pattern of interactions was found. A large number of players made and received no gestures, but made a lot of public utterances. The ethnographic data helped researchers to interpret this finding too—the starport was a good place to advertise as there were many people gathered waiting for a shuttle. Another set of players at the starport said very little; the researchers believe that these were people looking for trainers to give them a particular skill they needed in order to progress in the game. ■

8.4 Simple qualitative analysis

As with quantitative analysis, the first step in qualitative analysis is to gain an overall impression of the data and to start looking for patterns. Some patterns will have emerged during the data gathering itself, and so you may already have some idea of the kinds of pattern to look for, but it is important to confirm and re-confirm findings to make sure that initial impressions are not biasing analysis. For observation data, the guiding framework will have given some structure to the data. For example, the framework for observation from Goetz and LeCompte (1984) introduced in Chapter 7, will have resulted in a focus on questions such as "Who is present," "What is happening" and "Where is it happening." Using this framework you may notice that when someone from the accounts department comes to the administration office to meet staff members, then there is a lot of interest and everyone from the office attends the meeting. However, when visitors from other departments come to the administration office, or when accounts meetings are held in the accounts office, there is less interest. Using Robson's framework, patterns relating to physical objects, people's goals, sequences of events, and so on are likely to emerge.

There are three simple types of qualitative analysis that we discuss here: identifying recurring patterns and themes, categorizing data, and analyzing critical incidents. These are not mutually exclusive and can each be used with the others.

8.4.1 Identifying recurring patterns or themes

As you become more familiar with the data, recurring themes or patterns will emerge. An example is noticing that most senior managers interviewed express frustration at the lack of up-to-date information they have from the marketing department.

Nearly all data analysis begins with identifying patterns or themes. This is true when working with quantitative and qualitative data. Sometimes the patterns or themes form the primary set of findings for the analysis and sometimes they are just the starting point for more detailed investigation of the data. Patterns in quantitative data may be identified through graphical representation (as discussed above), but identifying themes in qualitative data requires the researcher to be immersed in the data. Themes emerge and evolve over this time.

The study goals provide an orienting focus for the formulation of themes. For example, consider a survey to evaluate whether the information displayed on a train travel website is adequate and sufficient. Several of the respondents add comments to the survey suggesting that, as well as the origin and destination stations, the station stops in between should also be displayed. This is a theme relevant to the study goals and would be reported as a main theme. In another part of the survey, under 'further comments' you might notice that several respondents comment that the company's logo is distracting. Although this too is a theme in the data, it is not directly relevant to the study's goals and may be reported only as a minor theme.

One aspect of this form of analysis is to keep clear and consistent records of what has been found, and a close description of themes or patterns that are emerging. If the description is not specific enough then you may end up with a set of observations that do not address the goals. If the description is too specific then you may find that you have lots of themes, each with only one or two pieces of evidence.

Studying the data, focusing on the study goals, and keeping clear records of the analysis as it progresses are important. Box 8.4 and Case Study 8.1 describe studies where themes have been identified from qualitative data and reported as a significant part of their results. The results in Box 8.4 were arrived at by immersion in the data; the box for Case Study 8.1 illustrates the use of a specific technique for ordering data—the affinity diagram.

Note that patterns and themes in your data may relate to a variety of aspects: to behavior, to your user group, to places or situations where certain events happen, and so on. Each of these kinds of theme may be relevant to your goals. For example, descriptions of typical users (personas) may be an outcome of data analysis that focuses on patterns of participant characteristics.

Box 8.4
Themes in European culture

Bell (2001) reports on ethnographic research in Italy, Germany, France, the UK, and Spain that focused on European culture. She and her team visited 45 households from small towns, cities, and major metropolitan centers. The aim of the study was to understand what people do and don't do in their homes, how a household relates to the wider community, what technologies were present, and how they were used. The work they conducted informed the design of existing products and pointed to new product opportunities such as computing in public spaces.

vork Solutions

Figure 8.8 Bell interviewing a German family

The researchers used an approach which allowed them to track important cultural values—in each country they started by visiting a small town, then moved to a city, and then to a larger metropolitan area. In this way, they could initially understand the daily rhythm of life in the country in a manageable context before moving to the more complex situations. They assumed that any patterns which were observed in all three different contexts were likely to be significant. Taking an ethnographic stance, the researchers tried to do everything that native people would normally do. They followed people around and asked lots of questions about what life was like and what people do. Four significant themes (called 'domains' by the researchers) were identified from this work: togetherness, media experiences, consumption habits, and life outside of the home.

Togetherness. Family, kinship, and community were found to be very significant in Europe. For example, the importance of the family eating together was a recurrent theme in the interviews and in the team's observations. Other occasions also promote social gatherings, such as sporting events and leisure activities. The researchers noted that sometimes people spend time together simply watching television. They found an emphasis on face-to-face social time throughout their studies, and the willingness of people to expend effort to maintain this 'togetherness.'

Media experiences. The researchers found that many different kinds of media play a variety of roles in European life—both consumption and production of content. For example, they found people painting, playing musical instruments, sketching and drawing in nearly every population center they visited. Television and print media also play an important role. Television is talked about explicitly by European families for its educational role. The researchers found print media of various kinds (magazines, newspapers, catalogues, pricelists, etc.) in the European homes they visited, and also observed rituals of reading and use of these materials, for example buying more than one daily newspaper in order to gain different perspectives on the news articles.

Consumption habits. "Food shopping is a really important part of daily life in most European countries." Europeans frequent a wide variety of shops and have a distinct preference for very fresh food. The open-air market is a particularly important part of French daily life, and the preparation, cooking, and consumption of the food is highly valued. In addition to purchasing items, shopping is also a social activity which connects people to their communities.

Life outside of the home. The researchers were struck by the variety of spaces outside the home where people socialized, and by the diversity of behaviors they observed. For example, people talk, flirt, play games, admire, create art, listen to music, eat, dance, swim, walk, and 'hang out' in gardens, parks, bars, pubs, cafes, promenades, markets, boulevards, and plazas. How often people frequent these places, and what they do there, changes with age and life stage. ■

CASE STUDY 8.1
Using ethnographic data to understand Indian ATM usage

This case study focuses on an investigation into the use of ATMs (Automated Teller Machines) in Mumbai, India. It illustrates the use of ethnographic data to answer questions such as: "What is the general attitude towards ATMs use?" and "What problems do people face when using ATMs?"

The project involved data collection through field observations and semi-structured interviews with early ATM adopters, bank customers who do not use the ATM, and customers who used the ATM for the first time during this study. Over 40 interviews were recorded, and photographs and videos were taken where possible. In addition, user profiles representing six different social classes were generated. Together with observations of ATM usage the project collected a considerable amount of data.

The project's use of affinity diagrams to help analyze the information that they collected is described by De Angeli *et al.* (2004). The affinity diagram (see Figure 8.9 for an example) which is used in contextual design (Beyer and Holtzblatt, 1998) aims to organize individual ideas and insights into a hierarchy showing common structures and themes. Notes are grouped together

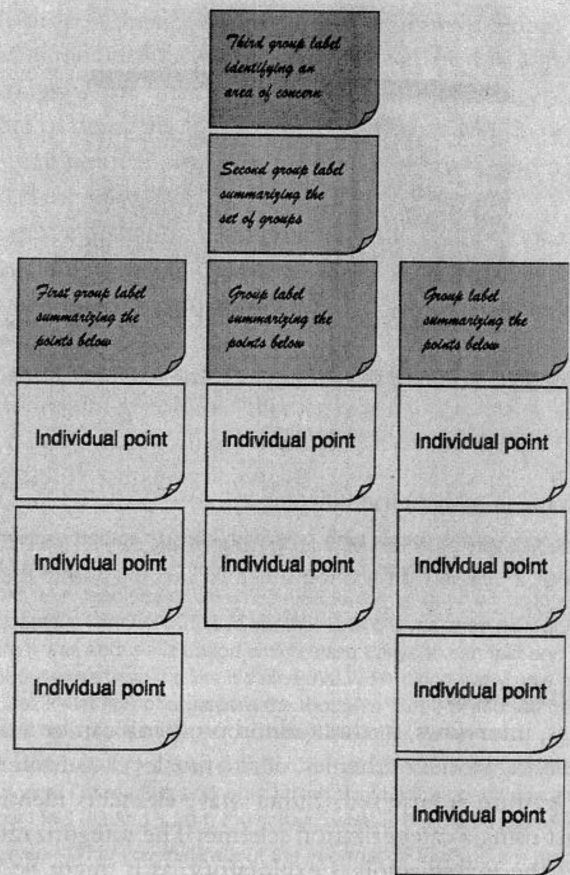

Figure 8.9 The structure of an affinity diagram

because they are similar in some fashion. The groups are not predefined, but must emerge from the data. The process was originally introduced into the software quality community from Japan, where it is regarded as one of the seven quality processes. The affinity diagram is built by a process of induction. One note is put up first, and then the team searches for other notes that are related in some way.

