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An Observational Methodology for Studying Group Design Activity

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Abstract. A methodology for observing and analyzing group design activity is presented. This methodology is based on ethnographic and interaction analysis methods from the social sciences. Using it to study collaborative design activity leads to a descriptive analysis that identifies what resources the designers use and what obstacles they must overcome to accomplish their work. Based on this analysis, a better understanding of the needs of designers can be used to guide the design of tools to support group design activity. For example, this analysis led to an understanding of the role of hand gestures in collaborative design activity. Gestures are used to help demonstrate actions and establish shared reference. Hand gestures are often conducted in relation to sketches and other objects in the shared workspace. Descriptions of how to record group activity on videotape, represent and analyze the data (using a hypertext system), and abstract general observations from the data are presented.

1 Introduction

The design process is a complex and creative activity that has long been the subject of study. Several different methodologies have been applied to study design activity, as reported in the overview papers of Bessant [1979], Wallace [1987], and Finger and Dixon [1989]. To name a few, Thomas and Carroll [1979] conducted psychological experiments probing design activity, Ullman et al. [1987] applied protocol analysis on individual designers "thinking aloud," and Wallace and Hales [1987] used participant observation to study an engineering design project for almost 3 years.

The research presented in this paper draws upon an existing methodology known as interaction analysis, to study group design activity. Videotape records of actual design activity are analyzed to identify how the designers accomplish their work and what problems they encounter along the way. This qualitative description of design activity leads to a deeper understanding of the design process and raises implications for the development of technology to support it. This methodology was used in recent research to study small group, conceptual design activity [Tang, 1989], leading to design implications for tools to support that activity. In applying this methodology to *study* a particular design activity, we also discovered ways in which it could be used *as part of* any design process to understand the needs of the end user.

This paper presents a methodology for studying group design activity based on interaction analysis methods, which are introduced in Section 2. Detailed descriptions of how to observe and analyze group design activity are presented in Sections 3 and 4. As an example of the kind of findings that this methodology yields, Section 5 discusses observations on the role of hand gestures in collaborative design activity. The advantages and constraints of this methodology are discussed in Section 6, and applying it as part of the design process is discussed in Section 7.

2 An Introduction to Interaction Analysis

The observational methodology presented in this paper is based on interaction analysis, a qualitative analysis method used in the social sciences. In the fields of anthropology and sociology, qualitative methods are used to investigate human activity. Since group design activity is a complex social activity, it is appropriate to apply these methods to study it. Other design researchers [Wallace, 1987; Darke, 1979; Bessant and McMahon, 1979] have also advocated applying social science methods to study design activity.

In the field of anthropology, ethonographic stud-

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ies observe the activities of a culture by participating in it through an extended period of time. The daily life of the culture is studied in its natural setting with minimal disruption to that activity. The resulting ethnography is a description of the common practices of that culture, as experienced by the observer. Recently, ethnographic methods have been used to study not only foreign cultures, but professional subcultures in developed countries [Latour and Woolgar, 1979; Lynch, 1985], and design activity in particular [Bucciarelli, 1988].

Interaction analysis is a recent development in anthropology and qualitative sociology that integrates an ethnographic perspective with fine-grained analysis of human interaction. This methodology involves analyzing records of human activity in order to understand how that activity is accomplished through the interactions among the participants and the artifacts in their environment. Ideally, the participants should be observed in their natural working environment addressing a real task. Logistics sometimes dictate that the situation be structured to the extent that a realistic task is given to the participants in an environment where they can be easily observed. A crucial element of this approach is that the researcher not intervene in the group's activity once they have begun working on the task. The participants are free to organize their work as they wish, and it is the observer's responsibility to record and analyze the activity that subsequently unfolds. The goal is to capture samples of human activity in contexts in which they would naturally occur.

The activity is typically recorded on videotape, which is analyzed to identify patterns in how the participants accomplish or are hindered from accomplishing their work. By collecting and comparing among examples from the data, specific resources that the participants use to help them accomplish their work or obstacles that hinder their work can be identified.

Conversation analysis is a prominent form of this kind of analysis that studies how people interact through conversation [Sacks et al., 1974; Levinson, 1983]. Interaction analysis extends beyond focusing only on the conversation of the participants to include other aspects of how people interact with each other and their environment. Examples of video-based interaction analysis include the study of the accompanying nonverbal behavior in conversation [Goodwin, 1981; Heath, 1986] and the interaction between humans and technology [Suchman, 1987]. Our research extends the use of interaction analysis to study group design activity.

