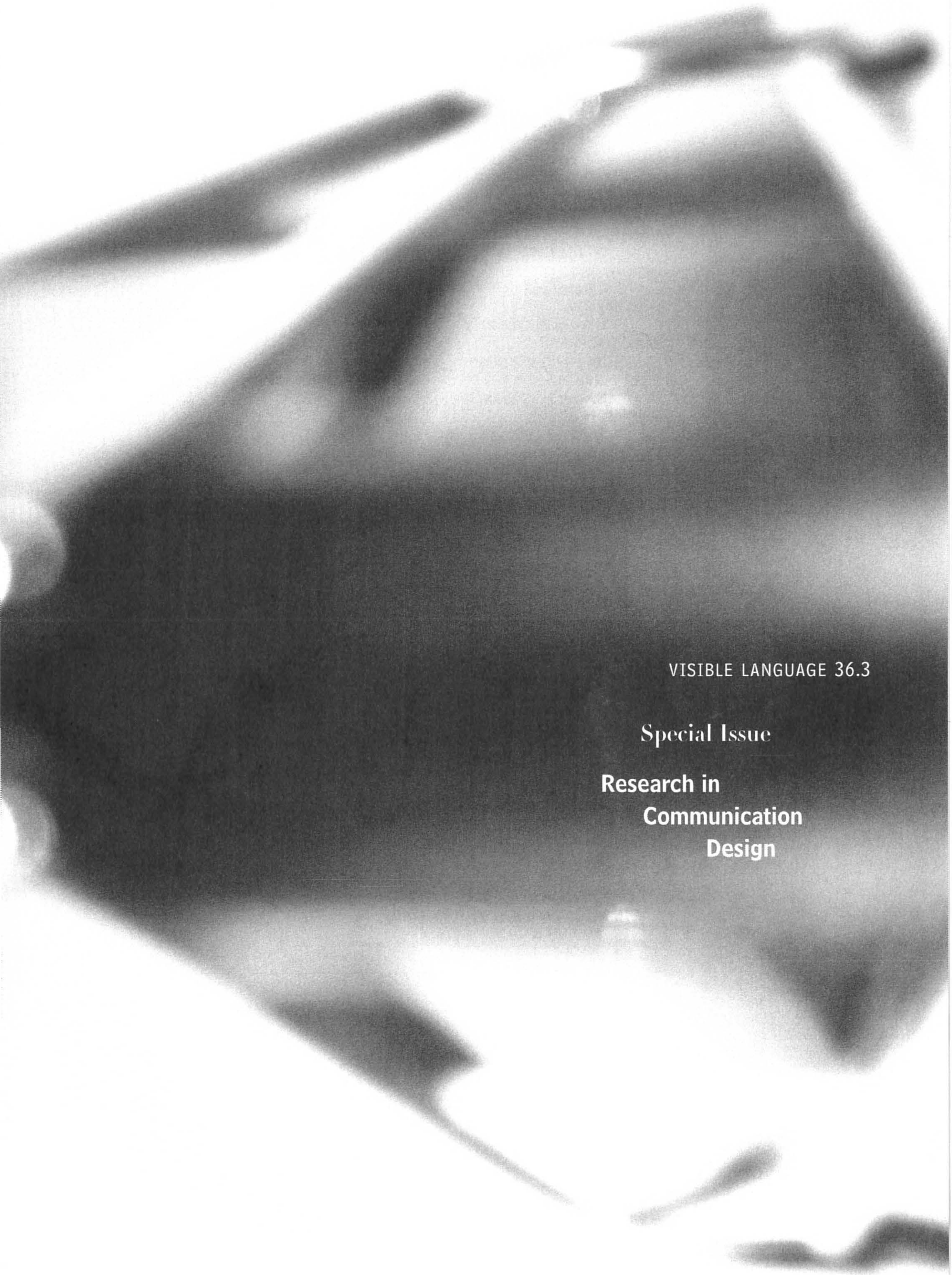

VISIBLE LANGUAGE 36.3

Special Issue

Research in Communication Design

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Special Issue

Research in Communication Design

CONTENTS

PASSIONATE about letterforms and space,
Colin Banks was the quintessential man of letters.
Literate and cultured, he practised design as a social good.
Travelling the world, he generously shared his knowledge,
experience and enthusiasm for typography and design.

COLIN BANKS

1932–2002

A long time friend and supporter of *Visible Language*, he matched principles with practise. His design for the United Kingdom telephone directories elegantly improved legibility while saving an impressive number of trees. He set a high standard for performance, aesthetics and social responsibility that we honor by dedicating this special issue of the journal to his life work and memory.

COMMEMORATION

CULTIVATING an Interest in DESIGN RESEARCH

Sharon Helmer Poggenpohl

This introduction to a special issue, **Research in Communication Design**, provides a brief argument for why design research is important now. The importance and difference of design research needs from that of other disciplines is stressed. Development of knowledge useful in the practice of design is the focus. It also challenges the black box of design and questions the limits to its knowledge. Articles are briefly introduced with a commentary on their research classification and particular research approach.

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Visible Language 36.3
Poggenpohl, 246–252

Several factors are converging that support and sustain a renewed interest in communication research, now from a design perspective. These factors can be divided into three categories: technological influences, contextual change and educational opportunity. ▷ technology Under technology, digital technology opens new access and research opportunities for communication as new media is still in an evolutionary state. At a basic level, technology provides access to all, with or without design training and experience. Novice communicators learn technique and operate by imitation and trial and error. Design is rule-driven to only a limited extent and at the limits of rule is judgment. This is where trouble begins for the novice. Access to technology by this group has put pressure on designers to perform with greater reliability, hence a greater interest in the findings of research. ▷ contextual change Under contextual change, information as a scarce commodity is replaced by its overabundance creating intense competition for human attention—rendering attention itself scarce. Interdisciplinary problem solving is accelerating, putting design principles, information and knowledge under scrutiny and pressure to be more explicit. To this is added the fact that communication performance is taken more seriously with penalties for failure. ▷ educational opportunity Under educational opportunity, doctoral programs in design open research training to those who were formerly practitioners. In research oriented doctoral programs, knowledge of what is known and what is unknown becomes clear, helping to identify where research is needed and when intuition and judgment must suffice.

▼ Individuals engaged in the construction of communications are faced with what is known and what is unknown in the context of their communication problem.

What knowledge can be accessed with regard to: their audience, the technological possibilities of media, usefulness of various communication strategies, the context of information use and the purposes of the user? What knowledge is available with regard to: interactivity or feedback possibilities, the usefulness, tension or complementarity between various coding systems (text and typography, diagrams, images, etc.)?

This questioning of what is known and what is unknown creates the arena in which research questions develop. Questions are powerful tools for locating a possible contribution to knowledge (Poggenpohl, 2000). By beginning with questions we can avoid methodological rigidity, attempt to balance logic and creativity and sustain active curiosity throughout a rigorous research process. Two articles submitted to this special issue from the University of Reading arrived with titles in the form of questions; this is common practice there.

Disciplines with strong research traditions, psychology and sociology for example, have long provided information to those engaged in design. The knowledge transfer has been both substantive and methodological. But the questions these disciplines ask and the manner in which they are answered are often difficult to interpret in terms of design action. Design is about action and projected change; it goes beyond problem investigation or description of a situation and into the synthesis of a solution. There is another problem in this translation process from social science research to design action as design works with many variables simultaneously and projected solutions are contextual and sometimes unpredictable. Nevertheless, many questions have been answered and the answers from the social sciences provide guidelines for design performance.

Now design is beginning to ask its particular questions as it participates in research development for its own discipline. In this issue and the continuation of this special issue in *Visible Language* 37.1, four authors are doctoral candidates in design and one has received a Ph.D. in Design. This is a new situation worth celebrating. Now not only is research in design more specifically possible, there are an increasing number of conferences in which to share research. The growth of the doctorate in design, its research training and performance, together with focused conference venues and peer-reviewed journals, will alter design education and practice. The current orientation in many design programs leans toward art. The change in view will reorient the balance by providing a more science-oriented counterpoint. Design is not science or art; it exists in the space between them and must be able to work across both boundaries.

Research is a social construction of knowledge. Researchers build upon each other's findings; they replicate studies; query each other and submit their findings to report, review and publication as part of the design research process. Research can be done in many ways depending on the question, the method and the desired character of the answer. The nature of research itself meets challenges and takes form according to whether the question under consideration opens new territory or extends previous work; is early in its particular development, a pilot study for example, or late; can use existing research methods or must develop a new strategy. A common categorization of research is into three classes: basic, applied and clinical. Basic research asks fundamental questions, the answer to which can be generally applied in many situations. Applied research may examine classes of clinical research in order to find patterns. For example, case studies in design are a recent phenomenon. They often are after-the-fact reports of success rather than critical records of development and its problems. Clinical research often is a single case of inquiry grounded in practice. Over time the experience of many single cases as experienced by a doctor or craftsperson may lead to a principle or particular method. Clinical research in many fields and especially design is unreported as it is often proprietary.

As the journal mission states,

"The shift from page to screen is comparable in its significance to the shift from manuscript to print. Developing the knowledge base and conventions for this new media will take time and challenge our ability to move beyond the book into more fluid, relational and responsive systems of presentation."

The articles in this issue explore these ideas and cover some interesting territory in terms of their research approach.

The first contribution, **Methodology for Uncovering Motion Affordance in Interactive Media**, is basic research, searching for fundamental knowledge. The research method developed to uncover motion affordance is adapted from experimental psychology. The underlying research question addresses whether people attach common meanings to particular motions and whether these motions and meanings have any common emotional charge. It is interesting to observe that the increasing research interest in emotion (Damasio, 1999; Johnson, 1999) makes investigation respectable. This research challenges ordinary design practice in its intuitive use of motion on screen whether for navigation, cueing or other purpose. Based on a question of interest to the field of design, an entire research program can be developed from this work that will yield practical and beneficial results for creators and users of interactive media.

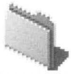
Likewise, the second contribution, **Methods for Manipulating Electronic Documents in Relation to Information Retrieval**, is also basic research, based on experimental psychology and developed from a design perspective. Navigation is a well documented problem in web design. This research builds from studies of reading in terms of efficiency in finding and using information. The particular focus of this study is to compare various structural properties of web navigation including scrolling, linking, paging or framing. Searching electronic text for specifics is certainly easier than scanning physical pages for a remembered text, or finding it through an index. But reading from screen presents the problem of accessing the text stream through a technical selection that may interrupt the rhythm and flow of reading for the reader. A disjointed and frustrating experience may result.

In complete contrast to the previous two articles, the third article, **Communicating Cuneiform**, is applied research of a very particular kind, directed to the development of a tool—a database. This research is based on analysis of the techniques of cuneiform scholarship, analysis of the technological possibilities and limitations of an on-line interactive, visual database, followed by construction of the tool itself. This process of research, based on analyses and heuristics, is practical and performance oriented because the final result must work. Various domains of knowledge from esoteric and ancient to practical and contemporary, are increasingly organized into databases to facilitate search, comparison and manipulation of information. The charm of this research is the juxtaposition of ancient writing (cuneiform) with digital technology and the projected acceleration of analyses and understanding this supports. An estimated 100,000 known tablets remain untranslated (Vergano, 2002) with more possibly buried in ancient sites in Iraq. Not only cuneiform experts, but historians and anthropologists stand to benefit from these translations of the world's first legal code (Code of Hammurabi), tax receipts, medical prescriptions and religious practices. This can translate into a deeper understanding of our literate origins.

The last article, **Typographic Cueing on Screen**, is also based on studies of reading. Based on experimental psychology methods, it is basic research. Here the question is to what degree typographic cues facilitate comprehension, search and memory. While this has been extensively studied with regard to print, this study focuses on screen reading.

Authors routinely cue important words or concepts in their text. Editors often use pull quotes not only as an attraction but to emphasize key content points. Designers sometimes try to open dense text to make it more accessible through various cueing systems. Whether these are effective ideas from the reader/user's perspective is at the heart of this research.

What sets research apart from a simple assertion is an analysis from substantial evidence. Gathering, analyzing and reporting results are expected. But perhaps it is necessary to help practitioners to use research by emphasizing the meaning and application of the findings. Research is done not for its own sake in design, but to help design practitioners and others make better constructions that have been found to be useful and enjoyable for people as they process information and communication.



research and design's black box

Communication design is facing new challenges. More than ever, communicative performance is expected and valued. But since design happens in a situation of complexity, uncertainty and value conflict (Schön, 1983), the current situation of change complicates the process of building an understanding of what variables in the communicative process can be adequately accounted for and controlled and what variables are subject to control only through design judgment. Separating these into what is knowable in some more clear sense from what is subject to judgment requires design researchers and practitioners to become increasingly explicit in their understanding of design attributes and processes. In both education and practice, design has been based on implicit knowledge, learned through a master/apprentice model. Such knowledge is hard to specify, it is tacit (Polanyi, 1983), developed through imitation and internalized as a craft. Now there is a growing need for explicit knowledge that can be externalized through principles, formalized through educational process, subject to revision or extension through research. This design knowledge is constructed on past research and is arguable in terms of its process and findings.

To adequately address current and emergent communication problems with regard to globalization, technological developments or human information processing limitations requires an ability to ask good questions, perform research, interpret results and meaningfully communicate to practice. This is the agenda of the two special issues on Research in Communication Design.

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References

Damasio, Antonio. 1999. *The Feeling of What Happens, Body and Emotion in the Making of Consciousness*. New York: Harcourt Brace.

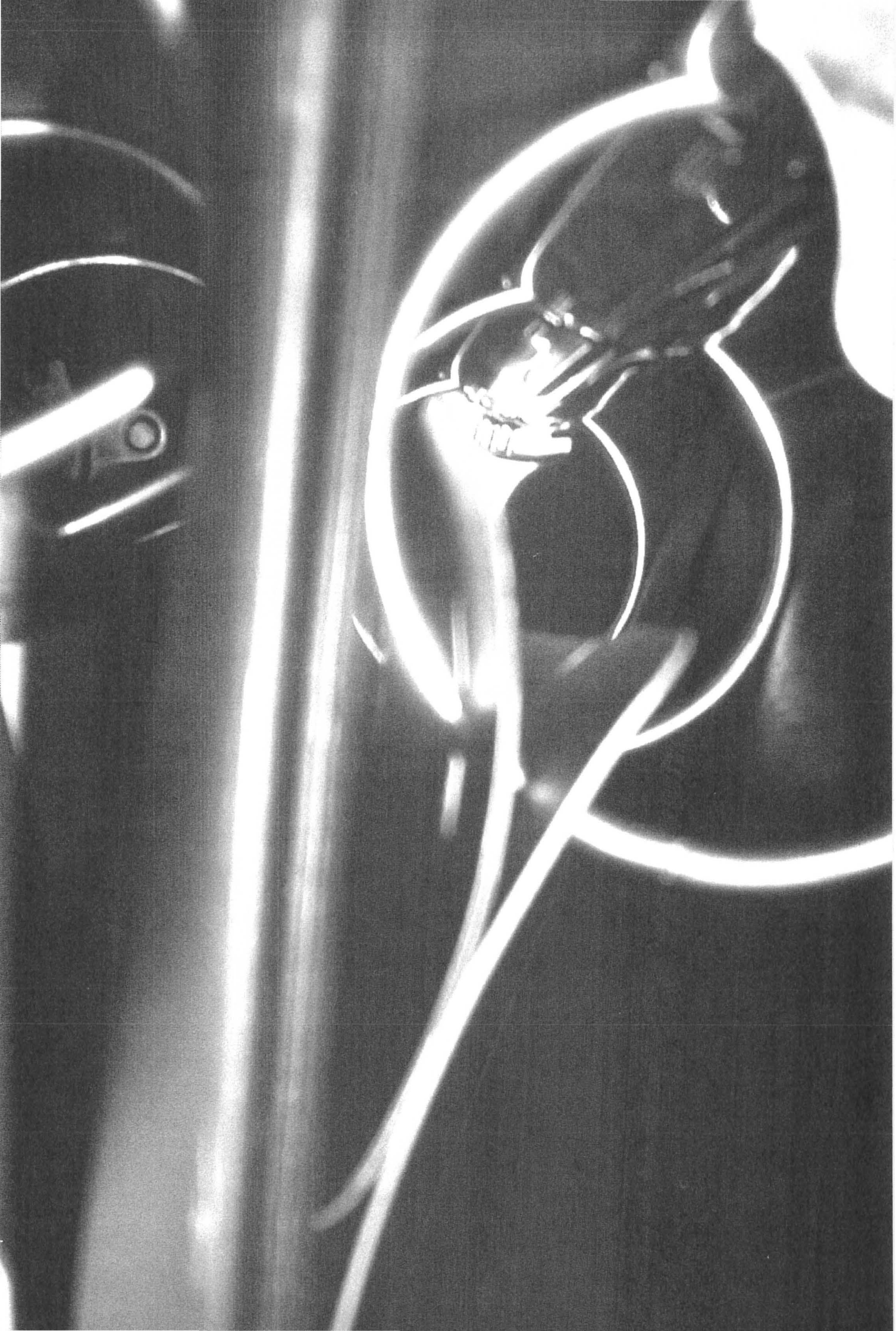
Johnson, Victor S. 1999. *Why We Feel, The Science of Human Emotions*. Reading, MS: Perseus Books.

Poggenpohl, Sharon. 2000. Constructing Knowledge of Design, Part 2: Questions—an approach to design research. In Durling, David et al, editor. *Proceedings of the Conference, Doctoral Education in Design: Foundations for the Future*. Staffordshire, UK: Staffordshire University Press.

Polanyi, Michael. 1983. *The Tacit Dimension*. Gloucester, MA: Peter Smith.

Schön, Donald. 1983. *The Reflective Practitioner*. New York: Basic Books.

Vergano, Dan. 2000. Ancient Writing System gets Internet Update. *USA Today*, May 21.



METHODOLOGY

for Uncovering **MOTION AFFORDANCE**

in Interactive Media

Chujit Jeamsinkul & Sharon Poggenpohl

INTERACTIVE MEDIA allows the user to have control over navigation and interactivity with the information. The nature of interactive media is dynamic and changes through time. To support this dynamic change, knowledge of how to communicate information effficiently beyond static representation needs exploration.

Motion is a key element in interactive environments. Motion helps the user to perceive a change of state. The characteristics and capabilities of motion demonstrate its potential benefit to interaction, but there is very little guidance available regarding when and how to use motion in interactive media.

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Jeamsinkul and Poggenpohl,
254–280

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Though Baecker and Small performed research concerning motion's utility in interface, questions still remain: "How do we design such animation so that they are clear and comprehensible, attractive and appealing? How do we prevent animation from being too complex to be effective? Such questions can be answered only through the extensive development of prototypes and through user testing" (Baecker and Small, 1990). By looking at motion systematically with regard to how users understand it, knowledge of how to use motion effectively in interactive media can be revealed. This paper examines the process of designing an experimental situation in which the meaning of motion can be revealed. Because the experiment was executed, data is analyzed, results are discussed and further developments are identified.