The affinity diagram organized the insights, ideas, and cultural influences gathered during the interviews and observations into a set of 10 top-level categories including perceptions of ATMs, banking habits, what people do while waiting in banks, and social and language barriers to banking (see Figure 8.10). Using the affinity diagram technique also highlighted some opposite behaviors. For example, two women who both wanted to avoid temptation

Figure 8.10 Building the affinity diagram of Indian ATM usage

(that of spending too much money) had different attitudes to the ATM. One used the ATM routinely but only to draw out enough cash to cover her immediate requirements. The other felt that having 24-hour access to cash was too much of a temptation in itself.

8.4.2 Categorizing data

Transcripts of meetings, interviews, or think-aloud protocols can be analyzed at a high level of detail, such as identifying stories or themes, or at a fine level of detail in which each word, phrase, utterance, or gesture is analyzed. Either way, elements identified in the data are usually categorized first using a categorization scheme. The categorization scheme may arise from the data itself, if the investigation is exploratory, as it might be in the requirements activity, or it might originate elsewhere in a well-recognized categorization scheme, or a combination of these two approaches may be used. The principle here is that the data is divided up into elements and each element is then categorized.

Which categories to use is largely determined by the goal of the study. One of its most challenging aspects is determining meaningful categories that are orthogonal—i.e. do not overlap each other in any way. Another is deciding on the appropriate granularity for the categories, e.g. at word, phrase, sentence, or paragraph level; this is also dependent on the goal of the study and the data being analyzed.

The categorization scheme used must be reliable so that the analysis can be replicated. This can be demonstrated by training a second person to use the categories. When training is complete, both people analyze the same data sample. If there is a large discrepancy between the two analyses, either training was inadequate or the categorization is not working and needs to be refined. Talking to those applying the categorization scheme can determine the source of the problem, which is usually with the categorization. If so, then the categorization scheme needs to be revised and re-tested. However, if the individuals do not seem to know how to carry out the process then they probably need more training.

When a high level of reliability is reached, it can be quantified by calculating the *inter-rater reliability*. This is the percentage of agreement between the two researchers, defined as the number of items that both people categorized in the same way, expressed as a percentage of the total number of items examined. It provides a measure of the efficacy of the technique and the rigor of the category definition.

To illustrate categorization, we present an example derived from a set of studies looking at the use of different navigation aids in an online educational setting (Armitage, 2004). These studies involved observing users working through some online educational material (about evaluation methods), using the think-aloud technique. The think-aloud protocol was recorded and then transcribed before being analyzed from various perspectives, one of which was to identify usability problems that the participants were having with the online environment (Nestor Navigator, Zeiliger *et al.* (1997)). An excerpt from the transcription is shown in Figure 8.11.

> I'm thinking that it's just a lot of information to absorb from the screen. I just I don't concentrate very well when I'm looking at the screen. I have a very clear idea of what I've read so far . . . but it's because of the headings I know OK this is another kind of evaluation now and before it was about evaluation which wasn't anyone can test and here it's about experts so it's like it's nice that I'm clicking every now and then coz it just sort of organises the thoughts. But it would still be nice to see it on a piece of paper because it's a lot of text to read.
>
> Am I supposed to, just one question, am supposed to say something about what I'm reading and what I think about it the conditions as well or how I feel reading it from the screen, what is the best thing really?
>
> *Observer – What you think about the information that you are reading on the screen . . . you don't need to give me comments . . . if you think this bit fits together.*
>
> There's so much reference to all those previously said like I'm like I've already forgotten the name of the other evaluation so it said unlike the other evaluation this one like, there really is not much contrast with the other it just says what it is may be . . . so I think I think of. . .
>
> May be it would be nice to have other evaluations listed to see other evaluations you know here, to have the names of other evaluations other evaluations just to, because now when I click previous I have to click it several times so it would be nice to have this navigation, extra links.

***Figure 8.11** Excerpt from a transcript of a think-aloud protocol when using an online educational environment. Note the prompt from the observer about half way through*

This excerpt was analyzed using a categorization scheme derived from a set of negative effects of a system on a user given in van Rens (1997) and was iteratively extended to accommodate the specific kinds of interaction observed in these studies. The categorization scheme is shown in Figure 8.12.

1. Interface Problems

- **1.1.** Verbalisations show evidence of dissatisfaction about an aspect of the interface.
- **1.2.** Verbalisations show evidence of confusion/uncertainty about an aspect of the interface.
- **1.3.** Verbalisations show evidence of confusion/surprise at the outcome of an action.
- **1.4.** Verbalisations show evidence of physical discomfort.
- **1.5.** Verbalisations show evidence of fatigue.
- **1.6.** Verbalisations show evidence of difficulty in seeing particular aspects of the interface.
- **1.7.** Verbalisations show evidence that they are having problems achieving a goal that they have set themselves, or the overall task goal.
- **1.8.** Verbalisations show evidence that the user has made an error.
- **1.9.** The participant is unable to recover from error without external help from the experimenter.
- **1.10.** The participant makes a suggestion for redesign of the interface of the electronic texts.

2. Content Problems

- **2.1.** Verbalisations show evidence of dissatisfaction about aspects of the content of the electronic text.
- **2.2.** Verbalisations show evidence of confusion/uncertainty about aspects of the content of the electronic text.
- **2.3.** Verbalisations show evidence of a misunderstanding of the electronic text content (the user may not have noticed this immediately).
- **2.4.** The participant makes a suggestion for re-writing the electronic text content.

Identified problems should be coded as **[UP, ≪ problem no. ≫]**.

Figure 8.12 *Criteria for identifying usability problems from verbal protocol transcriptions*

This scheme developed and evolved as the transcripts were analyzed. Figure 8.13 shows the excerpt above coded using this categorization scheme. Note that the transcript is divided up using square brackets to indicate which element is being identified as showing a particular usability problem.

A rigid categorization scheme means that the data is structured only according to the prespecified categories. However, where a significant set of data cannot be categorized, the scheme can be extended. In this case the categorization scheme and the categorization itself develop in parallel, with the scheme evolving as more analysis is done.

Having categorized the data, the results can be used to answer the study goals. In the example above, the study allowed the researchers to be able to quantify the number of usability problems encountered overall by participants, the mean number of problems per

[I'm thinking that it's just a lot of information to absorb from the screen. **UP 1.1]**[I just I don't concentrate very well when I'm looking at the screen **UP 1.1]**. I have a very clear idea of what I've read so far . . . [but it's because of the headings **UP 1.1]** I know OK this is another kind of evaluation now and before it was about evaluation which wasn't anyone can test and here it's about experts so it's like it's nice that I'm clicking every now and then coz it just sort of organises the thoughts. [But it would still be nice to see it on a piece of paper **UP 1.10]** [because it's a lot of text to read **UP 1.1]**.

Am I supposed to, just one question, am supposed to say something about what I'm reading and what I think about it the conditions as well or how I feel reading it from the screen, what is the best thing really?

Observer — What you think about the information that you are reading on the screen . . . you don't need to give me comments . . . if you think this bit fits together.

[There's so much reference to all those previously said **UP2.1]** [like I'm like I've already forgotten the name of the other evaluation so it said unlike the other evaluation this one like, there really is not much contrast with the other it just says what it is may be . . . so I think I think of . . . **UP 2.2]**

[May be it would be nice to have other evaluations listed to see other evaluations you know here, to have the names of other evaluations other evaluations **UP 1.10]** just to, [because now when I click previous I have to click it several times **UP 1.1, 1.7]** [so it would be nice to have this navigation, extra links **UP 1.10]**.

Figure 8.13 *The excerpt in Figure 8.11 coded using the categorization scheme in Figure 8.12*

participant for each of the test conditions, and the number of unique problems of each type per participant. This also helped to identify patterns of behavior and recurring problems. Having the think-aloud protocol meant that the overall view of the usability problems could take context into account.

Activity 8.2

The following is another think-aloud extract from the same study. Using the categorization scheme in Figure 8.12, code this extract for usability problems. Remember to put brackets around the complete element of the extract that you are coding.

Well, looking at the map, again there's no obvious start point, there should be something highlighted that says "start here."

Ok, the next keyword that's highlighted is evaluating, but I'm not sure that's where I want to go straight away, so I'm just going to go back to the introduction.

Yeah, so I probably want to read about usability problems before I start looking at evaluation. So, I, yeah. I would have thought that the links in each one of the pages would take you to the next logical point, but my logic might be different to other people's. Just going to go and have a look at usability problems.

