission to use co-authored work from our papers:

Scott, S.D., Carpendale, M.S.T, Habelski, S. (submitted). Storage Bins: Mobile Storage for Collaborative Tabletop Displays. To appear in *IEEE Computer Graphics and Applications: Special Issue on Large Displays* (submitted December 10, 2004).

Scott, S.D., Carpendale, M.S.T, & Inkpen, K.M. (2004). Territoriality in Collaborative Tabletop Workspaces. In *Proceedings of CSCW'04: ACM Conference on Computer-Supported Cooperative Work*, November 6-10, 2004, Chicago, IL, USA, pp. 294-303.

Scott, S.D., Carpendale, M.S.T., & Inkpen, K.M. (2004). Exploring Casual Tabletop Interactions. Technical Report 2004-742-07. Department of Computer Science, University of Calgary.

for Chapters 3, 4, 5, and 6 of her Ph.D. dissertation and to have this work microfilmed.

Sincerely,

M. Sheelagh Carpendale
Associate Professor