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October 2007

# Representations of time in computer interface design

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# Representations of Time

Marilyn Mitchell and Peter van Sommers

## *Abstract*

The linguistic representation of time or *tense* is based upon a spatial metaphor: *time is a path or trajectory*. This metaphor has analogies in computer interface design in graphics such as feedback indicators, buttons and application windows that represent their current availability, icons that contain arrows to represent screen movements, and icons used to help users temporally orient themselves within an interface. It is generally agreed that the success of graphical user interfaces is based upon their ability to provide appropriate conceptual models for enabling human-computer action. One important model for such interaction is for time, which incorporates notions of change and movement. To describe how time is represented in computer interfaces, the paper makes comparisons to the structure of tense in both spoken language and in the sign language of the deaf, and also looks at the impact of the structure of writing on representations of time. It is argued that visual representations of time help computer users by providing information about the *length* of time for a process to complete; the functions that are available *now* versus those used in the past or ones available in the future; how to *move* through a set of data; how an object on screen can *move*; and for some applications, the *time order* in which data has been received or used, or the order in which operations were or are to be performed.

**Marilyn Mitchell** is Assistant Professor of Communication at Bond University in Australia. Prior to moving to academia, she worked as an information developer and systems engineer for IBM. Her doctoral research involved how time is represented graphically in devices such as clocks, timers and calendars, and also in graphics such as timelines.







Formerly a Professor of Psychology and more recently graphic arts, **Peter van Sommers** is now a botanical photographer and fine art printer. His research interests are in the neuropsychology of art production and imagery. He authored *Drawing and Cognition* (Cambridge University Press) in which he explored the complex variables involved in the production of drawing and writing.

# in Computer Interface Design

Bond University Visible Language 41.3 Mitchell and van Sommers, 220-245  
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## Introduction

A fundamental representation in language is for time or *tense*, which appears in every spoken sentence to identify when an event happened, how it generally happens, how it might happen and so on. Many studies across many languages have noted that the deep structure of tense is based upon a spatial metaphor: *time is a path or trajectory* (Clark, 1973; Traugott, 1975; Lakoff and Johnson, 1980, 1999; Nunez and Sweetser, 2006).

This structure of tense has direct analogies in graphics that represent time directly, such as clocks and calendars, and in graphics that represent time as a secondary construct, such as family trees or process diagrams. Tense is also present in the interfaces of computer applications and web pages in the designs of graphics that provide feedback regarding computing processes (e.g., progress bars ) , in buttons and application windows that visually indicate their state of availability (e.g., in Microsoft Word 2000, there are visual markers that differentiate between icons that are active *now*, for example  and icons that *were or could be active at other times*, for example ) , in icons such as arrows that directly represent computer movements or actions (e.g.,  represents the action of indenting text in Microsoft Word 2000) and in icons and text that help users to orient themselves temporally in the interface (e.g.,  in Windows Explorer represents possible movements through web pages). There are also a variety of icons and feedback indicators that represent time using images of clocks, sundials and other time-measurement tools (e.g., the history icon in Windows Explorer  and the coffee cup, the hourglass and the rotating radial lines that appear on Macintosh screens). Tense is also present in some arrangements of information on the screen such as the history of user actions in Adobe Photoshop.

The aim of this paper is to provide descriptions of visual representations of time in computer graphical user interfaces (GUIs). The paper considers these representations from a linguistic framework following Clark's (1996) pragmatic approach. Clark defines languages as *signals*, which are deliberate actions made by one person to mean something for another person. To this analysis, the paper also brings a cognitive perspective since according to Nuyts

(2004, p. 135), "an adequate account of language in general, or of any linguistic phenomenon in particular, has to focus on both the communicative functional and cognitive dimensions simultaneously in an integrative way!" Our aim is to build a description of functional representations of time in GUIs that could be useful in the design process. We have previously built a taxonomy of visual representations of

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Our aim is to build a description of functional representations of time in GUIs that could be useful in the design process. We have previously built a taxonomy of visual representations of time in clocks, timers and still representations of time (Mitchell, 2006), and this research builds on that taxonomy with descriptions of the animated representations of time that are found in GUIs. For spoken and signed languages, researchers are building evermore detailed descriptions of the representation of time, with aims of capturing the rich variety of ways in which people represent their experiences of the world, for attempting to determine what motivates these representations, to establish whether there are common motivations among cultures for these representations and for using this knowledge to generally improve communication. We have the same aims as these researchers. While we do not wish to imply that verbal and visual communication serve the same communication functions or are built upon the same cognitive models, we believe that the detailed models provided in language provide a useful starting base for understanding the models in visuals.

As a background to this analysis of the visual structure of time in GUIs, this paper first presents a general psychological definition of the term *time*, and then discusses the types of time that appear to be of use to computer users as evidenced by visual representations of time in computer interfaces. Next, the paper looks at the structure of tense in both spoken language and in the sign language of the deaf. Then, the paper considers the impact of writing on time-related graphics since there is a known correlation between strategies of writing and the perception of time on two-dimensional surfaces (Lieblich, Ninio and Kugelmass, 1975; Kugelmass and Lieblich, 1970; van Sommers, 1984; Zwann in Winn, 1994). Finally, comparisons are made between computer icons that directly represent movement and comic-style illustrations of sign language of the deaf such as found in sign language dictionaries. We have chosen illustrations of sign language of the deaf as models

for comparison because there is an existing taxonomy provided by Stokoe (1960) of the features of this language to which we can bring an analysis of the representation of movement.

Many of the examples in this paper come from Microsoft and Adobe products since they are familiar to most computer users, have been tested widely, have been used successfully for many years and are readily available for analysis. Other examples come from various web sites and utilities.

### Types of visual representations of time that appear in GUIs

While time is not something that can be directly seen, smelled, tasted, touched or heard, it is something that as the psychologist Fraisse (1984) has noted, we perceive through changes in the world and the duration between changes. To effectively communicate about the many and varied perceptions of time, people have developed a broad array of representational frameworks. As stated earlier, these include devices that represent time in a primary way, such as clocks, timers, calendars and planners, and devices that represent time as a secondary construct such as timelines, family trees and process diagrams. Each framework was developed to meet particular human needs regarding time.