Ok, again I'm going to flip back to the introduction. I'm just thinking if I was going to do this myself I would still have a link back to the introduction, but I would take people through the logical sequence of each one of these bits that fans out, rather than expecting them to go back all the time.

Going back ... to the introduction. Look at the types. Observation, didn't really want to go there. What's this bit [pointing to Types of UE on map]? Going straight to types of...

Ok, right, yeah, I've already been there before. We've already looked at usability problems, yep that's ok, so we'll have a look at these references.

I clicked on the map rather than going back via introduction, to be honest I get fed up going back to introduction all the time.

Comment

Coding transcripts is not easy, and you may have had some difficulties doing this, but this activity will have given you an idea of the kind of decisions that need to be taken. As with much data analysis, it gets easier with practice. Our coded extract is below:

[Well, looking at the map, again there's no obvious start point **UP 1.2, 2.2]**, [there should be something highlighted that says "start here" **UP 1.1, 1.10]**.

Ok, the next keyword that's highlighted is evaluating, but [I'm not sure that's where I want to go straight away **UP 2.2]**, so I'm just going to go back to the introduction.

Yeah, so I probably want to read about usability problems before I start looking at evaluation. So, I, yeah. [I would have thought that the links in each one of the pages would take you to the next logical point, but my logic might be different to other people's **UP 1.3]**. Just going to go and have a look at usability problems.

Ok, again I'm going to flip back to the introduction. [I'm just thinking if I was going to do this myself I would still have a link back to the introduction, but I would take people through the logical sequence of each one of these bits that fans out, rather than expecting them to go back all the time **UP 1.10]**.

Going back ... to the introduction. [Look at the types. Observation, didn't really want to go there. What's this bit [pointing to Types of UE on map]? **UP 2.2]** Going straight to types of...

Ok, right, yeah, I've already been there before. We've already looked at usability problems, yep that's ok, so we'll have a look at these references.

I clicked on the map rather than going back via introduction, [to be honest I get fed up going back to introduction all the time. **UP 1.1]**

The example above used a form of content analysis. Content analysis typically involves categorizing the data and then studying the frequency of category occurrences. For example, Maria Ebling and Bonnie John (2000) developed a hierarchical content classification for analyzing data when evaluating a graphical interface for a distributed file system.

An informal version of content analysis is often used as the first stage in identifying software objects from descriptions of the domain. In this approach, nouns and verbs are identified and scrutinized to see if they represent significant classes.

Another way of analyzing a transcript is to use discourse analysis. Discourse analysis focuses on the dialog, i.e. the meaning of what is said, and how words are used to convey meaning. Discourse analysis is strongly interpretive, pays great attention to context, and views language not only as reflecting psychological and social aspects but also as constructing it (Coyle, 1995). An underlying assumption of discourse analysis is that there is no objective scientific truth. Language is a form of social reality that is open to interpretation from different perspectives. In this sense, the underlying philosophy of discourse analysis is similar to that of ethnography. Language is viewed as a constructive tool and discourse analysis provides a way of focusing upon how people use language to construct versions of their worlds (Fiske, 1994).

Small changes in wording can change meaning, as the following excerpts indicate (Coyle, 1995):

> ***Discourse analysis is what you do when you are saying that you are doing discourse analysis . . .***

> ***According to Coyle, discourse analysis is what you do when you are saying that you are doing discourse analysis . . .***

By adding just three words, "According to Coyle," the sense of authority changes, depending on what the reader knows about Coyle's work and reputation.

Conversation analysis is a very fine-grained form of discourse analysis. In conversation analysis the semantics of the discourse are examined in fine detail, and the focus is on how conversations are conducted. This technique is used in sociological studies and examines how conversations start, how turn-taking is structured, and other rules of conversation. This analysis technique has been used to analyze interactions on the Internet, e.g. in chatrooms, bulletin boards, and virtual worlds, and has started to influence designers' understanding about users' needs in these environments. It can also be used to compare conversations that take place through different media, e.g. face-to-face versus email.

8.4.3 Looking for critical incidents

Data gathering sessions for interaction design usually result in a lot of data. Analyzing all of that data in any detail would be very time-consuming, and is often not necessary. We have already suggested that themes, patterns and categories can be used to identify areas where detailed analysis is appropriate. Another approach is to use the 'critical incident technique.'

The critical incident technique is a flexible set of principles that emerged from work carried out in the United States Army Air Forces where the goal was to identify the critical requirements of 'good' and 'bad' performance by pilots (Flanagan, 1954). It has two basic principles: "(a) reporting facts regarding behaviour is preferable to the collection of interpretations, ratings and opinions based on general impressions; (b) reporting should be limited to those behaviours which, according to competent observers, make a significant contribution to the activity" (Flanagan, 1954, p. 355). In the interaction design context, the use of well-planned observation sessions as discussed in Chapter 7 satisfies the first principle. The second principle is referring to critical incidents, i.e. incidents which are significant or pivotal to the activity being observed, in either a desirable or an undesirable way.

In interaction design, critical incident analysis has been used in a variety of ways, but the main focus is to identify specific incidents that are significant, and then to focus on these and analyze them in detail, using the rest of the data collected as context to inform their interpretation. These may be identified by the users, through a retrospective discussion of a recent event, or they may be identified by an observer either through studying video footage, or from observation of the event in real time. For example, in an evaluation study a critical incident may be signalled by times when users were obviously stuck—usually marked by a comment, silence, looks of puzzlement, etc. Jurgen Koenemann-Belliveau *et al.* (1994) used this approach to compare the efficacy of two versions of a Smalltalk programming manual for supporting novice programmers. They examined breakdowns or problems in achieving a programming task and identified possible threats of incidents, and they were able to trace through a sequence of incidents and achieve a more holistic understanding of the problem. For example, they found that they needed to emphasize how objects interact in teaching object-oriented programming.

Another example is reported in Curzon *et al.* (2002). They identified a set of critical incidents through field trials of an in-car navigation device. One example incident in this context was "On one journey, the system gave directions to turn right when the destination was to the left. Its route was to go round the block to go in the other direction. A car following ignored this turn and went the more obvious way, arriving first."

Activity 8.3

Set yourself or a friend the task of identifying the next available theatre or cinema performance you'd like to attend in your local area. As you perform this task, or watch your friend do it, make a note of critical incidents associated with the activity. Remember that a critical incident may be a positive or a negative event.

Comment

In my local area, information about entertainment is available through the local paper, the Internet, ringing up local cinemas or theaters, or by visiting the local library where they stock leaflets about the entertainment on in the area. When I asked my daughter to attempt this task, I noticed several critical incidents including the following:

1. **After searching around the house for a while, she found a copy of the local paper for the correct week.**
2. **The local paper she had found did not have details of the cinema that she wanted to visit.**
3. **When trying to book the cinema tickets by phone she discovered that she needed a credit card which she doesn't have, and so she had to give me the phone!**

As with data gathering, it is common practice to employ more than one complementary data analysis approach. For example, following a critical incident analysis, themes may be identified around the circumstances that caused the incident to occur, and then discourse analysis may be conducted to understand the detail. Analyzing video material brings its own challenges; we address video analysis in Box 8.5.

Box 8.5
Analyzing video material

One approach to analyzing video data is interaction analysis (IA), outlined by Jordan and Henderson (1995). They describe it as an in-depth microanalysis of how people interact with one another, their physical environment, and the documents, artifacts, and technologies in that environment. A focus is on the patterns and anomalies in people's routine interactions and the events that unfold throughout time. These are described in terms of the turns people take in talking and physical actions they perform, e.g. writing. The approach also looks to see if there are seamless transitions between events, e.g. handovers between shift workers, or there is some awkwardness or something does not happen, e.g. one shift worker forgets to pass on information to another. Other approaches to analyzing and interpreting video data are distributed cognition and grounded theory, covered in Section 8.5. Here, again, the emphasis is on revealing phenomena that are important to an ongoing activity. Ethnographically and anthropologically informed analyses of human and social conduct in work, home, and everyday spaces are also popular, e.g. Heath and Luff (1994).

A good way to start a video analysis is to watch what has been recorded all the way through while writing a high-level narrative of what happens, noting down where in the video there are any potentially interesting events. How you decide which is an interesting event will depend on what is being observed. For example, if you are studying the interruptions that occur in an open plan office, you would include each time a person breaks off from an ongoing activity, e.g. phone rings, someone walks into their cubicle, email arrives. If it is a study of how pairs of students use a collaborative learning tool then activities such as turn-taking, sharing of input device/s, speaking over one another, and 'fighting' over shared objects would be appropriate to record.

Chronological and video time is used to index and number events. These may not be the same, since videotape can run at different speeds to real time. Labels for certain routine events are also used, e.g. lunchtime, coffee break, staff meeting, doctor's round. Spreadsheets are used to record the classification and description of events, together with annotations and notes of how the events began, how they unfold, and how they end.