This approach contrasts with experimental methods where tightly controlled situations are constructed to test a preformulated hypothesis. Rather, interaction analysis explores naturally occurring activity to identify and understand what parameters and relationships are important to the interaction. This approach also contrasts with participant observation, which relies solely on the accuracy, completeness, and objectivity of notes collected by the participant observers. Rather, the activity is recorded on videotape, which can be reviewed again and again from a variety of perspectives. These underlying tenets of interaction analysis are described in Suchman's [1987] study of human–machine interaction:

> This study proceeded, therefore, in a setting where video technology could be used in a sort of uncontrolled experimentation. On the one hand, the situation was constructed so as to make certain issues observable. . . . On the other hand, once given those tasks, the subjects were left entirely on their own. In the analysis, by the same token, the goal was to construct a characterization of the "interaction" that ensued, rather than to apply a predetermined coding scheme. Both predetermined coding schemes and controlled experiments presuppose a characterization of the phenomenon studied, varying only certain parameters to test the characterization. Application of that methodology to the problem of human–machine interaction would be at the least premature. The point of departure for the study was the assumption that we *lack* a description of the structure of situated action. And because the hunch is that the structure lies in a relation between action and its circumstances that we have yet to uncover, we do not want to *presuppose* what are the relevant conditions, or their relationship to the structure of the action. We need to begin, therefore, at the beginning, with observations that capture as much of the phenomenon, and presuppose as little, as possible. [Suchman, 1987, p. 114, original emphasis]

Our research is premised on the need to observe and understand what design teams actually do in order to guide the design, development, and introduction of tools to support their activity. Our research applies the interaction analysis methodology to study the activity of design teams.

3 Observing Group Design Activity

In our studies, eight different sessions of small groups (3–4 people each) working on conceptual design tasks were observed. The groups consisted of peer participants who were not in the context of any formal authority hierarchy (i.e., no supervisors

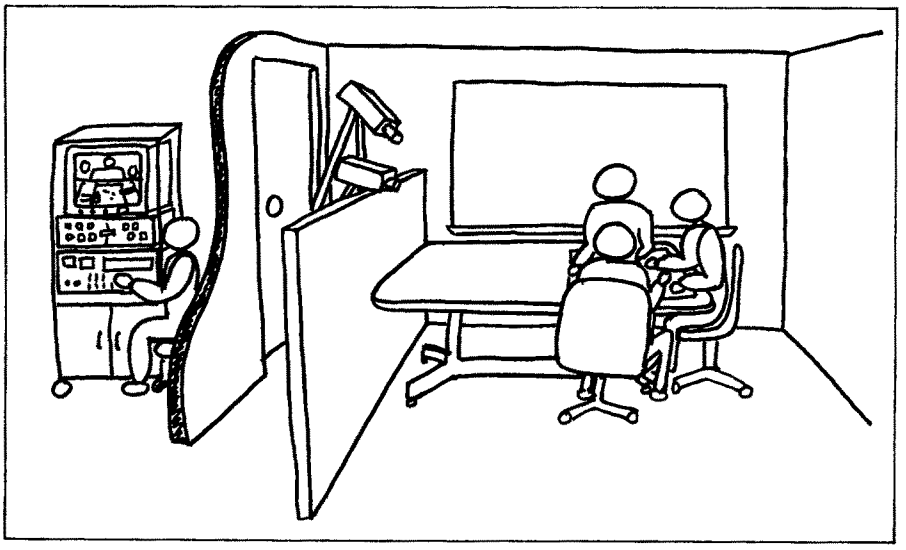

Fig. 1. *Observational configuration.* The participants were separated from the observational equipment and the experimenter. One camera is aimed at the shared workspace of the group, another captures a wide angle view of the group as a whole.

with people who report to them). The observed sessions were the first time that the participants worked together as a group on the task, thus capturing the earlier, more conceptual stages of the design process. All of the tasks that the groups worked on were human–machine interface design problems (see sample problem statement in Appendix). The groups typically worked on the task for about 1½ hours, deciding on their own when to end their session.

Videotape was used to record the design activity for later analysis. The final configuration for the observational equipment used in our research is depicted in Fig. 1. Two video cameras were mounted on tripods: one aimed at the shared workspace of the group, while the other captured a wide angle view of the group as a whole. The cameras were "passive" in that they were not moved or re-aimed during the session. This arrangement is considered less distracting than having an active cameraperson in the room aiming and focusing the cameras. The cameras were partially obscured from the participants by a partition, and the experimenter and recording equipment were located in a neighboring room. The signals from the two video cameras were combined into one split-screen video image, shown in Fig. 2. A time stamp that displays the date and elapsed time in hours, minutes, and seconds was included in the video image. This time stamp was used to index the contents of the videotape. The split-screen image with time stamp and the accompanying audio were recorded on videotape. An additional audiotape recording was made as a backup and for use in transcribing equipment to help make a transcript of the verbal dialog.