In looking at computer interfaces, there are particular time-related graphics that assist with human-computer interaction. The ones that we have noted and will discuss in this paper are as follows:

- *Animated progress bars*: These visuals represent the relative amount of completion over time of a requested computer action. The purpose of these bars is to show users that the computer is actively processing a request (and is not stalled) and are recommended for any process that takes longer than five seconds (Galitz, 1994). They also help users estimate how long a process will take.
- *Icons and windows that visually represent their current state of activity*: These visuals assist users by marking the functions that are currently selected and in operation on the screen so that users can find them more easily.
- *Icons that contain arrows that directly represent computer*

movements  
or actions.  
These  
icons are  
a type of  
process  
diagram  
that con-  
tain only  
one move-  
ment.  
They help  
users by  
providing  
a concrete  
representa-  
tion of a  
particular  
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action.  
• VCR-  
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These  
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- *Icons and windows that visually represent their current state of activity:*

These visuals assist users by marking the functions that are currently selected and in operation on the screen so that users can find them more easily.

- *Icons that contain arrows that directly represent computer*

*movements or actions:* These icons are a type of process diagram that contain only one movement. They help users by providing a concrete representation of a particular computer action.

- *VCR-style icons:* These icons help users to orient themselves in an interface.

We will also discuss some time-related arrangements of information in GUIs.

### **The linguistic representation of time**

As mentioned earlier, time in language is represented primarily through spatial metaphors. The two most commonly found in languages around the world are referred to as the *moving-ego* and *stationary-ego* metaphors of time (Clark, 1973; Traugott, 1975; Nunez and Sweetser, 2006).

In these metaphors, speakers *stand in the present*. They see the future ahead of them and have the past at their backs. In every sentence they speak, there is at least an implication of *now*, which is their current position upon the path, and *then*, which points to the location of the event that they are discussing. In the *moving-ego* metaphor, speakers walk along the path of time whereas in the *stationary-ego* metaphor, speakers stand still while time flows past them. Figure 1 illustrates these metaphors and presents examples of their use.

The path of time also appears in the sign language of the deaf, which represents time as a horizontal path that extends from the front of speakers towards the back. Figure 3 shows this line of time in American Sign Language (ASL) and Figure 2 shows graphic representations of the hand-signs for *past*, *present* and *future*.

In an analysis of the Aymara language, which is spoken in western Bolivia, southeastern Peru and northern Chile, the researchers Nunez and Sweetser (2006) have found a linguistic model of time that differs from those of other languages. In Aymara, the present is just in front of speakers, the past is further in front and the future is behind them. A researcher on Chinese languages (Yu, 1998), has also reported vertical metaphors of time in which some Chinese phrases have earlier times above later times.

Figure 1 Moving-ego and stationary-ego versions of time.

**The moving-ego version of time:  
We walk through time**



Past  
Earlier  
Behind

Future  
Later  
In front

Examples:  
"We look forward to meeting you."  
"There are many years ahead of us."  
"I'll see you later."  
"Put that behind you."

**The stationary-ego version of time:  
We stand still and time moves past us**



Past  
Front  
Preceding

Future  
Behind  
Following

Examples:  
"The meeting has been brought forward from 4:00 to 2:00."  
"Autumn has passed."  
"The school holidays are approaching."

Figure 2 Signs for past, present and future in ASL. © 2006, reproduced by permission. Source: <http://www.Lifeprint.com>

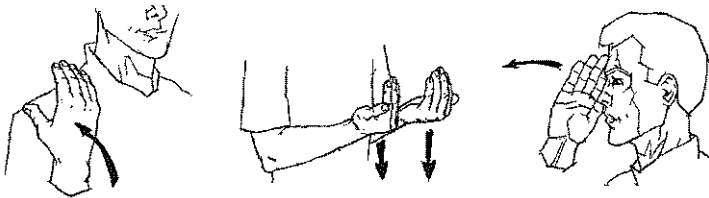
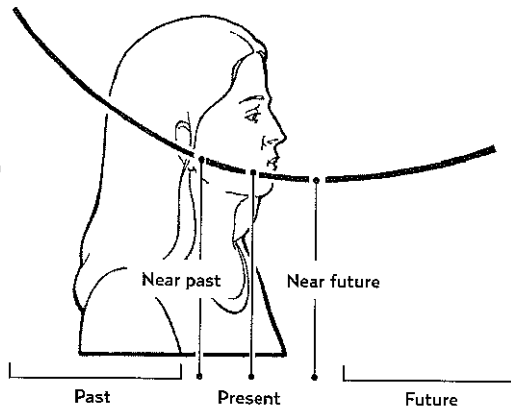


Figure 3 The timeline in American Sign Language (ASL). (Adapted from Frishberg and Cough, 1973.)



Considering all of these representations together, Nunez and Sweetser (2000) have suggested a model of tense that is based upon reference points rather than movement. The commonalities among these representations are that time is a unidirectional line, that the position of the speaker marks the position of the present and that the future and the past lie on opposite sides of the speaker. In most languages of the world, however, tense is represented as a horizontal path and the future lies in front of speakers.

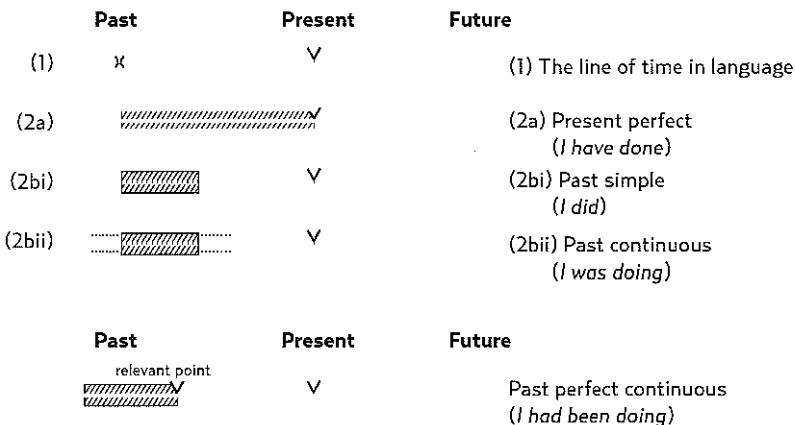


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A description of time in language is pivotal to the description of time in graphics since it is primarily through language that we derive nuances regarding time. As evidence consider the following graphics from a linguistic textbook (*figure 4*).

