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Theory of Tabletop Territoriality

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Abstract This chapter discusses empirical and theoretical investigations of the practice of tabletop territoriality in order to understand how to exploit such social interaction practices that people have developed over years of collaborating in traditional tabletop environments in the design of digital tabletops. These investigations reveal that collaborators at traditional tabletop workspaces use three types of tabletop territories to help coordinate their interactions within the shared 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 to share a tabletop workspace by clarifying which regions are available for individual or joint task work, to delegate task responsibilities, to coordinate access to task resources by providing lightweight mechanisms to reserve and share task resources, and to organize the task resources in the workspace.

Introduction

Few existing technologies provide the rich, fluid interactions that occur during co-located collaboration on traditional tables with traditional media, such as paper and pens. In hopes of leveraging the collaborative benefits of traditional tabletop workspaces, researchers have begun to develop tabletop systems that enable access to digital media during a variety of collaborative activities, such as photo sharing, layout design, and educational games. Yet there are many open issues related to the design of collaborative tabletop systems, such as whether these systems should automatically enforce ownership of workspace content. This chapter discusses a set of empirical studies that investigated tabletop territoriality as manifested on traditional tables to better understand these open issues and to learn how to transfer the interaction skills people have developed over years of collaborating at traditional tables to digital tabletop interaction. The findings from these studies reveal that collaborators use three types of tabletop territories to help coordinate their interactions within the shared 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.

In this chapter, we will explore the theoretical meta-understanding that can be developed by examining these studies in conjunction with the ongoing application of these study results to digital tabletop interaction using the extensive more general research on human territoriality as a lens. The goals of this chapter are:

- To describe the empirical studies (both ours and others) that have informed the theory of tabletop territoriality,
- To provide background on the theoretical underpinnings of tabletop territoriality in the broader human territoriality literature,
- To describe the theory of tabletop territoriality and its implications for the design of digital tabletops, and
- To discuss possible future directions for this research, especially related to developing further knowledge of how territoriality manifests in digital tabletop settings.

Background

In the late 1980's and 1990's, several foundational studies occurred in the Computer-Supported Cooperative Work (CSCW) research community that focused on understanding collaborative interaction practices at a shared tabletop workspace [3, 8, 24]. Although these studies were conducted to inform the design of distributed groupware systems involving shared virtual workspaces, such as virtual whiteboards used during desktop conferencing, their findings provided the first detailed evidence of collaborative use of a tabletop workspace. This evidence provides an initial foundation for developing collaborative interaction theory that can be used, in turn, to develop design requirements for collaborative digital tabletop systems.

A key collaborative work practice identified by these early studies was workspace partitioning. In a study of collaborative tabletop design sessions, Tang [24] observed that workspace partitioning was a key resource for mediating group interactions. A subsequent study by Kruger et al. [10], which investigated the role of orientation in collaborative tabletop use, identified similar partitioning behaviour. Both Tang and Kruger et al. observed that 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 themselves 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' personal spaces were used 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 themselves.

Although these studies provide a good starting point in understanding the practice of workspace partitioning, they offer limited insight into how or why partitioning facilitates collaboration. As such details may influence the design requirements of systems developed to support this work practice, we decided to conduct additional observational studies specifically designed to investigate tabletop interaction practices for the purpose of informing tabletop system design.

Our studies indicate that the partitioning behaviour reported in the literature is part of a more complex practice of establishing *tabletop territories* on a tabletop workspace, akin to the broader human behavioural practice of establishing *territories* in our physical environments (e.g., a roommate's 'side of the room'). Taylor [25] 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" [25, p. 89]. Our observational data support Taylor's theory that territorial behaviour occurs during human interaction at a table. Our research also confirms Tang's [24] claim that workspace partitioning (or tabletop territoriality) can provide collaborative benefits, including task and group facilitation. These findings are consistent with research on human territoriality, which asserts that territories help mediate social interactions [1, 6, 25].

Facilitating task and group interactions on a digital tabletop system seems a worthwhile design goal, as it would allow people to focus on completing their task activities rather than expending time and effort coordinating their actions in the workspace. The remainder of this chapter describes our efforts to understand how to address this design goal.

Territoriality on Traditional Tabletop Workspaces

To further understand the potential task and collaborative benefits of the practice of tabletop territoriality and to elucidate how digital tabletop systems could be designed to support this collaborative practice, we conducted new observational studies of traditional tabletop collaboration. In this chapter evidence gathered from these studies is synthesized with reported findings from prior tabletop studies. This synthesis provides a broad view of collaborative interactions practices on a shared tabletop workspace over a wide variety of tasks and user groups. The theoretical human territoriality literature was used to interpret the meaning and generalizability of these empirical findings.

To address the inherent tradeoff between realism (ensuring ecologically valid scenarios and behaviour) and precision (being able to experimentally control extraneous influencers of behaviour and to accurately record behaviours) in existing (and ethical) research methods [11], we conducted two observational studies that were carefully designed to complement the existing studies of tabletop collaboration and to enable data triangulation and concept generalization [11].