OVERVIEW

INTRODUCTION

Motion is fundamental for survival. Humans perceive and live in motion in space and time. We are creatures with both body and mind: our perception and emotion is bio-basic. Neuroscience is uncovering the physiology of the active mind (Damasio, 1999), resulting in new theories of consciousness and emotion. Western philosophy and linguistics (Lakoff & Johnson, 1999) are reuniting mind and body into a unitary entity that interacts with and interprets the world. "Emotion, as the word indicates, is about movement, about externalized behavior, about certain orchestrations of reactions to a given cause, within a given environment. Emotions are part of the bio-regulatory devices with which we come equipped to survive. That is why Darwin was able to catalog the emotional expressions of so many species and find consistency in those expressions and that is why, in different parts of the world and across different cultures, emotions are so easily recognized. That makes cross-cultural relations possible and that allows for art and literature, music and film, to cross frontiers." (Damasio, 1999) It is from these perspectives that the following work emerges. What we perceive, feel and understand about motion in the real world is emblematic of how we process and interact with information on the screen. Because our perception of motion and its affordances are bio-basic, a common set of motion meaning on screen is plausible to explore.

The focus of this research concentrates on the experimental method to uncover the meaning of motion in terms of how users perceive, feel, understand and respond to various types of motion in interactive media. Types of motion are systematically identified in a motion structure in order to develop a variable framework for creating an experiment to gather information from users. The experiment is designed to capture three types of motion meaning: interpretative meaning, emotional response and motion affordance in interaction functions. Quantitative methods are used to analyze patterns and relationships of motion and its meaning. Two measurement scales; nominal measurement scales and interval measurement scales are applied in this experiment. The nominal measurement takes the form of a checklist. The user chooses one answer from a set of multiple choices. Semantic Differential Scales (Osgood, Suci and Tannen-baum, 1957) are used to measure the emotional meanings users ascribe to a specific type of motion at the interval level. The analysis from these relationships recommends when and how to use motion effectively in interactive media.

The findings of these common meaning dimensions for each discrete motion can generalize to use in many ways depending on what function the motion represents. For instance, designing for a 'warning' and suggesting a cue for 'next' require different degrees of attraction and attention. Psychologically, attracting attention with a degree of annoyance would urge the user to do something more than attracting attention with pleasure, which is better for cueing. This research supports designers' need for effective, comprehensible and natural ways of employing motion to enhance and facilitate the user's activities while navigating through interactive media.

REVIEW OF LITERATURE

Based on the earlier study (Jeamsinkul and Poggenpohl, 2001), five aspects of motion from five disciplines, psychology, neuroscience, film, computer animation and design, are included in this study. Psychological research focuses on motion phenomenon to understand why and how we see motion (Epstein & Sheena, 1995; Gibson, 1979; Hoffman, 1998). Neuroscience research focuses on motion-motor processing to understand what part of the brain or nervous system responds to motion (Berthoz, 2000). Film research focuses on how to convey meaning and elicit viewers' feeling through manipulating time, camera technique, editing technique, lighting and so on (Chandler, 1994). Computer animation research focuses on motion structure at an operational level in order to simulate or imitate real world motion (Owen, 1986; Thalmann, 1985; Ullman, 1979). Existing design research focuses on application and operation of motion in terms of applying knowledge of computer animation to design principles on screen (Sivasankaran and Owen, 1992; Nishimura and Sato, 1985).

Even though, motion has been researched in many areas, knowledge of motion cognition or how humans understand and respond to certain types of motion is not well developed. Questions remain: What is the relationship of motion representation and control structure to motion perception? Do people interpret motion in similar ways? Existing motion research is either very specific or abstract and does not

Motion = Change (event) of Object(s)' Behavior(s) in Space (Environment) through Time

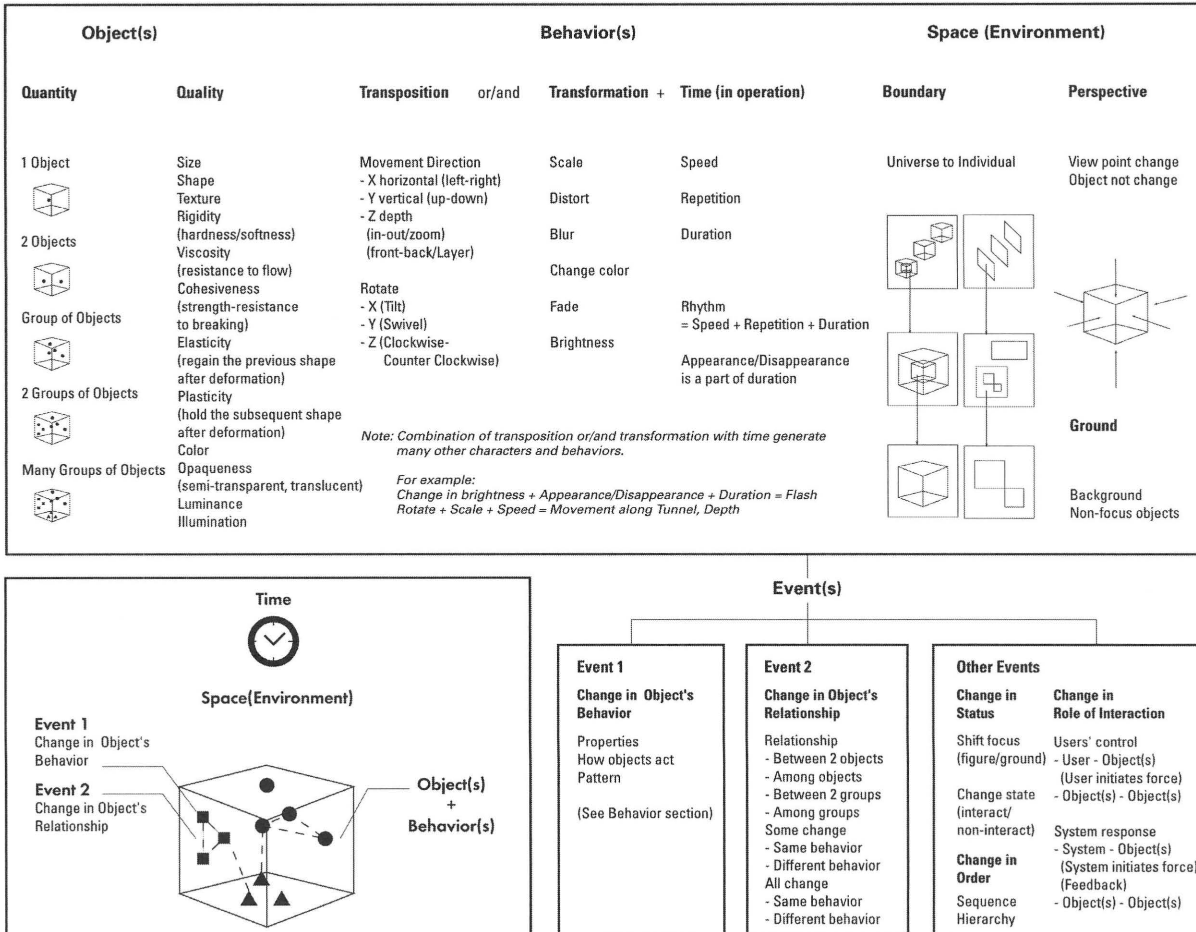

FIGURE 1
Motion Structure

answer the operational questions regarding motion use and interpretation in interactive media that design needs answered.

MOTION STRUCTURE

The Motion Structure (*figure 1*) was generated from analyzing and synthesizing literature related to motion. Motion occurs when there is a change of behavior of object(s) in space through time. Thus, motion on screen is composed of four crucial components: object(s), behavior(s), space and time. These four components generate different types of events as seen in figure 1.

UNDERSTANDING INTERACTION IN INTERACTIVE MEDIA

Interaction occurs in a feedback loop between human and machine. In this research, 'interaction functions' means functions that the system should provide users in order to enhance their efficiency of interaction. Interaction functions derive from various levels and viewpoints in human-computer interaction (HCI). To understand what interaction functions are, user's stages in interacting with the media are analyzed. Donald Norman identified seven stages of action in *The Psychology of Everyday Things*, 1988 as in the following diagram (*figure 2*).

MAPPING BETWEEN MOTION STRUCTURE AND INTERACTION

Basically, these stages could group into three fundamental stages as: Before Executing Action (attraction), Executing Action (engagement) and After Executing Action (extension) as shown in figure 3. To define the function of a specific interaction is to look at what is happening in each state. Attracting attention is the beginning of the process. At this point, the user processes information before acting. Then the user responds to the information by acting. After the user's responses are sent to the machine, the machine sends back user feedback, status and cues. All these behaviors lead to interaction functions as specified in figure 3.

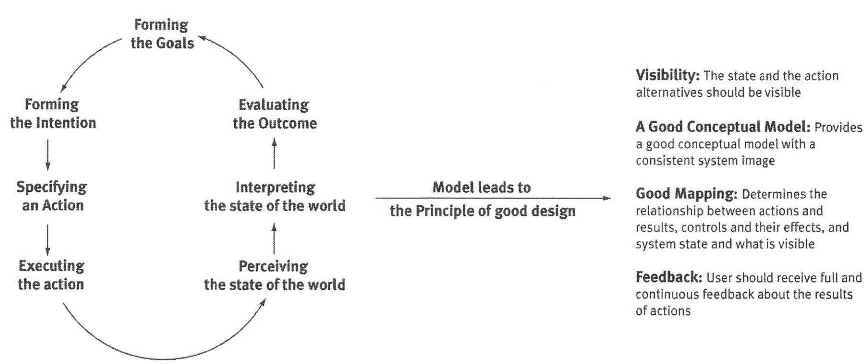

FIGURE 2
Link between user's stages in interacting with media and principle of good interaction design, adapted from Norman, 1988

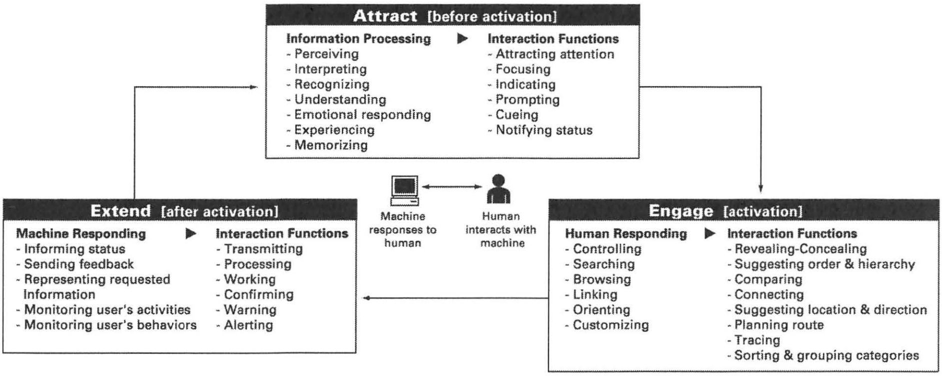

FIGURE 3
Interaction Model
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In figure 3 interaction functions are outlined from a human perspective. The experiment is constructed in order to find the motion meaning that will link the relationship between types of motion and interaction functions. (The experiment is explained in detail later in the methodology section.)

SCOPE OF RESEARCH

RESEARCH GOAL

The object of this research is to analyze the meaning and affordance of motion in interactive media by testing variables of motion as they affect perceivers. Inevitably motion expresses itself through its own language. It is used ubiquitously in a variety of interactive applications, making communication through motion a crucial element to convey meanings in an effective way. Thus, this research generates a methodology for uncovering motion language and identifying motion affordances in interactive media.

RESEARCH QUESTIONS

> What are the affordances of motion in interaction? And what attributes do people associate with them in terms of the effects (meaning) of each type of motion to users?

> Do users have common understandings of motion?

METHODOLOGY

The purpose of this research is to uncover the fundamental meaning of motion and its relationships by understanding how users perceive, feel, understand and respond to various types of motion in interactive media. To accomplish this purpose, the following considerations and procedures were developed with regard to the experimental design. First, the number of motion variables had to be controlled. (Possibilities for 427 motion variable combinations were identified.) After identifying the motion variables for study, the second step was to create the stimuli for them. (The details are described in the later section.) The third step was developing questions. The nature of interaction in interactive media is spontaneous action, response and turn taking. Developing questions that capture the user's intuitive response to motion was crucial. Furthermore, the notion of motion meaning itself has many perspectives and can be descriptive meaning, interpretative meaning, expressive meaning and purposeful meaning. The experiment has multiple questions to capture various notions of meaning. The forth step is developing choices for each question. All choices depend on the nature of motion variables. With all material in hand, the last step was creating the experiment and its instruction as a pre-test, the experiment prototype was tried with small number of participants to identify problems in the experimental design. This also facilitates improvement of questions and choices. (The pilot study of this research was published in the proceedings of Asian Design Conference 2001.) The process of designing this experiment is explained in the following sections.

SELECTING MOTION VARIABLES TO TEST

Motion occurs when there is a change of behavior of object(s) in space through time. Thus, motion on screen is composed of four crucial components: object(s), behavior(s), space and time. By altering variables in these four components, numerous different types of events, depending on which variable combinations are selected (see table 1), can be generated.

Setting up an experiment to test all possible motion events at the same time would be impossibly large. Therefore, this research focuses on the most fundamental motion path by concentrating on motion behavior variables only. Nine types of motion behaviors are presented: 6 from transposition (Move X, Y, Z and

Rotate X, Y, Z) and 3 from transformation (Blur, Brightness and Opacity). Direction is another significant variable that causes motion behavior to signify different meanings. This experiment applies 2 directions to each motion: forward (d1) and backward (d2). Speed is also a very important variable that could alter perceivers' emotional response. Obviously, fast movement may be perceived as more exciting than slow movement. If we incorporate 3 levels of speed (fast, medium and slow) in this experiment, the number of stimuli would be 54 movies (*see table 1 in study #2*).

Study	Object			Behavior Variables[1]				Time Variables			Direction			Motion Movies
	1 object	More than 1 Object	Groups of Objects	1 variable	Mix Variables			Speed	Repetition	Duration	→	←	←→	
					TP+TP	TF+TF	TP+TF							
1	■			■							■	■		18
2	■			■				■			■	■		54
3	■			■					■		■	■		18
4	■			■						■	■	■		54
5	■				■						■			15
6	■				■							■		15
7	■					■					■			3
8	■					■						■		3
9	■						■				■			18
10		■		■							■			9
11		■		■									■	9
12			■	■				■			■			27
...														...

TABLE 1
Overview of Motion Variables

TP = Transposition Move X, Move Y, Rotate X, Rotate Y, Rotate Z

TF = Transformation: Blur, Brightness, Opacity

This considerable amount of stimuli could cause an habituation problem as occurred in the pilot study when participants did the experiment with 36 movies. For this reason, speed requires a future experiment. Therefore in this experiment, time variables, the number of objects and environmental space is fixed. These conditions reduce the stimuli in this experiment to one object and one behavior variable in two directions leading to a total of 18 motion movies for this experiment.

CREATING STIMULI

The stimuli need to be as neutral as possible in terms of color and shape, thus meanings attached to those factors will not interfere with the pure meaning of motion itself. Gray is the appropriate color to apply, as it is a neutral color. The simplicity of abstract forms such as geometric shapes: triangle, circle and square are taken into account. Triangles imply direction, circles in plain gray are not noticeable when rotated in Z direction. Compared to other geometric forms, squares are a good choice for the stimuli, as they are directionless and will deform in space and motion. The stimuli consist of 18 movies created by animating a gray square in a black environment (*see figure 4*). To focus on the meaning of each motion behavior, control of time variables are required for all movies. Every short motion clip has the same speed, one repetition and a 2-second duration.

DEVELOPING QUESTIONS FOR EXPERIMENT

To support the process of uncovering motion meaning, three types of questions are developed. Sensory question, "What is the square doing?" is to capture descriptive and interpretative meaning. Feeling question, "How do you feel about the movie?" is to elicit expressive meaning or emotional responses. Behavioral question, "What activities does the movies remind you of?" is to link to purposeful meaning, in this case interaction functions.

The format for answer for questions could be closed or open. Pilot study results suggested pro and con for both formats. An open answer allows participants to use their own words. This is a direct answer from participants' point of view. However, an open answer causes participants spend a long time thinking about what they should answer, which does not match the research purpose in terms of capturing an immediate intuitive response. Moreover, similar answers need subjective interpretation to determine the level of agreement. On the other hand, a closed answer provides participants with a limited number of choices from which to choose. These choices might not cover every meaning participants have in mind, however, these choices are strongly related to the research objective. This format also does not require a subjective interpretation, consequently it generates a clear degree of agreement.

By using an open question in the pilot study, the answers capture possible choices that might have been ignored. Answers from the pilot study enriched consideration of the final language choices for the closed answers of the primary experiment.