4 Analyzing the Data

Videotape records of design activity contain a wealth of data for analysis, which can initially be overwhelming. Reviewing the videotape data itself quickly suggests more specific foci for analysis. Analyzing the video data involves:

- Becoming familiar with the data
- Developing a workable representation of the data for analysis
- Abstracting patterns and general observations from the data

Although it is clearer to introduce this process of analysis as if these activities occurred in a three-step sequence, the actual analysis was much more

Fig. 2. *The recorded video image.* The split-screen image combines the wide angle view of the group (top) with a close-up view of the group's shared workspace activity (bottom).

CustomPhone-1 transcript section

S3: What if on your machine you just had no screen, you just had like, you could have like a little written area that you write, just a little paper card with a little plastic over it and there's a little LED next to it and
S1: Right. A button next to it, sure you could do that too, why not?
S3: a button next to that, or maybe your button is a lit button, and you come home and this one is blinking or not blinking and this is you, so you hit it

S1: Yeah, and you pop it and there it, you get your messages.
S3: Yeah

S1: Sure you could do it that way, too

S3: There's no security on this but maybe we shouldn't worry about security ((pause))

S2: Well.
For housemates it's not so important, but it would always be a nice added feature

S1: Say you have a key slot here

S3: ((laughs)) Then you have to carry this little key around
S2: It could have, it could have, umm, fingerprint recognition
S1: Oooo! There you go, high technology! Yay
S3: Oooo! That's a good idea! Yeah!
So you put your finger on this to get your message, that's great!
Ok
((pause))

Fig. 3. *Sample transcript section.* This sample section of a transcript illustrates how the verbal dialog and its pacing are represented. The speaker is designated by the "S" labels.

complex. The three activities occurred concurrently and were informed by each other. It was often the case that representing the data or identifying patterns in the data led to a new perspective on it, prompting a re-familiarization with the data or a modified representation for the data for further analysis. For clarity of presentation, this section presents an idealized, three-step framework for the analysis. However, the examples drawn from our study of group design activity will indicate that the analysis that actually occurred was a much more interrelated process.

4.1 Becoming Familiar with the Data

After videotaping the design sessions, the initial task in analyzing the data is to review the tapes to become acquainted with the sequence of events in the session and to note incidents for closer examination. A good exercise for becoming familiar with the data is to make a transcript of the verbal dialog of the session. Deciphering who said what and in what order is a prerequisite for deeper understanding of the activity. Figure 3 shows a section of transcript from a design session. The speaker associated with the text is designated by the "S" labels. Some indication for the pacing of the speech is given through the punctuation and line formatting. Turns of talk from different speakers with no line space between them indicate overlapping talk.

In our study of group design activity, making a transcript of the verbal dialog not only helped us become familiar with the data, but also revealed that the transcript by itself did not adequately represent the recorded design activity. Understanding the transcript often required attending to the accompanying drawing and gesturing activity that was observable on the videotape. This initial familiarization exercise led to the development of a representation that included these nonverbal activities, as will be described later.

Another technique that is helpful for developing an overall perspective on the data is to bring several different viewpoints to bear on the video data. At the time of this research, a working group of designers, anthropologists, and computer scientists (called the Interaction Analysis Lab) met weekly at the Xerox Palo Alto Research Center to review videotapes of human activity. These meetings brought together insights on the data from the different perspectives of these disciplines. Since the researchers came from different academic disciplines, they each brought different sensitivities to bear on analyzing the video data. Furthermore, they were forced to demonstrate their claims about the activity by observable evidence from the video data, rather than relying on any single discipline's characterization of human activity. This emphasis on understanding human activity through the directly observable interactions among people and their environment is a distinctive characteristic of interaction analysis. This approach contrasts with cognitive orientations that account for human activity by mental activity that is not directly observable.

Multidisciplinary group analysis is a practical technique for assuring that the resulting observations are based on observable evidence from the data.

Selected segments of our video data on group design activity were reviewed in the Interaction Analysis Lab. One issue that emerged from these analysis sessions is the variety of activities that could be observed in the recorded design activity and their interrelationships: talking, writing text, drawing graphics, and gesturing. These sessions helped identify some of the patterns of activity (e.g., instances of using hand gestures, classifying the various uses of gestures, quick alternation among writing, drawing, and gesturing) that we focused on in our research, as will be discussed later.