Video can be augmented with captured screens or logged data of people's interactions with a computer display. There are various logging and screen capture tools, e.g. Camtasia or SnagIt, available for this purpose that enable you to play back the interactions as a movie, showing screen objects being opened, moved, selected, and so on. These can then be played in parallel with the video to provide different perspectives on the talk, physical interactions, and the system's responses that occur. Having a combination of data streams can enable more detailed and fine-grained patterns of behavior to be interpreted. ■

8.5 Tools to support data analysis

It would be possible to analyze even large data sets using only manual techniques, however most people would agree that it is quicker, easier, and more accurate to use a software tool of some kind. We introduced the idea of using a simple spreadsheet application in Section 8.3, but there are other more sophisticated tools available—some of which support the organization and manipulation of the data, and some of which are focused on performing statistical tests.

New tools are developed and existing ones are enhanced on a regular basis, so we do not attempt to provide a comprehensive survey of this area. Instead, we discuss the kind of support available, and describe briefly some of the more popular tools used in interaction design.

For qualitative data, there are two broad types of package available. The first supports the categorization and theme-based analysis of data. These typically provide facilities to associate labels (categories, themes, etc.) with sections of data, search the data for key words or phrases, investigate the relationships between different themes or categories, and help to develop the coding scheme further; some packages can also generate graphical representations. The second supports the quantitative analysis of text-based data. These help with techniques such as content analysis which focus on the number of occurrences of words, or words with similar meanings. Some of these provide very sophisticated mechanisms to show the occurrence and co-occurrence of words or phrases. Both types of package provide searching, coding, project management, writing and annotating, and report generation facilities. Although it is useful to distinguish between these two types of package, software that is primarily focused on quantitative analysis now also includes some coding facilities, and vice versa, and so the distinction is very blurred.

More detail regarding software tools to support the analysis of qualitative data can be found through the CAQDAS Networking Project, based at the University of Surrey (`http://caqdas.soc.surrey.ac.uk/`).

One popular example of the first type of package is N6 (formerly NUD*IST), which supports the annotation and coding of textual data. Using N6, field notes can be searched for key words or phrases and a report printed listing every occasion the word or phrase is used. The information can also be printed out as a tree showing the relationship of occurrences. Similarly, N6 can be used to search a body of text to identify specific predetermined categories or words for content analysis. Like all software packages, N6 has advantages and disadvantages, but it is particularly powerful for handling very large sets of data. Nvivo is another package developed by the same people as N6, and this provides more sophisticated facilities for exploring, merging, and manipulating codes and data. Both packages can generate output for statistical packages such as SPSS.

SPSS (Statistical Package for the Social Sciences) is one of the more popular quantitative analysis packages that supports the use of statistical tests. SPSS is a sophisticated package which assumes that the user knows and understands statistical analysis. As we pointed out above, many of the qualitative data analysis tools produce output that can be fed into a statistical analysis package such as SPSS, facilitating the quantitative analysis of qualitative data. SPSS offers a wide range of statistical tests for things such as frequency distributions, rank correlations (to determine statistical significance), regression analysis, and cluster analysis.

Box 8.6 briefly describes the Observer Video-Pro tool which is designed to help the analysis of video data.

Box 8.6
The Observer Video-Pro: an automated data analysis tool

The Observer Video-Pro provides the following features (Noldus, 2000):

- **During preparation of a video tape recording, a *time code generator* adds a time code to each video frame.**
- **During a data collection session, a *time***

code reader retrieves the time code from the tape, allowing frame-accurate event timing independent of the playback speed of the video cassette recorder (VCR).

- Each keyboard entry is firmly anchored to the video frame displayed at the instant the evaluator presses the first key of a behavior code or free-format note. The evaluator can also use a mouse to score events.
- Observational data can be reviewed and edited, with synchronized display of the corresponding video images.
- For optimal visual feedback during coding, the evaluator can display the video image in a window on the computer screen.
- The VCR can be controlled by the computer, allowing software-controlled 'jog,' 'shuttle,' and 'search' functions.
- Video images can be captured and saved as disk files for use as illustrations in documents, slides for presentations, etc.
- Marked video episodes can be copied to an Edit Decision List for easy creation of highlight tapes. ■

Activity 8.4

What does the Observer Video-Pro tool allow you to search for in the data collected?

Comment

Depending on how the logs have been annotated, using the Observer Video-Pro product you can search the data for various things including the following:

Video time—a specific time, e.g. 02:24:36.04 (hh:mm:ss.dd).

Marker—a previously entered free-format annotation.

Event—a combination of actor, behavior, and modifiers, with optional wildcards, e.g. the first occurrence of "glazed look" or "Sarah approaches Janice".

Text—any word or alphanumeric text string occurring in the coded event records or free-format notes.

8.6 Using theoretical frameworks

Structuring the analysis of qualitative data around a theoretical framework can lead to additional insights that go beyond the results found from the simple techniques introduced earlier. This approach also relies less on the study goals to focus analysis. However, these frameworks are quite sophisticated and using them requires investment to make sure that the framework is understood and applied appropriately. This section discusses three frameworks that are commonly used in interaction design to structure the analysis of data gathered in the field, such as ethnographic data: grounded theory, distributed cognition, and activity theory.

8.6.1 Grounded theory

Grounded theory is an approach to qualitative data analysis that aims to develop theory from the systematic analysis and interpretation of empirical data, i.e. the theory derived is grounded in the data. The approach was originally developed by Glaser and Strauss (1967) and since has been adopted by several researchers, with some adaptations to different circumstances. In particular, Glaser and Strauss have individually (and with others) developed the theory in slightly different ways, but the aim of this approach remains the same. Glaser (1992) provides further information about the differences and areas of controversy.

The aim of grounded theory is to develop a theory that fits a set of collected data. By 'theory' is meant in this context: "a set of well-developed concepts related through statements of relationship, which together constitute an integrated framework that can be used to explain or predict phenomena" (Strauss and Corbin, 1998). Development of a 'grounded' theory progresses through alternating data collection and data analysis: first data is collected and analyzed to identify categories, then that analysis leads to the need for further data collection, which is analyzed, and more data is then collected. Data gathering is hence driven by the emerging theory. This approach continues until no new insights emerge and the theory is well-developed. During this process, the researcher needs to maintain a balance between objectivity and sensitivity. Objectivity is needed to maintain accurate and impartial interpretation of events; sensitivity is required to notice the subtleties in the data and identify relationships between concepts.

The thrust of the analysis undertaken is to identify and define the properties and dimensions of relevant categories and then to use these as the basis for constructing a theory. Category identification and definition is achieved by 'coding' the data, i.e. marking it up according to the emerging categories. According to Strauss and Corbin (1998), this coding has three aspects, which are iteratively performed through the cycle of data collection and analysis:

(i) *Open coding*. Open coding is the process through which categories, their properties, and dimensions are discovered in the data. This process is similar to our discussion of categorization above, including the question of granularity of coding (at the word, line, sentence, conversation level, etc.).

(ii) *Axial coding*. Axial coding is the process of systematically fleshing out categories and relating them to their subcategories.

(iii) *Selective coding*. Selective coding is the process of refining and integrating categories to form a larger theoretical scheme. The categories are organized around one central category that forms the backbone of the theory. Initially, the theory will contain only an outline of the categories but as more data is collected, they are refined and developed further.

Grounded theory says little about what data collection techniques should be used, but focuses instead on the analysis. Strauss and Corbin (1998) encourage the use of written records of analysis and diagrammatic representations of categories (which they call memos and diagrams). These memos and diagrams evolve as data analysis progresses. The following analytic tools are used to help stimulate the analyst's thinking and identify and characterize relevant categories:

- The use of questioning (not questioning your participants, but questioning the data): questions can help an analyst to generate ideas or consider different ways of looking at the data. It can be useful to ask questions when analysis appears to be in a rut.
- Analysis of a word, phrase, or sentence: considering in detail the meaning of an utterance can also help to trigger different perspectives on the data.
- Further analysis through comparisons: comparisons may be made between objects or between abstract categories. In either case, comparing one with the other brings alternative interpretations. Sharp *et al.* (2005) take this idea further and use metaphor as an analysis technique with qualitative data.

One of the things that distinguishes a grounded theory approach to data gathering and analysis from ethnographic approaches is that researchers are encouraged to draw on their own theoretical backgrounds to help inform the study, provided that they are alert to the possibility of unintentional bias.