Traugott (1975) referred to the three important subsystems of linguistic time, which are tense, temporal sequencing and aspect. *Tense* indicates when events are happening, have happened or will happen (e.g., past simple – “I watched a film last night”; present – “I am watching a film right now”; future – “I will watch a film tonight”). *Temporal sequencing* indicates how events occur relative to each another (e.g., “We met Mary and Lee and then we watched the film together”). *Aspect* indicates how long events last, what



**Figure 4** Timelines used to represent tense (graphics in Quirk and Greenbaum, 1973, pp. 42, 45).

boundaries they have and how they recur (e.g., “The film lasted for two hours” - fully-bounded aspect); “We started going to that theater six years ago and have been going there ever since” (bounded beginning and unbounded end); “They watch a film every Saturday night” (regular recurrence); “That’s just the way things are around here” (unbounded). In addition, there is a subsystem of future tense, namely *mood*, which expresses information about such things as the likelihood of events occurring (e.g., event A *will* happen versus event A *might* happen). As will be shown, tense, temporal sequencing, aspect and mood in language all have analogues in graphical interface design.

As has been implied above, the past and future are represented asymmetrically in language (Harner, 1982). For example, in English, verbs are represented in their past tense usually by adding *-ed* to their present tense form. In contrast, to create the future form, speakers place *modal auxiliaries* before the present tense. Some examples of modal auxiliaries are: *must, will, shall, is going to, could, might* and *should*. The difference in the representation of the past and future occurs because of a fundamental fact about the world, which is that the past is resolved while the future is yet to happen and has varying amounts of certainty about it. The amount of certainty that speakers perceive is indicated through their choice of modal auxiliary. If they perceive an event as more certain, they will choose the modal auxiliaries *is going to, will, shall* and *must*. If they perceive less certainty, they will choose among *could, would* or *might*. As will be discussed shortly, the sense of such modal auxiliaries appears in the design of computer interfaces.

### The visual representation of tense in GUIs

To represent *tense*, graphic representations must include the following (Mitchell, 2006, p.20):

1. Something that points to now (the reference point)
2. Something that points to then (the time of the event, which could be in the past or in the future)
3. Something that differentiates the past from the future, and
4. If an event is predicted to happen in the future, something that indicates the degree of certainty we have over whether the future event will happen.

One visual representation of tense in computer interface appears in progress indicators, which clearly indicate the past, present and future in their designs. In the example in Figure 5, which represents the starting of a remote-access computing application, the past is clearly differentiated from the future by its position in relation to the present and by its contrasting color.

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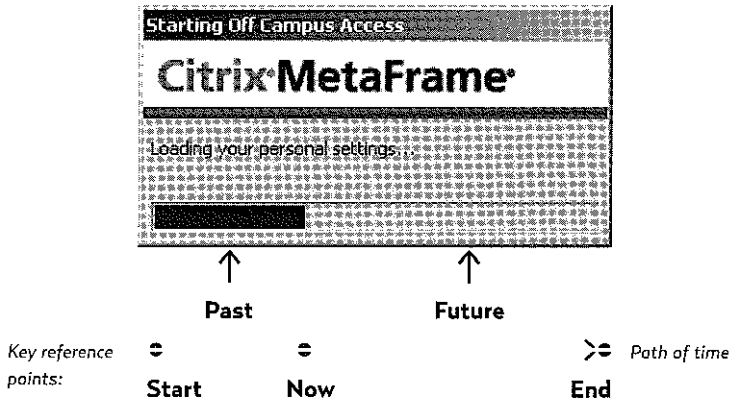
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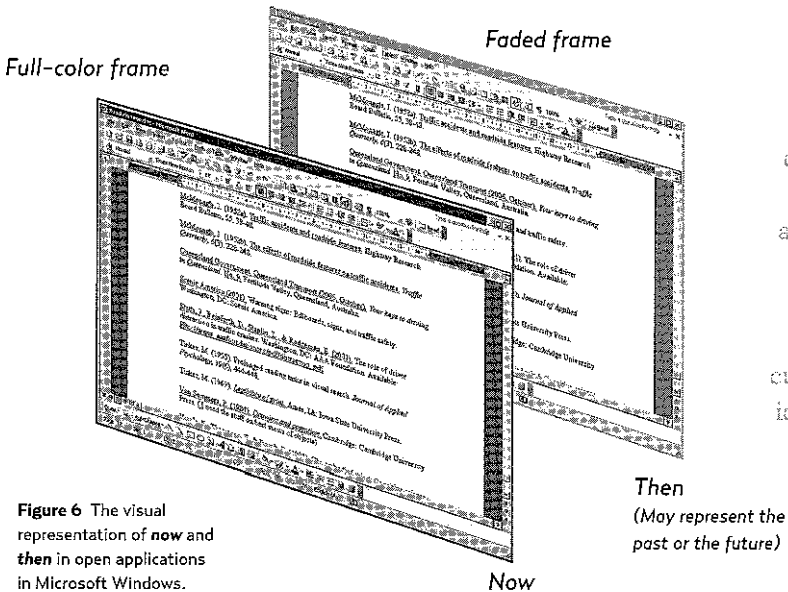
Progress bars also often include a digital readout of the amount of time left for processing and a percentage and a numerical summary of the amount of data that has been processed. One might ask why a graphical representation is useful for presenting the processing of data and why a numerical read-out of the remaining time or the amount of data processed is not satisfactory enough. This is the same issue as that affecting analogue versus digital clock and watch faces. Although both types of representations indicate the time, some people select the analogue because of the eloquence of the spatial relationships and the redundancy.

The progress bar design correlates directly to the linguistic representation of time as a horizontal path. Designed specifically for providing computer feedback, it better suits this need than designs based upon previous technologies such as circular countdown timers, which are associated with a 60-second or 60-minute timeframe, or kitchen sandglasses associated with a 3-minute timeframe. Users can associate any amount of time with a progress bar.