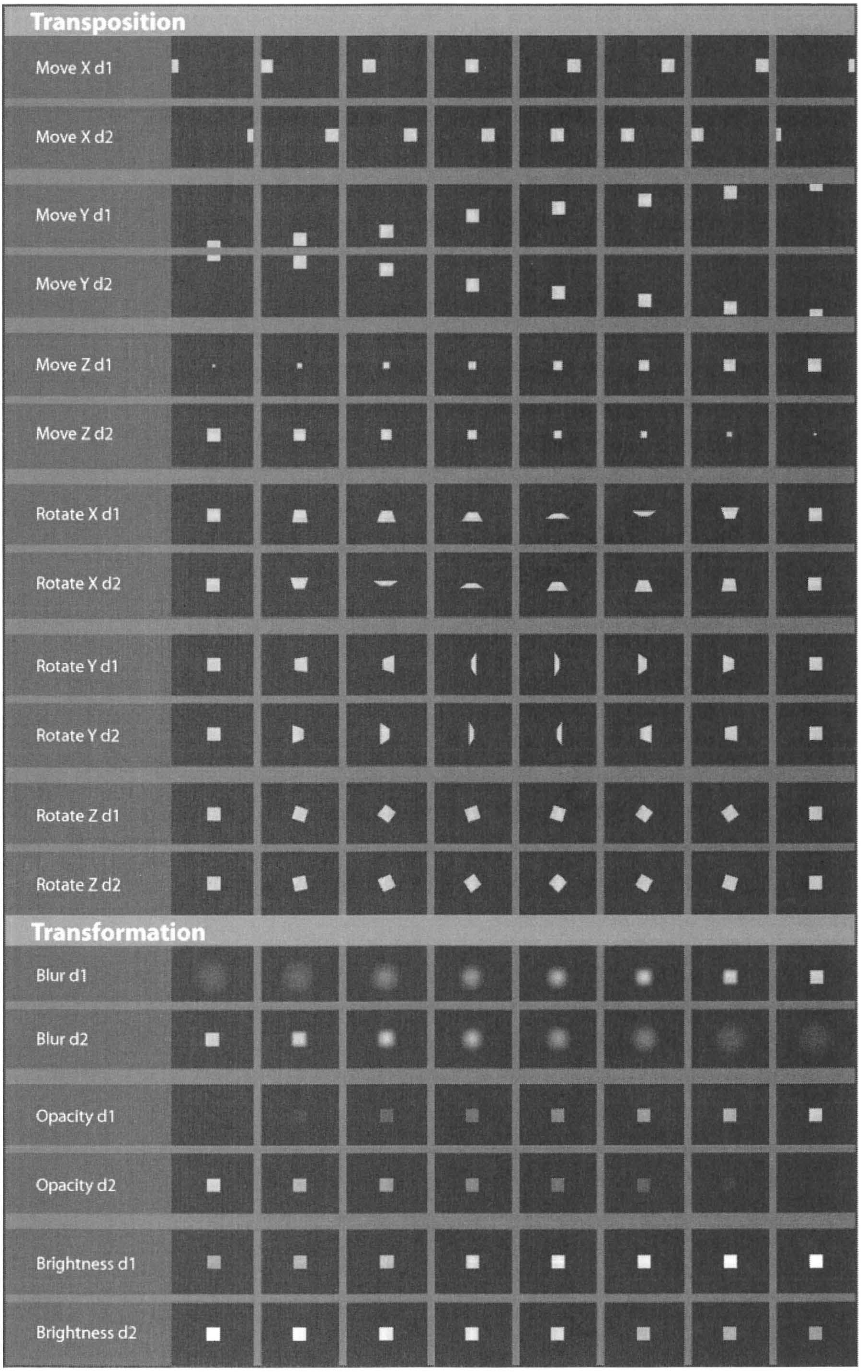


FIGURE 4
Picture sequences of 18 movies

All movies in the experiment need the same answer selection to facilitate comparison. The following diagram (*figure 5*) is an overview of choices for each question. (The process of how to develop answer selection is explained in detail later.)

DEVELOPING CHOICES

Development of choices in question 1

What is the square doing?

In question 1, choices came from analyzing all of the pilot study choices in 30 movies and choices that participants in the pilot study added categorizing in position map as shown in figure 6.

Most of the interpretative choices are more useful than descriptive choices in relation to interaction functions. Moreover those choices are general enough to apply to all movies. Therefore in the primary experiment, the choices are selected from the interpretative side. The potential choices in question 1 are; Advancing, Retracting, Increasing, Decreasing, Forwarding, Reversing, Revealing, Concealing, Focusing, Losing focus, Emphasizing and De-emphasizing.

Development of emotional categories in question 2

How do you feel about the movie?

The diagram in figure 5 presents three types of emotions based on dimensional approaches to emotion (Lang, 1995; Osgood, Suci and Tannenbaum, 1957; Russell and Mehrabian, 1977). **Arousal** and **hedonic valence** are the two most commonly cited emotion dimensions and the third, less frequently used dimension, is **dominance.** The dimension of **autonomic arousal** is characterized by a continuous response ranging from energized, excited and alert to calm, drowsy or peaceful. The **valence** dimension is a continuous range of affective response extending from pleasant or positive valence at one pole, to unpleasant or negative valence at the other (Detenber et al, 1998). These two dimensions, valence and arousal,

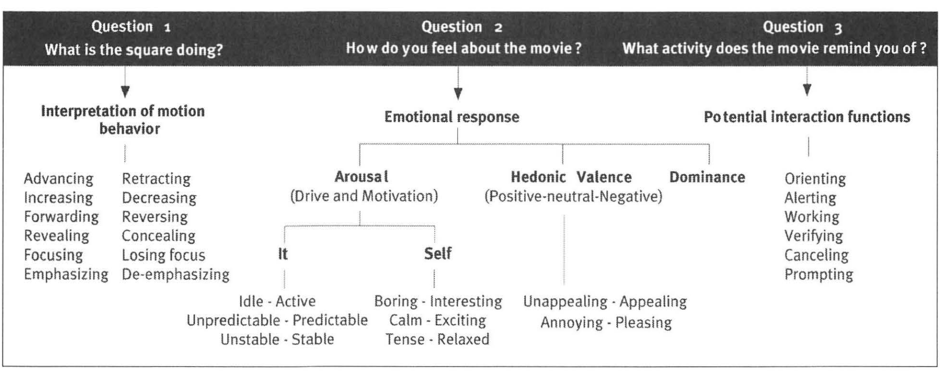


FIGURE 5
Overview of choices for each question

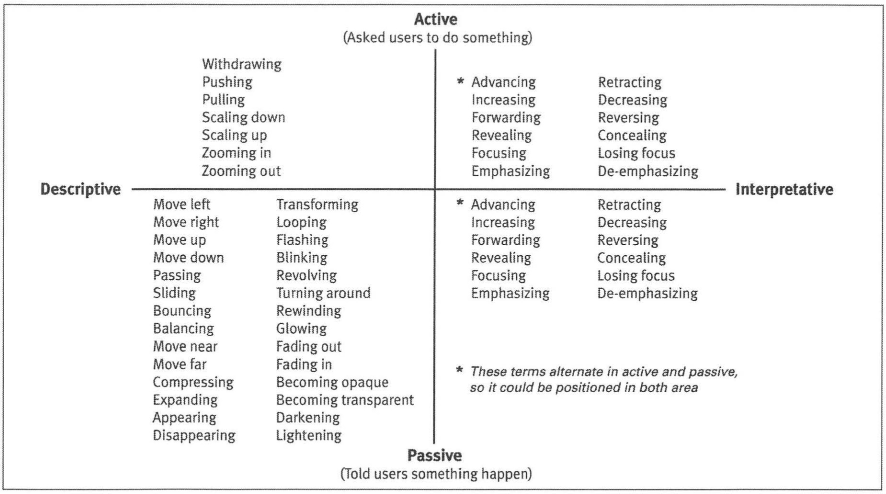


FIGURE 6
Development of answer choice for question 1

account for most of the independent variance in emotional responses (Greenwald, Cook and Lang, 1989), and are the only ones considered in this study (*see figure 6*). Based on the nature of interactive media, which requires users' motivation, this research concentrates mainly on the arousal group. Arousal divides into two viewpoints: it, in this case the motion and self, the viewer. Consequently, the potential emotion categories are Boring-Interesting, Unpredictable-Predictable, Idle-Active, Annoying-Pleasing, Unstable-Stable, Calm-Exciting and Tense-Relaxing. Appealing-Unappealing is not included in this study because it involves subjective judgments. Moreover, these emotions imply an aesthetic value, which this study excludes.

Development of choices in question 3

What activity does the movie remind you of?

The expectation in the Q3's answer is to understand what kinds of interaction function are appropriate for which types of motion and what kind of motions would trigger a user to perform which action. Based on Interaction Model (*figure 3*) three stages of interaction: Before Executing Action, Executing Action and After Executing Action,

FUNDAMENTAL INTERACTION FUNCTIONS (general functions, which are applied to any interaction design)			
PERCEIVING	**PROMPTING/CUEING**	**VERIFYING/CONFIRMING**	**ORIENTING**
Preview Just Looking Focus	Hinting Allow Typing Ahead Show the Format Required	Shield Think Twice	Navigating Spaces List Browser Continuous Filter Automatic Mode Switching The MVC Architecture Contextual Menu Helping Hands (Toggle) Softkeys
WORKING	**CANCELLING**	**ALERTING/ALARMING**	
Identify Progress Show Computer is Thinking	Undo Emergency Exit	Give a Warning	
SPECIFIC INTERACTION FUNCTIONS (specific functions, which depended on content of the project)			
CUSTOMIZING	**SIGNIFYING AREA**	**REPRESENTING AFFORDANCE**	
Preference Managing Favourites Setting Attributes Wizard	Command Area Container Navigation Grid Layout	Like in the Real World... Change Mode Cursor Unambiguous Format Magnetism	

TABLE 2
Interaction Function Analysis

interaction functions can be identified in detail by looking at the available guidelines for interactive media such as hypertext system and software interface (Nielsen, 2000; Welie and Traetteberg, 2000; The Usability Group, 2001). Selected guidelines are categorized and the groups are named as interaction functions (*see table 2*).

In this experiment, the focus is on the fundamental interaction functions because these can generalize and apply to any kind of interaction design. The final list for the interaction function choices are Orienting, Alerting, Working, Verifying, Canceling and Prompting.

CREATING EXPERIMENTAL PROTOTYPE

When all stimuli, experimental questions and supported choices are prepared, integrating and representing them to study participants is an essential step. Four main issues are: media selection, instruction for the experiment as a tutorial, order of stimuli (movies) and questions and method of capturing answers.

The result from this experiment will be used to generate motion knowledge for interactive media on screen, therefore setting up an experiment on a computer is appropriate. This research is a quantitative experiment. Collecting quantitative data requires many participants to produce stable results. Thus the prototype contains an integral tutorial requiring no supervision. The tutorial is interactive allowing the participant to become accustomed to the experimental process before answering the actual questions. Furthermore, the description in the tutorial provides the same information to every participant.

The order of the movies can affect the answers, because the participant might see relationships between movies when they are similar and in proximity. All movies are random ordered based on three rules: 1) no consecutive movie has the same motion behavior, even if it has a different direction; 2) the same direction of movement cannot follow each other; and 3) movies alternate with regard to type of movement, rotation and transformation. Interpretative meaning choices are considered as a sub-function of the interaction function choices. To avoid creating a relationship among answers, the emotional response question is segregated.

Coding script in Director plays a considerable role in making possible automatic capture of all answers to text files while the experiment is in progress. These files are ready to import to an analysis program such as Excel and SPSS. Auto capture reduces the time between experiment and analysis and removes errors in manual entry of data.

RESEARCH PARTICIPANTS

One hundred participants from 16 countries participated in this experiment. Participant background was diverse with 42 Thais, 31 Americans, 5 Indians, 3 Chinese, 3 Indonesians, 3 Mexicans, 2 Brazilians, 2 Japanese, 2 Koreans, 1 Taiwan, 1 Canadian, 1 Columbian, 1 Pakistanis, 1 Hungarian, 1 Swiss and 1 Turk. Distribution of gender is in the proportion of female 61 and male 39. The age range of participants was from 15 to 55 years with the majority between 21–30 years. More than half the participants had much experience with computers (more than 5 years).

EXPERIMENTAL PROCEDURE

Participants are provided with an interactive tutorial with a voice over describing all procedures step-by-step. This tutorial serves as a practice before the real experiment. It also requires the completion of a demographic survey (*see figure 7*) in the first page before advancing to the experiment section. The experiment asks individuals to watch a set of movies and answer questions. The entire experiment runs seamlessly

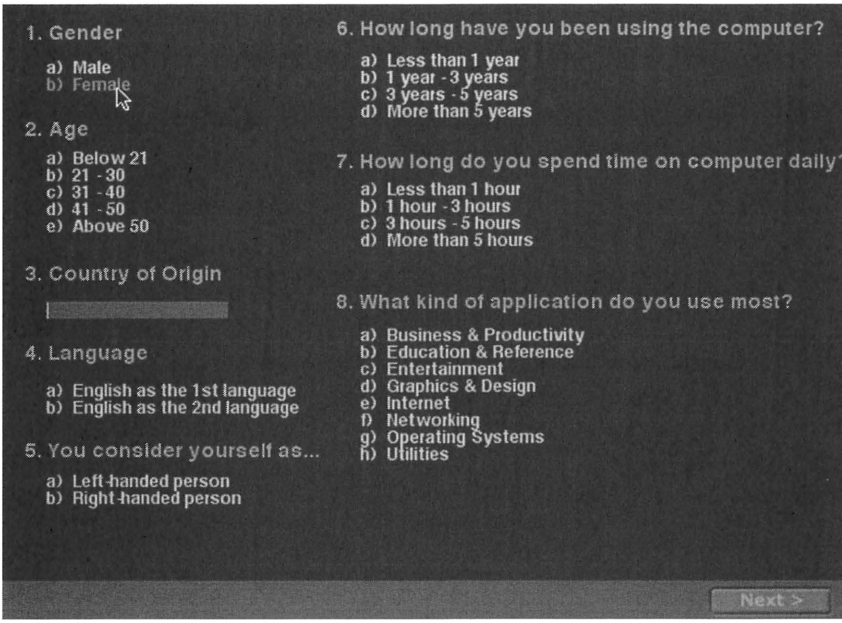


FIGURE 7
Demographic data collection

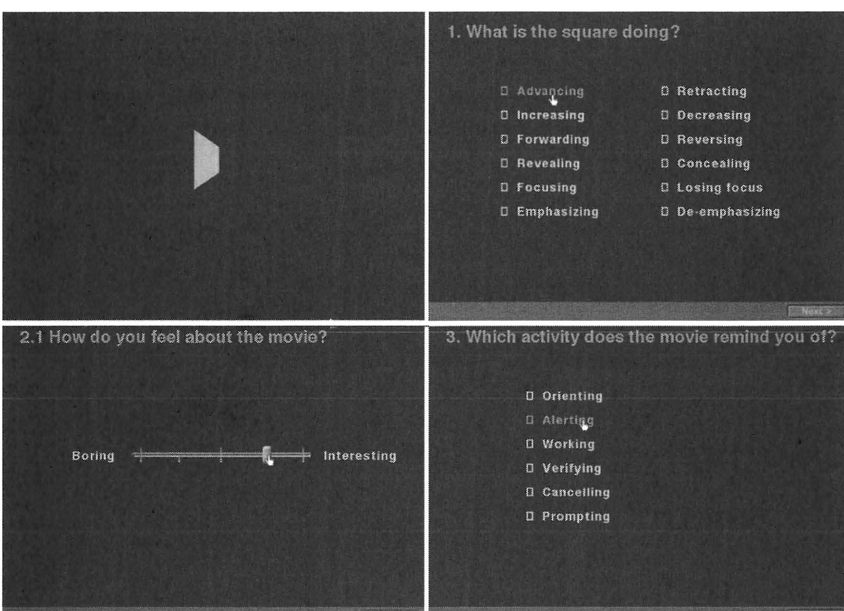


FIGURE 8
Experiment format

on a laptop computer. Each movie lasts 2 seconds. After each movie, subjects are asked to select one answer from 12 choices in the first question, rate their emotional response to the movie just seen and select one answer from 6 choices in the last question (see *figure 8*). Subject's answers are captured directly to the computer. The entire experiment lasts between 15 to 20 minutes.

RESULTS AND ANALYSIS

METHODS OF ANALYZING AND SYNTHESIZING DATA

To analyze quantitative data, two types of statistical data analysis are possible: Descriptive and Inferential. Both are used.

Descriptive statistical data analysis summarizes an entire set of quantitative data, which describe the results from participants from the following perspectives:

> Which movies have high agreement and low agreement in interpretative meaning, emotional response and interaction function

> What are the similarities and differences among motion types

> Which movies represent which choices most (in both meanings and functions)

> Which movie has the most extreme emotional response in either a positive or negative way

Inferential statistical data analysis examines how likely difference is between groups and relationships between variables occurring by chance, which interpret results in the following inquiry:

> Do culture, professional training such as designer/non-designer, computer experience, gender and age range influence the way participants respond to the meaning, emotion and function of motions?

DESCRIPTIVE STATISTICAL DATA ANALYSIS

There are two types of levels of measurement in the experimental results. The first is a nominal scale, which is derived from the participants' answers selected from multiple-choices in question 1: interpretative meanings and question 3: Interaction functions. All answers in question 1 and 3 were plotted into a matrix to analyze their pattern and the relationship among movies and choices. The second is an interval scale, which is derived from rating the semantic differential scale of emotional response categories. The mean of each emotional response category in each movie was plotted into semantic differential profiles to compare patterns among direction and motion types. The details follow.

Matrix Analysis of All Movies with All Choices

From the experiment with 18 movies, a total of 43 bar graphs was generated. Thirty-six bar graphs (not shown): each set of 18 graphs from question 1 and question 3 display frequency counts for each choice. The answers for question 2 (emotional response) are analyzed in 7 categories: Boring-Interesting, Unpredictable-Predictable, Idle-Active, Annoying-Pleasing, Unstable-Stable, Calm-Exciting and Tense-Relaxing in a scale from -2 to 2. Zero represents a neutral response with -2 and 2 the extreme emotional responses. Rating scales in Q2 were translated into frequency counts and combine scale -2 and -1 together as well as combine scale 1 and 2. Then the numbers with the highest percentage of each selected choice were brought together and plotted in the matrix (*see table 3*) to analyze patterns and relationships of motion types and their meanings, emotional responses and functions.

From the results in all questions, the high numbers of frequently selected choices were plotted in the matrix (*see table 3*).

Insight from Matrix Analysis

The levels of high agreement throughout the 3 questions vary. For instance, blur in both direction 1 and direction 2 have the highest agreement in interpretative meaning, while opacity d2 has the highest agreement in interaction function. Emotional response generates significantly high agreement when compared with interpretative meanings and interaction functions.

TABLE 3
Matrix comparison of motion movies to meaning

Interpretative Meanings

	Advance	Retract	Increase	Decrease	Forward	Reverse	Reveal	Conceal	Focusing	Losing focus	Emphasizing	De-emphasizing
Move X d1	31				44							
Move X d2		23				40						
Move Y d1	26		33									
Move Y d2				50								
Move Z d1	29		26									
Move Z d2		40		27								
Rotate X d1						34	20					
Rotate X d2	16				19	19	17					
Rotate Yd1					16	23	26					
Rotate Y d2					11	38	20					
Rotate Z d1	17				23				17		24	
Rotate Z d2						33			20		20	
Blur d1									63			
Blur d2										63		
Opacity d1							38		19		18	
Opacity d2								17		20		29
Brightness d1							18		24		38	
Brightness d2										17		42

Interaction Functions

	Orienting	Alerting	Working	Verifying	Canceling	Prompting
Move X d1	36		40			
Move X d2	32				29	
Move Y d1	35		33			
Move Y d2	31		20		27	
Move Z d1	20	25	21			20
Move Z d2					68	
Rotate X d1	16	18	34			
Rotate X d2	18	26	31			
Rotate Yd1	11	32	37			
Rotate Y d2	15	24	34			
Rotate Z d1	15	19	43			
Rotate Z d2	16	19	39			
Blur d1	16	26		26		15
Blur d2					61	
Opacity d1		21		25		29
Opacity d2					75	
Brightness d1		19		40		20
Brightness d2					47	

Emotional Responses

	Boring	Interesting	Unpredictable	Predictable	Idle	Active	Annoying	Pleasing	Unstable	Stable	Calm	Exciting	Tense	Relaxing
Move X d1				67		80		60						
Move X d2				60										
Move Y d1						79								
Move Y d2														
Move Z d1		74		66		75		57		58				
Move Z d2				60					36					
Rotate X d1		76				81	23					63	40	
Rotate X d2						84	23		45			62	41	
Rotate Yd1						88			39			61	34	
Rotate Y d2						75			39			61	38	
Rotate Z d1						76						56		
Rotate Z d2						76								
Blur d1		86						70		54		56		46
Blur d2		76	58				25		57					50
Opacity d1					27					58	42			
Opacity d2					35				37		53			65
Brightness d1	30				34					61	50			
Brightness d2	27		51		35		26		34		49			43

Represent highest agreement % of each motion related to each meaning

Represent highest agreement % of both meaning and motion

Total Participants = 100

The following table (*table 4*) demonstrates some insights from analyzing the pattern in the matrix (*table 3*). Characteristics of motion pattern can be divided into three groups by similarity: transposition in movement, transposition in rotation and transformation. Each motion group has its own strong area of meaning, emotional response and interaction function. For instance, transposition in movement supports an orienting function best because it also signifies the direction in interpretative meaning, whereas transposition in rotation supports working function better. Alerting function can apply to both rotatation and transformation depending on the degree of intensity. Rotation motions are more tense and exciting than transformation motions, hence rotation could serve as a warning and high alert whereas transformation would serve better for cueing.