The first study focused on observing spatial tabletop interaction in a casual setting where a variety of tabletop games were available for individual and group use. The study occurred in an open, public location (a university lounge and café area), where participants could come and go as desired. This created a relaxed, friendly atmosphere where people felt comfortable joining ongoing games or starting new ones. This setting provided opportunities to observe a wide variety of tabletop interaction practices, including patterns of individual and group tabletop use, usage patterns across different types of tabletop gaming activities (e.g. puzzles, boards games, card games), and interaction patterns across tables of different size and shape and across groups of different sizes and interpersonal dynamics.

While these observations provided significant insights into participants' broad patterns of spatial interaction practices, including workspace partitioning, their interactions could not be recorded in precise detail due to the study protocol. To establish the relaxed atmosphere described above, and engender realistic individual and social behaviour that is difficult to reproduce in a laboratory setting, information posters that established implicit consent to study participation upon interaction with the study materials were used (see Scott [19] for details). Since we used implicit consent, only handwritten observer field notes were used to record participants' spatial interactions. To supplement this broad view of tabletop interaction practices, a laboratory-based study was then conducted that enabled participants' spatial interactions during a collaborative tabletop design activity to be captured in fine detail using a video camera.

The specifics of these two studies are described below, along with the findings from the spatial interaction analyses conducted on each data set.

Study 1: tabletop territoriality in a casual setting

Several activity tables were set up in an open area adjacent to a lounge and café area where students, staff, and faculty often congregated at Dalhousie University in Halifax, NS, Canada. Observations were made during a consecutive, five-hour period, during which 18 students participated in the various activities, for various lengths of time (10 minutes to several hours). A casual, 'drop-in' style procedure was used. An implied method of subject consent was used whereby large signs were posted that advised people that by interacting at the activity tables they were consenting to be observed by the researcher.

Basic instructions were provided to explain each activity. Three activity tables were set-up: a puzzle table, a Pictionary® table, and a LEGO® table. The puzzle table consisted of two adjoining tables (76 cm^2 each), containing several puzzles: Tangram, a word puzzle, and a jigsaw puzzle. The Pictionary® table consisted of a round table (94 cm diameter) containing the Pictionary® game, in which teams competed to advance around a game board by identifying target phrases drawn by teammates. The LEGO® table consisted of one rectangular table (61x153 cm) containing a variety of Lego® blocks and instructions suggesting re-designing the university's Computer Science building, though participants were free to build whatever they wished. An opportunity also arose to observe (with their consent) several students playing the Magic™ card game (these students often played near the observational area). While primarily a card game played in the hand, the Magic™ game also involves placing cards and small game pieces on the table. Participants' tabletop interactions were recorded in observational field notes.

Data Analysis

Based on preliminary data analyses that indicated that tabletop collaborators tend to establish three types of tabletop territories, personal, group, and storage territories, the Study 1 field notes (textual notes and sketches of participants' tabletop interactions) were first reviewed to identify any overall interaction patterns that appeared to correspond to each type of tabletop territory. Next, the *affinity diagramming* analysis method [9] was applied to the field notes to help reveal the particular characteristics of each type of tabletop territory. To prepare the data for this process, each tabletop activity or interaction that appeared to correspond to a tabletop territory was recorded separately (duplicates were made if an activity or interaction appeared to correspond to multiple territories). 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.

Results and Discussion

The field note review 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, typical activities that occurred in each territory, and the spatial properties of each territory. The following sections provide the details of these characteristics for each type of tabletop territory.

Table 1. Characteristics of personal territories.

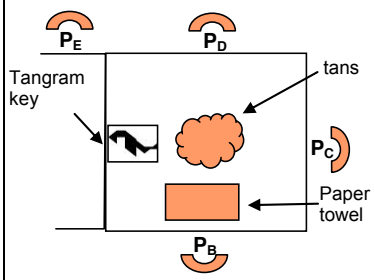
Purpose
• working on main task activities, by individuals alone at the table
• working individually on same task that the group is working on in group space (e.g. exploring a tangram solution)
• temporarily holding group resources
• monitoring a collaborator's activities (sometimes used as a reference 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 use larger personal territories when working alone than when working in groups

Characteristics of Personal Territories

Personal territories correspond to the "personal spaces" or "personal areas" that others have reported tabletop collaborators using for individual activities such as note-taking, reading, or writing [e.g., 10, 24]. The characteristics of personal territories revealed by the data analysis are summarized in Table 1. 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 puzzle pieces. 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, or to reserve a task resource.

In addition to being useful for their respective 'owners,' personal territories were also a useful resource for other group members at the table. People occasionally monitored the activities and task items within their collaborators' personal territories. In an example from the tangram task, shown in Fig. 1, a participant, P_B, used his personal territory to explore an alternate solution to a tangram problem while the rest of the group continued to work on the problem 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 understand his actions in the group territory.



TRANSCRIPT EXCERPT:

P_E watches 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.

…

P_B continues to draw on paper towel. Next, he moves 2 tans together in the middle of table, then returns to paper towel.

P_B says "Ok." He moves the tans around on the table. The other players are all looking at his paper.