Sometimes in computer interfaces, reference points in time are created not through a path across, up or down a screen, but through visual layers and unique marking of the currently active layer (*figure 6*). This pattern for representing time is taken when users need to work with several applications or documents at the same time, there is limited screen space or a need to conserve space. Galitz (1989) has noted that layered or cascaded windows (in contrast to tiled windows) are useful when users need to switch between tasks. In this design, the specially-marked top layer represents the *present* and underlying inactive layers represent both the *past* (layers that were previously active) and the *future* (layers that could be active later). When considering the underlying layers from a past perspective, the layer that is immediately beneath the top layer



**Figure 5** Representation of the past, present and future in a progress bar (this animated bar represents the starting of an application).




**Figure 6** The visual representation of **now** and **then** in open applications in Microsoft Windows.

represents the one that was last used. When considering the underlying layers from a future perspective, any of the layers could represent the future. Another technique for representing reference points in time is through changes in an object's color, background and framing (figure 7). Designers use this visual approach on icons to indicate those that are currently active, inactive or available. In terms of tense, the currently active icon represents the present and the inactive or unavailable icons represent either the past or the future.

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### The visual representation of temporal aspect in GUIs

In visual representations of time, *temporal aspect* (how long events last, what boundaries they have and how they recur) can be represented by different graphical starting and ending points and can be reflected in a graphic's shape. For example, in the progress bar previously discussed, time is represented as having a definite starting point (the beginning of a solid line) and a definite ending point (the ending of a solid line). In contrast, in the 'rotate' icon  of Microsoft Word 2000, the circular line with an arrowhead on the end indicates that the movement can continue indefinitely in the same pattern (around and around).

### The visual representation of temporal sequencing in GUIs

*Temporal sequencing*, which describes when one event happens relative to another, can also be present in computer interface design. Sequencing involves, for example, whether one event preceded another and if so, by how much; whether one event happened after another event; or whether the events overlapped in time. Some examples of temporal sequencing in verbal language are as follows:

- She is going to the library *before she goes to the shop*.
- The boy delivered the gift *the day before his friend's birthday*.
- She'll go to work *after she visits her mother*.
- He was in Chicago *while she was traveling to Sydney*.
- After she *had opened her email*, she sent notes to her friends.

The key difference between *tense* and *sequencing* is that tense refers to the speaker, who stands in the present and

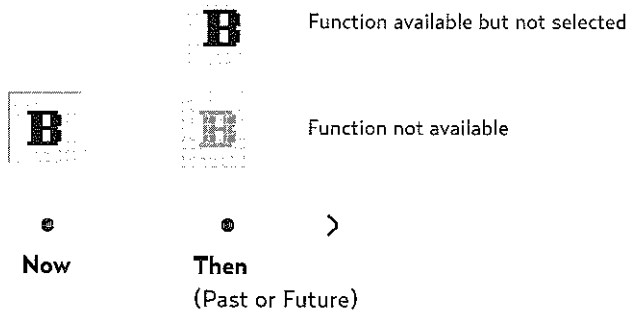


Figure 7 The visual representation of tense in Microsoft Word 2000 command icons.

points at times in the past and future, while sequencing attaches events to one another in time. Temporal sequencing appears in a graphic when the graphic represents more than one event. Temporal sequencing of visual information can be helpful in numerous ways: it can help users to locate information such as email notes, data files and the last application window that they opened; it can help users to locate information such as email notes,

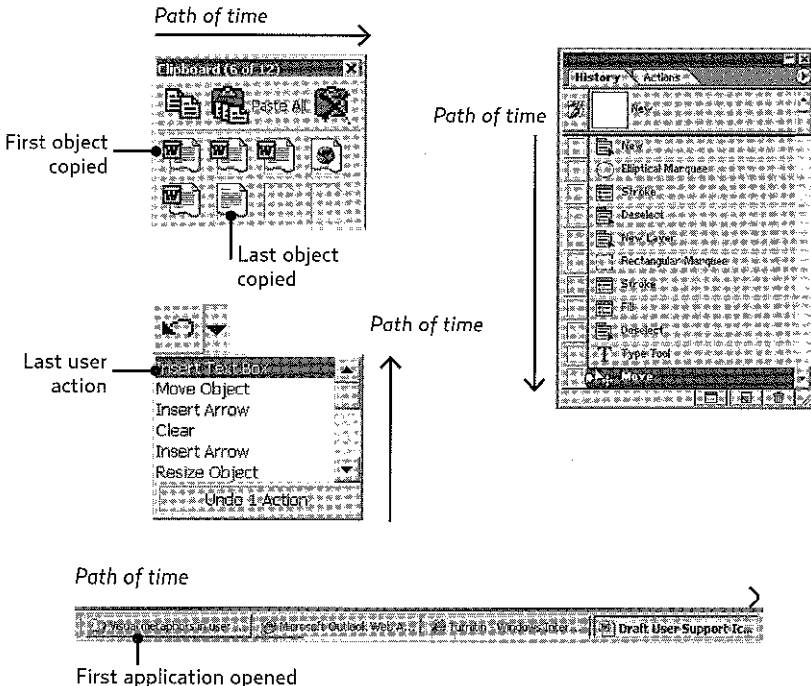
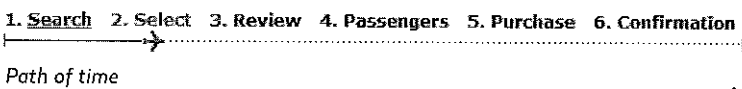


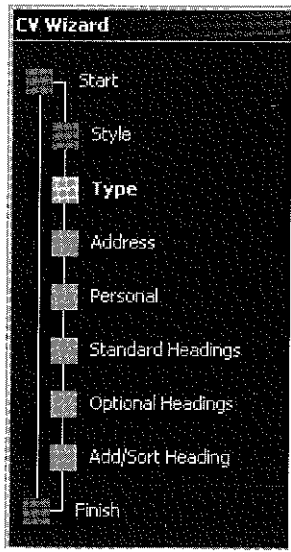
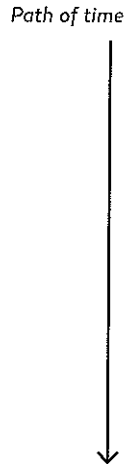
Figure 8 Examples of temporal sequencing of past events in Microsoft Word 2000, Windows XP and Adobe Photoshop 6.0