The videotapes can also be reviewed with the participants themselves to elicit their perspectives and help focus the analysis of the video data. In our research, the participants were invited individually to review the videotape. This technique was modeled on the work of Frankel and Beckman [1982] in their analysis of doctor–patient interactions. The participants were encouraged to comment freely on what they saw; they could stop the tape at any time to interject their thoughts. These sessions also provided us an opportunity to ask the participants specific questions about issues that arose in our prior examinations of the tape. We believe that reviewing the actual data with the participants elicits more detailed recollections than if they were asked in an interview to recall their thoughts from memory. These review sessions were audiotaped to record their comments.

4.2 Representation of the Activity for Analysis

Developing a representation for relating the verbal transcript, notes on nonverbal activity, and comments from other researchers and participants is a major methodological issue. In our studies of group design activity, the NoteCards software system was used to help manage this wealth of data and organize its analysis. NoteCards is a hyptertext system that runs in the Xerox Lisp environment [Halasz et al., 1987]. It is analogous to index cards, in that it encourages breaking data down into small units, called cards. These cards can be pieces of text, graphics, or other information representable in the Lisp environment. NoteCards provides mechanisms for linking and grouping these cards to facilitate organizing them. The cards can be connected by links, which can be designated by type (e.g., comment, related, next). Cards can also be grouped together into fileboxes. NoteCards offers several mechanisms for structuring, displaying, and navigating through large networks of cards and links. It also allows users to program functions to execute customized operations on the data.

An example will demonstrate both how NoteCards was used to develop a representation of the activity and how that representation was used in this analysis. After creating a transcript of the verbal dialog, the transcript was divided into segments. Each segment consisted of an interactional exchange over a particular focus of attention. When the group's attention shifted to a new focus, a division between segments was marked. The segments averaged less than a minute in length and typically comprised 3–7 turns of talk. No claims in the analysis are based on the definition of these segments. This segmentation was done to facilitate the analysis—to be able to distinguish, identify, and group together different segments of the activity. While many of the segment boundaries were clear-cut, some were rather arbitrary. An alternative method proposed by Fish [1988] divided the data into segments of fixed time intervals (i.e., 30-second segments) without attending to the content of the activity.

Each segment of transcript was placed on a separate card, and linked to the segment which followed it, creating a chronological chain of links through all the cards. Each segment was linked to other segments dealing with a related topic, or grouped together into fileboxes that collected segments exhibiting a common pattern of activity. Segments were also linked to comments by the researchers or participants that refer to some part of the activity included in the segment.

As mentioned earlier, our initial work on making a transcript and analyzing the data as a group led to a focus on the listing, drawing, and gesturing activity that occurs in collaborative design work. Portions of the videotaped data were selected to investigate these drawing space activities more intensively. For one entire 1½-hour design session and a 10-minute section of a second design session (where the group specified a design for one of their ideas), each instance of listing, drawing, and gesturing was described on an individual card. Each transcript segment was annotated by links to those cards noting any instances of listing, drawing, or gesturing that occurred during that segment. A sample segment from the transcript of Fig. 3 and the cards that it is linked to are shown in Fig. 4. In this way, NoteCards was used to manage and keep track of a variety of information, comments, and relationships among the empirical data.