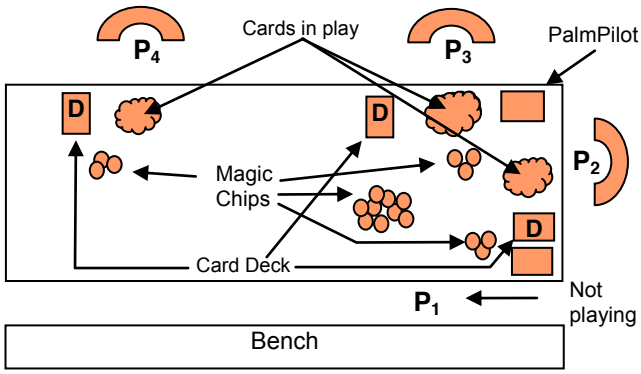
P_D says "Now you need to get that inside."

P_E says "How many did you solve so far?" [to the group]

Fig. 1. Tangram table configuration.

On occasion, people offered assistance in someone else's personal territory. In an example from the Magic™ game, shown in Fig. 2, the player P_3 assists another player, P_4, 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.

These two episodes both illustrate the importance of allowing group members to view, and sometimes access, other 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 perform in the group territory.



TRANSCRIPT EXCERPT:

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 dealt into the game.

Fig. 2. Magic™ card game table configuration.

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.

People typically established personal territories directly in front of them on the table. Group members also tended to restrict their personal territories to smaller areas than a person alone at a table. Additionally, the size and shape personal territories tended to vary, expanding and contracting as the number of people at the table varies as people transitioned between working independently or in concert with the group. In general, people easily 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.

Characteristics of Group Territories

Group territories correspond to the "group spaces" or "shared areas" that others have reported tabletop collaborators using when cooperatively creating designs, playing games, or sharing tabletop objects [e.g., 10, 24]. Not surprisingly, our analysis revealed that group territories only emerged when there was more than one person at the table. Individuals performed tabletop activities using personal and storage territories only.

The characteristics of group territories revealed by the data analysis are summarized in Table 2. The group territory appeared to be available 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. People working in their personal territories sometimes also referred 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 facilitate quick glances between these two territories. Moreover, as illustrated in Fig. 1, people often transition quickly between using personal and group territories, so easy access to both territories should be provided.

Although assistance from other group members sometimes occurred in the per-

Table 2. Characteristics of group territories.

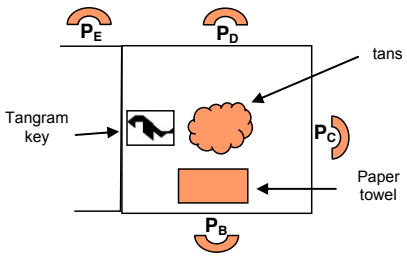
Purpose
• working on group product or task by several members of the group
• working on group product or task by an individual, while others in group discuss the problem (e.g., tangram)
• placement of reference items for individual work when task is offloaded to personal territory to try new ideas (e.g., tangram)
• assistance from other group members (e.g., tangram, moving a game piece out of the way)
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)
• fluctuate in size, shape, and location in response to changes in personal territories, group size, and current task needs

sonal territories, it typically occurred in the group territory. Assistance often resulted from one group member explicitly asking for help on a task activity. Unsolicited assistance was also observed, often after someone noticed a collaborator was having difficulty with a task activity. An example of unsolicited assistance is shown in **Error! Reference source not found.**, from the tangram task. In this episode, the participant, P_D, assists his partners, P_B and P_C, as they assemble the tangram silhouette in the group territory. As P_D watches his collaborators work in the group territory, he offers verbal suggestions, accompanied by gestures above the table surface.

People tended to establish one main 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.

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 an 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 group territory, which enabled them to anticipate the needs of their collaborators and helped them coordinate their interactions in this shared space.

Typical actions in 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, other types of interactions would likely 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



TRANSCRIPT EXCERPT:

They switch the tangram key to a new silhouette.

In the middle of the table, P_B and P_C slide, pick up, replace, and arrange tans. P_D points and suggests moves but does not interact with tans.

P_D says "What about the small triangle?"

P_B says "You had it right the first time." Points to the tans with the pen. He draws on the paper towel again.

P_D says "You had the neck right before."

Fig. 3. Tangram table configuration.

any support tools that the system may provide for facilitating these activities.

Characteristics of Storage Territories

Storage territories are areas on the table used for storing and organizing task resources and non-task items (e.g. food, drinks, and books). The characteristics of storage territories revealed by the data analysis are summarized in Table 3. Storage territories served as a place to store task resources (e.g., loose puzzle pieces, spare paper or pencils), reference items (e.g., the tangram key), and non-task items (e.g., food and drinks). Establishing storage territories appeared to help participants organize task and non-task items in the workspace.

Typical storage territory activities related to organizing stored task resources. Participants often piled, searched, and sorted items within these 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. The contents within storage territories were typically very loosely arranged: little effort was made to keep the storage areas strictly organized. For example in the jigsaw puzzle task, participants created separate piles of items in the storage territories for various classes of puzzle pieces. The box lids, turned upside down to act as makeshift trays, were often used to store loose piles of puzzle 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

Table 3. Characteristics of group storage.