Some examples of temporal sequencing in verbal language are as follows:

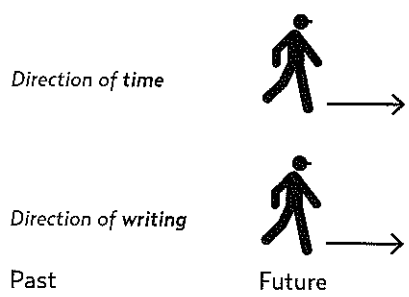


- She is going to the library *before she goes to the shop.*
- The boy delivered the gift *the day before his friend's birthday.*
- She'll go to work *after she visits her mother.*
- He was in Chicago *while she was traveling to Sydney.*

After she had opened her email, she sent notes to her friends. The key difference between tense and sequencing is that tense refers to the speaker, who stands in the present and



**Figure 9** Examples of temporal sequencing for events that could happen at any time in the Qantas Airlines Internet flight selector (<http://www.qantas.com.au/regions/do/dyn/QuickSearch>) and the Microsoft Word 2000 Resume Wizard.



**Figure 10** The relationship between writing direction and the flow of time on the screen in cultures that read from left to right.

points at times in the past and future, while sequencing attaches events to one another in time. Temporal sequencing appears in a graphic when the graphic represents more than one event. Temporal sequencing of visual information can be helpful in numerous ways: It can help users to locate information such as email notes, data files and the last application window that they opened; it can help users undo the entries that they made to a file up to a certain point in time (e.g., the 'undo' command in Microsoft Word 2000 and the 'history' list in Adobe Photoshop both provide this assistance); and it can help users see all of the steps they need to perform to complete a task. Figure 8 presents examples of temporal sequencing of past events and Figure 9 presents examples of temporal sequencing of events that occur in the same way all of the time. A discussion regarding horizontal and vertical sequencing and the reference points for starting a sequence is explored in more detail in the next section.

### Effects of writing on the path of time

As stated earlier, not only does language itself affect how time and movement are graphically represented, so does the direction of writing on two-dimensional surfaces. Zwaan (as cited in Winn, 1994) found that people generally perceive the flow of time across a page to match the direction in which they read. He based this finding upon research conducted with Dutch and Israeli subjects. The Dutch subjects, who read from left to right, associated the left sides of pages with the concepts of 'proximity,' 'past' and 'self,' while the Israeli subjects, who read from right to left, associated these concepts with the right sides. Other research having similar results is reported by Kugelmass and Lieblich (1970; 1979) and Lieblich, Ninio and Kugelmass (1975). The same correlation applies to text on a computer screen (see figure 10).

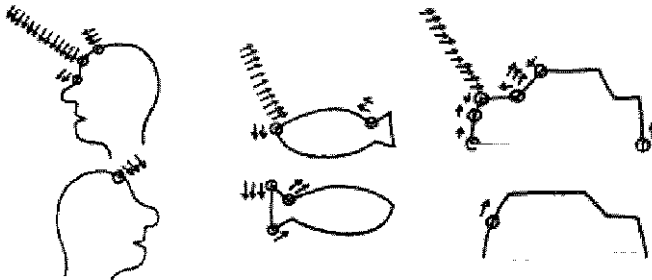
In this paper, we argue that for carefully-made drawings that represent movement towards the future, illustrators will deliberately turn objects so that they face the future (that is, the right side of the page or screen). As an example, refer back to Figure 2, which illustrated the timeline in sign language (with the future on the right), with a person's profile oriented towards the right. This argument regarding

facings  
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(figure 11).

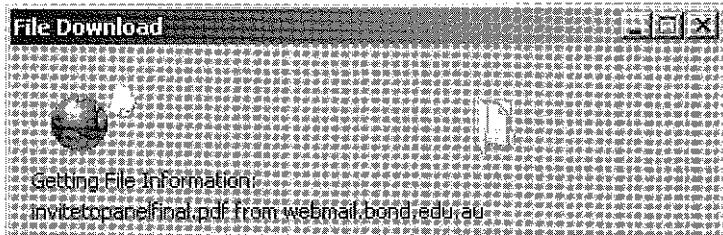


In this paper, we argue that for carefully-made drawings that represent movement towards the future, illustrators will deliberately turn objects so that they face the future (that is, the right side of the page or screen). As an example, refer back to Figure 2, which illustrated the time-line in sign language (with the future on the right), with person's profile oriented towards the right. This argument regarding

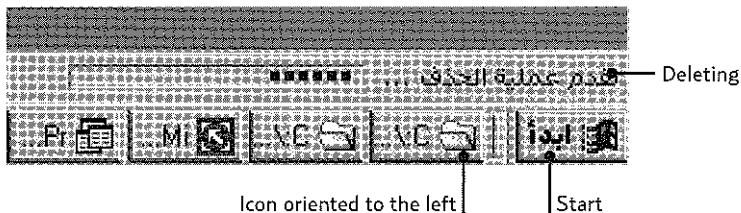
**Figure 11** Most right-handed people begin drawings on the left and face objects in profile towards the left (van Sommers, 1984).



**An animated document flies from the left to the right of a panel to represent time passing (in Microsoft Outlook Web Access)**



**Figure 12** Visuals of computer processing activities also take advantage of the left-to-right path of writing and its association to the flow of time.



**Figure 13** Example of a progress bar for Arab speakers.

facings and time is based upon research by van Sommers (1984) who studied both the direction of facing of objects drawn in profile and the place within an object where people begin drawing the object. Van Sommers found that when asked to draw a face in profile, most right-handed people will orient the face towards the left and will begin drawing it on the left (*figure 11*). He found the same to be true of many other objects drawn in profile.

Van Sommers found that the direction of facing and the starting position of a drawing are based ultimately upon preferred finger and wrist movements. Therefore, when illustrators orient a face towards the right in the context of a visual representation of time as the illustrator of Figure 2 did, they are overriding these production constraints and are motivated to do so by the orientation of time on the page. (More detail regarding preferred movements of the fingers and wrist while writing and drawing is available in van Sommers, 1991.)