An example of applying the grounded theory approach to qualitative data analysis

Sarker *et al.* (2001) used the grounded theory approach to develop a model of collaboration in virtual teams. The virtual teams used in the study were made up of students from two universities—one in Canada and one in the United States of America. Each team consisted of four to five members from each university. Each team was given the task of studying a business systems problem, producing a systems design for it, and developing a working prototype. The projects themselves lasted about 14 weeks and a total of 12 teams participated in the study. The team members could communicate directly with each other using various technologies such as email, videoconferencing, telephone, and fax. The main communication channel, however, was Webboard, a collaborative message board tool supporting threaded discussions, email discussions, chat rooms, instant messaging, calendar, whiteboard, blogging, and so on. Using Webboard meant that communication was more public, and could be recorded more easily.

All communication data through Webboard was automatically saved, minutes of any videoconferences, telephone calls, or Internet chat sessions undertaken were posted on Webboard, and the team members were also asked to provide any additional emails they received or sent to other team members. In addition to this data, the team's final project reports, individual team members' reflections on the lessons learned through the project, feedback on fellow team members' performance, and comments on the virtual project itself were all collected and used as data for the study.

As soon as the teams were formed, informal data analysis began and two of the researchers became participant observers in the project teams, developing sensitivity to the project and its goals. They also began to reflect on their own backgrounds to see what theoretical frameworks they could draw on.

Open coding. This was done initially on a line-by-line basis, but later coding was done at the message level, while other documents such as reports and reflections were coded at document level. Over 200 categories were generated, and as these were refined, some informal axial coding was also done. Table 8.5 shows two messages posted at the beginning of a project, and illustrates how these messages were coded during the open coding process.

Sarker *et al.* note that codes emerged and continued to be refined over the life of the project. Also, a significant number of the codes that were ultimately used in the theory

Message	Post date, week #, time	Sample codes generated (underlined) and notes
Hi there in UB, I'm Henry. I just wanted to say hello and provide you with the rest of our group members' email address. [Names and email addresses] Well, I guess we'll see each other on Saturday at the videoconference.	1/22/98, week 1, 1:41:52 PM	1. Leadership—initiative to represent. 2. Establishing team's co-presence on the Internet. 3. Implying preference for communication technology (email). 4. Implying technology (VC) can bridge the time and space gap.
Hello UB. Just letting you know that you are free to email us anytime. I might be getting an ICQ account going so that if any of you are into real-time chat and wish to communicate that way, it might be something to try ...	1/26/98, week 1, 2:56:37 PM	1. UB members' identity viewed at an aggregate level (as in msg. #1). 2. Collapsing/bridging across time boundaries. 3. Invitation. 4. Implying preference for communication technology. 5. Properties of communication technology/medium (real-time, synchronous?). 6. Novelty of technology, recognizing the need to try/explore.

Table 8.5 *An illustration of open coding*

building were recurrent, for example, preference for technology and time gaps/boundaries. Finally, some of the key categories were identified when considering messages as one unit and looking at comparable strips in other data segments.

Through constant comparison of data across categories, the names of categories were refined, merged, and changed over time.

Axial coding. Sarker *et al.* found the suggestions in Strauss and Corbin about how to relate subcategories too constraining. They instead used a two-step process for axial coding:

1. The major categories, e.g. technology, norms, social practices, stages of team development, and frames of reference, were hierarchically related to subcategories. For example, the category technology was linked to the subcategories purpose of technology, nature of ownership, accessibility (by time, location, cost, awareness), future potential, degree of novelty, and interconnectedness. At the next level, purpose of technology was linked to information sharing, triggering, and so on (see Figure 8.14). During this process, the researchers returned to open coding and refined categories further.
2. For each major category researchers created a description (called a 'memo') that attempted to integrate as many of the categories and subcategories as possible. These memos also

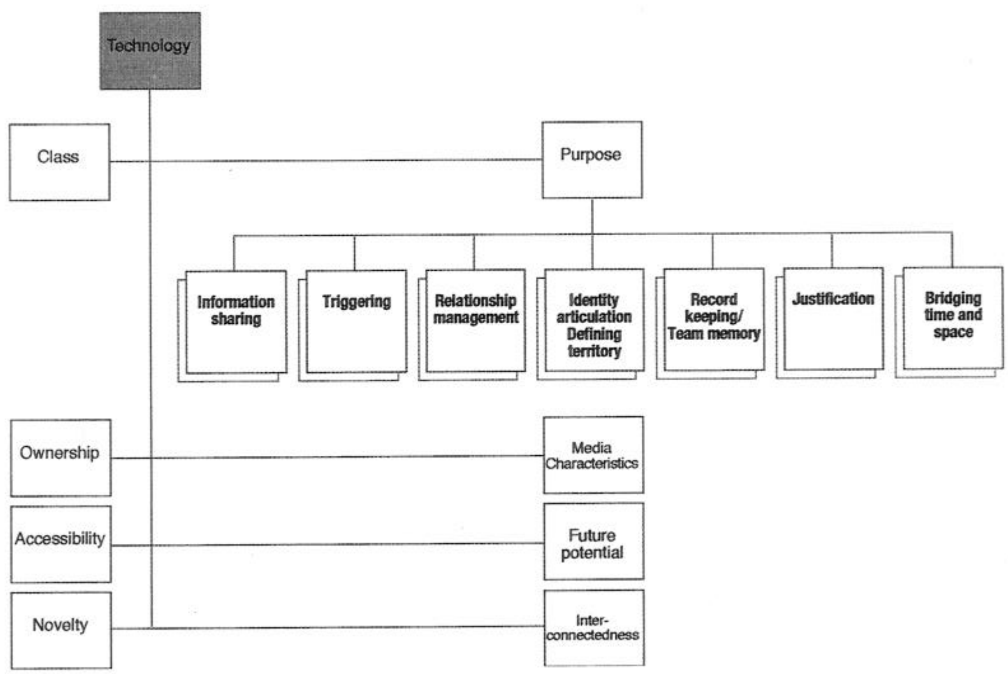

Figure 8.14 Axial coding for the technology category

Collaboration across time and space requires mediation by technology for both symbolic and substantive purposes. Substantive purposes include sharing information, record-keeping, managing relationships, pacing and triggering of activities in collaboration. Some symbolic uses of technology involve the articulation of the self and group identity and legitimising different courses of action by appealing to the use of technology.

Different classes of technology provide different capabilities, some of them different to the features of technology as defined from the designers' or the implementers' point of view. For example, we wanted Webboard to be a public record... students have extended this use by creating a local enclave for information exchange with local members in a domain traditionally thought of as being public. The Webboard has also become a project archive, conserving team memory through the documentation of agendas, minutes, project steps, and deliverables.

Figure 8.15 *An excerpt from an early draft of an integrative memo for the technology category*

evolved as analysis progressed. Figure 8.15 contains an excerpt from an early draft memo for the technology category.

Selective coding. This stage of coding involves linking the categories and subcategories into a theory, and as theory building is quite complex, we only present an overview of the process here.

Sarker *et al.* wanted to develop a theory of virtual teams, and so they used two approaches from their background to help them. One of these approaches (Couch, 1996) emphasizes the concepts that a theory of human conduct must use. The other focuses on social structure (Giddens, 1984). Using these two approaches, the category 'stages of team development' was chosen as the core category for the grounded theory to be built from this data set, and other categories were linked around it. This theory was further elaborated upon through discussions and reading of theory, and evolved into a theory of how virtual teams develop over time. More details can be found in Sarker and Sahay (2003).

How useful is a grounded theory approach to analysis?

A grounded theory approach to analysis emphasizes the important role of empirical data in the derivation of theory. It has become increasingly popular in interaction design to answer specific questions and design concerns.

For example, Adams *et al.* (2005) describe their use of grounded theory to investigate how technology can empower or exclude its users due to interactions between social context, system design, and implementation. They studied the introduction and use of digital libraries in four settings over a four-year period, collecting data from a total of 144 users. Focus groups and interviews were the primary data collection techniques. They concluded that where technology is integrated with the communities and their practice, through an information intermediary, perceptions of empowerment were increased; where technology is deployed within communities, yet with poor design and support, technologies were perceived as complex and threatening; and where technology was designed in isolation from the communities, users were either unaware of the technology or perceived it as complex or threatening.

Dourish *et al.* (2004) used semi-structured interviews and grounded theory to examine how people answer the question "Is this system secure enough for what I want to do now?," in the context of ubiquitous and mobile technologies. This qualitative approach was used to explore the issues before moving on to develop more detailed questions, but their conclusions included suggested design modifications to take this perspective on security into account.

8.6.2 Distributed cognition

We introduced the distributed cognition approach in Chapter 3, as a theoretical account of the distributed nature of cognitive phenomena across individuals, artifacts, and internal and external representations (Hutchins, 1995). Here, we illustrate how to conduct a distributed cognition analysis by providing a worked example.