Purpose
• 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 and partial storage areas – some appear to be more ‘temporary’ than others
• can be piled (e.g. jigsaw puzzle box lids)

evolved. For example as one participant assembling the jigsaw puzzle came across each corner piece in a pile of pieces in the box lids, he added them to a pile of corner pieces beside 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 needed. 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 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. Multiple storage territories were often kept on the table. Participants also established temporary storage territories that contained artefacts that were quickly reincorporated into the main activity. 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 table edges, nearby chairs, box lids, people's laps, and the floor.

In summary, the analysis of 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 (e.g., reading, writing, and sorting resource items), and also appear to serve an important collaborative role by providing a visible, accessible area for other group members to keep track of a teammate's independent activities. The group territory provides a space for collaborators to work together on the task product and to assist each other in task activities. Finally, storage territories provide a space for organizing resource items on the table, and can be created on auxiliary surfaces that can be moved around the table.

Study 2: tabletop interactions in a formal setting

The second study involved three small groups (2-3 participants each) performing a layout planning activity on a table using traditional media in a laboratory setting. Seven university students from a variety of academic backgrounds were paid to participate in the experiment. Participants performed the experimental task seated at a round table (94 cm diameter) located in a usability laboratory at Dalhousie University.

Each group was asked to create a furniture layout plan for a reading room in a library, which adhered to a set of design requirements. 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 other resources were piled on the table edge. The task took between 30-45 minutes to complete. Participants' activities were videotaped and observational field notes were collected.

Data Analysis

To help understand the significance of participants' interactions within the tabletop workspace a new video analysis method was developed, called *spatial action analysis*. This analysis method involved first partitioning the tabletop workspace into various interaction zones. 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* **Fig. 4**) and 4 *radial zones* (**Fig. 5**). Participants' tabletop activities were then transcribed from the video data and coded according to their directional and radial zone locations.

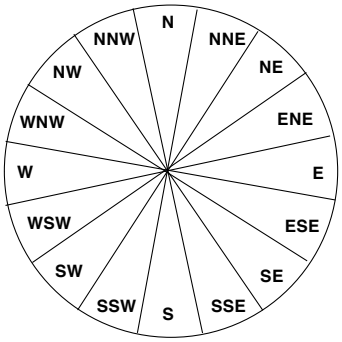


Fig. 4. Directional Zones.

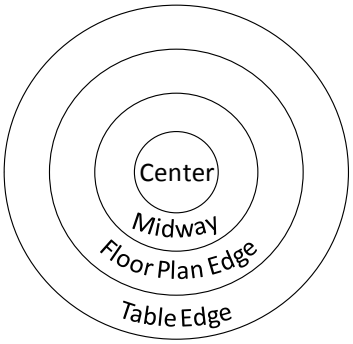
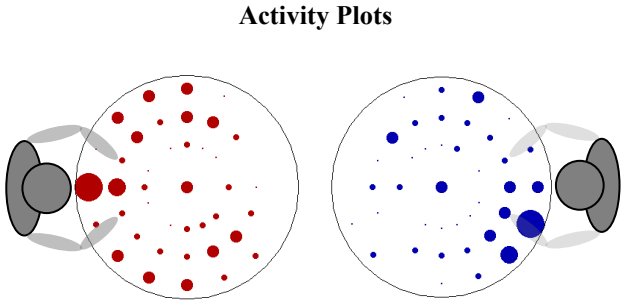
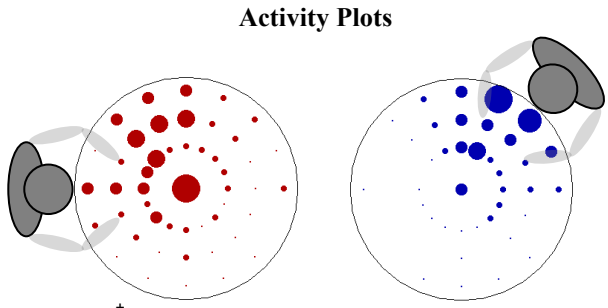


Fig. 5. Radial Zones.

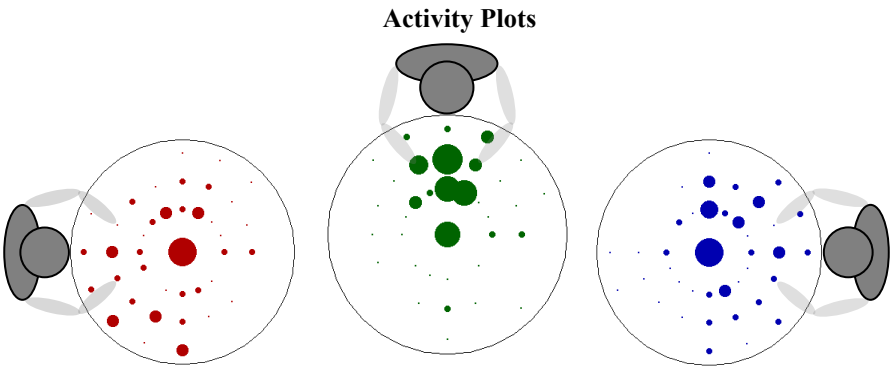
To help interpret the results of the spatial action analysis, an *activity plot* was created for each study participant (Fig. 6). Each activity plot summarized the tabletop activity that one group member performed in each tabletop zone during their entire collaborative session. The tabletop activity 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. The amount of activity is mapped to six dot sizes (smallest to largest): 1-9%, 10-29%, 30-49%, 50-69%, 70-89%, and 90-100%. The absence of a dot corresponds to an absence of activity by that participant in that zone. The location of the participant who performed the actions is indicated beside the plot with a silhouette icon.



a. Group 1.



b. Group2. † This person spent 5 minutes at N then moved to NE.



c. Group 3.