Semantic Differential Analysis

Because the answer for emotional response is in the format of semantic differential scales, semantic differential profile analysis is applied for detail analysis regarding how similar or different participants' responses to motion types are. To analyze emotional response relationships in detail, the means of the highest number of subjects using a particular scale were plotted into semantic differential profiles (*see figure 9*). Not only can this type of profile be used for comparing how participants respond to each motion type, but it also expresses how direction effects motion behaviors.

Insight from Semantic Differential Analysis

Comparing these semantic differential profiles in all motion types and directions illustrate their similarity and difference pattern as described in the table 5. Two types of relationship between direction 1 and direction 2 and between motion types have been analyzed. Changing direction effects how participants respond to emotion in

	Insight from Analysis Interpretative Meaning [Q1]	Insight from Analysis Emotional Response [Q2]	Insight from Analysis Interaction Function [Q3]
Transposition: **Move X** **Move Y** **Move Z**	In move X, Y, and Z, direction1 most have the opposite meaning with direction2. For instance, move X is more explicit in forward-reverse but for increase-decrease move Y is better. Move Z represents in advancing and retracting best.	Most of move X, Y, Z motions are active and predictable.	Move X, Y, Z in both directions are good for orienting and working. Move Z d1 shares both transposition and transformation qualities. Beside orienting and working, move Z d1 also suggests alerting and prompting as transformation.
Transposition: **Rotate X** **Rotate Y** **Rotate Z**	Most participants did not recognize the direction of rotation. 3 choices: forward, reverse, and reveal have been selected extensively in rotate X and Y regardless of direction. Some rotatation movies such as rotate X d2 has the highest selection rate in both forward and reverse. Rotate Z has additional meaning beside forward-reverse in terms of focusing and emphasizing in both direction.	Rotation motions mostly elicit exciting and tense feeling.	Most of rotatation movements are good for working and alerting. The best one for working is rotate Z d1. Rotate Y d1 has also high agreement in alerting!
Transformation: **Blur** **Opacity** **Brightness**	In transformation, 3 meaning: reveal-conceal, focusing-losing focus, and emphasizing-de-emphasizing have been selected most. There is more strength in one than another such that brightness is better for emphasizing-de-emphasizing than opacity which is good for revealing-concealing. Blur has the highest agreement in all movies for focusing-losing focus.	Most of transformation motions especially d2 are more idle, calm, and relaxed. Blur in both direction is most interesting.	Interaction functions that transformation suggests most are verifying, prompting, and alerting. Opacity has high agreement in prompting. For verifying brightness and blur are high selected respectively. Blur is also good for alerting.
Note 1		Active goes along with working	Beside rotatation motions, d2 of the rest of the motion types are high agreement in canceling function.

TABLE 4
Example summary insights from analysis

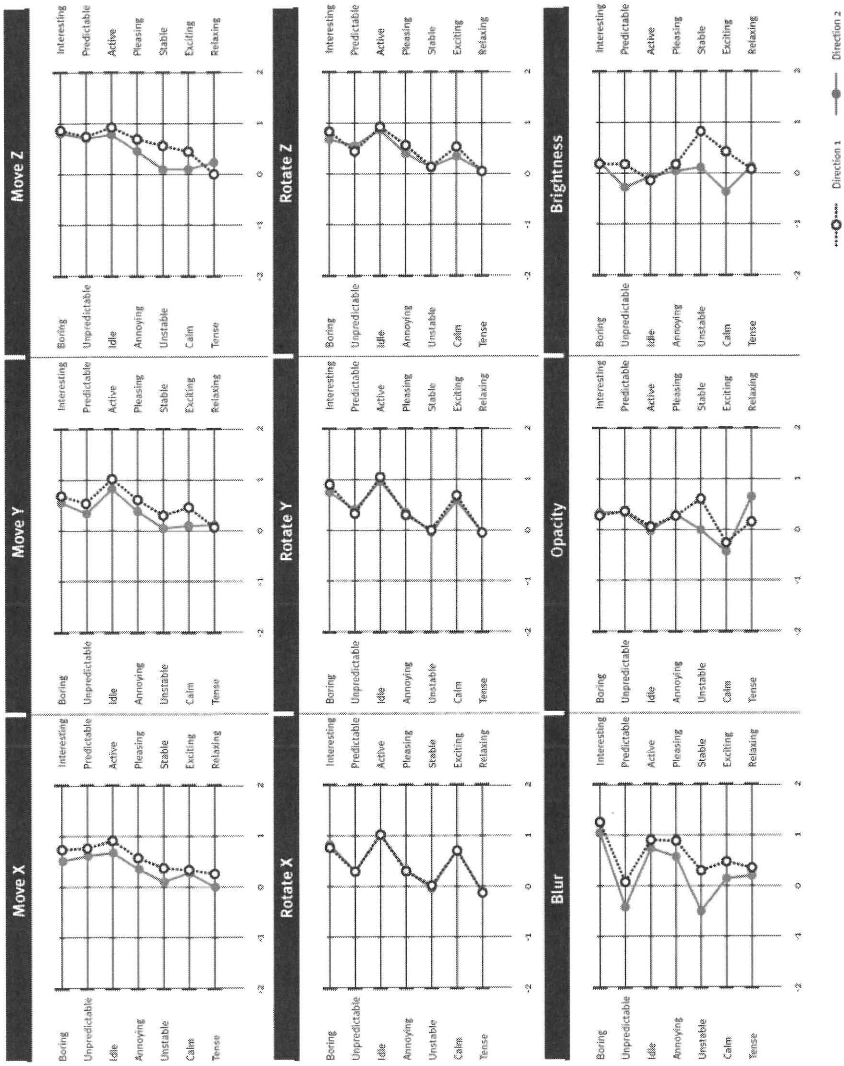


FIGURE 9
Semantic Differential Profile of Transposition: Move X, Y and Z, Rotate X, Y and Z and Transformation in direction 1 and direction 2

	Insight from Analysis Emotional Response Pattern between d1 & d2	Same	Similar	Different
Move X	Patterns are very similar in terms of quite interesting, predictable, pleasing, and active but d1 is more stable and relax than d2		•	
Move Y	Patterns are similar in the first 4 emotional categories. D1 is more stable and exciting than d2		•	
Move Z	Patterns are similar in the first 4 emotional categories. D1 is more stable and exciting than d2		•	
Rotate X	Patterns are the same	•		
Rotate Y	Patterns are the same	•		
Rotate Z	Patterns are similar except d1 has more pleasing and exciting than d2		•	
Blur	Patterns are similar except d2 has more unpredictable and more unstable than d1		•	
Opacity	Patterns are similar except d1 has more stable and d2 is more relaxing		•	
Brightness	Patterns are very different especially in d1 is more stable and exciting than d2			•
Note 1	*Emotional categories that essentially effected by direction are unstable-stable, calm-exciting, and tense-relaxing.*			

	Insight from Analysis Emotional Response Pattern between Motion Types	Same	Similar	Different
Brightness & Opacity	Even though many participants said that they did not recognize the difference between those two motion types, the result of emotion response showns that brightness d1 is more stable and more exciting than opacity d1. Opacity d2 is more pleasing, calm, and relaxing than brightness d2.			•
Among Rotation	There is no difference in emotional response in cases of rotatation regardless of axis and direction except rotate Z d1 which is more pleasing and exciting than d2	•		• Z

TABLE 5
Example insights from emotional response analysis

transformation but there is little effect on rotation. This also is confirmed by verbal report from some participants; they did not recognize the difference between rotation in direction 1 and rotation in direction 2.

INFERENTIAL STATISTICAL DATA ANALYSIS

Going beyond descriptions of the data, data was analyzed to examine whether participants' demographic factors, for example culture, professional training (e.g., designer/non-designer), gender and age range, influence the way they answer questions. All data was recoded into SPSS analysis program. The results are summarized in four categories: Western-Eastern, Designer-Non-designer, Male-Female and five ranges of age.

The analysis of results in question 1: interpretative meanings and question 3: interaction function are different, based on demographic factors as follows:

IN CULTURE: western-eastern, the analysis of results demonstrates that participants in eastern culture interpret and understand motion differently from western culture. Looking closely in each motion type, there is high agreement regardless of culture in transformation motions but for transposition western and eastern participants tend to respond differently.

IN PROFESSIONAL TRAINING: designers-non-designers, the analysis of results demonstrates that designers interpret and understand motion differently than non-designers, especially in move Z. Again there is no differentiation of responses in transformation motions between those two groups.

IN GENDER AND AGE: the analysis shows much higher agreement than those of culture and professional training. There is almost no differentiation of response between male and female in interpreting and understanding motion.

The analysis in the emotional response categories has much higher agreement than the answers in interpretative meaning and interaction function, especially in the first 4 categories: Boring-Interesting, Unpredictable-Predictable, Idle-Active and Annoying-Pleasing. There is almost no significant difference in how western and eastern participants feel about motion.

APPLYING FINDINGS

Insights from the analysis provide beneficial guidelines for both designers who would like to use motion more effectively and researchers who are interested in building motion language.

For designers, a Motion Library will be generated by integrating the results and analysis from all three answers: interaction function, interpretative meanings as sub-functions and emotional responses. The Motion Library serves as a resource for linking fundamental knowledge of motion, created by experiment, to how designers can apply that knowledge in practice. Not only does the Motion Library comprise the meaning of each motion type represented, it also includes the patterns and relationships among them. This library helps designers to narrow down and select appropriate motions to apply to an interaction function, based on understanding how users respond to each type of motion. The Motion Library also applies FEM

(Function-Emotion-Motion) framework (*figure 10 below*). FEM framework is the logic behind the process of how to use the Motion Library. One interaction function can be represented by several alternative motions. To select an appropriate motion, designers need to consider what interaction function and type of emotional response they need. Then match one or more emotional responses that are associated with the particular interaction function to obtain possible motions (*see figure 10*). The motion possibilities are selected from the motion library, determined from experimental results. In practical application of this work, the ensemble of interaction functions needed and their contrasting behaviors and possible motion representations enter into the selection and planning of interactive signals.

For researchers, the methodology of how to set up an experiment to explore more motion variables has been explained throughout the methodology section. Researchers can use Mix and Match Motion Variables Framework (*table 1*) as the foundation to set up the scope of their experiment. Sharing results and analysis in future experiments can expand the motion library and fill out the motion language.

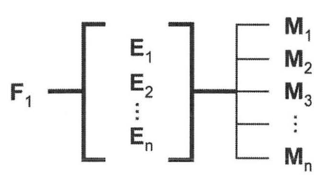
DISCUSSION AND FURTHER DEVELOPMENTS

The three main contributions of this research are: the establishment of a motion structure as a systematic foundation for exploring motion meanings and their affordances, the methodology of developing a motion experiment and examples of how knowledge from this type of research can be applied to design practice.

The motion structure is generated from analyzing and synthesizing reviews of literature related to motion. It provides a systematic approach for integrating

FIGURE 10
FEM (Function-Emotion-Motion) Framework and sample application

FEM framework:
Matching Interaction Functions and emotional responses to Motions



E_1, E_2, ..., E_n are a set of emotional responses that F_1 (an Interaction Function + a Sub function) should consider. M_1,M_2, ..., M_n are motions corresponding to the same set of interaction function and emotional responses. Matching possible motions requires insights from matrix pattern (e.g. table x.x).

Interaction Functions (F)		Emotional Response (E)	Motion Possibilities (M)	
Orienting	Advancing	Active Predictable	Move X d1	Move Z d1
	Retracting	Predictable	Move Y d2	
	Increasing	Active	Move Y d1	Move Z d1
	Decreasing	Predictable	Move Y d2	
	Forwarding	Active Exciting	Rotate Z d1	
	Reversing	Predictable	Move X d2	
Alerting	Revealing	Active Tense	Rotate X d1 Rotate X d2	Rotate Y d1 Rotate Y d2
	Focusing	Interesting Pleasing	Blur d1	
	Emphasizing	Calm Stable	Brightness d1	Opacity d1
Canceling	Concealing	Calm Relax	Opacity d2	
	Losing focus	Interesting Unpredictable	Blur d2	
	De-emphasize	Idle Relax	Brightness d2	Opacity d2

all motion variables. This motion structure is a foundation for the Mix and Match Motion Variable framework (*table 1*). After setting the scope for motion variable investigation from the motion framework, the experimental research begins.

One of the most critical processes in developing the experiment is developing choices for interpretative meaning in question 1 and interaction function in question 3. All choices in question 1 should have the same level of interpretation. In this experiment, the descriptive level was not applied. Interaction function choices depend on the nature of the selected set of motion variables. For instance, if researchers are interested in the relationship of motion between 2 objects in the same space, comparing function could be one of the choices. For future experiments, choices might require modification in order to be suitable for a particular motion variable set. The pilot study is an essential step to verify whether the choices provided cover all possibilities of interpretative meaning and interaction function.

From high-low agreement in matrix analysis and significant difference testing, the result demonstrates that emotional responses tend to be universal. On the other hand, culture and professional training affect the way individuals interpret motion, especially in transposition motion. Focusing on only the emotional dimension could allow us to acquire a global meaning of motion in terms of emotional response. For interpretative meanings and functions, constraining the demographic group, especially by culture and professional training, would lead to results more specifically useful for particular groups.

This research is a starting point for motion for interactive media. The research intention is to establish a research system that can be built on. Completing the Motion Library requires a great number of experiments. The possibilities are immense as shown in table 1. Analysis of results of motion variable relationships among cooperative experiments can contribute deeper understanding of motion language. This research identified reasonable methodology to obtain the motion pattern and demonstrate that meaning and qualitative attributes are not beyond serious study. The development and results can feedback to practice. This knowledge can assist designers in understanding a language of motion leading to its more effective use.

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References

Badler, Norman L. and John K. Tsotsos. 1983. *Motion: Representation and Perception*. ACM SIGGRAPH/SIGART, New York, North-Holland.

Baecker, Ronald and Ian Small. 1990. *Animation at the Interface, The Art of Human-Computer Interface Design*. New York: Addison Wesley Longman, Inc., 251–267.

Chandler, Daniel. 1994. *The 'Grammar' of TV and film*, http://users.aber.ac.uk/dgc/gramtv.html

Damasio, Antonio. 1999. *The Feeling of What Happens: Body and Emotion in the Making of Consciousness*. New York: Harcourt, Inc., 50–71.

Detenber, B.H., R.F. Simons and G.G. Bennett. 1998. Roll 'Em: The effects of picture motion on emotional responses. *Journal of Broadcasting and Electronic Media*, 42, 112–126.

Epstein, William and Sheena J. Rogers, editors. 1995. *Perception of Space and Motion*. San Diego: Academic Press.

Gibson, James J. 1979. *The Ecological Approach to Visual Perception*. New Jersey: Lawrence Erlbaum Associates, Inc.

Hoffman, Donald D. 1998. *Visual Intelligence: How we create what we see*. New York: W.W. Norton and Company.

Jeamsinkul, Chujit and Sharon Poggenpohl. 2001. *Motion Language for Interactive Media: Developing an Experiment to Uncover Common Meanings of Motion*. The Proceedings of the 5th Asian Design Conference: International Symposium on Design Science, 2001.

Lakoff, George and Mark Johnson. 1999. *Philosophy in the Flesh, The Embodied Mind and Its Challenge to Western Thought*. New York: Basic Books.

Nielsen, Jacob. 2000. *Designing Web Usability*. Indianapolis, IN: New Riders Publishing.

Nishimura, Yoshiki and Keiichi Sato. Dynamic Information Display. *Visible Language*, 19.2.

Norman, Donald A. 1988. *The Psychology of Everyday Things*. New York: Basic Books.

Osgood, C., G. Suci, G., P. Tannenbaum. 1957. *The Measurement of Meaning*. Urbana, IL: University of Illinois Press.

Owen, Charles L. 1986. *Computer-Supported Design: The Integration of Design Methods and Graphic Processes*. Nicograph.

Sivasankaran, Vijay K. and Charles L. Owen. 1992. Data Exploration: Transposition Operations in Dynamic Diagrams. *Visible Language*, 26.3&4.

Thalmann, Nadia and Daniel Magnenat. 1985. *Computer Animation: Theory and Practice*. New York: Springer-Verlag.

Ullman, Shimon. 1979. *Interpretation of Visual Motion*. Cambridge, The MIT Press.

The Usability Group. 2001. *Usability Pattern Collection*. Brighton, UK: the University of Brighton, http://www.it.brighton.ac.uk/cil/usability/patterns/Index.html, (access on 9/2/01)

Welie, Martijn van and Hallvard Traetteberg. 2000. *Interaction Patterns in User Interface*, 7th Pattern Language of Program Conference (PLoP 2000).

Methods for Manipulating **Electronic Documents** in Relation to Information Retrieval

María González de Cosío and Mary C. Dyson

This study
is part of
preliminary work
aiming to find out
which graphic elements
help users navigate
in electronic information space.

The study explores
alternative methods
that can be used
to manipulate the content
of web pages,
looking at their effects
on finding
specific material
and acquiring
an understanding
of the content.

Four versions of an extract from a Human Computer Interaction (HCI) textbook were created:

a scrolling document

a document with links

a paging document

a document with frames

A series of tasks was carried out by two different groups of readers. Readers within each group were divided between the four versions of the document, with each reader reading only one version. Readers were asked to find information; read a text; answer a question; write a synopsis. Measures were taken of speed to locate information, comprehension of an issue and comprehension and memory of the text read.

