Collaborating over Physical and Electronic Tables

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ABSTRACT
Electronic tables running single display groupware have good potential for enhancing face-to-face collaborations. Our goal is to understand how people collaborate over physical and electronic tables. We articulate the unique collaborative characteristics of tables, and describe our initial observations of people collaborating on a regular table, a table display, and a vertical display.

INTRODUCTION
Many researchers within HCI and CSCW advocate embedding displays into a room's environment: its walls, chairs, and tables [3,4]. Our own interest is in tabletop displays and how they serve as groupware. We know that physical tables naturally support face-to-face interactions over a work surface, and we believe that computer-augmented table displays can enhance these collaborations. To be effective, we expect these table displays will implement single display groupware (SDG): a system where people simultaneously use multiple input devices when collaborating over a single shared display [2].

While there is a reasonable amount of research in SDG, the majority concerns vertical displays. Those few describing table displays are mostly proof of concepts, such as GMD's InteracTable [3] and ConnecTable [4], Wellner's augmented DigitalDesk [6], or MERL's DiamondTouch [1] display table that affords multiple touches.

We set ourselves the research goal of understanding the design space of tables. In particular, we wanted to articulate foundational issues that describe the unique characteristics of tables and what people can do with them. To achieve this goal, we took two different but complimentary approaches. First, we brainstormed and discussed the nature of regular tables in the western culture; this was both a reflective process that leveraged our own experiences with tables of differing sorts, and a review process that compared our intuitions with observations of how people work around a table [5]. Second, we compared how people interacted when using a physical table, a vertical display, and our newly constructed table display called the e-Table. This was a qualitative observation, where we wanted to identify what people actually did, the differences in how they performed identical tasks over these displays, and the issues that would emerge. From this, we wanted to articulate the e-Table's unique characteristics and limitations.

THE COLLABORATIVE NATURE OF A TABLE
The list below highlights some of the characteristics of physical tables (the size of a kitchen table or smaller), and how these characteristics contrast with vertical displays.

Reach. People can easily reach anywhere on the table's surface. This means that people can annotate any writable area on the table e.g., large pieces of paper [5], and can manipulate objects lying anywhere on its surface. In contrast, people have to move around each other to reach different parts of a vertical display.

Seating. People usually sit down when using a table. This has several significant implications. First, it is more comfortable, meaning that people can spend longer times at a table *vs.* standing at a whiteboard. Second, people's seating positions tend to be more stable, as people rarely switch chairs in the middle of a session, and sometimes even claim the same chair in successive sessions. In contrast, people move around vertical displays.

Engagement. Where people sit—side-by-side, kitty-corner, opposite sides—affects their interaction style. It changes what is in their line of site, their peripheral awareness of activities occurring on the table, as well as their sense of proximity to one another. In this sense, a table allows people to decide how close they want to be to each other, and how directly they want to face each other. In contrast, vertical displays only allow side-by-side interaction.

Personal space. When people are seated, the area directly in front of each individual is often used as their personal space. Vertical displays do not have this property [5].

Orientation. People seated at opposite sides of a table do not share the same orientation of the objects on it. Orientation can be a problem, as people have more difficulty reading or manipulating objects that are upside-down. However, people can use orientation as a resource to indicate whether a drawing is personal (oriented towards the drawer and within one's own personal space) vs. shared (oriented towards the viewer and outside one's personal space) [5].

Simultaneous interaction. Tables promote many simultaneous activities, more so than vertical displays [5]. We suspect this is due to the easy reachability of objects, and that one's personal space on the table defines an area where one can work without getting in the way of others.

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Holding of objects. Since a table is flat, people place actual physical objects on its surface. This is in sharp contrast to vertical displays. We suspect this is a strong reason why groups gather around tables, as it is easy to bring both personal and group artifacts into the conversation.

Sharing. Because of holding, reach, seating and simultaneous interaction, people can easily share artifacts by passing them around the surface.

Casual interaction. Because of seating and holding, a table encourages casual interactions. People sit at tables for comfort, for recreation (eating lunch, playing games), and impromptu meetings. Thus tables are multipurpose devices.

Table shape. Positions around circular or square tables promote equality, whereas rectangular tables place certain people at more advantageous positions than others.

Table size. Size affects reach, people's sense of proximity, and how many objects they can hold without clutter.

E-TABLE: OBSERVATIONS OF USE

We compared how people interact when using a physical table, a vertical display, and a table display. We gave people a puzzle task in these three conditions: puzzles are reasonable since they are often done collaboratively and require a horizontal surface. To make this possible, we first constructed the e-Table (Figure 1), a table display that offers some—but not all—of the characteristics of conventional tables. The e-Table comprises a small rectangular table with an embedded 20" LCD flat-panel display. Up to four multiple mice serve as the input devices. We then created an SDG puzzle that ran on both a vertical monitor and our e-Table, and a similarly-sized physical puzzle. People sat across from each other for both tables, and side-by-side in front of the vertical display.

While our observations of people's interactions are still preliminary, we saw that the e-Table shared many characteristics of the physical table: reach (through the mice), seating, simultaneous interaction, and sharing. However, there were differences between the 3 conditions.

Holding. The fragile look of the LCD monitor discouraged people from touching or placing physical objects on it.

Seating. The e-Table physically supports more people around its perimeter than a vertical display. Unlike the vertical display, people find it harder to view the e-Table at a distance because of its oblique angle.

Orientation. Orientation problems occurred on the e-Table. When all objects were orientated upright, people felt far more comfortable on the vertical display, especially when viewing text. People also felt the LCD monitor's physical characteristics projected a pre-defined orientation through its logo and labeled buttons. Thus only one seat had the 'correct' orientation.

Shape. Because the e-Table was rectangular *vs* circular or square, we believe that people seated at the shorter sides felt disadvantaged.

Figure 1: The e-Table

Mice. People wanted to take advantage of the tactile qualities of the e-Table by directly manipulate objects on it instead of using indirect manipulation afforded by mice.

Collaboration. People were generally more comfortable sitting across from one another over the e-Table *vs.* sitting side-by-side in front of the vertical display. Most found face-to-face communication over both the e-Table and regular table more natural than the vertical display's side-by-side communication. Awareness of a partner's actions was afforded by sitting face-to-face across the e-Table, and by the closer proximity by those sitting side-by-side in front of the vertical display.

Shared use of space. People felt that the area directly in front of them on the regular table was their personal space, and that the area in the middle was shared public space. However, no such distinctions were made on the e-Table and vertical display.

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