Fig. 6. Activity plots for each group: (a) Group 1, (b) Group 2, and (c) Group 3. Each plot indicates the relative amount of activity that each person performed in the various regions on the shared tabletop workspace throughout the entire collaborative session. © 2009 ACM, Inc. Included here by permission.

Results and Discussion

The results of the spatial action analysis confirm that participants made use of tabletop territories to help coordinate their actions during the layout planning activity. The analysis reveals that participants in Study 2 also established personal, group, and storage territories during their collaborative sessions. The analysis also provides 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.

Personal Territories

Participants' spatial interactions during their collaborative sessions are shown in the activity plots in Fig. 6. These plots 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 is reserved for use by that person.

In general, when a group member wanted an item that was located in someone else's personal 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. Alternatively, people would also just move their arms to the left or right as their partner accessed items in their personal territory, while continuing to interact with items on the table. Sometimes the owner would more actively accommodate their partner's interactions by helping them find a resource item, returning to their previous activities once the desired resources were found.

Group Territories

Fig. 6 indicates that personal territories were the only areas consistently avoided by others. 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 to discuss layout ideas and to assist others in creating or modifying furniture arrangements. Moreover, it served as a place to share task resources. Participants would often pass each other resource items via 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 (Fig. 6). Unlike the personal territories though, no area of the group territory appeared to be exclusively reserved for use by any one group member. The partitioning of the group territory appeared to help group members avoid conflicts while sharing the workspace by clarifying who should work where. This partitioning 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[1]). 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[1]).

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 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 collaborators can potentially impact the ease of coordinating activities in a tabletop workspace.

One observed event 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. The rotation was initiated by the participant seated at West, who wanted to work on an area of the Floor Plan located across the table from her. Together, she and her partner carefully rotated the Floor Plan about 110° counter-clockwise on the table. After the workspace rotation, the area she wanted to work on was 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 (Fig. 6b).

Before the rotation, the participant at NE (pNE) expressed his concern that an arrangement his partner (pW) had created on the table in front of her was too cluttered. At the time, pNE made some minor adjustments to it, but pW immediately readjusted the arrangement, almost back to its original state. After the rotation, this arrangement was located near pNE (in the E direction). He soon began remov-

[1] 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.

ing items from the arrangement and readjusting it. pW helped him a little, readjusting the arrangement while pNE removed items, but in the end, they agreed on a final arrangement that contained much fewer furniture items. pW seemed much more open to pNE's input on 'her' arrangement once it had moved closer to him (or farther from her) on the table. pNE also appeared more comfortable taking charge of the arrangement in its new position. Interestingly, pNE appeared to be the less dominant team member. Throughout their session, pW appeared more comfortable interacting on pNE's '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 disruptive to the group activity if other members are not expecting the action to occur.

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 loosely arranged individual items, piles of items, or a mix of both. Using storage territories to casually store workspace items appeared to help collaborators organize their task resources during the layout planning 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. How quickly these resources migrated from a large storage territory in the centre of the table to several storage territories along the table edge, however, depended on the organizational preferences and working style of each group. In general, the mobility of the storage territories enabled groups to access task resources where they needed them, when they needed them.

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 benefit the layout task by prompting discussions about the current state of furniture arrangements. For example, during one of Group 3's discussions of what type of chairs to use in a specific furniture arrangement, one participant asked the group the difference between two types of chairs he had 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.

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 [4, 20]. 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.

Interaction between Territories

Each type of tabletop territory played an important role in helping participants share the tabletop workspace while performing the layout planning 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. Personal territories appeared to be extensions of group members' personal spaces [23]; thus, a personal territory existed in the tabletop workspace directly adjacent to each person and was generally reserved for use by that 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, at least in tasks that afford a divide-and-conquer strategy.

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.

In summary, the spatial action analysis of Study 2 clarifies our understanding of personal, group, and storage territories. Personal territories tend to be used almost exclusively by their 'owner', while the group territory tends to be shared by group members. The analysis also reveals that when a task lends itself to a division of labour, partitions emerge within the group territory. These partitions appear to clarify the responsibilities of each group member in the workspace, helping group members coordinate their use of the workspace. However, the findings also suggest that such 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. Rotating the workspace may help mediate this situation. Such workspace actions should be done with caution, however, as they might introduce ambiguity as to the responsibilities of each group member in the workspace, which may increase the need for explicit coordination and verbal negotiation.

The study findings also indicate that storage territories appear to sit atop the group and personal territories, rather than existing as separate partitions in the workspace. Storage territories appear to take on the accessibility property of whichever territory over which they are currently positioned. The ability to move storage territories in the workspace appears to provide a lightweight, commonly understood, mechanism 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.