The results indicated that the paging document and document with links enabled readers to find information more quickly. There were no differences among versions in the time taken to read the text, but second semester students read faster than seventh semester.

The methods of manipulating electronic documents offer advantages and disadvantages depending on the purpose of the text and the readers' tasks. It seems that if readers wish to find information quickly from an electronic document, the method of manipulating the document should be different from that applied to a large document which needs to be remembered.

University of Reading
Visible Language 36.3
De Cosío and Dyson, 282–306

INTRODUCTION

Electronic documents have become an indispensable tool for almost all facets of everyday life. Readers of electronic documents can perform a variety of activities using the computer: read, search for information, buy, subscribe, communicate, answer questions, place orders, etc. Regardless of their tasks, readers have to search, read and make decisions.

Up to now, there exists little information on how readers are supported by the design of electronic documents. Web designers are guided by intuitive notions without knowing which elements can support readers and which other elements interfere with their interaction with computers.

The development of "theories of scope" or frameworks that can predict how some design features can work in specific circumstances would support design decisions for better documents (Wright, 1998). This study attempts to find out how methods of manipulation affect readers' performance in searching for information in hypertext.

READERS' PROBLEMS WHEN INTERACTING WITH ELECTRONIC DOCUMENTS

Navigation has been one of the problems in readers' interaction with electronic documents. The main concern is how readers adjust to technology when they are looking for information. Some of these adjustments are described below.

1) Readers have to learn a new language and new methods of manipulation and interaction with electronic documents:

> Readers have to learn the basic vocabulary to perform any task, such as 'download, browse, bookmark, link,' etc., and have to learn a new graphic language of icons displayed on the screen (Honeywell, 2000; Goonetilleke, 2001). Some readers may also have to learn these new terms in a foreign language as they have no meaning in their own language.

> Readers have to learn basic technical manipulations to navigate, such as the use of back-forward buttons, horizontal and vertical scroll, paging, links or frames, download time, history list, etc. (Schwarz, Beldie and Pastoor, 1983; Dyson and Kipping, 1997; van Nimwegen, Pouw and van Oostendorp, 1999).

2) Readers are presented with new ways of displaying information:

> Readers find a variety of images, text, links, buttons, sound, elements in motion; they face a new medium and new appearance not known in print.

> Readers have difficulty in recognizing the type of document they are accessing, in terms of size, form, contents, depth, interactivity, etc. The layout of most documents does not give any feedback as to whether readers are accessing the information they are looking for or not (Dillon and Gushrowski, 2000; Beghtol, 2001; Kwasnik, Crowston, Nilan and Roussinov, 2001; Toms, 2001).

3) Readers have to learn a new concept of movement in electronic space:

> Readers are afraid of getting lost, of not knowing where they are located, where they have been and where they are aiming for. They might be afraid of taking the wrong route and losing their present position or not finding their way back (Edwards and Hardman, 1989; Nielsen, 1990; Kim and Hirtle, 1995; Dillon and Vaughan, 1997; Allinson and Hammond, 1999; Otter and Johnson, 2000; Ahuja and Webster, 2001).

> Readers want to navigate fast and perform their task in the shortest possible time.

4) Readers have to cope with different cognitive demands from electronic documents:

- Readers have to understand the different structure of information in electronic documents, which consists of nodes of information connected in a non-linear pattern. Readers have to decide which path to take from the broad range of possibilities offered (On links: DeRose, 1989; Campbell and Maglio, 1999; Pajares, 2000. On structure: van Nimwegen et al, 1999; Gullikson et al, 1999).

- Readers are afraid of losing the 'thread of investigation' because they can be easily distracted in their search for information ending in an unexpected topic (Conklin, 1987; Kim and Hirtle, 1995).

- Readers could be overwhelmed by the amount of information presented when they find thousands of possible links that contain information in a search machine; they do not know which site to access. There is always the uncertainty that their information might exist in the links not accessed (Wurman, 1989; Nielsen, 1990; Boiarski, 1997).

These are some of the situations that readers have to face when learning to access electronic documents. In this study, we will focus on the method of manipulation, which is one of the basic interactions of readers with this technology.

METHODS OF MANIPULATING DOCUMENTS

One of the first challenges for users of electronic documents is how to manipulate the pages on the screen. Two basic methods have been addressed: scrolling and paging. There have been few studies regarding these issues that can shed some light on how readers perform with each method of manipulation. Two other methods will also be presented in this study: frames and links.

Scrolling and paging

Scrolling can be defined as the vertical or horizontal movement of the page on screen. This movement can be done through the use of a scroll-bar which slides up and down, right and left and helps the reader to go through the text.

'With scrolling, pages are visibly connected in a linear order. One can scroll to the next page but a part of the other page will be still visible, at least at the beginning, providing some temporary context. When the linearity is pronounced, or direct, this will lead to a clear insight into the structure' (van Nimwegen et al, 1999). Scrolling is more useful to present information that is lying close together (Schwarz et al, 1983). (The term scroll also refers to the way the ancient papyrus scrolls were used.)

Software designers have included some features to help readers scroll a page such as the arrows on the right border, and the square or bar that slides down and indicates the depth of the page being consulted. In word processors this square can also indicate the page number and the topic within the document. However, a disadvantage of the scrolling system is that it does not provide enough 'tangible data about the location of information shown on the screen. Each time the scroll tools are used they disrupt the spatial layout, making it difficult for writers to build a 2D representation of the set of information' (Piolat, Roussey and Thunin, 1997).

The paging manipulation tries to emulate turning the pages of a book. The reader will click on a specific mark on the page and a new page appears, completely changing the screen. This 'does not pronounce the linearity very well' and makes it difficult to know at which level of depth the reader is (van Nimwegen et al, 1999). Schwarz et al (1983) suggest that paging is better to connect information that is less related or lying apart. On the other hand, Piolat et al (1997) believe this change of screen helps readers feel like they are in the same document, just changing pages of a book.

There have been studies regarding these two methods of manipulation with contrasting outcomes. The first studies presented here are supportive of the paging manipulation over the scrolling mode. One of the first studies was done by Schwarz et al (1983) who applied a test to inexperienced users to find out in which 'mode of operation' the participants performed better in a word reading task, line searching and sorting words. Even though the results do not show any statistically significant time differences, they state in their discussion 'in no case did scrolling prove to be superior to paging.' Moreover, paging was clearly preferred for the reading of a continuous text. Scrolling can therefore be considered as the less suitable mode of operation for the tasks they tested.

Another study that supports paging over scrolling was done by Dyson and Kipping (1997). Their test explored ease of reading different formats, either one column with long lines of text or three columns of text. Participants had to read three documents, two in a single-column, scrolled and paged, and one in three-columns and paged. The results showed no differences in reading rate between one-column with scrolling movement and three-columns paged format. They found that participants had different reading styles, whether long scrolling movements and/or repeated very small movements. 'The differences in reading rates that were identified show that paging is faster than scrolling' (Dyson and Kipping, 1997).

Piolat et al (1997) found that paging is better than scrolling in a text-reading and text-revising task. They describe their test as looking for 'screen dynamics' that is the way a text is presented on a computer screen and how users can reach various passages in the text. Their first experiment was to find out the participants' reading performance depending on the text presentation using scrolling or page-by-page.[1] Participants had to perform various tasks such as reading, sentence locating and summarizing. The results of this study show better performance of paging over scrolling. Piolat et al reported that readers using the paging version had a better grasp of content because of its similar presentation to a printed book and because readers could develop a better 'sense of text.'

[1] It is important to note that their page-by-page mode is different from the definition previously stated. They are referring to a page-by-page tool that only word processors have which allows a reader/writer to go from one page to the previous or next page.

On the other hand, van Nimwegen et al (1999) have found support for scrolling over paging by studying the influences of structure and reading-manipulation. They also studied three aspects of usability (efficiency, ease of learning and user-satisfaction) in five different electronic documents. The texts were organized in two different structures which were purely hierarchical or hierarchical structure with partial linearity, and two methods of manipulation. A fifth structure combined the hierarchical structure with linearity, with scrolling within sections and paging between sections. The participants had to complete 24 search tasks on a city guide of Utrecht. They had to find the information as fast and as accurately as possible. Van Nimwegen et al found that scrolling is more usable than paging. 'Scrolling leads to a better insight into the structure than paging, which produces better performance'. They concluded that purely hierarchical structure and scrolling as reading-manipulation are the best use. Spool (1998) in his article on-line strongly supports scrolling or longer pages over paging or short pages. Longer pages make readers scroll down to see 'what lies below each screen...having greater success when the content is on a single page.' Unfortunately he does not give any further information on his research that would give additional insight into the problem.

As these results show, there is no clear guidance as to whether paging or scrolling methods of manipulation help readers perform their tasks. Another two methods of manipulation that are discussed are that of frames and use of links, since they are included in the study presented here.

Links

Links are the connections of nodes of information contained in a hypertext document, such as a web page. A 'node is a sort of stimulus material that can be activated and presented to a user' (Seyer, 1991). Links show readers the departure point to an explicit object when they are activated (Nielsen, 1990), they are mere indicators that another related content can be accessed. By choosing and responding to links, readers interact with the hypertext system. 'If a word or a picture is highlighted, the reader has to understand that it points to a relevant development of the text' (Nielsen, 1990).

'Links do not interrupt the flow of meaning: on the contrary, they enliven it' (Pajares, 2000). Pajares regards hypertext as a dialogue between the document and the reader. The author builds the hypertext to say something and expects the reader to answer actively, interpreting and deciding upon which link to access. In her study on poetry displayed on screen, words have an extended meaning by the links that can be accessed; she states that not only structure and meaning can be perceived from hypertext but also a lower level that can be called lyrical. When readers follow the links they build their own interpretations or 'implicatures' enriching their experience with electronic documents. Pajares also suggests another kind of treatment of links if the document is regarded as informational. She suggests providing descriptive links, avoiding ambiguity and hence less interpretations, giving the readers a clear direction where the links are taking them, providing navigational aids, such as maps or buttons and creating indexes to show the overall structure (Pajares, 2000).[2]

[2] For an additional classification of links see DeRose (1989).

Links have been studied as a key element in navigation, especially because their incorrect use can make readers get lost in hypertext systems. Otter and Johnson (2000) developed a way of measuring how people become lost and suggest that 'some types of links have greater impact on lostness than others.' They presented a list, which summarizes the causes of lostness that readers reported in a questionnaire. The causes presented here are only those related to links:

- poorly or ambiguously labelled links
- confusing number of links or options
- continuing train of thought along many links
- location of the links on the page
- pictures that are non-obvious links
- getting distracted by attractive looking links
- more than one link to same destination
- links not following a logical order

Links are a unique characteristic of electronic documents. They are indicated in different ways, such as underlined words, arrows transforming into a pointing hand indicating a sensitive area, images or text changing color or shape when the cursor steps on them, flashing elements, etc. The use of links and the way to indicate them might suggest that conventions are beginning to emerge.

Frames

There have been a number of discussions on the inconvenience of using frames, since they were first introduced. A summary of these positive and negative points are presented here. All these opinions come from authors who publish their views on the world wide web, (Nielsen, 1996; Merholz, 1998; Roselli, 1999; IS/Web Communications, 2001) and most of them do not present any data to support their findings. However, these opinions are shared by most specialists consulted and seem to come from their own experiences.[3]

[3] These opinions deal specifically with web sites as electronic documents.

The use of frames on a web page implies the division of the page into separate web pages next to each other. The frames are contained within a frameset, which defines the position and dimension of each frame; they might have a border, a scroll bar, different color or any sign to let the reader know that there are other active spaces that can be clicked on. One or two of the frames have fixed text that usually corresponds to the table of contents or the navigation bar; the other frames change their contents depending on the link that the reader accesses.

The readers get an overall view of the information placed on the screen that facilitates their navigation; with frames, readers have to take a sequence of actions to go through the document. Nielsen (1996) mentions that the concept of frames is against the idea of 'the page' as a unit, as Berners-Lee conceived it.

The advantages of using frames are:

> Content and navigation can be separated from each other. The divisions of the page provide separate areas for different materials as well as a separate space for navigation.

> Contents can be organized in alphabetical order for quick access to information. Readers can jump quickly by choosing the letter of the alphabet displayed in the frame.

> Information within a frame is always present, avoiding multiplication of texts.

> Frames allow the placing of commentaries at the same time as fixed information is presented.

> They are recommended for complex web sites that have intranet and several depths of information because frames can provide an always-present navigational menu. Intranets have a captive audience that can be trained in their use of the web site.

> Used properly, frames can add structure and ease of use to the site.

The disadvantages of using frames are:

NAVIGATION WISE:

> Frames add unnecessary complexity to design and navigation.

> Some browsers do not support the use of frames. Even some new browsers made the decision not to support frames.

> The back button can be broken because of the way frames are used.

> Scrolling navigation bars in the middle of the page can be confusing.

> Readers might feel confused when they want to access a site and only a frameset appears.

> Frames can increase load time. In some browsers, they override user preferences for image-loading, thus increasing actual load time.

PRINTING USE:

> Readers do not always get the print they expect. They will usually get the frame they are selecting and not the whole page as it is viewed on screen.

USE OF SPACE:

> Frames remove space from the screen that can be used by the contents.

COPYRIGHT ISSUES:

> There have been situations where one site's content appears in another site's frame.

BOOKMARKING:

> It is not possible to bookmark a page within a frameset. Browsers only mark the initial frameset, which can cause readers to access pages with no contents. The URL does not change as a user navigates through the site.

SEARCH ENGINES:

> There are several search engines that do not index framesets because the home page is only a frame with little content. Therefore many sites cannot be accessed this way. However, there are ways to avoid these problems.

MAINTENANCE:

> It is difficult to update sites with frames because it requires keeping track of the files.

READERS' OPINION:

> Several authors report negative opinions from readers who dislike the use of frames.

Merholz (1998) distinguishes two types of web sites, those related to information and those to application. Information sites are those that offer thorough information to be read. Application sites are those where readers are interacting with the web, such as performing tasks and making interactions. Merholz suggests the use of frames for application sites because they are not affected by bookmarking, are controlled by the server, the elements do not have to be scrolled and they appear all at the same time.

An analysis of fifty web sites by the authors (González de Cosío and Dyson, in press) found similar results that agree with Merholz's distinction of web sites. The analysis found that there are different kinds of texts, depending on the sites profile. Those sites that need rapid transactions such as getting a ticket, consulting data from the bank, buying a product, etc. need specific and brief text. On the other hand, there are sites that offer a lot of information in their internal pages, such as descriptions, cultural information, texts on art, archaeology, results of research, etc. These sites are consulted for deeper and thorough reading.

There have been few studies done on the use of frames. A recent study that is closely related to the one presented in this paper, and looks at the performance and preference of framed and non-framed documents was done in Wichita State University (Bernard, Hull and Drake, 2001). Participants were presented with four versions of a document; each document had a different 'linking arrangement':

> Links embedded in the document

> Links at the upper left of the document

> A top frame with links

> Links within a vertical frame on the left of the document

Participants had to search for specific information and find answers to ten questions. Each answer should be found within five minutes to be considered correct. The authors did not find significant differences in search performance, accuracy, search time and search efficiency or preference among the four conditions. In a further study, Bernard and Hull (2002) compared the top-left links version with the vertical frame version in terms of preference. They asked participants questions on ease of navigation and ease of finding information and found significant differences that favored the frame condition.

This study attempts to identify which methods of manipulation allow readers to perform faster and more accurately when searching for information. A series of tests were prepared to find how scrolling, linking, paging or using frames were used to manipulate an electronic document.

THE STUDY

This test measured:

> time to find specific information: a definition, a list, a figure

> time to read a text

> accuracy and correctness in answering a question

> how much was remembered of the text through formulating a synopsis

Readers

The tests were applied to two different groups of readers; the first group were forty second-semester Psychology and Design students; the second group were forty-one seventh-semester students from a variety of disciplines from the Universidad de las Américas-Puebla in Mexico. Within each group, readers were assigned one of four versions of the document. Different levels of English were distributed evenly between versions. Most students stayed throughout the test, but some of them had to leave before finishing the six tasks.[4]

Topic

The selected topic for the test was 'Perception and Representation' from J. Preece's book *Human Computer Interaction*[5] This chapter is suited to the test because it is a well structured text organized into sections, exercises, comments, questions and key points of the text; it is well supported by visual representations, such as photographs, schemas and tables that explain and exemplify various definitions.

[4] We thank professors Julio Penagős and Jorge Galicia for their support in performing the test with their students. Professor Penagős also helped with suggetsions and comments.

[5] Preece, J. 1994 *Human Computer Interaction*. The Open University: Addision and Wesley, 75–97.

Versions of electronic documents for the test

The test consisted of four versions of the text presented as a web site document. The content was kept exactly the same as the printed text. There were slight differences, just to adjust the content to the method of manipulation. The major differences among versions relied on the reader's manipulation of the document.

> Version 1: scrolling

The whole text was contained in one page, thus emphasizing a linear sequence of reading. The document had to be consulted through scrolling up and down; readers could know the length of the document. No links were contained in the text (*figure 1*).

> Version 2: linking

The document was contained in one page, but offered a table of contents with links to each topic and a back-button, on each section, to the beginning of the text; the readers could know the length of the document and navigate through links or use vertical scrolling. The title of the visited sections changed color (*see figure 2*).

> Version 3: paging

The text had a table of contents and links to each topic; every topic was placed on a separate page and had a back-button to the table of contents. Readers did not have an overall idea of the length of the document unless they linked to each section. The title of the visited sections changed color (*see figure 3*).

> Version 4: frames

The text had a table of contents (using a frame) to link to other sections of the document. It was always present in the document and independent from the rest of the text. The reading space was reduced by the table of contents and readers could not have an overall idea of the length of the document unless they navigated into each section. The title of the visited section changed color (*see figure 4*).

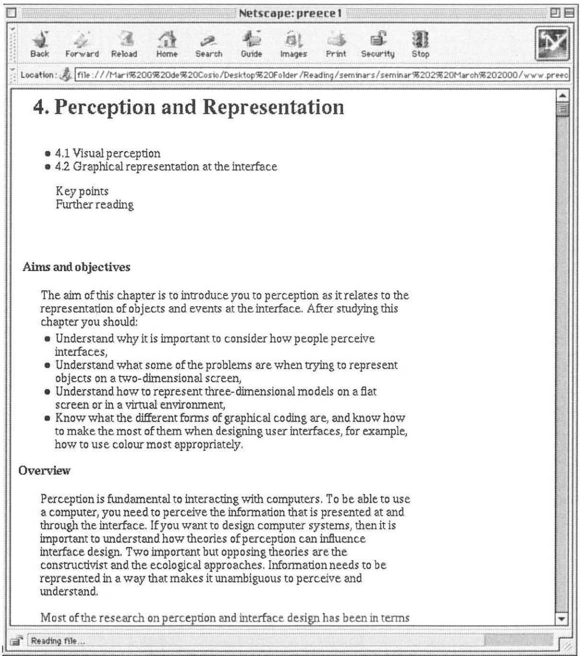

FIGURE 1
The first version is the scrolling layout. The students had to read the document by scrolling vertically. No links were contained in the text and no table of contents. The beginning of the document is shown in this image.