Typically, a distributed cognition analysis results in an event-driven description which emphasizes information and its propagation through the cognitive system under study. The cognitive system under study might be one person's use of a computational tool, such as a calculator; two people's joint activities when designing the layout for the front page of a newspaper, using a shared authoring tool, or more widely, a large team of software developers and programmers, examining how they coordinate their work with one another, using a variety of mediating artifacts, such as schedules, clocks, to-do lists, and shared files.

The granularity of analysis varies depending on the activities and cognitive system being observed and the research or design questions being asked. For example, if the goal is to examine how a team of pilots fly a plane—with a view to improving communication between them—then the focus will be on the interactions and communications that take place between them and their instruments, at a fine level of granularity. If the goal is to understand how pilots learn how to fly—with a view to developing new training materials—then the focus will be at a coarser grain of analysis, taking into account the cultural, historical, and learning aspects involved in becoming a pilot.

The description produced may cover a period of a day, an hour, or only minutes, depending on the study's focus. For the longer periods, verbal descriptions are primarily used. For the shorter periods, micro-level analyses of the cognitive processes are meticulously plotted using diagrammatic forms and other graphical representations. The rationale for performing the finer levels of analysis is to reveal practices and discrepancies that would go unnoticed using coarser grains of analysis, but which reveal themselves as critical to the work activity.

Ed Hutchins emphasizes that an important part of doing a distributed cognition analysis is to have a deep understanding of the work domain that is being studied. He even recommends, where possible, that the investigators take steps to learn 'the trade' under study and become an accomplished pilot or sailor (as he has done himself in both cases). This can take a team of researchers several months and even years to accomplish and in most cases this is impractical for a research or design team to do.

Alternatively, it is possible to spend a few weeks immersed in the culture and setting of a specific team to learn enough about the organization and its work practices to conduct a focused analysis of a particular cognitive system. For example, I spent six weeks with an engineering team, where I was able to learn enough about their work practice to gain a good understanding of how they worked together on projects, how they coordinated their work with each other, and how the technologies that were used mediated their work activities. I was then able to document and analyze a number of problems they were experiencing through the introduction of new networking technology. Using the distributed cognition framework, I described how seemingly simple communication problems led to large delays and recommended how the situation could be improved (Rogers, 1993, 1994).

Performing a distributed cognition analysis

It should be stressed that there is not one single way of doing a distributed cognition analysis, nor is there an off-the-shelf manual that can be followed. A good way to begin analyzing and interpreting the data collected is to describe the official work practices, in terms of the routines and procedures followed, and the workarounds that teams develop when coping with the various demands placed upon them at different times during their work. In so doing, any breakdowns, incidents, or unusual happenings should be highlighted, especially where it was discovered that excessive time was being spent doing something, errors were made using a system, or a piece of information was passed on incorrectly to someone else or misheard. While writing these observations down it is good to start posing specific research questions related to them, e.g. "Why did X not let Y know the printer was broken when he came back from his break?" and to contemplate further, e.g. "Was it a communication failure, a problem with being overloaded at the time, or a technology problem?"

It is at this point that knowledge of the theory of distributed cognition can help in interpreting and representing the observations of a work setting (see Chapter 3 and Hutchins, 1995). It provides an analytic framework and a set of concepts to describe what is happening at a higher level of abstraction. Problems can be described in terms of the communication pathways that are being hindered or the breakdowns arising due to information not propagating effectively from one representational state to another (see Box 8.7). The framework can reveal where information is being 'distorted,' resulting in poor communication or inefficiency. Conversely, it can show when different technologies and the representations displayed via them are effective at mediating certain work activities and how well they are coordinated.

Box 8.7
Distributed cognition concepts

A distributed cognition analysis involves producing a detailed description of the domain area at varying levels of granularity. At the micro-level, a small set of cognitive terms are used to depict the representations employed in a cognitive activity and the processes acting upon them. The terms are intended to steer the analysis towards conceptualizing problems in terms of distributed information and representations. This level of description can also directly lead to recommendations, suggesting how to change or redesign an aspect of the cognitive system, such as a display or a socially mediated practice. The main terms used are:

The cognitive system—the interactions among people, the artifacts they use, and the environment they are working in.

The communicative pathways—the channels by which information is passed between people, e.g. phone, email, physical gesture.

Propagation of representational states—how information is transformed across different media. Media refers to external artifacts (e.g. instruments, maps, paper notes) and internal representations (e.g. human memory). These can be socially mediated (e.g. passing on a message verbally), technologically mediated (e.g. pressing a key on a computer), or mentally mediated (e.g. reading the time on a clock).

An example of applying the distributed cognition approach: call centers

Ackermann and Halverson's research (Ackermann and Halverson, 2000; Halverson, 2002) has used the distributed cognition framework to understand, at a cognitive level, how call centers work. Call centers have greatly increased during the last 10 years—now fronting many organizations, including banks, computer companies, postal services, and government offices. Their main function is to field phone-based queries, offering help and advice to customers about their products, services, etc.

The aim of Ackermann and Halverson's study was to find out how the operators of a typical call center manage the fast-paced and information-intensive process they are engaged in and, in particular, how they answer queries and what information resources they use to achieve this. Their study lasted 18 months, where they collected large amounts of data, including observations, videos, and semi-structured interviews. From their assortment of data, they initially described the domain area and what the phone operators do to accomplish their work. They also noted the unusual demands placed upon the operators and the methods and workarounds they used.

One of the first things they noted is that call center operators are under a lot of pressure. They need to begin forming their answers within 45–60 seconds of answering a call. This can be very demanding, given the diversity of questions that can be asked and the round-about way of talking some callers adopt. However, they also observed that many of the queries the operators encounter are similar, enabling the operators to classify them into types and develop 'routines' for finding the information needed for a given type. At a finer level of analysis, Ackermann and Halverson decided to focus on the routines. They observed over 300 calls, taped 60 of them, and chose to analyze 10 in detail. The 10 were transcribed, covering the actions taken and the conversations that took place. One example of 'Joan' is used in their write up of the study to illustrate what is involved in a typical routine.

To begin, they drew a schematic bird's eye view of Joan's workplace, illustrating the physical set-up (see Figure 8.16). The figure shows how the different workspaces are related to each other and the various resources that are used during calls. What stands out immediately from the figure is the way the resources are spread out, requiring Joan to walk from her desk to a shared table for every call. While keeping her fit, it also reveals that certain types of information have to be 'carried' between the different locations.

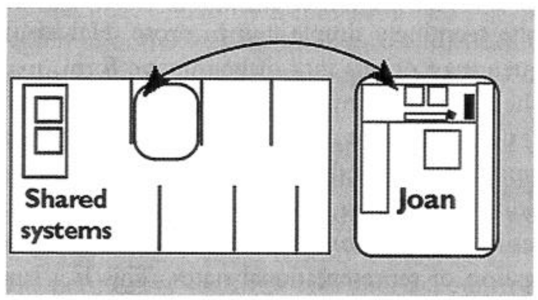

Figure 8.16 Joan's workplace and the shared resources used by the operators. The left-hand diagram shows how the cubicles are positioned in relation to one another and the right-hand diagram is a blown-up schematic of Joan's space

The representations and technologies that are used at Joan's desk and elsewhere are then described. These include software applications, monitors, the telephone, manuals, lists, scraps of paper, and post-it notes. The way that incoming calls are handled is also highlighted: pointing out how the telephone system allocates incoming calls to the next available operator.

The type of call that is then analyzed is one of the most common, which in this call center concerns employment verification. Ackermann and Halverson describe a specific example that is representative of many others. A caller (a mortgage lender) wishes to find out whether one of its customers is actually employed by Company X and so calls the call center to verify this. Joan, who receives the call, looks up this information using a database (EMPLOY) that can only be accessed at the shared terminal that is 3 meters away from her desk. For every call she has to disconnect her headset from the phone, and walk to the central table to access the database to find out the information needed. In addition, Joan has to enter a record for every call using a computer-based tracking system (CAT) that is accessed via the terminal on her desk. When she answers the call, she has at the same time to close out the one she was previously working on. While doing this, she asks the caller for details about the person in question. This she types into the new record (the overlapping of tasks is noted by the analysts as being significant). Joan then writes this down on a piece of paper. The reason for this duplication of the same information is that she needs to carry it over to the EMPLOY system. The information (including a social security number) is too much to remember and would be easy to get mixed up or forgotten while walking over to the other terminal. She walks over to the EMPLOY system with the piece of paper and copies the information into the software, to enable her to get the new information she needs. She writes this down on the same piece of paper. She then returns to her desk and relays this new piece of information back to the caller, while completing the details of the call in the record on the CAT system (the overlapping of tasks at this stage is noted by the analysts as also being significant).