Fig. 7 shows a conceptual diagram of the relationship between the three types of tabletop territories. 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, and moving with the person's tabletop location. 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.

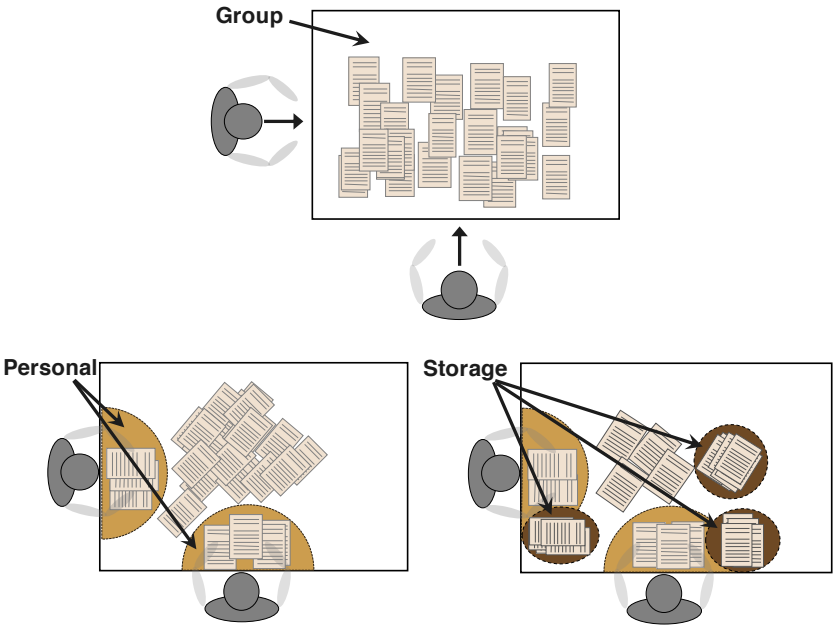


Fig. 7. Conceptual diagram of the three types of tabletop territories.

Theoretical perspective from the human territoriality literature

To help us understand the practice of tabletop territoriality in the broader context of human interaction, this section discusses the more general phenomenon of *human territoriality*. Over our lifetime we develop many strategies to mediate our interactions with the people we encounter and work with in our homes, in our workplaces, on the street, at a table, and so on. One such strategy is human territoriality. Territoriality helps mediate people's social interactions [2, 5, 18, 25]. Fisher et al. [6] 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).

There is little agreement in the literature on a precise definition of territoriality (Table 4 provides several examples); however, 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., 2, 5-7, 18, 25]. Gifford [7] explains the lack of agreement on a precise definition as a "matter of emphasis" (p. 137). As shown in

Table 4, some researchers emphasize the 'control' aspect of territoriality (e.g., over a space or a person), while others emphasize the 'preservation' aspect of territoriality (e.g., the ability to maintain personal space in a crowded place).

Taylor's definition of territoriality was given in earlier in the chapter (and also appears in Table 4) 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 our analyses 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 that are detailed below 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. Fisher et al. [6] 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 our investigations reveal 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 [2], Gifford's [7], and Taylor's [25] discussions of human territoriality. As our studies show, when people interact 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 understood by all group members.

Table 4. Sample definitions of human territoriality.

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." [6, 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." [7, 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." [25, 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." [2, 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." [18, p. 19]

Primary, Secondary, and Public Territories

Many environment psychologists distinguish between three main types of territories used by humans: primary, secondary, and public [e.g., 2, 6, 7]. 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 [6]. 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 territory has a moderate level of perceived ownership, whereby 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.

With respect to these three types of human territories, work tables are likely 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 table space and the resulting level of territoriality exhibited. Whether the contents of the table are owned by a particular group member may also affect the level of territoriality exhibited. However, for 'peer' collaborations where group members have come together for a shared purpose, it is likely that group members would perceive a fairly equal level of ownership of the shared table space. Thus, for our purposes we will consider work tables as public territories. Taylor [25] asserts that people exhibit 'minimal territorial functioning' in public territories, which helps in "facilitating usage and minimizing conflict" (p. 222).

Design 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 [2] 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 reasonable to assume that other aspects of territoriality, such as the role it plays in mediating people's social interactions, will be affected by poor spatial design. The findings from our studies support this supposition: in situations where collaborators had a compromised tabletop workspace (e.g., the table was small or people were seated close together) they exhibited less territorial behaviour, and required more explicit verbal and non-verbal negotiation to share the workspace.

It must be noted 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 often willing to make 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. The primary goal of our investigations is to uncover precisely how territorial behaviour can help people *work together* on a tabletop workspace. Our hope is that this knowledge will enable the design of digital tabletop workspaces that effectively support people's social and task interactions.

Implications for the Design of Digital Tabletop Systems

Consistent with Taylor's assertion that territoriality in public territories is context dependent, our findings indicate that the social meaning attributed to tabletop regions was derived from the current context of tabletop activities and often changed over time. We observed that the size, shape, and sometimes location, of tabletop territories often changed as a tabletop activity evolved. Within the human territoriality literature a location, or partition of space, and a territory are often considered equivalent. Yet, our findings revealed that tabletop territories are not necessarily mutually exclusive partitions in the workspace. 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. This knowledge can then be used to guide the design of digital tabletops to support the practice of tabletop territoriality.