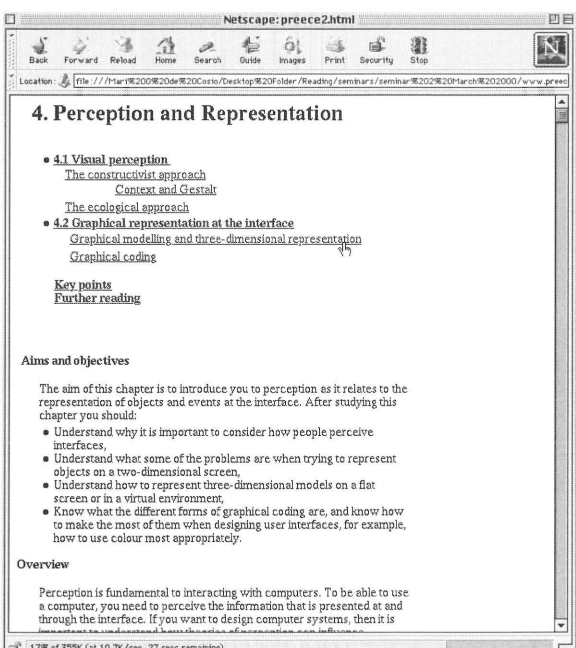

FIGURE 2
The second version is the linking document. The students could check the table of contents at the beginning of the text and link to the desired position. Everything was contained in the same web page, so the readers could also scroll up and down or use the 'back' button within the document. The table of contents is shown in this image.

FIGURE 3
The third version is the paging document. Each topic is contained in a single page. The students could go to each topic by linking from the table of contents. A 'back' button was provided to go to the previous topic accessed. A specific topic of the document is shown here.

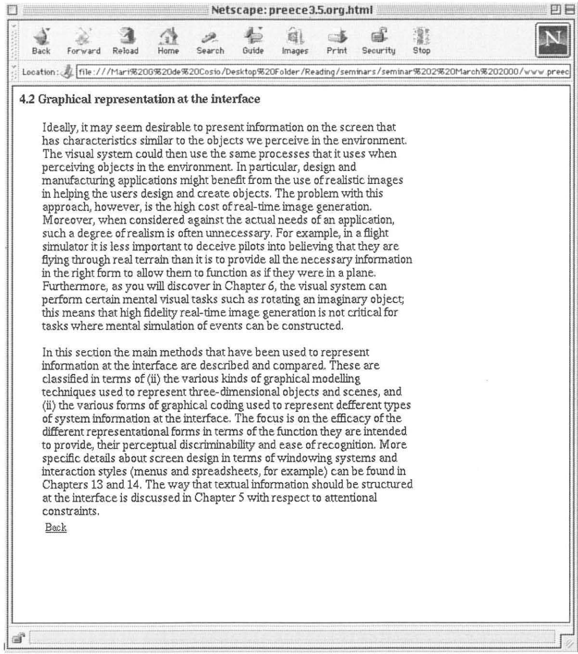

FIGURE 4
The fourth version is the frame document. The table of contents is presented in a frame. The students could always see the topics and navigate through the text without having a clear idea of the length of the text. The frame with the table of contents and one of the topics is shown in this image.

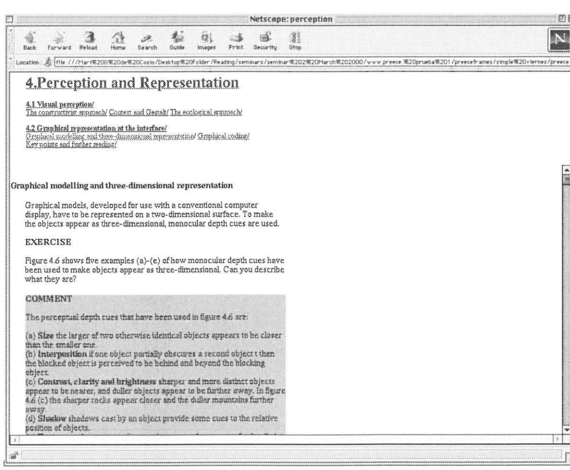

FIGURE 5
View of the classroom where the test was done. Each computer had the same characteristics on screen in terms of fonts and size of window.

Each version had advantages or disadvantages: either complete or sectioned information, slow or quick reference through links to specific subjects. In other words, participants read sections that varied in length, (but overall length of text was the same), had more or less control over the document or controlled their reading in a linear or non-linear way.

Physical setting

The test was developed in a special classroom that has a space for lecturing and a separate space for 24 Imac computers distributed in a line. The computers were divided into four groups; every six computers had a different version of the document (*figure 5*).

The tests

The students received the instructions on three separate pieces of paper: the first instruction (tasks 1–3) was given at the beginning of the test, so the results would not interfere with the next step that asked them to read the whole text (task 4). The participants specified the time it took them to perform each task by checking the clock on their computer. When the participants had finished task 4, they answered the question (task 5) on their instruction paper and received the last instruction which was performed in the classroom, with pen and paper, and without any access to the electronic document (task 6).

Readers were asked to do the following tasks:

- Find Information. Participants had to find different kinds of information whether specific text, a list or an image. The different tasks were:

    Task 1: find a definition

    Task 2: find a list of text

    Task 3: find a figure

- Read a text

    Task 4: read the text on 'Perception and Representation'

- Answer a question

    Task 5: answer a question related to the text read

- Write a synopsis

    Task 6: make a synopsis or scheme of the text just read

RESULTS AND DISCUSSION

The first three tasks measured speed to locate different presentations of information, the fourth task measured time to read the text, the fifth task measured comprehension of an issue and the sixth task measured comprehension and memory.

> FINDING INFORMATION

This was measured by the time the students took to locate the text, the figure and the list; the time was recorded by the students on the instruction paper. Figure 6 shows the means for each version (tasks 1–3 combined) for each group of students. A comparison of the two groups of students across the four versions found only one main effect of version, ($F(3,73) = 3.91$, $p<0.025$) and no interaction. Linking and paging are faster than scrolling and frames.

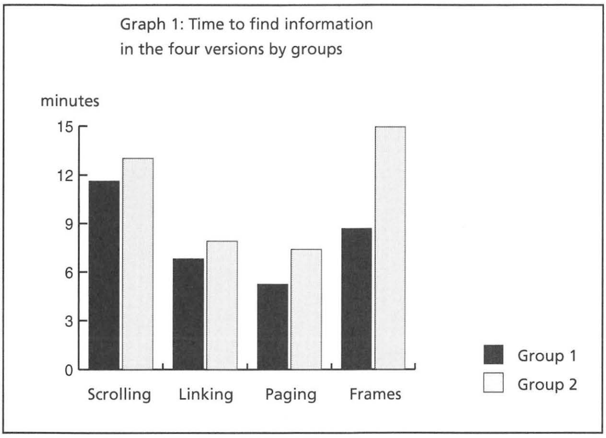

FIGURE 6
Finding information was faster when using paging and linking versions of the document in tasks 1–3.

It is interesting to observe contrasting results to those found by Bernard et al (2001). In their study, they did not find any difference in search performance between frames and non-frame versions, whereas in this study there is a clear difference among the methods of manipulation.

> READING THE TEXT

There were no significant differences between the four versions in time to read the text. However, there was a difference between the two groups ($F(1,70) = 6.53$, $p < 0.025$). In this task, the second semester students read significantly faster than the seventh semester students (*figure 7*) . It seems to be that seventh semester students were more motivated and interested in the topic than the younger students.

> ANSWERING A QUESTION

Complete and accurate answers were coded as 'correct'; incomplete answers and wrong answers were coded as 'incorrect.' The data is shown in Table 1. The

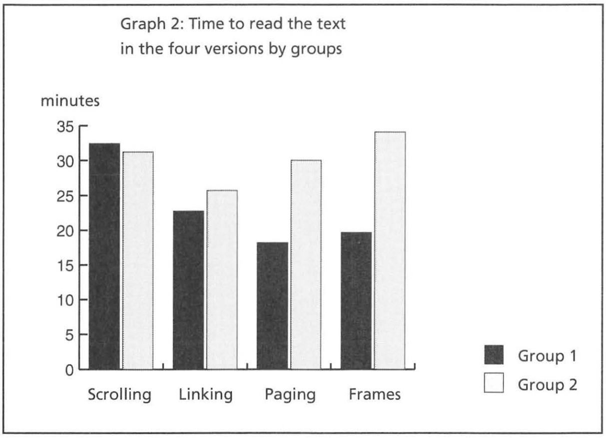

FIGURE 7
Younger students read the text faster in the paging version, whereas older students were faster in the linking version in task 4.

frequencies of incorrect answers were compared with correct answers. There were no differences among versions ($\chi^2 = 4.88$, 3 df, $p>0.05$). Although there were more incorrect answers compared to correct in the scrolling version, whereas the reverse was true in the three other conditions, the differences are too small to be reliable.

> Writing a synopsis

There were no differences among versions when developing a synopsis ($\chi^2 = 1.61$, 3 df, $p>0.05$). The data is shown in Table 2. Few students remembered the complete structure of the text, perhaps because it was rather long. However a repeated part of the structure was well remembered by most students; they could remember the text related to the answer of a question (task 5). This information supports the idea that active participation of students with the subject matter helps learning and memory.

CONCLUSIONS

Paging and linking are the two versions of documents that better supported readers in this test, in looking for information in the shortest time. This implies that quick scanning through a document might be easier in these two versions. These results agree with the outcomes of Dyson and Kipping (1997), Piolat et al (1997) and Schwarz et al (1983) studies which found superior performance for paging over scrolling. However, the integration of linking and frames version in this study as new variables shows that not only paging but also linking type of documents could better support readers.

It is worth mentioning that students did not have any distraction within the text while reading; there were no links to additional information nor linking images that they could explore. The students' concentration had to be dedicated to their document. This situation differs from readers' usual search for information on the web: distractions of text, color, images and links to other documents can interfere with their performance.

Task 5

	CORRECT	INCORRECT
SCROLLING	6	11
LINKING	13	6
PAGING	12	8
FRAMES	7	7

TABLE 1
Correct and incorrect answers in task 5

Task 6

	CORRECT	INCORRECT
SCROLLING	7	9
LINKING	6	13
PAGING	7	13
FRAMES	9	9

TABLE 2
Correct and incorrect answers in task 6

References

Ahuja, J S and J. Webster. 2001. Perceived Disorientation: An Examination of a New Measure to Assess Web Design Effectiveness. *Interacting with Computers*, 14, 15–29.

Allinson, L and N. Hammond. 1999. A Learning Support Environment: The Hitch-hiker's Guide. In R. McAleese, editor. *Hypertext: Theory into Practice* (2nd ed.), 53–63. Exeter: Intellect.

Beghtol, C. (Dec/Jan 2001, accessed July 2001). The Concept of Genre and Its Characteristics. Available: http://www.asis.org/Bulletin/Dec-01/beghtol.html. *Bulletin of The American Society for Information Science and Technology*, 27:2.

Bernard, M., S. Hull and D. Drake. (2001, accessed February 2002). Where Should You Put the Links? A Comparison of Four Locations. *Usability News 3.2*. Available: http://psychology.wichita.edu/surl/usabilitynews/3S/links.htm

Bernard, M. and S. Hull. (2002, accessed February 2002). Where Should You Put the Links? Comparing Embedded and Framed/Non-framed Links. *Usability News, 4. 1*. Available: http://psychology.wichita.edu/surl/usabilitynews/41/Link_position.htm

Boiarski, G. 1997. *The Psychology of New Media Technologies: Lessons from the Past*. Convergence, 3, 109–126.

Campbell, C. and P.P. Maglio. 1999. Facilitating Navigation in Information Spaces: Road Signs on the World Wide Web. *International Journal of Human-Computer Studies*, 50, 309–327.

Conklin, J. 1987. Hypertext: An Introduction and Survey. *IEEE Computer*, 29, 17–41.

DeRose, S. 1989. *Expanding the Notion of Links*. Proceedings of the Hypertext '89 Conference ACM, Chapel Hill.

Dillon, A. and B. Gushrowski. 2000. Genres and the Web: Is the Personal Home Page the first Uniquely Digital Genre? *Journal of the American Society for Information Science*, 51, 202–205.

Dillon, A. and M. Vaughan. 1997. It's the Journey and the Destination. Shape and the Emergent Property of Genre in Evaluating Digital Documents. *New Review of Multimedia and Hypermedia*, 3, 91–106.

Dyson, M.C. and G. Kipping. 1997. The Legibility of Screen Formats: Are Three Columns Better than One? *Computers & Graphics*, 21, 703–712.

Edwards, D, M. and L. Hardman. 1989. Lost in Hyperspace: Cognitive Mapping and Navigation in a Hypertext Environment. In R, McAleese, editor. *Hypertext: Theory into Practice*. 1st. edition, 105–125. Aberdeen, UK: Blackwell Scientific Publications.

Goonetilleke, R.S., H.S. Martins, H. Kai On and J. Fritsch. 2001. Effects of Training and Representational Characteristics in Icon Design. *International Journal of Human-Computer Studies*, 55, 741–760.

Gullikson, S., R. Blades, M. Bragdon, S. McKibbon, M. Sparling and E.G. Toms. 1999. The Impact of Information Architecture on Academic Web Site Usability. *The Electronic Library*, 17, 293–304.

Honeywell, P. 2000. Evaluating Appropriate Interface Metaphors. In M, Yazdani and P. Barker, editors. *Iconic Communication* 178–204. Bristol: Intellect.

IS/Web Communications Services (October 2001, accessed February 2002). Why Frames are Not Supported at MIT. Available: http://web.mit.edu/afs/athena.mit.edu/org/c/cwis/frames/

Kim, H. and S. Hirtle. 1995. Spatial Metaphors and Disorientation in Hypertext Browsing. *Behaviour & Information Technology*, 14, 239–250.

Kwasnik, B., K. Crowston, M. Nilan and D. Roussinov. (Dec/Jan 2001, accessed July 2001). Identifying Document Genre to Improve Web Search Effectiveness. Available: http://www.asis.org/Bulletin/Dec-01/kwasnikartic.html. *Bulletin of The American Society for Information Science and Technology*, 27:2.

Merholz, P. (September 1998, accessed February 2002). Frames: Information vs. Application. Available: http://peterme.com/index052498.html.

Nielsen, J. 1990. *Hypertext and Hypermedia*. Boston: Academic Press, Inc.

Nielsen, J. (December 1996, accessed February 2002). Why Frames Suck (most of the time) Fundamental Problems with Frames. Available: http://www.useit.com/alertbox/9612.html.

Otter, M. and H. Johnson. 2000. Lost in Hyperspace: Metrics and Mental Models. *Interacting with Computers*, 13, 1–40.

Pajares, S. 2000. A Pragmatics of Links. *Proceedings of the ACM, Hypertext 2000*, 77–84.

Piolat, A., J.I. Roussey and O. Thunin. 1997. Effects of Screen Presentation on Text Reading and Revising. *International Journal of Human-Computer Studies*, 47, 565–589.

Roselli, A. (July 1999, accessed February 2002). Some Caveats with Using Frames. Available: http://www.evolt.org/article/evolt/22/293

Schwarz, E., I.P. Beldie and S. Pastoor. 1983. A Comparison of Paging and Scrolling for Changing Screen Contents by Inexperienced Users. *Human Factors*, 25, 279–282.

Seyer, P. 1991. *Understanding Hypertext. Concepts and applications*. Pennsylvania: Windcrest.

Spool, J.M. (July/August 1998, accessed January 2002). As the Page Scrolls. Available: http://world.std.com/~uieweb/scrollin.htm.

Toms, E.G. (Dec/Jan 2001 accessed July 2001). Recognizing Digital Genre. Available: http://www.asis.org/Bulletin/Dec-01/toms.html. *Bulletin of the American Society for Information Science and Technology*, 27:2

UVA Information Technology and Communication. Web development support (October 2001, accessed February 2002). Available: http://www.itc.virginia.edu/desktop/web/frames_problems.html

van Nimwegen, C., M. Pouw and H. van Oostendorp. 1999. The Influence of Structure and Reading-manipulation on Usability of Hypertexts. *Interacting with Computers*, 12, 7–21.

Web Design Group. (July 1997, accessed February 2002). Guide to Frames Usage. Available: http://www.htmlhelp.com/design/frames/whatswrong.html

Wright, P. 1998. Designing Information-supported Performance: The Scope for Graphics. *Journal of Computer Documentation*, 22, 3–10.

Wurman, R. S. 1989. *Information Anxiety*. New York: Doubleday.

Yank, K. (N.D.) Designing with Frames—An Introduction. www.webmasterbase.com/article/622

AUTHOR NOTES

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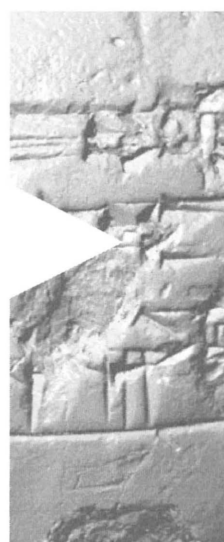
Communicating Cuneiform:
THE EVOLUTION OF A MULTIMEDIA CUNEIFORM DATABASE

S.I.Woolley, T.R.Davis, N.J.Flowers, J.Pinilla-Dutoit,
A.Livingstone, T.N.Arvanitis



Our paper presents the work of the Cuneiform Digital Forensic Project (CDFP), an interdisciplinary project at The University of Birmingham, concerned with the development of a multimedia database to support scholarly research into cuneiform, wedge-shaped writing imprinted onto clay tablets, and indeed the earliest real form of writing. We describe the evolutionary design process and dynamic research and developmental cycles associated with the database.

Unlike traditional publications, the electronic publication of resources offers the possibility of almost continuous revisions with the integration and support of new media and interfaces. However, if on-line resources are to win the favor and confidence of their respective communities, there must be a clear distinction between published and maintainable resources and developmental content. Published material should, ideally, be supported via standard web-browser interfaces with fully integrated tools so that users receive a reliable, homogenous and intuitive flow of information and media relevant to their needs.

We discuss the inherent dynamics of the design and publication of our on-line resource, starting with the basic design and maintenance aspects of the electronic database, which includes photographic instances of cuneiform signs, and show how the continuous review process identifies areas for further research and development, for example, the "sign processor" graphical search tool and three-dimensional content, the results of which then feed back into the maintained resource.