Having described the seemingly simple task in prose, Halverson and Ackermann re-represent the short sequence of events in a diagrammatic form, making explicit how the various media support the way the information is propagated across different representational states. The diagram reveals the different cognitive memories that are used during the various transformations (see Figure 8.17), including Joan's and the caller's, indicating how they are transformed from working memory to long-term memory. Importantly, by representing this common routine using the notation, nine different memories were revealed as being involved in the propagation of representational states. This is a large number and shows how the routine task is far from simple, involving a complex set of overlapping steps.

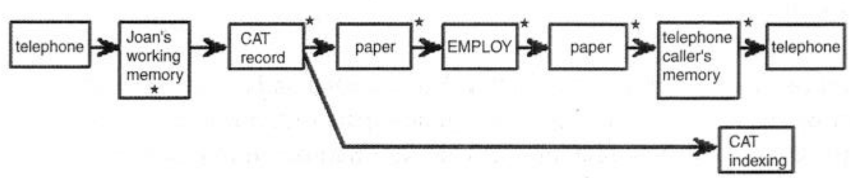

Figure 8.17 A diagram showing the propagation of representational states for the employee verification process. The boxes show the different representational states for different media (e.g. telephone, paper, Joan's memory) and the arrows show the transformations on these. The asterixes indicate where Joan's working memory is also involved

Through examining the diagram and revisiting their textual descriptions, Ackermann and Halverson were able to reflect upon the implications of the many overlapping tasks Joan has to accomplish, some simultaneously. They subsequently performed an even finer grain of analysis, examining how the multiple memories are interleaved at a physical level, noting the actual physical movements involved in each change in representation state, e.g. when Joan moved and clicked the mouse, alongside what was said at that point. Another notation was used for this purpose.

How useful is distributed cognition?

What is gained from conducting a detailed distributed cognition analysis such as this one? To a manager or outsider, the routine call would appear to involve a simple request and yet Ackermann and Halverson's analysis reveals it to be a complex cognitive task. An outcome of performing their micro-level analysis was to make explicit the nature of the complexity: showing how memories are distributed and interwoven; sometimes they belong to an individual, e.g. Joan's note written down on a piece of paper, and other times they are part of the system, e.g. the call handling procedure embedded in the telephone system. Furthermore, it describes systematically how a piece of information is propagated through multiple representational states, being verbally, physically, and mentally transformed, that has implications for the redesign of the supporting systems. It identifies the cognitive workload that is involved when different resources have to be used and coordinated for the same task.

What are the design implications? Simply enabling the EMPLOY database to be accessed at the same terminal as the CAT system would seem like an obvious solution. However, the information still needs to be propagated between applications and the cutting and pasting editing functions may not be compatible between the different applications. Moreover, the operator may be put under even more pressure to complete a call in even less time, if it is perceived that the operators no longer have to walk anywhere to access information resources. However, this perspective does not take into account the amount of cognitive effort required to access and enter information via different information systems.

Performing a detailed distributed cognition analysis enables researchers and designers to explore the trade-offs and likely outcomes of potential solutions and in so doing suggest a more grounded set of cognitive requirements, e.g. types of information resources, that are considered suitable for specific kinds of activities. Clearly, such a painstaking level of analysis and the expertise required in the interpretation is very costly. In the commercial world, where deadlines and budgets are always looming, it is unlikely to be practical. However, in large-scale and safety critical projects, where more time and resources are available, it can be a valuable analytic tool to use.

8.6.3 Activity theory

Activity theory (AT) is a product of Soviet psychology that explains human behavior in terms of our practical activity with the world. It originated as part of the attempt to produce a Marxist psychology, an enterprise usually associated with Vygotsky (e.g. 1926/1962) and later Leontiev (e.g. 1978, 1989). In the last 20–30 years, versions of AT have become popular elsewhere, particularly in Scandinavia, Germany, and now growing in the USA and UK. The newer 'versions' of AT have been popular in research investigating 'applied' problems, particularly those to do with work, technology, and education.

Activity theory provides a framework that focuses analysis around the concept of an 'activity' and helps to identify tensions between the different elements of the system. For example, Wendy Mackay *et al.* (2000) analyzed a 4-minute excerpt from a video of users working with a new software tool. They identified 19 shifts in attention between different parts of the tool interface and the task at hand. In fact, some users spent so much time engaged in these shifts that they lost track of their original task. Using the theory helped evaluators to focus on relevant incidents.

AT outlines two key models: one which outlines what constitutes an 'activity' and one which models the mediating role of artifacts.

The individual model

AT models activities in a hierarchical way. At the bottom level are 'operations,' routinized behaviors that require little conscious attention, e.g. rapid typing. At an intermediate level are 'actions,' behavior that is characterized by conscious planning, e.g. producing a glossary. The top level is the activity, and that provides a minimum meaningful context for understanding the individual actions, e.g. writing an essay (see Figure 8.18). There may be many different operations capable of fulfilling an action, and many actions capable of serving the same activity.

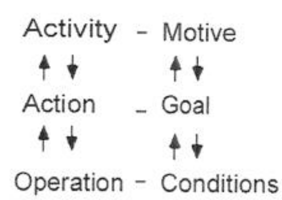

***Figure 8.18** The original activity theory model*

Activities can be identified on the basis of the motives that elicit them, actions on the basis of conscious goals that guide them, and operations by the conditions necessary to attain the goals. However, there is an intimate and fluid link between levels. Actions can become operations as they become more automatic and operations can become actions when an operation encounters an obstacle, thus requiring conscious planning. Similarly there is no strict demarcation between action and activity. If 'motive' changes then an activity can become an action. It is also important to realize that activities are not self-contained. Activities relate to others while actions may be part of different activities, and so on.

The role of artifacts

Artifacts can be physical, such as a book or a stone, or they can be abstract, such as a system of symbols or a set of rules. Physical artifacts have physical properties that cause humans to respond to them as direct objects to be acted upon. They also embody a set of social practices, their design reflecting a history of particular use. Leontiev describes the process of learning what these inherent properties are as one of 'appropriation,' signifying the active nature of the learning that is needed. The kind of learning involved is one of identifying and participating in the activity appropriate to the artifact. Consider an infant learning to feed with a spoon. Leontiev (1981) observed that, at first, the infant carries the spoon to its mouth as though it were handling any other object, not considering the need to hold it horizontal. Over time, with adult guidance, the spoon is shaped in the way it is because of the social practice—the activity—of feeding and, in turn, the infant's task is to learn that relationship—to discover what practice(s) the object embodies. By contrast a spoon dropped into the cage of a mouse, say, will only ever have the status of just another physical object—no different from that of a stone.

The idea of abstract artifacts follows from the idea of 'mediation,' i.e. a fundamental characteristic of human development is the change from a direct mode of acting on the world to one that is mediated by something else. In AT, the artifacts involved in an activity mediate between the elements of it.

AT also emphasizes the social context of an activity. Even when apparently working alone, an individual is still engaged in activities that are given meaning by a wider set of practices.

The classic view of an activity has a subject (who performs the activity) and an object (on which the activity is performed). Recent developments in AT, particularly by Engeström (e.g. 1999) and Nardi (e.g. 1996), have widened the focus from the 'individual' triangle of a single activity (subject, activity, and object) to include supra-individual concepts—tools, rules, community, and division of labor. By tool is meant the artifacts, signs, and means that mediate the subject and object; by community is meant those who share the same object; by rules is meant a set of agreed conventions and policies covering what it means to be a member of that community (set by laws, parents, managers, boards, etc.); and by division of labor is meant the primary means of classifying the labor in a workplace, e.g. manager, engineer, receptionist. The extended versions allow consideration of networks of interrelated activities—forming an 'activity system' (see Figure 8.19).

Performing an analysis driven by activity theory

AT does not present a clear methodological prescription for the description or analysis of behavior as a set of procedures to be followed. The conceptual model (Figure 8.18) is the main framework that is used to describe levels within an activity. This means that identifying elements will be highly dependent on individual interpretation. Christiansen (1996, p. 177)

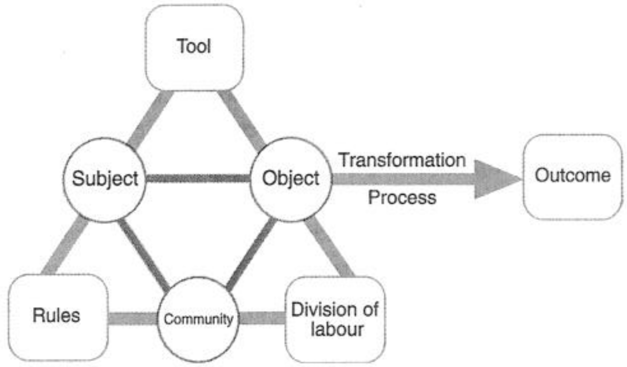

Figure 8.19 Engeström's (1999) activity system model. The tool element is sometimes referred to as the mediating artifact

summarizes: "Methodologically . . . the ideal data for an application of AT consist of longitudinal ethnographic observation, interviews and discussion in real-life settings, supplemented by experiments." She continues that you "cannot interview people directly through rote questions but must interpret their actions and opinions after some careful reflection," which is a difficult process. Nevertheless, the original and later versions of the AT framework have become popular amongst researchers and some practitioners as a way of identifying needs for new tools and to analyze problems that are present in a work or other setting.