Table 5 summarizes these three aspects of group, personal, and storage territories. This table synthesizes our findings with related findings from the literature to provide a broader picture of tabletop territoriality. The spatial properties listed in this table represent the general spatial properties of tabletop territories. In practice, the size and shape of these tabletop territories often fluctuate during collaborative tabletop interaction, again, depending on the context. Factors that influence this dynamic behaviour are discussed below.

Table 5. Design aspects of personal, group, and storage territories.

	Personal Territories	Group Territories	Storage Territories
Purpose	• Provides space for independent activities away from the main group interactions[1,2], enabling various levels of participation in group activity • Provides 'semi-private' space to explore alternate ideas that may later be integrated into main group activity[1]	• Provides space to perform main task activities[1,2], including: – working together on the task – working independently the task[3] – sharing task resources[3] – discussing ideas[1,4] • Provides space to assist others [4]	• Provides place to store task resources (e.g., tools, reference materials) • Organizes tabletop items • Enables people to access task resources *where* they need them, *when* they need them • Enables reservation of task resources
Spatial Properties	• Typically established directly in front of each group member, within immediate reach[2] • Typically stationary while the person remains at the same tabletop location	• Typically one central group territory[1,2] • Occupies areas available for sharing, typically within reach of group members (e.g., centre of table and table edges between group members) • Sub-group territories are sometimes established between adjacent team members	• Sit atop the other tabletop territories • Mobile in the workspace • Often positioned near the edges of personal or group territories
Interactions	• Typical task interactions, such as reading, writing, and manipulating items • Items tend to be oriented toward the territory 'owner'[2] • Task items often smaller here than in group territory; proximity makes items easy for 'owner' to see[1]. Small items helps create 'semi-private' space[1]	• Often mix of tightly-coupled and loosely-coupled interactions[1,4] • People sometimes partition the group territory, assuming responsibility for proximate regions[5] • People tend to use larger task objects (when available), enabling sharing of objects[6] • 'Compromised' orientation of items used to accommodate most group members[2]	• Organizational activities, including: – adding and removing items – reorganizing individual and piled items – searching and comparing items • Items are added or removed, one at a time or in groups of items at a time

[1][24], [2][10], [3][8], [4][3], [5][17], [6][15]

Factors Influencing the Spatial Properties of Tabletop Territories

Our investigations revealed five distinct factors can influence the spatial boundaries of tabletop territories:

Group size and seating arrangement. People easily accommodate others at the table by altering the size of their personal territories. When people are close together, they generally use small personal territories. This provides extra space for the group territory and for other people's personal territories.

Size of the table. Small tables force people to sit close together, influencing the establishment of tabletop territories as discussed above. A small table may prevent group members from simultaneously establishing personal, group, and storage territories. It may also compromise the group's ability to share the table space. A larger table enables people to sit at a comfortable distance and establish tabletop territories within their reach. However, an overly large table may force group members to sit far apart, which may hinder people's ability to access items in the group territory.

Visible barriers. A visible demarcation of tabletop regions can restrict people's perceived personal space [6]. Such visible barriers in the tabletop workspace may create a psychological barrier to expanding a tabletop territory across it. For instance, the edge of the cardboard Floor Plan in Study 2 appeared to restrict peoples' personal territories from this edge to the table edge.

Task activities. Tabletop territories often change shape and size as the task activity evolves. People expand and contract their personal territories based on whether they are currently working independently or in concert with the group. These spatial changes to the personal territories lead to corresponding spatial changes to the group territory. Also, storage territories are often expanded when someone is searching for a stored item.

Task materials. Larger task items will necessarily need more space for manipulating and sharing than smaller task items. For instance, a group sharing a large map will need a larger group territory than a group sharing a few Post-it™ notes. Having a large task item covering the table (e.g., an architectural schematic) may also restrict people's ability to establish personal territories.

Overall, the spatial properties of tabletop territories reflect people's opportunistic use of table space: they tend to use whatever space is available. At the same time these spatial properties are strongly influenced by social protocol that requires people to accommodate others at the table. People typically restrict their personal activities to 'socially appropriate' areas on the table. They generally refrain from using the table space directly in front of others and try to accommodate their collaborators as well as they can given the available table space.

One of the most important findings revealed by our investigations is that providing fixed visible partitions in the workspace may in fact hinder natural territorial behaviour during tabletop collaboration. The above discussion illustrates 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 [12, 21, 22] may in fact present a visible barrier to collaborators that may hinder optimal usage of table space. Supporting the practice of tabletop territoriality in digital tabletop workspaces appears to need a more subtle approach.

The spatial properties, purpose, and interactions supported by each type of tabletop territory described in Table 5 can be used to develop collaborative tabletop workspaces that support a variety of usage scenarios. A key theme revealed by the tabletop studies discussed in this chapter is that traditional tabletop workspaces enable appropriation of a single workspace for a wide variety of uses and users. The same table can support different individual and collaborative working styles, task materials (large and small, and few and many task items), individual and collaborative task activities (games, design, planning, reading, writing, conversations, etc.), and fluctuations in group membership.