The orientation of objects to reflect the path of time on the page is seen in many computer-interface designs, for example in the progress bars shown earlier. Another example is shown in Figure 12, which represents a document being downloaded from the world-wide web to a folder on the user's computer.

For cultures that read from right to left, time-related graphics such as progress bars should be oriented from right to left as in Figure 13. The design shown, however, still contains text in English, which is obviously not ideal for Arabic readers.

Since many computer users in Arabic-speaking countries have learned to use interfaces that are written in English, it is probably prudent (and good practice) for designers to conduct research on their Arabic audiences before making any final design choices. For example, one Bahraini informant told us that although English is his second language, he learned to use the computer in English and would find this right-to-left progress bar annoying.


To examine the visual perspective that people take of time on the page, van Sommers (1984) asked people to imagine or depict themselves on a horizontal timeline across a page. All of the subjects placed themselves inside-on perspective on the far left of the timeline. None

provided a top-down or map-like perspective. Van Sommers suggested that they represented themselves side-on since they see time as one-dimensional and a side-on representation provided the best and simplest view of themselves in time. He further noted that a two-dimensional map-like time perspective is a special-purpose device. Let us now consider some vertical arrangements.

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Let us now consider some vertical arrangements. Time is sometimes represented along the vertical, but sometimes it is represented as moving up the page (as in many evolutionary-tree diagrams) and sometimes down the page (as in many family trees). To understand how people conceptualize time along the vertical, van Sommers (1984) asked people to place themselves in a plan view along a vertical path. Some people drew themselves traveling up the page, some drew themselves traveling down and some represented the arrow of time traveling both up and down. Van Sommers proposed that the representations were inconsistent because the vertical plan view is not a natural way for people to represent time and the subjects faced various contradictions.

These contradictions are that different types of vertical representations of time are based upon different visual structures. When a model follows the vertical pattern that is set up by reading, time should start at the top of the page and flow down. When a model follows the pattern created by a Cartesian-grid, time should begin at the bottom of the page and flow up. When the model is of walking forward or into a page like this , the path of time will flow up from the bottom of the page. Often, time flows up the page for pragmatic reasons. For example, when email notes are represented on the page, it is more useful to have the most current or last received note at the top of the page where reading begins.

### **The representation of movement within icons**

It is useful for designers of computer-support icons to understand the visual principles that underlie comic-style representations of sign language since like computer-support icons, drawings of sign languages are designed primarily to be functional. In addition, these drawings provide excellent models for many types of functional images since sign language itself is considered by many



Figure 14 An inventory of handshapes (Friedman, 1977, pp 16-17.)

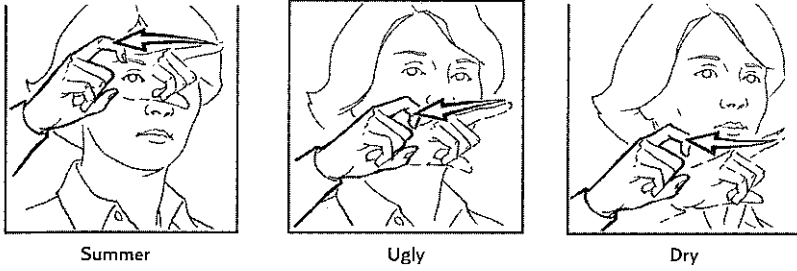
## The representation of movement within icons

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to be difficult to draw (Bailey and Dolby, 2002) and illustrators take great care to make the illustrations easy to understand. Further, comic-style representations of sign language are drawn to be concrete (that is, to represent body movements directly) and the most useful computer-support icons are considered to be those that provide direct representations of screen actions. Although some applications use icons to represent the most abstract commands, Mullet and Sano (1995, p. 202) have recommended that icons be reserved for those actions that allow users to directly act upon screen information. They have argued that more abstract commands should be placed as words in menus and "the visible portion of the display [should be reserved] for important tools and direct access to properties with an inherently spatial character." For all of these reasons, principles for creating comic-style representations of sign language are important and relevant for computer-support icons.

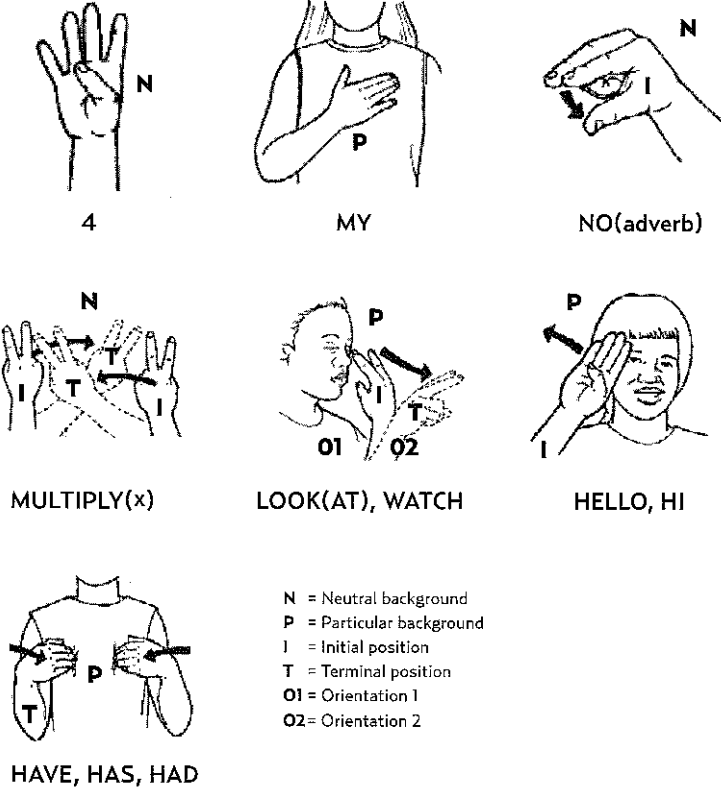
As an introduction to the visual representation of movement in sign language, the next few paragraphs describe the visual parameters of sign language as provided by Stokoe (1960). He observed that the language was formed by handshapes, body locations, paths of movement of the hands, palm orientation and sometimes non-manual features such as those found in movements of the mouth, brows, shoulders, head and body. Friedman (1977) has listed forty-one different handshapes and these are presented in Figure 14. From a graphical point of view, these handshapes must be drawn in their best view with particular attention to the visibility of curved or clenched fingers so that they are easily recognizable. Like handshapes, the objects chosen for computer icons must also be drawn in their canonical position for ease of recognition.