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INTRODUCTION

During the late fourth millennium BC there was a major technological breakthrough: cuneiform writing was invented. Previously, writing on clay was primarily pictographic, probably done with a pointed implement that executed stylized drawings on the wet clay. Cuneiform writing is much more like letterpress printing: the sharp corner of a triangular-sectioned writing implement was pushed into the clay to make a three-dimensional wedge shape. All of the characters are composed of combinations of these wedge shapes.

The power of cuneiform is in its restriction. The pointed end of a drawing stylus can be freely guided, so drawn pictograms will vary considerably from writer to writer, whereas the triangular end of a cuneiform stylus can only produce wedges, and one wedge is much like another. The power of a writing system is in its versatility, which depends on an agreed stylization, easy differentiation, flexibility and simplicity of the component elements: cuneiform was a great leap forward.

The resulting medium was long-lived and widespread. Cuneiform was, at times, the medium of communication of the whole of the ancient near east, from Egypt to Iran, and was used until the beginning of the Christian era. Great libraries were created, and, since clay is much less fragile than papyrus, vellum or paper, much of this priceless record is still extant. If you burn a cuneiform library you help to preserve the content.

The first generation of cuneiform scholarship, which accomplished the extraordinary task of finding out how to read this record, depended largely on hand copies of cuneiform tablets for their data: chemical photography is expensive, and publication of chemical photographs much more so. Digital photography, on the other hand, and web publication are virtually free, and this is providing new opportunities as well as posing a new challenge to the present generation of cuneiformists. In order to take advantage of this new technology, the Cuneiform Digital Forensic Project (CDFP) at The University of Birmingham has brought together a team of experts from widely differing disciplines in order to answer questions about cuneiform that had previously been impossible to investigate.

EVOLUTIONARY DESIGN

At its inception three years ago, a fundamental objective of the CDFP was the development of an electronic, on-line cuneiform database for scholarly research. This database system is now fully functional and is accessible via the Internet. It currently contains a sample set of signs that have been used to test and demonstrate the system. Extensive population of the database is envisaged over the next several years.

The design specification of our database evolved during the first 18–24 months of the project as we, a very diverse research team, developed an important common understanding of the basic system requirements. The merging of perspectives involved in this process was essential to the establishment of a shared vocabulary and a fluid design concept. As shown in figure 1, this resulted in the development of 1) a maintainable system, i.e., the working multimedia cuneiform sign database, 2) developmental projects and 3) plans for future research activities for more advanced functionality.

The generation and discussion of various prototypes significantly improved our team's early understandings of the overall requirements. These prototypes took various forms from design drafts such as overview schemas, formal entity diagrams and sketches of user interfaces to real software

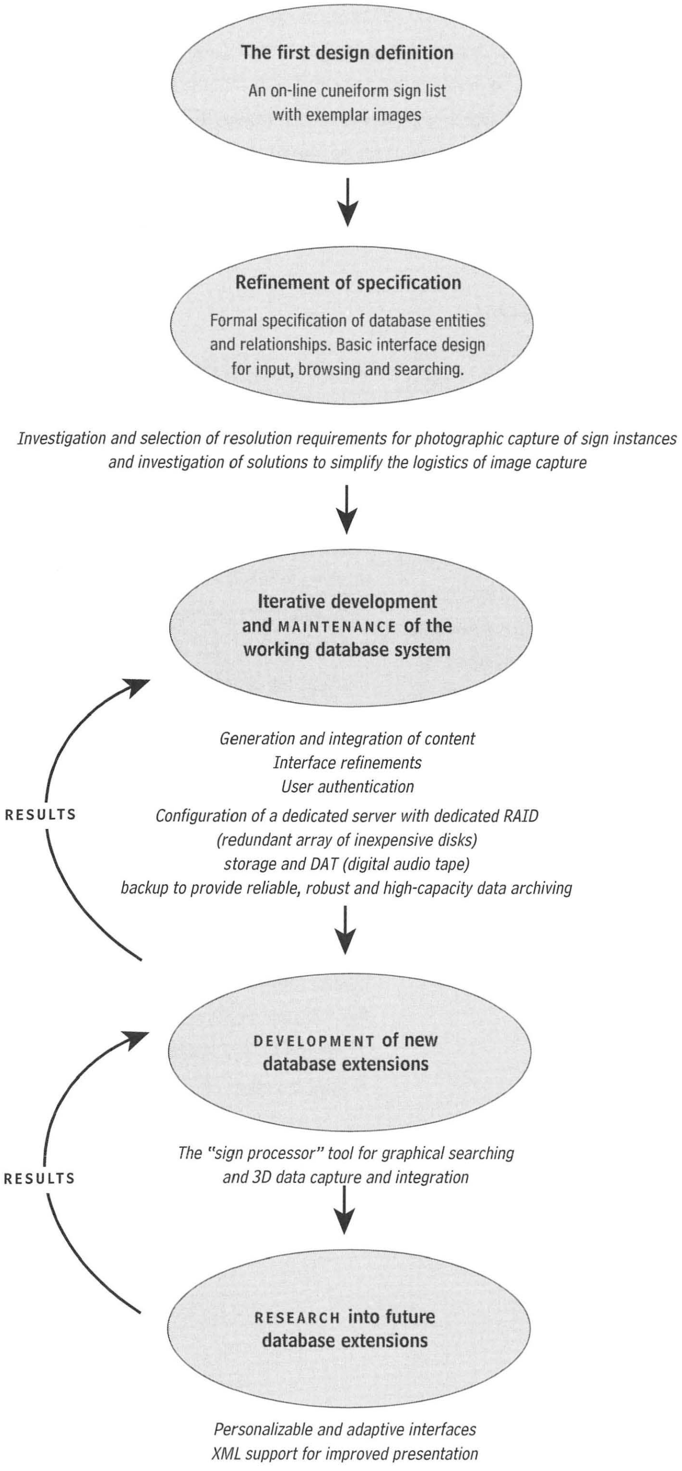
FIGURE 1
An overview of the design evolution and the establishment of three broad activities

1 MAINTENANCE of the working system

2 DEVELOPMENT of new systems

3 RESEARCH into future systems

Examples of each are shown immediately below each activity.



implementations, and, resulted in a working server implementation with an agreed set of interfaces for data input, search and browsing. These prototypes provided important tangible examples for the team to discuss and test; enabling content, indexing and interaction design and development to occur simultaneously. This dynamic design process also encouraged creative discussion within the team for further extensions to the content and interface. New developmental projects included the "sign processor" for graphical search queries and three-dimensional content, while future research was planned for scaleable delivery of content, metadata for object tagging, and personalizable and adaptive interfaces.

DATABASE DESIGN AND CONfiGURATION

The levels at which a cuneiform sign can be classified provide the main structure of the database. We defined three levels: the *sign*, *allograph* and *instance*, which are summarized in figure 2 and described in detail in endnote one.[1]

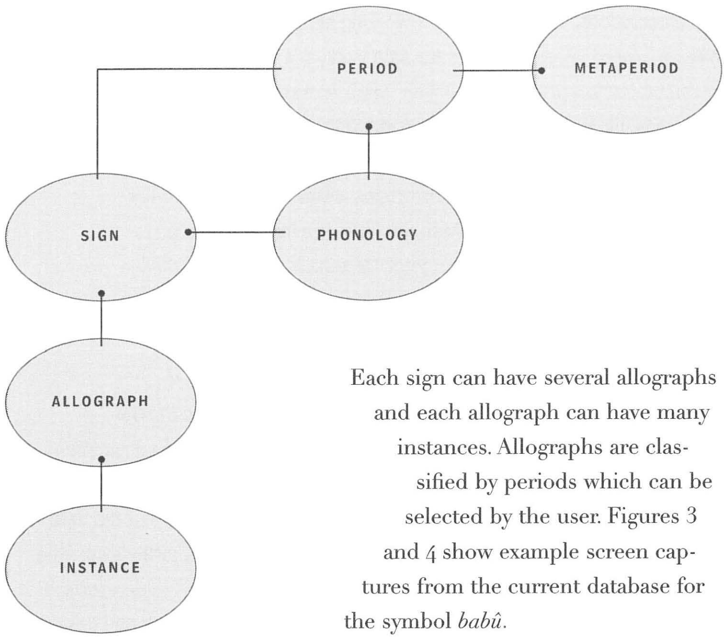
The top level of our hierarchy is the *sign* represented by the *grapheme*, a label that uniquely identifies the sign.

The intermediate level contains a set of *allographs*, consisting of each one of the valid representations of the grapheme. These are simple graphics that represent the variations in sign construction, for example, variations across historical periods.

The *instance* represents the bottom level of our hierarchy, i.e., actual realizations of the sign in the clay. Instances are currently represented by digital pictures.

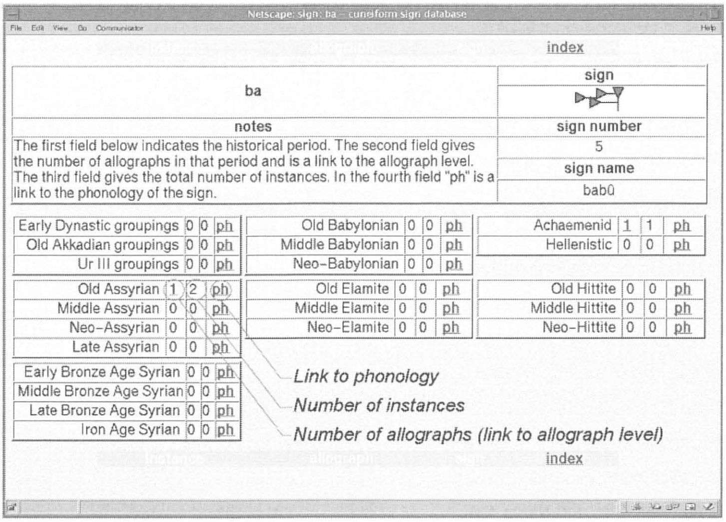
[1] **Arvanitis, T.N., T.R. Davis, N. Hayward, A. Livingstone, J. Pinilla-Dutoit, S.I. Woolley. 2000. "The Work of the Cuneiform Digital Forensic Project."** ***VAST: Virtual Archaeology between Scientific Research and Territorial Marketing.*** **Arrezo, Italy, 24–25.**

FIGURE 2
A simplified entity relationship diagram of the cuneiform database



Each sign can have several allographs and each allograph can have many instances. Allographs are classified by periods which can be selected by the user. Figures 3 and 4 show example screen captures from the current database for the symbol *babû*.

Having agreed on the basic specification and discussed the future life-cycle of the cuneiform database, it became clear that the serving system required a robust and high-capacity long-term archiving ability, capable of delivering high-bandwidth content. Since extensive population of the database is planned over the next several years, an independent web server was configured with its own disk storage facility and backup mechanisms. The database server currently employs JavaServerlet technology and presents data to Internet users via standard web-browser interfaces.



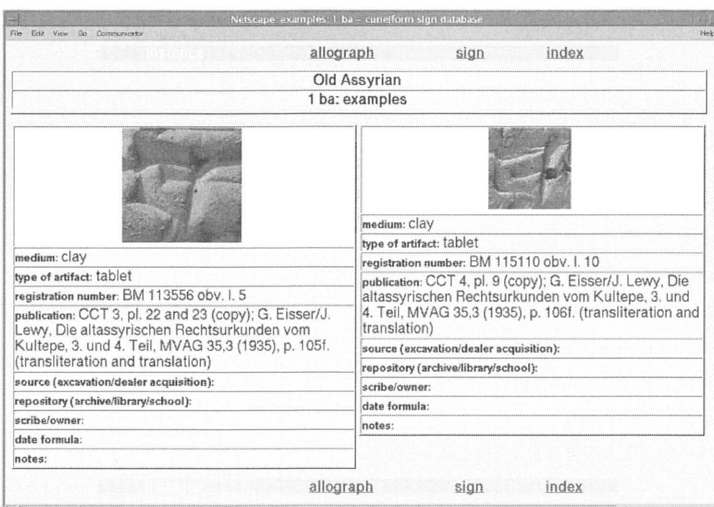


FIGURE 3
The database entry for the sign *babû*

FIGURE 4
The Old Assyrian allograph entry for the sign *babû*

THE SIGN PROCESSOR

Any reference collection, particularly one as large as a cuneiform sign database, needs an index: a search tool. It is of course easy to search lists of signs by their conventional names, and then work downwards in the hierarchy from name to sign to allograph to instance, but that kind of search is only useful if the name of the sign is known. The student of cuneiform is often in the position of looking at an instance of a sign on a tablet and not knowing which sign it is. He or she therefore needs a means of moving upwards through the hierarchy: from (unrecognized) instance to allograph to sign. No conventional search technique will allow that, because what is unknown is an unidentified graphic shape, and there are no purely graphic search engines. Therefore one had to be invented.

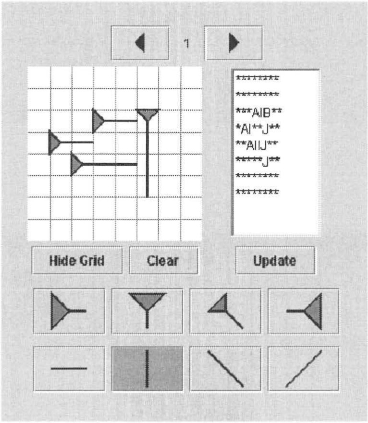


FIGURE 5
The sign processor showing a graphical entry mode where the user has sketched the babû symbol

The "sign processor" is an extension to the original database design which will enable graphical search queries. As can be seen in figure 5, the sign processor allows users to draw instances of signs, taking advantage of the highly stylized nature of cuneiform: any sign consists of groups of very few basic elements, which are combined in very simple ways.

The user employs the simple tools and a point and click interface to produce a stylized representation of the unknown sign on a grid. During this drawing process the computer creates an alphabetic representation of the resulting drawing (seen on the right of the image). All allographs in the sign list will have been drawn using the sign processor and the alphabetic representation stored as part of the data for that allograph. It thus becomes possible for the user to search for matches of the unknown instance. We are developing loose or fuzzy search methods to assist this process. What is particularly useful is that a user of cuneiform will often be working with broken tablets, and therefore fragments of signs; the sign processor will allow the input of partial signs and search for partial matches.

PHOTOGRAPHIC AND THREE-DIMENSIONAL REPRESENTATION OF CUNEIFORM TABLETS AND SIGN INSTANCES

PHOTOGRAPHIC DATA CAPTURE Our analysis of the tablets established a resolution requirement of approximately 0.025mm to support forensic study of sign instances sufficient to distinguish between different scribal hands. However, we anticipated that users may, more often, be interested in the general shape and size of the tablets, and a simple, low-resolution image may suffice. Other scholars may be interested in reading the symbols and would therefore require more intelligible, higher resolution renditions, but not at the same high resolution required by forensic analysis.

For our photographic experiments we used a 3.34 megapixel digital camera (the Nikon CoolPix 990) at The British Museum, using a four-light bed with adjustable camera height and with tablets mounted on a sand tray to stabilize their orientation. The photography of cuneiform tablets poses several challenges due to the densely compacted inscriptions on both sides, with text running over rounded edges and frequently continuing along each side edge. This makes the complete photographic capture of tablet signs problematic even with many exposures from different angles. Lighting proved problematic, not least because of repeated burns from the directional spotlights. The depth of the impressions also made the selection of correct lighting both difficult and time-consuming. Other challenges included the development of systems to preserve scale information and enable the correct attachment of catalogue and context information.

THREE-DIMENSIONAL DATA CAPTURE

The problem with photographs is that the lighting and shadows are fixed and cannot be manipulated by the viewer. When reading real tablets, experts tend to rotate them constantly: grossly in order to present all the signs to inspection, but also subtly, in order to use light and shadow to bring out the indentations clearly. In order to duplicate the 'viewing experience' on a computer, we investigated the provision of three-dimensional models of signs and tablets as an extension to the database design.[2]

FIGURE 6A
Three-dimensional capture of tablets in The British Museum archive

There are a number of different techniques for capturing three-dimensional models of real objects, each offering different scanning areas and resolutions. The Digital Michelangelo Project at Stanford University[3] involved scanning larger objects, e.g., Michael Angelo's statue of David, at a resolution of up to 0.25mm using laser triangulation rangefinding. The 3D-Matic project[4] at the Turing Institute and The University of Glasgow used 'photogrammetry' to give a resolution of 0.5mm.

[2] Woolley, S.I., N.J.Flowers, T.N. Arvanitis, A. Livingstone, T.R. Davis and J. Ellison. 2001. "3D Capture, Representation and Manipulation of Cuneiform Tablets." *IST/SPIE Electronic Imaging 2001*, Vol. 4298, 103–110.

[3] The Digital Michelangelo Project, Stanford University. http://graphics.stanford.edu/projects/mich/

[4] 3D-Matic Research laboratory, The University of Glasgow, United Kingdom. http://www.faraday.gla.ac.uk

Our stringent forensic resolution requirement of 0.025mm resolution over the entire surface of a cuneiform tablet (typical size 50mm by 70mm by 20mm) was achieved using the Breuckmann OptoTOP scanner.[5] With the assistance of Scientifica[6] (a distributor of the Breuckmann system) we obtained high-resolution scans of some cuneiform tablets held at The British Museum. Figure 6a shows the scanning operation in progress at the museum and figure 6b shows an example of a captured tablet. The tablet depicted belongs to a category of tablets known as "buns." This one measures about nine centimetres across and is about three centimetres thick. The inscription is an invocation for a long life addressed to the Babylonian king Samsuiluna, who reigned from 1749 to 1712 BC, and who was the son and successor of the famous Babylonian king Hammurabi, best known for his code of laws. This bun is from an ancient scribal school. The master would write on the inscription on one side and the pupil would have to memorize it and write it on the other side without peeking.

Our high-resolution three-dimensional scans contain all the information required to fully represent a cuneiform tablet. However, the resulting file sizes are typically over 100MBytes. Files of this size are extremely difficult to manipulate in real-time and are unsuited to communication over the Internet. For example, even at the maximum transfer rate, a 28.8kbits/second modem connection (i.e., 3.6kBytes/second) would require almost 8 hours to download a small tablet. This would

[5] Breuckmann GmbH. http://www.breuckmann.com/english/optoTOP.html

[6] Scientifica Ltd. http://www.scientifica.uk.com/

FIGURE 6B
An example of a rendered three-dimensional scan of a cuneiform tablet with a resolution of 0.005mm.

be a very inefficient means of delivery and wasteful of network bandwidth particularly for users only requiring a low-resolution model. In order to satisfy the needs of various users, scalable delivery is desirable. A typical scenario would be this: the user first obtains a model of the entire tablet at a low resolution. Then, if the user chooses to zoom in on a specific region, additional information is transferred to increase the resolution of the area of interest. The important difference between this technique and standard delivery mechanisms is that the user would not need to download an entire high-resolution model in order to zoom in on a small area.