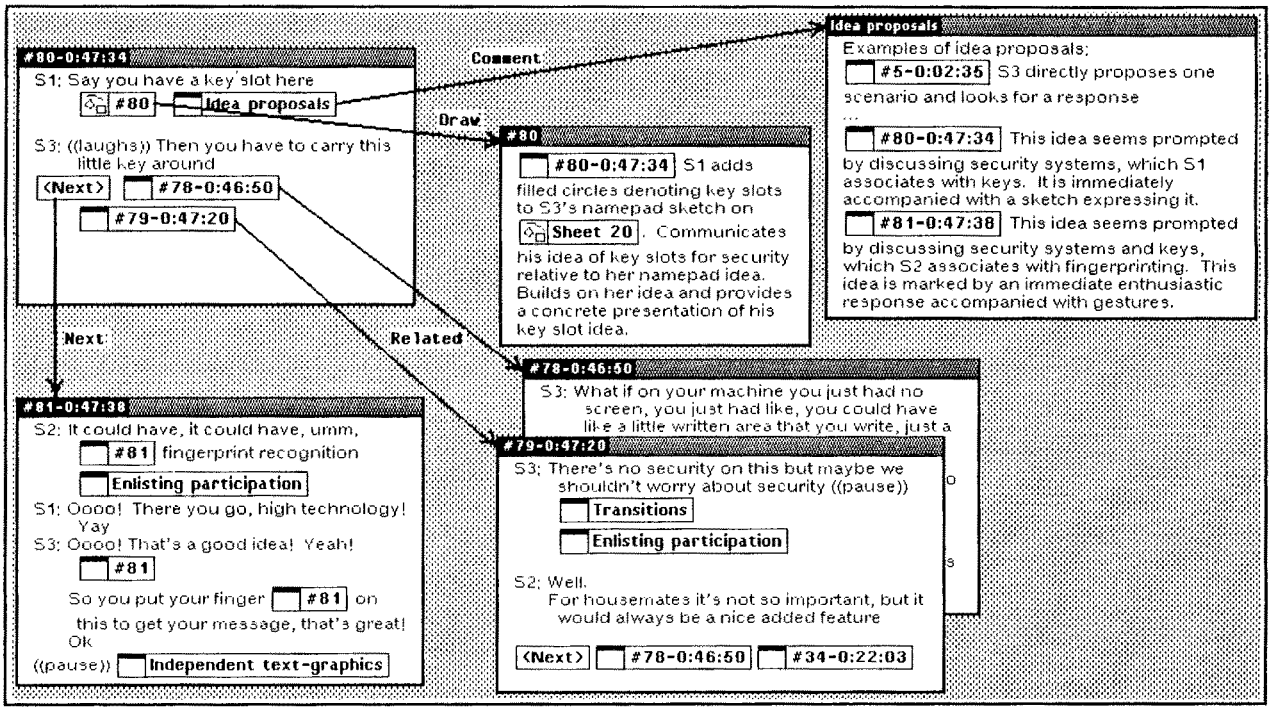

Fig. 4. *How segments are linked to other objects.* Arrows from the link icons indicate how a segment from a design session transcript is linked to other segments, notes on the workspace activity, and comments of analysis.

4.3 Abstracting Observations from the Data

The goal of this analysis is to identify generalizable observations about design activity from the videotaped data. One strategy in this analytical process is to look for "collectibles"—recurring patterns of activity that can be collected throughout a session, or across a variety of sessions. This strategy is a common technique in conversation analysis (see for example [Levinson, 1983]) that has been extended to interaction analysis [Tatar, 1989]. Patterns of activity were identified and other examples of that pattern were collected. Comparing and contrasting among several different examples (while being sensitive to the contexts in which they were situated) leads to a better understanding of that activity.

In particular, our interest in analyzing group design activity was to identify implications for the design of tools to support that activity. We focused on identifying collectibles that led to an understanding of what resources the designers used or what obstacles they encountered in accomplishing their work. Analyzing these collectibles led to an understanding of specific resources and obstacles for the designers.

For example, one pattern of activity identified as a collectible in our study of group design activity was the use of hand gestures. Many instances of the use of hand gestures were collected from the recorded design sessions. This collection of data raised several research questions:

- What did these hand gestures accomplish?
- What relationship did these gestures have with the group's other ongoing activity (e.g., talking, drawing)?
- What problems arose from the use of these hand gestures?

Comparing and contrasting among this collection of data led to an understanding of what resources and obstacles are associated with gestures. For example, the relationship of gestures to the drawing space is a resource for interpreting them, since gestures often refer to marks in the drawing space. On the other hand, visual obstructions that prevent collaborators from sharing a view of their gestures can be an obstacle. These observations are discussed in more detail in the next section.

In summary, the analysis consists of (a) identifying specific patterns of activity of interest; (b) collecting instances of that activity in a variety of situations; and (c) comparing and contrasting among the collected instances to explain the activity and its variation across different situations. The advantage of this approach is that the resulting observations are closely tied to the empirical data. It is the data that initially suggests the collectibles and groupings, rather than hypothesized groups being imposed