Some meanings are created simply by a single handshape, but many are created by the placement of a particular handshape against a particular location of the body. Parts of the body other than hands are included in an illustration usually only when the location at which a sign is made effects the sign's meaning. For example, the motions for the signs *summer*, *ugly* and *dry* are identical except for the location across the face at which they are made (see figure 15). Different researchers have noted different numbers



**Figure 15** The same handshape made at different locations on the body can create different meanings. (Reprinted by permission of the publisher from *The Signs of Language*, Edward Klima and Ursula Bellugi, p.42, Cambridge, MA: Harvard University Press. ©1979 by President and Fellows of Harvard College.)

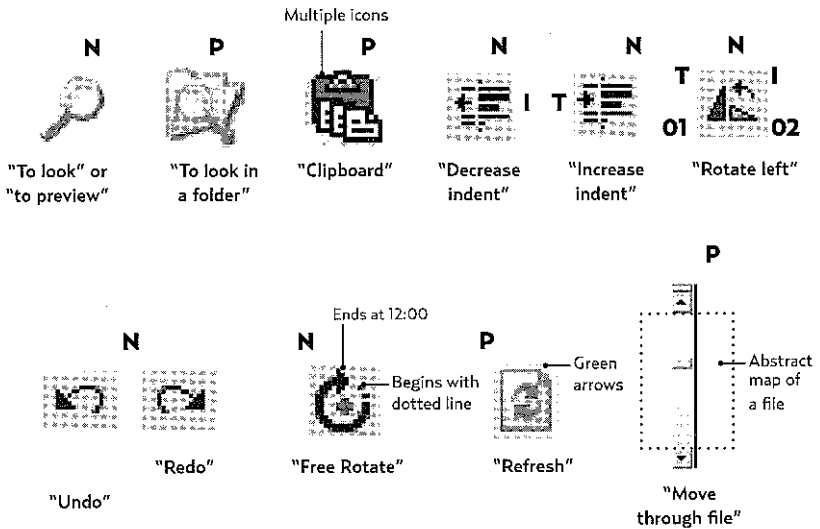
Word 2000 and the 'history' list in Adobe Photoshop both provide this assistance); and it can help users see all of the steps they need to perform to complete a task. Figure 8 presents examples of temporal sequencing of past events and Figure 9 presents examples of temporal sequencing of events that occur in the same way all of the time. A discussion regarding horizontal and vertical sequencing and the reference points for



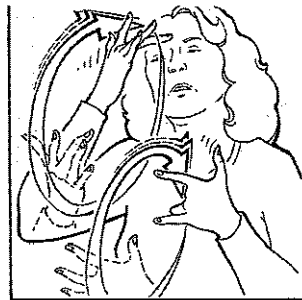
**Figure 16** Typical compositions in sign language. (ASL graphics from Terry, Witherell and O'Connor, 1998. Figure based upon Mitchell, 2006.)

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**Figure 17** Compositions of icons in Microsoft Word 2000 that have similar structures to those in comics of sign language. The lower set differs from representations of sign language in that arrows appear alone.



*Sick for a long time*

**Figure 18** Multiple lines with arrowheads can represent more of something in sign language. (Reprinted by permission of the publisher from *The Signs of Language*, Edward Klima and Ursula Bellugi, p.257, Cambridge, MA: Harvard University Press. ©1979 by President and Fellows of Harvard College.)

of distinct signing locations on the body: Corina (1990) listed thirty-six, while Johnson and Liddell (1988) found fifty-six.

In composition, the following differences are typical in sign language. Some illustrations contain only a handshape, some show a handshape drawn against a particular location, some show a handshape and a line with arrowhead that represents the path of movement, some show the initial and the terminal positions of handshapes, some show the initial and terminal handshapes in different orientations against particular locations with a line and arrowhead. Some show just the initial or terminal position with an arrow.

Figure 16 illustrates these different compositions. Similar compositions and some others that are related to time are found in computer-support icons as shown in Figure 17.

At least two explanations can be provided as to why both the initial and terminal handshapes are drawn in a single image. First, both are drawn when the handshape is different in each phase, and second when the orientation of the handshape is different in each phase. Among the computer icons shown in Figure 17, the 'rotate left' icon is the only one that represents both the initial and final position of an object. In this case, the icon's purpose is to indicate that the orientation of the object changes when the icon is selected and so both positions are shown.

Sometimes when illustrators draw both the initial and terminal handshapes, they may draw the handshapes in different ways. Typically, one of the representations will be less detailed than the other. Such a difference in representation is helpful since if the handshapes overlap, the different drawing styles will allow the shapes to be clearly differentiated from one another. The difference in representation is also helpful because it provides visual redundancy and also because showing each handshape differently is analogous to the linguistic model of time in which the past and future are marked differently. Among the computer-support icons shown, the 'rotate left' icon represents the initial and terminal positions differently, with the initial presented as outlined (less detail) and the terminal as solid.

Since many lines with arrowheads appear in the Microsoft Word 2000 interface, they are represented

to dif-  
ferentiate  
among their  
various  
func-  
tions. The  
simplest  
arrowhead  
design is a  
'v' and  
this design  
is used more  
frequently  
on the  
screen than  
any other  
style of  
arrowhead.  
Its function  
is to move  
application-  
related  
informa-  
tion. Icons  
smaller  
size. It  
opens small  
drop-down  
windows  
and in its  
larger size it  
associates users  
in scrolling  
through  
files; some-  
times a shift  
through  
90 degrees  
codes for  
the listing of  
contents of  
a file.