Such multipurpose capability is enabled, to a large degree, by the fact that traditional tabletop workspaces and tools place few constraints on what parts of the table can be used, on where materials must be located, on where interaction must occur, or on who must perform those interactions. This flexible use of the workspace and available tools enables group members to use adaptable protocols, such as territoriality, to guide the collaborative work process. When changes in individual or collaborative activities are necessary or desired during the task progression, group members are free to change their use of the space and tools appropriately.

Future Trends

This chapter focused on territoriality on traditional, non-digital tabletop workspaces. Our own [19] and others' research [13, 16] have confirmed that territorial behaviour is also exhibited when people collaborate at a digital tabletop workspace. However, this practice has not yet been studied in detail in technology-augmented environments. Studies of new digital tabletop interaction techniques, for example, which enable people to access distant workspace objects, indicate that, although territorial functioning occurs, it may manifest in different ways [14]. To understand the impact of such new interface and interaction designs, more in-depth investigation of territoriality in digital environments is needed.

Digitizing the workspace also enables workspace configuration possibilities such as multi-display systems that provide a shared tabletop workspace connected to multiple mobile personal workspaces displayed on tablets or smartphone devic-

es, and distributed tabletop systems (see Chapter 17). Investigations by Tuddingham and Robinson [27] of group work on a distributed tabletop system indicate that territoriality tends to be more subtle. Remote collaborators still partition the (virtually) shared workspace, but the partitions in their study tended to resemble a "patchwork rather than a strict left-right arrangment" (p. 2142).

This patchwork partitioning was often structured by the task itself: while performing a furniture arrangement, individuals' workspace interactions tended to be bound by "the 'walls' in the floor plan … or new 'walls' created by the participants during the task" (p. 2143). Similar task-structured workspace partitioning was observed by Tse et al. [26] in an investigation of collaborative drawing activities on a desktop single display groupware system where pairs of people used multiple mice to draw on a shared desktop computer. They found that by default a proximity-based partitioning of the shared workspace (similar to the group territory partitioning found in Study 2) was adopted by their participants, yet when the task structure suggested a more efficient partitioning of the workspace, people tended to adopt the task-based partitioning will little to no discussion. The furniture arrangement task studied by Tuddingham and Robinson provided a fairly complex room layout structure that did not offer an obvious "split" in task structure. Thus, not surprisingly, they observed significantly more explicit verbal coordination (as compared to their co-located tabletop collaboration condition), such as "'I'll do the common room now' … 'You can start on the secretary's room'" (p. 2146). We found similar explicit verbal coordination Study 2 when ownership of particular areas of the table was ambiguous because multiple people could easily (or with similar levels of effort) reach these areas (e.g., in centralized areas).

Interestingly, Tuddingham and Robinson concluded that the presence of patchwork partitioning "suggest[s] that remote tabletops do not support the work practice of territoriality" (p. 2146). Insights from the human territoriality literature discussed above, however, provide an alternative interpretation: that territorial functioning was still present, but that it was less spatially bound due to the lack of physical constraints normally placed on co-located collaborators. Recall Gifford's [7] definition of territoriality provided in Table 4 that states that territorial behaviour is "based on perceived, attempted, or actual control of a definable physical space, *object*, or *idea*" (p. 137, emphasis added). An alternative explanation of the non-proximity based partitioning behaviour exhibited by collaborators using a distributed tabletop system is that they were, through verbal communication, establishing *perceived control* of an *object* or *idea*, such as "the common room." Once such control is established, and commonly understood, their partners will then concentrate on other objects/ideas within the task. This is a different manifestation of territorial behaviour than the primarily proximity-based partitioning behaviour discussed in this chapter, but it likely served the same purpose: to help people maintain order in their shared interactions. Providing a task structure than can easily be divvied up, even conceptually, may help reduce the need for explicit verbal coordination in remote collaborative situations.

Designing tasks or shared workspaces that lend themselves to implicit, or minimally explicit, assignment of responsibility across group members needs further investigation. Such knowledge could inform the design of distributed collaboration systems (tabletop-based or potentially otherwise) that exploit natural territorial behaviour to gain the collaborative benefits this social practice provides.

Conclusion

This chapter carefully examines the practice of tabletop territoriality. This practice involves the establishment and maintenance of various tabletop territories on a shared tabletop workspace. In particular, people tend to establish three types of tabletop territories: personal, group, and storage territories. Careful analyses of territorial behaviour from two observational studies reveal that the three types of tabletop territories have dynamic spatial properties that fluidly change as task activities evolve. The analyses also indicate that tabletop territoriality facilitates task and group interactions on a table by providing commonly understood social protocols that help people:

- share the tabletop workspace by clarifying which regions are available for joint task work, for assisting others, and for performing individual activities separate from the group,
- delegate task responsibilities,
- easily coordinate access to task resources by providing lightweight mechanisms to reserve and share task resources, and
- organize the task resources in the workspace.

This work also indicates that enabling the practice of tabletop territoriality in a digital tabletop workspace requires careful application of the nuances of tabletop territoriality discussed in this chapter to the design of digital tabletop systems. The insights gained from 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.

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