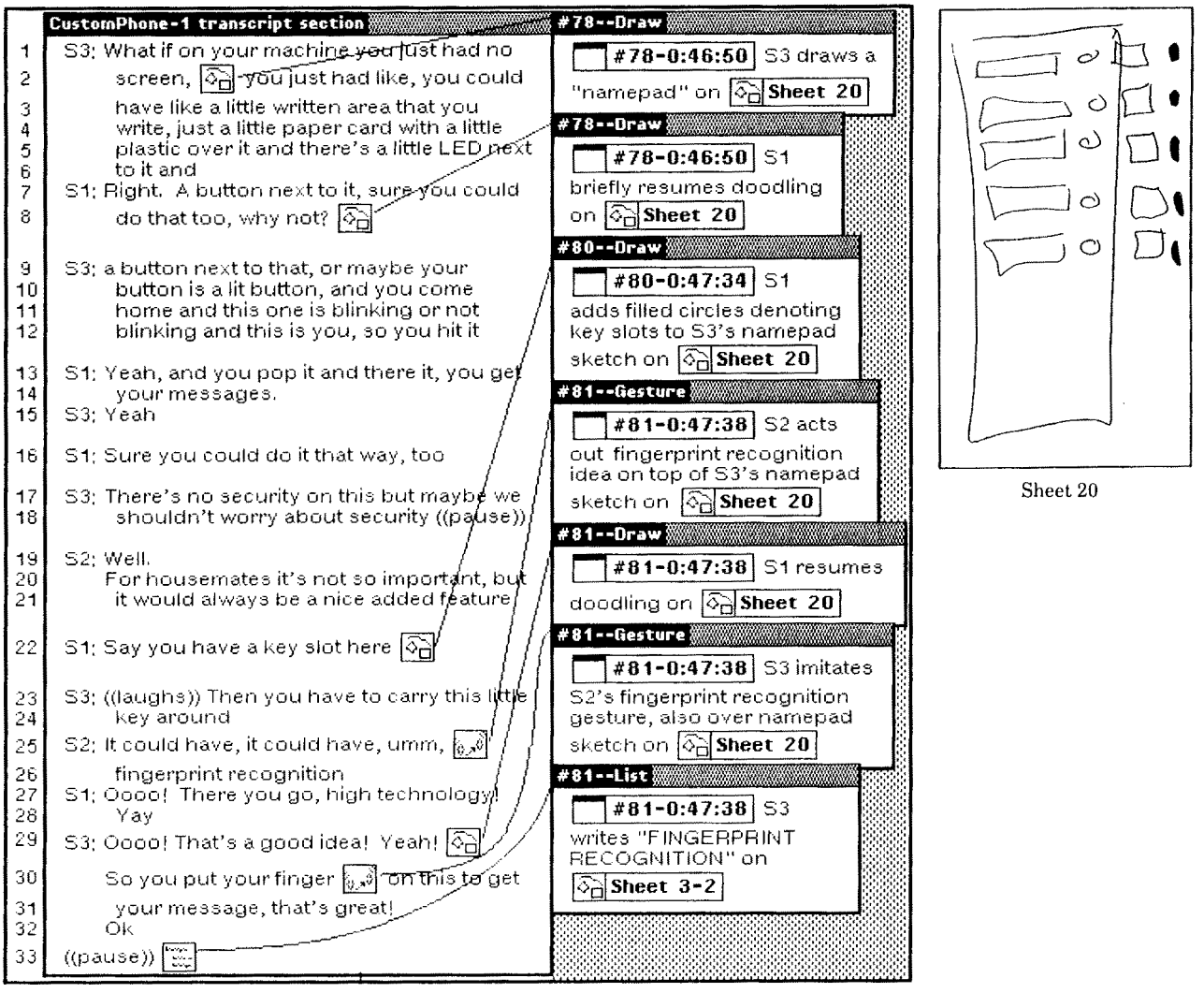

Fig. 5. *Annotated transcript section from design session.* A section of transcript from a design session, linked to notes on the instances of listing, drawing, and gesturing that occurred. The area of the paper being worked on during this section is shown at the right.

onto the data. The disadvantage of this approach is that it is very time-consuming. Careful attention is required to identify collectibles and to collect enough relevant instances of each collectible for analysis. Much qualitative analysis is needed to compare and contrast among the collected instances in order to gain an understanding of the activity that leads to generalizable observations. Tang [1991] describes observations that were raised in using this methodology to study group design activity.

5 Findings: The Uses of Hand Gestures

One issue that emerged from analyzing the data was understanding the use of hand gestures. There is a long history of studying gestures in human interaction (see for example [Kendon, 1986; Goodwin, 1986]), and the prevalence of gestures in collaborative design activity is obvious. Our research focused on what gestures accomplish in group design and how they could be supported by collaborative tools. We observed that gestures can be used to: enact a simulation of an idea; help mediate the group's interaction; and possibly help store information. An important feature of gestures is their relationship to drawings and other objects in the drawing space. These observations are illustrated with an annotated transcript representing a scene from the video data, shown in Fig. 5.

5.1 Scene from the Video Data

The section of transcript shown in Fig. 5 is annotated with brief descriptions of every instance of

listing, drawing, and gesturing that occurred during the section. An icon is placed in the text of the transcript at approximately the point where the listing, drawing, or gesturing activity begins. That icon is linked to a note describing the activity. The line numbers along the left margin are used throughout this section to index locations in the transcript. The region of the paper where the participants are making their marks and sketches is included to the right of the transcript.

The designers have chosen to design a custom phone-answering machine to service a household that has several different inhabitants (see Appendix for complete problem statement). At this stage of the session, they have established that the answering machine routes incoming phone messages to particular recipients in the household. In this section, they talk about how those recipients retrieve their phone messages, and especially how they could prevent their own messages from being accessed by others. In this section, S3 first proposes a "namepad" configuration where each recipient has a slot and can select to hear their own phone messages when a flashing LED indicates that their slot has messages. However, S3 realizes that this solution does not prevent other people from accessing the phone messages directed to a particular person, a security issue that the group had previously raised. S1 proposed that each button could be locked with a key. Then S2 proposes that the machine sense the person's fingerprint when pressing the button to access messages, and recognize whether to grant access to them or not. This idea gets an enthusiastic response, culminating in S3 imitating the fingerprint recognition gesture and documenting it.