The difference in representation is analogous to the linguistic model of time in which the past and future are marked differently. Among the computer-support icons shown, the 'rotate left' icon represents the initial and terminal positions differently, with the initial presented as outlined (less detail) and the terminal as solid. Since many lines with arrowheads appear in the Microsoft Word 2000 interface, they are represented

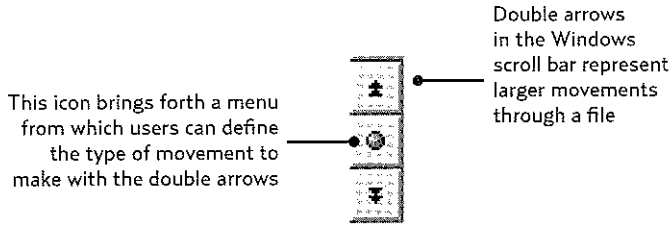
differently to differentiate among their various functions. The simplest arrowhead design is ▲ (or ▼) and this design is used more frequently on the screen than any other style of arrowhead. Its function is to move application-related information. In its smaller size, it opens small drop-down windows and in its larger size it assists users in scrolling through files; sometimes a shift through 90 degrees codes for the listing of contents of a file. For example, the downward pointing arrowhead ▼ points to the revealed content.

Color occasionally helps to differentiate among the arrowheads with lines. Not only are different colors used, but for some icons, the colors carry meaning, for example as in the green arrows on the *refresh* icon, which requests the computer to check for updates to the screen. (Reading patterns for icons that consist primarily of arrowheads are discussed in the next section.)

Klima and Bellugi (1979) have studied how *temporal aspect* is represented in sign language. As mentioned earlier, aspect indicates an event's boundaries, such as when it began and ended or whether it is always occurring, or whether it occurred all of a sudden. One type of aspect, which refers to a *lengthy event*, is indicated with repeated hand movements and is graphically represented with multiple movement lines with arrowheads. An example is shown in Figure 18. In computer interfaces, types of movement other than the norm are often represented with double arrows (for an example, see figure 19).

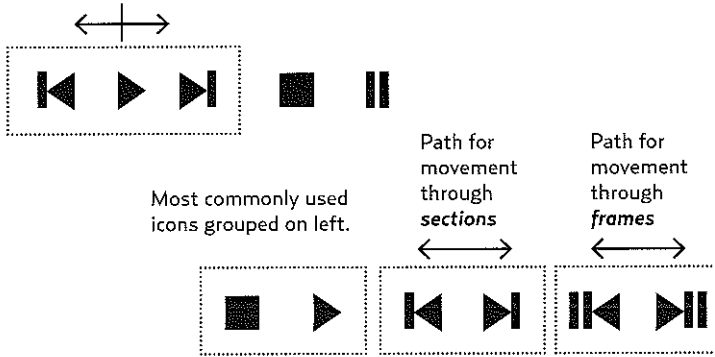
### Arrangements of VCR-style icons

Along the horizontal, there appear to be different possibilities for organizing time-related, VCR-style icons and each possibility may be explained by pragmatics or by the type of time that a designer wishes to convey. Commonly they are arranged so that the icons that move the data forward are all on the right and those that move the data backwards are on the left. Sometimes they are arranged according to the type of forward and backward motion that they provide. For example, the icons that move a video forward by frames are grouped together and the icons that move a video forward by sections are grouped together. Often, a combination of strategies is used. For example, the most commonly-used icons are grouped together on the left and those that move



**Figure 19** In Windows, double arrowheads represent larger movements through a file.

Arrowheads grouped according to their direction.



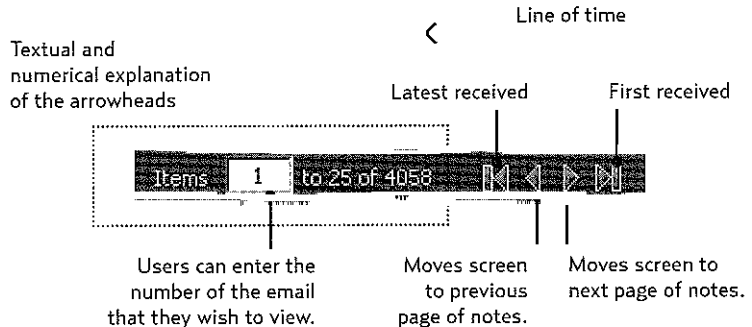
Most commonly used icons grouped on left.

Arrowheads are grouped according to their direction.



**Figure 20** Arrangements of icons in computer video players.

forward and backward in any way are grouped together on the right. Figure 20 presents these different possibilities. Another arrangement of arrowheads (an example of which is shown in figure 21) is to have the most current item on the left and the oldest item on the right.



**Figure 21** Icons arranged along a reversed horizontal timeline (Microsoft Outlook Web Access).

those that move the data backwards are on the left. Sometimes they are arranged according to the type of forward and backward motion that they provide. For example, the icons that move a video forward by frames are grouped together and the icons that move a video forward by sections are grouped together. Often, a combination of strategies is used. For example, the most commonly-used icons are grouped together on the left and those that move

forward and backward in any way are grouped together on the right. Figure 20 presents these different possibilities.

Another arrangement of arrowheads (an example of which is shown in *figure 21*) is to have the most current item on the left and the oldest item on the right. Since this arrangement is a reversal of the norm, it is typically supplemented with text. Such an arrangement is useful when a user needs to view first the latest item received or the last action performed. This example is from the email software Microsoft Outlook Web Access.

## Conclusions

The paper began with a discussion of the linguistic representation of time: *time is a path or trajectory*. Using this model, the visual representation of time in computer interface design consists of a line that has a direction and a key reference point. As discussed, this line may be represented in the two dimensions of virtual depth in the form of layers or it may go across the screen. Sometimes, only a single reference point along the line is represented. Along the horizontal, representations of time tend to follow writing but may be reversed for pragmatic reasons. Along the vertical, there appears to be no particular standard for whether time travels up or down and depends upon the particular design situation. For example, when designers find that a situation requires them to follow the pattern created by writing, time will start at the top of the page. If however, they think that for example, the latest event in a series is most important, they will graphically represent that event in a position that makes it stand out or be most convenient for a user. To be useful, representations of time in computer interface designs must reflect people's conceptions of time and represent the kinds of time that people require when using a computer.

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