One of the biggest problems with doing an AT analysis is working out when something should be described as a top-level activity and when something is better described as a lower-level action. In Figure 8.20, completing a software project is considered to be a top-level activity, while programming a module as an action. However, equally, programming a module could be viewed as an activity—if that was the object of the subject (person).

Activity level	- Building a house	- Completing a software project	- Carrying out research into a topic
Action level	- Fixing the roofing - Transporting bricks by truck	- Programming a module - Arranging a meeting	- Searching for references - Participating in a conference - Writing a report
Operation level	- Hammering - Changing gears when driving	- Using operating system commands - Selecting appropriate programming language constructs	- Using logical syllogisms - Selecting appropriate wording

***Figure 8.20** Examples of activities, actions, and operations*

An example of applying the activity system approach: customer support center

To illustrate how AT can be used to interpret a work setting, we describe how it was used by Collins *et al.* (2002), who together with a small in-house IT support team, set out to identify the tools needed by customer support engineers whose job it is to document solutions to customer problems. The version of AT they used was the popular Engeström one (Figure 8.19). The domain chosen overlaps with the call center analyzed using the distributed cognition approach. We have selected these two projects on purpose to show the different emphases between the two approaches.

Documenting solutions to customer problems was identified as the activity to be focused on. This was seen in the wider context of knowledge management—a concept that has received much attention in recent years. The primary method of data collection was through interview: 32 employees were interviewed for one to one-and-a-half hours each. The interviews were transcribed and documented with notes and artifacts produced by the interviewees during the conversation. These were then annotated in terms of particular elements of the activity system, e.g. rules, object. Examples of subjects were frontline and backline engineers who deal with the calls; examples of tools were a knowledge repository tool with documented answers and the computer network used to run it on.

The analysts noted the tensions that the interviewees had talked about within or between elements, e.g. subject versus rules. These provided them with talking points by which to consider the system dynamics together with opportunities for thinking about new tools to support the customer support people. Examples of within and between element tensions include:

- *Community*—limited communication across stakeholder groups contributes to a lack of appreciation among the backline engineers of the needs of frontline customer support engineers.
- *Tool*—combination of a new knowledge repository tool and the physical computer from which it ran (the hardware and network on which the tool ran were not fast enough to enable timely access to the desired knowledge).
- *Division of labor versus subject*—workload balance and focus was lacking for the backline engineers who were expected to handle the majority of customer calls that do not currently have documented solutions the frontline staff can handle.
- *Subject versus rules*—the organization has a set of explicit and implicit rules for rating the knowledge documents. However, there was considerable conflict between the subjects involved in authoring and annotating them as to which was the most important. As a consequence, many did not use the rating system.

In presenting the results, excerpts from the interviews are used to back up many of the identified tensions, for example, an answer to the question "When you're talking to a customer, do you do documentation in real time" was "I try to. This is the best way, but it's real hard to get all that down. A lot of times I summarize it or if I can get another call while I am finishing up this call . . . if another one is coming, I'll answer the phone and start working on it. I'll then have to go back and work from memory to update this other call. It's not a good habit to get into. If the phone is ringing, it's ringing, you know."

How useful is activity theory?

Many examples of tensions were identified in Collins' *et al.* analysis. Hence they built up a picture of the company by, firstly, identifying the core elements in the customer support center in terms of rules, objects, etc., and then assigning examples of tensions and conflict within and between them. Using these as discussion points, the team were able to suggest specific improvements to the knowledge management tool being developed, including:

- Delay in retrieval of relevant documents must be reconciled with user expectations for speed.
- Software tools must support individual user preferences for communication media, e.g. email, instant messaging.

Performing an AT analysis enables researchers and designers to identify the tensions in a workplace leading to specific needs for new technological tools. It can be difficult, however, getting to grips with the concepts and being able to determine how to label the points raised in the interviews. Expertise and a good background in the Soviet version of activity theory are recommended to become competent in it. Similar to the distributed cognition approach, in the commercial world, where deadlines and budgets are always looming, it is unlikely to be practical. As with distributed cognition, where more time and resources are available, it can be a valuable analytic tool.

Activity 8.5

Give some examples of how this activity theory (AT) analysis differs from and is similar to the distributed cognition (DC) analysis of the call center in the previous section.

Comment

Some of the main differences and similarities are:

1. **AT focuses on describing the tensions between parts of the AT system, using quotes to back them up, whereas a DC analysis focuses on drilling down on the way representations and technologies are used for a given distributed activity.**
2. **AT provides a set of concepts by which to label and instantiate specific observations for an activity system, whereas DC represents the sequence of events (often in a diagrammatic form) making explicit how the various media**

support the way information is propagated across different representational states.

3. Both AT and DC analyses reveal problems with existing technologies leading the analysts to suggest design recommendations for improving the existing set-up.
4. The AT analysis used a large number of interviews and in-house team discussions to collect and articulate their data, whereas the DC analysis used data collected from a combination of observations and interviews.
5. The AT analysis provided specific requirements for a particular software tool being developed, whereas the DC analysis explored the trade-offs and likely outcomes of potential solutions suggesting a grounded set of cognitive requirements.

8.7 Presenting the findings

The best way to present findings depends on the audience, and the original goals of the study. However, it also is dependent on the data gathering and analysis techniques used.

In the previous sections of this chapter, you met many different ways of presenting findings—as numbers, through various graphical devices, in tables, in textual descriptions, as a set of themes or categories, and so on. These representations may be used directly to report your findings, provided they are appropriate for your audience and your purpose, or they may be used as background evidence for a different form of representation.

Broadly speaking, data gathering and analysis in interaction design is carried out for one of two purposes: to derive requirements for an interactive product, or to evaluate an interactive product under development. These two purposes have their own needs in terms of the notations to use and the information to be highlighted, but they also have similarities in terms of the choices to be made for presentation. For example, they usually involve reporting findings to a technical design team who will act on the findings.

In this section, we discuss three kinds of presentation style that we have not focused on as yet: using rigorous notations, using stories, and summarizing. There are other ways of presenting findings, but these are representative of the main options. In addition, these are not mutually exclusive and are often used in combination.

8.7.1 Rigorous notations

A number of rigorous notations have been developed to analyze, capture, and present information for interaction design. The term 'rigorous' is not intended to imply 'formal' or 'rigid,' but simply to say that the notations have clear syntax and semantics. For example, the work models promoted in contextual design (Beyer and Holtzblatt, 1998) use simple but clear conventions for representing flows, breakdowns, individual roles, and so on. The modeling language UML (Unified Modeling Language) has stricter and more precise syntax

John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester,
West Sussex PO19 8SQ, England

Telephone (+44) 1243 779777

Email (for orders and customer service enquiries): cs-books@wiley.co.uk
Visit our Home Page on www.wiley.com

Other Wiley Editorial Offices

John Wiley & Sons Inc., 111 River Street, Hoboken, NJ 07030, USA

Jossey-Bass, 989 Market Street, San Francisco, CA 94103-1741, USA

Wiley-VCH Verlag GmbH, Boschstr. 12, D-69469 Weinheim, Germany

John Wiley & Sons Australia Ltd, 42 McDougall Street, Milton, Queensland 4064, Australia

John Wiley & Sons (Asia) Pte Ltd, 2 Clementi Loop #02-01, Jin Xing Distripark, Singapore 129809

John Wiley & Sons Canada Ltd, 6045 Freemont Blvd, Mississauga, ONT, L5R 4J3, Canada

Wiley also publishes its books in a variety of electronic formats. Some content that appears in print may not be available in electronic books.

Library of Congress Cataloging-in-Publication Data:

Sharp, Helen.
Interaction design : beyond human-computer interaction / Helen Sharp,
Yvonne Rogers and Jenny Preece.—2nd ed.
p. cm.
Includes bibliographical references and index.
ISBN 978-0-470-01866-8 (pbk. : alk. paper)
1. Human-computer interaction. I. Rogers, Yvonne. II. Preece, Jennifer.
III. Title.
QA76.9.H85P72 2006
004'.019—dc22 2006030649

British Library Cataloguing in Publication Data

A catalogue record for this book is available from the British Library

ISBN 978-0-470-01866-8 (PB)

Typeset in 10/14 Bembo by Laserwords Private Limited, Chennai, India
Printed and bound by Graphos SA, Barcelona, Spain
This book is printed on acid-free paper responsibly manufactured from sustainable forestry in which at least two trees are planted for each one used for paper production.