5.2 *Observations on the Use of Hand Gestures*

One observed use of hand gestures is to enact ideas that involve a dynamic sequence of actions. Hand gestures can be an effective way to express these ideas to other group members. For example, in the gesture noted in line 25 of the transcript in Fig. 5, one designer acts out the fingerprint recognition idea. This gesture is shown in Fig. 6. By holding her finger over a button on the sketch of the phone machine recognizing her fingerprint and subsequently playing her phone messages. Enacting a sequence of actions through gestures is a convenient way of demonstrating behavior, especially how people will interact with the design. These gestures range from abstract motions to more detailed enactments, often done in relation to existing sketches or other objects in the drawing space.

Fig. 6. *Gesture example.* S2, on the far right, enacts the fingerprint recognition idea by pressing her finger on a sketch of a button.

Hand gestures are also commonly used to mediate the interaction of a group, such as raising a hand to indicate wanting the next turn in the conversation. As part of the gesture marked in line 25 of the transcript, S2's hand moves deliberately toward the namepad sketch, effectively commanding a turn in preparation for her acting out the fingerprint recognition idea. Gestures are also used to direct the group's attention by pointing to or otherwise referring to drawings or areas in the drawing space.

Gestures are not typically thought of as a medium for storing information because they do not leave behind any persistent record. However, the data showed some evidence that information can be effectively chunked and preserved through gestures, especially if the gesture is imitated by others and labeled in text or graphics. For example, on line 30 of the transcript, S3 imitates S2's gesture of the fingerprint recognition idea from line 25. The idea is later written down by S3, as noted in line 33, but the essence of the idea is encoded in the gesture, which is not otherwise persistently documented. The fact that the fingerprint recognition idea is not readily apparent just by looking at the marks made in the workspace is evidence that much of the idea is not preserved except through the gesture.

A most important characteristic of hand gestures is that they are typically made in relation to existing objects in the drawing space. Gestures that enact an idea are often acted out in the context of a sketch or other object in the drawing space (e.g., the fingerprint recognition gestures over the namepad sketch on lines 25 and 30). Gestures are often used to direct the group's attention by referring to sketches or other objects (e.g., pointing to another group member) in the drawing space. These observations indi-

cate that it is important to not only see the gesture, but also to see it in relation to the workspace and the other participants.

One observed problem concerning gestures is that they are sometimes not perceived by other team members, because their attention is focused elsewhere. Being able to clearly view gestures can be difficult, especially in meetings with many participants. Meetings in computer-augmented rooms (e.g., Colab [Stefik et al., 1987]) that are cluttered with computer equipment, or meetings involving participants in physically remote locations present greater challenges in sharing gestures.

Tools could be applied to convey gestures so that all of the participants can share in viewing them. Such tools should also preserve the relationship between gestures and their referents in the shared drawing space. VideoDraw [Tang and Minneman, 1990] is an example of a prototype tool that uses video to convey gestures in support of collaborative drawing activity. Hand gestures are captured by a video camera aimed at the drawing surface. This video image is presented as part of the shared drawing surface that the other collaborators view, so that everyone can see those gestures and see them in relation to the marks that they refer to on the drawing surface.

6 Advantages and Constraints of the Methodology

Video-based interaction analysis is a useful methodology for studying human activity. Studying how people actually accomplish an activity leads to a better understanding of the resources and hindrances that exist for the participants and suggests the design of tools to augment those resources while eliminating obstacles in their work. This methodology results in an analysis that is strongly tied to examples from realistic work activity.

Interaction analysis enables a new understanding of design activity that cannot be obtained by the previously discussed methods that have been applied to study it. For example, with respect to studying hand gestures, interaction analysis has enabled an understanding of how gestures are used in the context of collaborative design, leading to specific design implications for tools to support that activity. Psychological experiments would have studied gestures in isolation, possibly missing the importance of the relationship between gestures and their referent sketches. Protocol analysis would depend on people being sufficiently aware of their use of gesture to report on it in their thinking aloud. Yet, it is because gestures are so naturally and effortlessly used that they are an effective resource for designers in collaboration. The time scale of participant observation studies would not lend themselves to focusing on the role of hand gestures in the design process.

However, video-based interaction analysis has some constraints that suggest when it is and is not appropriate to use. Interaction analysis is limited to observing a tractable time period of activity (typically hours, rather than weeks or months). This may seem like a limited amount of observed activity, yet it contains a wealth of data that requires a large amount of time to analyze. Consequently, only a limited sample of activity can be studied using this fine-grained analysis.

A related concern is how the observations gained from this methodology can be generalized. Certainly, other kinds of activity might occur under different situations than those observed. Thus, it is important to present the findings in terms of the context in which they were observed. Those findings that are based on evidence that goes beyond that particular context (such as the observations reported here on the use of hand gestures) can be more broadly generalized. However, some findings will be more dependent on the specific context (e.g., that only one person tends to work at the chalkboard at a time), and can only be generalized to certain similar contexts.

A concern that is often raised in observational studies such as these is that observing the activity may affect the activity itself. There is evidence in the psychology literature that the initial effects of being observed fade quickly with time [Kelley and Thibaut, 1969, p. 6]. There is no rigorous test that can determine the effects of being observed. We assert that the passive observational method presented in this paper is less disrupting than the controlled experimental and protocol analysis methods used in other design studies. In the sessions that we have observed, there were only isolated references to the fact that the participants were being videotaped ("Don't mind the 'explosive' television cameras," "Oh I did that on TV"); otherwise the activity was focused on the design task. Besides these isolated references, there was no visible evidence that the observation affected the group's activity.

7 Applying this Methodology in the Design Process

In applying interaction analysis to study group design activity, we discovered that it could be used

not only to *study* the design process but also *as part of* the design process. In the research reported in this paper, the work activity of design teams is studied in order to help develop tools to better support group design activity. This research models a design process where the designers first understand the needs of their end users (which in this case are designers engaged in group work) before building tools to support the users' work. Applying interaction analysis to study the activity of the target end users could be used in *any* design process to understand the users' needs and guide the design of tools to support their work activity.

While designers are often encouraged to understand the users' needs and design technology that meets those needs, the designers are typically not equipped with any methodologies to help them accomplish this need-finding. Interaction analysis could be applied to study the work activity of target end users in order to help designers identify what resources are used and what hindrances are encountered by their target users. This understanding could help guide the designers in designing technology that augments resources while eliminating hindrances in users' work. In this way, interaction analysis can be an integral part of the design process.

When applying this methodology *as part of* the design process, a troublesome concern arises. Since this methodology depends on observing actual interaction with an artifact, it is difficult to apply it to the design of future technology that does not yet exist. The participants must have an artifact of some form to interact with in order to use this methodology to observe their interaction with it. A starting point is to study a related work activity in order to understand where to begin intervening with new technology. The research presented in this paper is an example of that approach: collaborative design activity using conventional tools (paper, pen, chalkboard) was studied in order to guide the design of new tools to support that activity.

Additionally, a rapid prototyping design approach that functionally prototypes or simulates the imagined new technology can give some indication of how the users will interact with it. Vertelney [1989] describes some techniques using computers and video to quickly prototype user interfaces. By iterating between observing prototypes in use and developing new prototypes, a new technology can emerge that is designed to fit the needs and capabilities of its users. Early experiences in applying the observational methodology as part of the design process to understand the needs of users are reported by Tatar [1989], Tang et al. [1990], and Suchman and Trigg [1990].

8 Conclusions

Video-based interaction analysis is a qualitative methodology that can be used to study group design activity. This methodology results in a descriptive analysis of the activity, leading to an explanation and understanding of how the group accomplished their work. It has been applied to study the collaborative drawing activity of design teams [Tang, 1989]. In this research, the methodology identified prominent features of group workspace activity (e.g., gestures, the process of creating drawings) and a better understanding of specific aspects of those features (e.g., the relationship of gestures to the workspace, the use of the drawing process to mediate interaction). Using this methodology to study design activity leads to a better understanding of the design process.

This methodology can also be used as part of the design process, to understand the needs of the users and guide the design of technology to meet those needs. In our studies of collaborative design activity, this methodology helped identify specific implications for the design of tools to support that activity. Using this methodology as part of the design process leads to the design of better artifacts that fulfill users' needs.

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Appendix

Problem statement for the design session:

In teams of 3 or 4, design a custom multifunction telephone for the user and environment of your choice.

It should have at least three of the following functions: autodial and redial, answering machine, calendar and clock, log or diary, call waiting and forwarding, hold and transfer, conferencing, call-back, speaker-phone, or any other you might think of relevant to your particular user(s).

The goal of this project is for you to be able to design complex computer-based products which are easy, efficient, safe, and satisfying to use. You should be able to use scenarios to describe users and environments, task analysis to determine information needs, key-stroke models to predict efficiency, and simple prototypes and storyboards to check learning.