THREE-DIMENSIONAL VISUALIZATION AND MANIPULATION Standard three-dimensional viewers download complete datasets rendering them on the screen depending on the user's chosen viewpoint. When used as a mechanism to view three-dimensional models such as cuneiform tablets, the user can select which part of the tablet to look at, zoom in and out, and rotate the tablet in all three axes. Examples of our scanned bun tablet are shown in different viewers in figures 7 and 8.

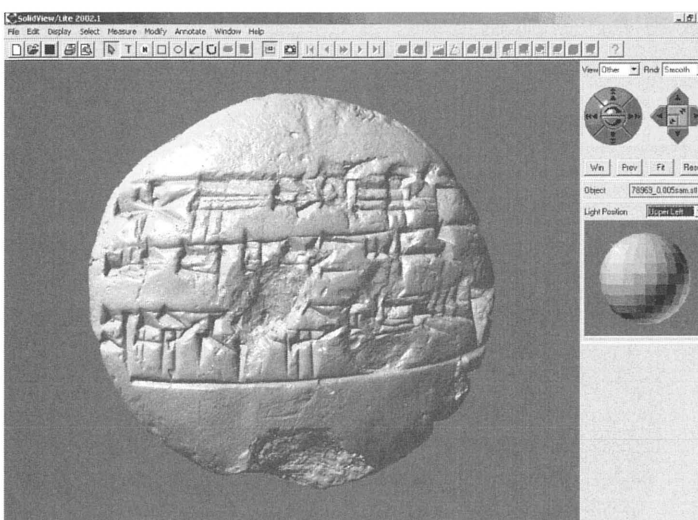


FIGURE 7
The bun tablet at the highest scan resolution of 0.005mm shown is the Solidview Lite 3D viewer. This freeware viewer allows manipulation of the tablet and a single light source (the controls for rotation, translation and zoom and light positioning are shown on the righthand-side).

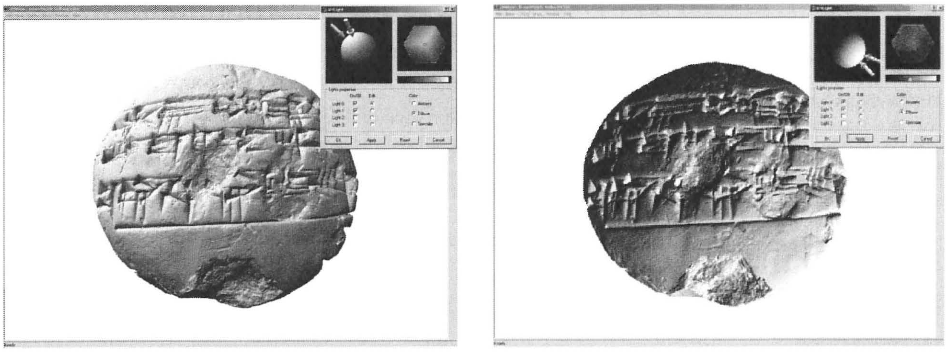


FIGURE 8
The bun tablet at a scanned resolution of 0.01mm shown in the Polyworks 3D viewer. This viewer allows manipulation of the tablet and up to four light source (ambient, diffuse or spectral). The lights can be easily manipulated with the mouse—two different settings of northwest vs. southeast illumination are shown left and right, respectively.

Some three-dimensional viewer interfaces can be confusing, particularly to novice users. If, for example, left-right movement of the input device produces rotation of the tablet, when the user may have been expecting a lateral movement in the viewing window. An additional complexity is added when illumination is taken into account; for correct viewing of the cuneiform tablets the user must be able to alter the position of one or more light sources to create the shadows to provide the necessary depth information.

However, our simple experiments with high-resolution scans clearly demonstrated the benefit of three-dimensional models over photographic representations of instances and we plan to continue working on methods to integrate three-dimensional instances with the image data of the sign list database.

FURTHER RESEARCH AND FUTURE DEVELOPMENTS

In addition to developmental activities, the team have identified several areas which would benefit from further research. Any results from these activities could, after development, be integrated into the maintained database system. The items of further research of particular relevance to electronic publishing are summarized below.

It is very important that the three-dimensional datasets are traceable throughout the entire capture, storage, delivery and manipulation process. There are several pieces of information associated with the electronic representation of each tablet, for example the catalogue number, physical dimensions, excavation details, storage location, ownership, etc. This "data about data" is called "metadata" and needs to be robustly connected, or "tagged," to the data it describes. As the user manipulates the data and zooms in, metadata referring to, for example, the physical size and location of the selected subset should be available.

Support of the new XML (extensible markup language) cuneiform standard is also considered important for future web publications.[7,8] Issues of copyright also require consideration when making high-resolution electronic scans of copyrighted artifacts. It may be necessary to provide mechanisms to scale delivery of scanned models based on user privileges. For example, public access could be given to low-resolution data, and access to the high-resolution models limited to authorized experts. To prevent copyright infringement, it is important that this information is also closely coupled to the data itself. Techniques such as digital watermarking could be used, although there are no standards at present.

[7] Livingston, A., S.I. Woolley, T.R. Davis, T.N. Arvanitis. 1999. "XML and Digital Imaging Considerations for an Interactive Cuneiform Sign Database." Electronic Publication of Ancient Near Eastern Texts (conference). The Oriental Institute of the University of Chicago. (Full paper on line.) http://www.eee.bham.ac.uk/cuneiform/files/cuneiform_chicago.ppt

[8] Cover, R., editor. 2002. "Cuneiform Digital Library Initiative to Use XML Encoding for Third Millenium." http://www.oasis-open.org/cover/xmlMarkupANE.html

An interesting area of new research in interface design involves the personalization and adaptation of interface settings and behaviors based on user models. We plan to investigate the potential for intelligent and adaptive interfaces to support user requirements and preferences.

SUMMARY

We have presented a summary of the maintenance, development and research aspects of our database, highlighting three separate activities whose interactions form an evolutionary development path for the database. An important limitation of these interactions is that new functions are researched and developed independently of the maintained system prior to integration, so that untested experimental content or functions are never presented to the database user.

A notable project in on-line cuneiform publication, which may be of interest to readers, is The Cuneiform Digital Library Initiative (CDLI), a joint project between UCLA and The Max Planck Institute for the History of Science, (on-line at http://early-cuneiform.humnet. ucla.edu). The aim of the project is to develop an electronic resource making 3rd millennium B.C. cuneiform tablets available on the internet. Full image data sets of the Hermitage, with its substantial archives of pre-Sargonic Lagash (c. 2400–2350 B.C.) and Ur III (c. 2050–2000 B.C.) administrative documents, and of all collections of tablets deriving from the period of proto-cuneiform (c. 3200–3000 B.C.) are in the process of being made available on the CDLI pages. The pages also provide links to many useful resources.

ACKNOWLEDGEMENTS

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AUTHOR NOTES

The Cuneiform Digital Forensic Project (CDFP) at The University of Birmingham, www.cuneiform.net consists of the following team: Drs. Sandra Woolley, Nicholas flowers, Javier Pinilla-Dutoit and Theodoros Arvanitis are digital imaging/networking/database engineers in the Department of Electronic, Electrical and Computer Engineering at The University of Birmingham. Dr. Tom Davis is the CDFP forensic handwriting expert in the Department of English Literature and Dr. Alasdair Livingstone is the CDFP leader and assyriologist in the Department of Ancient History and Archaeology.

Typographic Cueing ON SCREEN

Mary C. Dyson and Judy Gregory

The effects of typographic cues, such as bold, underline, italic, capitals have been studied in print. The indications are that typographic cueing can improve the recall of material and this is most evident if recall immediately follows reading. This study investigates whether cueing on screen facilitates recall and introduces factors that have been explored when cueing content in printed material. A series of documents was read on screen followed by a set of multiple choice questions, which covered a range of question types. Cued material was either a phrase or sentence in red type, and these related to either main facts or incidental details. A control condition contained no red. Instruction regarding cueing was also varied.

We found a difference in overall recall between the cueing conditions, but no significant difference between the experimental conditions and the control. The difference was attributable to better recall of cued phrases than cued sentences. However, this difference was found only for incidental material. These results suggest that cueing a whole sentence containing detail can hinder overall recall, but cueing the specific detail is helpful.

Looking at answers to particular questions, we found an interaction between the instruction regarding the use of red and the type of question. For most questions performance was better without instruction regarding red type, but this was not the case for some questions. Telling participants that red highlights the answers to some of the questions helped them locate where an item came within the text, if red was used.

Overall, these findings provide no evidence that cueing is generally useful, despite the close relationship between some cued material and questions and explicit information on this relationship. Mixing questions on cued and non-cued material may remove any possible benefits of cueing.

INTRODUCTION

Typographic cueing provides a non-verbal way of guiding readers and focusing attention. By using typographic techniques (such as bold, underline, italics or color) to cue material, information designers can help readers to focus on material that requires the most attention. Most existing work has looked at the application of cueing to printed material, whereas this study explores typographic cueing on screen.

Glynn (1978) suggests that one of the assumptions underlying typographic cueing is that it works because of an isolation effect; by using cueing to set apart some information, the cued information is more likely to be noticed by readers. This is also referred to as making material perceptually more salient (Ausubel, Novak and Hanasian, 1978). But while there is wide agreement on why typographic cueing may be useful for readers, there are few guidelines discussing what cues are appropriate and little research to suggest how cues are best used (Beck, 1991).

The general consensus emerging from the literature is that typographic cueing can improve the recall of cued material. Foster (1979), in his overview of the cueing literature, argues that there is considerable evidence that typographic cueing can improve recall. Improved recall is demonstrated most frequently if it is tested immediately after reading (193). Foster's conclusion is echoed by Beck (1984, 1991) who notes that cueing generally helps readers to recall the cued information.

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PROPORTION OF CUED MATERIAL

While typographic cueing may generally improve the recall of cued material, some research suggests that excessive cueing may reverse any positive effects. Excessive cueing may make it difficult for readers to focus on important information.

Marks (1966) explored the quantity of material that should be cued through a study of children's reading of simple instructions. Marks found that cueing key words (by using bold or larger type) tended to improve performance, but cueing the entire set of instructions (through underlining) was detrimental to performance. Although Marks' study suggests that cueing key words rather than entire passages may improve readers' performance, it is not possible to draw this conclusion from the study because of the different cueing devices used. However, Marks does conclude that readers' attention can be focused by cueing only key words, while excessive cueing and 'indiscriminate underlining created an extremely crowded effect which militated against readability' (150).

The effects of the density of cueing was also noted by Crouse and Idstein (1972). They found that fairly dense cueing (with the answers to 22 questions underlined in a 210-word text) failed to improve readers' ability to answer the questions. Sparse cueing (with the answers to 30 questions underlined in a 6,000-word text) significantly improved readers' recall. This study suggests that having fewer cues in a text may encourage readers to pay attention to the cued material. However, as Foster (1979) notes, this study leaves unanswered the question of whether there is an optimal proportion for cued material (195).

Complex cueing, which is using different types of cues to highlight different types of content, may not bring any advantages to readers (Hershberger, 1964). Hershberger tested several types of cueing (including underlining, variations in type size and color) with school children and found that complex cueing failed to improve their learning. Although the complex cueing appeared to reduce the amount of 'enrichment content' (unimportant material) learned, it failed to facilitate children's learning of 'core content', i.e., the most important material. In a follow-up study, Hershberger and Terry (1965) concluded that, in contrast, simple cueing can help participants to learn more of the core content. Their simple cueing involved using just one cue (red type) to distinguish core content from the enrichment content in black type.

TYPE OF CUED MATERIAL

Another concern for researchers, highlighted in Marks' (1966) study, is what type of material should be cued. Ausubel, Novak and Hanasian (1978) suggest that the effect of cueing is most pronounced when factual material, rather than abstract material, is cued. Readers may also be influenced by whether the cueing involves key words, key phrases, entire sentences or entire paragraphs. Marks concludes that cueing key words is most useful and that cueing entire passages creates problems for readers. But, as Foster (1979) notes, it is difficult to draw any conclusions about how much and what material should be cued because many studies do not specify how the cued material was chosen and because most studies of typographic cueing can not be compared. If the decision is made to cue the core content, identifying the most important sections can be criticized for being the subjective judgment of the research worker (194–195).

Foster (1979) also notes that relevant cues are most useful. In his study, Foster used capital letters to cue sentences within a passage of text. He used two cueing conditions: one condition cued sixteen sentences providing relevant core content, the other cued sixteen random sentences. Foster found that relevant cueing led to a greater recall of core content.

The relevance of cued information is likely to be linked to readers' trust about whether the cueing will be useful. Readers may make an initial judgment about the value of cues, and use this judgment to guide the attention that they give to all cues within a text. Fowler and Barker (1974) examined this question in their study of college students' recall of cued material. Fowler and Barker's experiment involved four conditions: some participants used a pen to actively highlight important information as they read, some read text highlighted by other students, some read text highlighted by the experimenter and some read text that was not highlighted. While Fowler and Barker found no reliable differences in participants' overall retention, they did find that highlighted material was significantly more likely to be remembered than non-highlighted material. In addition, they found that the degree of improvement was influenced by the faith that participants had in the person who did the highlighting. Participants reading text that had been highlighted by the experimenter performed significantly better in recalling the highlighted material.

EFFECTS OF CUEING ON OTHER MATERIAL

Typographic cueing may generally improve readers' recall of the cued content, but there is some evidence that this improved recall may come at the expense of non-cued content. Cueing may not influence the total amount of material recalled from a text; instead, it may influence what material is recalled (Glynn, 1978).

This trade-off in what material is recalled is evident in Fowler and Barker's (1974) study. They found no significant difference in overall recall across the four conditions used in their experiment. However, they did find that the recall of cued material was significantly better for participants reading cued text.

Beck (1991) explored this question because of concerns raised in other studies that highlighting intentional information may be detrimental to the learning of incidental (non-cued) information. Beck's work did not support this concern. In a series of studies with school children, he found that cueing helped children to retain intentional information without affecting their retention of incidental information.

An earlier study by Cashen and Leicht (1970) with older students seems to make even stronger claims for the retention of non-cued material. Using multiple choice questions, they tested recall of material that was adjacent to the cued (underlined) statements. They found superior performance for both underlined statements and those adjacent, when compared with the control condition (no cueing). In this study, the authors speculate that improved recall may have been due to spending longer on cued material as there were no limits on the length of time spent reading. However, this speed-accuracy trade-off does not appear to be necessary for superior performance. Hershberger and Terry (1965) reported no difference in reading times of cued and uncued material, but an improvement in recall of important information, relative to unimportant. There was also no overall reduction in the amount recalled.

INSTRUCTIONS TO PARTICIPANTS

The value of cueing may be influenced by what participants are told about the cues used in a text. For example, participants may perform differently if they are told at the beginning of an experiment that cued material contains important information or if they are provided with training in processing cued material (Beck, 1984). The importance of participants' initial impressions of the value of cues is clearly evident in the experiment conducted by Fowler and Barker (1974).

Typographic cueing may be most effective if the information that is cued is also directly relevant to the information required for follow-up tests. Crouse and Idstein (1972) note that, when cueing directs learners to the information required for a follow-up test, cueing is likely to improve recall. In their study, Crouse and Idstein specifically told participants to study the cued material.

How participants are instructed was explored by Coles and Foster (1975) who also cued material that was directly relevant to the questions in a follow-up test. In their first experiment, Coles and Foster did not inform participants about the cueing; they found that while the participants in the cued condition performed numerically better than those in the non-cued condition, there was no significant difference between the two conditions. In a second experiment, Coles and Foster informed participants that the cued material was important. Contrary to their expectations, they again found a numerical improvement but no significant difference between the cued and non-cued conditions. In a third experiment, Coles and Foster gave more elaborate instructions and encouraged participants to adopt a specific reading strategy. This time, they found a significant difference caused by cueing when readers were instructed to use the reading strategy. They conclude that the effects of cueing will vary between texts and readers, and that the value of cues will depend on readers' faith in them.

PRINT VERSUS SCREEN

The research reviewed so far has investigated typographic cueing in print. Various researchers have pursued general comparisons of reading from paper and reading from screen (e.g., Gould, Alfaro, Barnes, Finn, Grischkowsky and Minuto, 1987; Hansen and Haas, 1988; Oborne and Holton, 1988; Jorna and Snyder, 1991; Muter and Maurutto, 1991; O'Hara and Sellen, 1997). A main finding has been that reading from screen is significantly slower than reading from paper (Dillon, 1992). Rates that have been reported for reading from screen are 199 words per minute (Muter and Maurutto, 1991); 244 words per minute (Dyson and Haselgrove, 2000); 151 words per minute (Dyson and Haselgrove, 2001). Given the differences between individuals' reading rates, this degree of variation is not surprising. A further source of variation identified by Jackson and McClelland (1979) and found by Dyson and Haselgrove (2001) is the tendency for faster readers to have higher levels of recall.

Although research has looked at reading from screen, there appear to have been few attempts to explore how typographic cueing on screen may affect recall from passages of continuous text. An unpublished study (Backman, Lundberg, Nilsson and Ohlsson, 1984)[1] used red type to cue more important clauses, in contrast to white type on a blue background. This seemed to work better for good than poor readers, but the effect of red was still relatively weak. Ten years later, using the more sophisticated display of a Macintosh screen, Cory (1994) compared underlining and highlighting as cues to the most important sections of text. Unfortunately, the published article focuses solely on the other variable introduced into the study: the user's cognitive style.

[1] Summarized in an abstract by Rune Pettersson.

Color was once a primary means of typographic differentiation on screen, before it was possible to render different typefaces, type sizes, type styles etc. Consequently, articles from the 1980s address the use of color within systems in use at the time, i.e., teletext and viewdata (e.g., Reynolds, 1980; Bruce and Foster, 1982; Foster and Bruce, 1982; Backman et al., 1984; van Nes, 1986). Although color as a means of differentiating material was explored, this was generally as an aid to searching and retrieving information, rather than in the context of continuous reading.

The greater sophistication of current display technologies, and a significant increase in the amount of material that we can read from screen, particularly on the WWW, limit the generalizations which can be made from past research. However, color has been retained as a means of typographic cueing in web pages which frequently use color to indicate links or differentiate elements of text, such as headings.

RESEARCH QUESTIONS

This study explores whether typographic cueing on screen can aid recall, using red type as a simple cueing device. A comparison is made between the cueing of phrases and sentences. Based on the findings of Marks (1966) and Crouse and Idstein (1972), we would expect cueing less material (i.e., phrases) to produce better recall than denser cueing (i.e., sentences).

The type of material cued is also varied, comparing main facts and incidental details. We avoid subjectivity in selecting which material to cue by using documents and questions which were piloted for use in earlier experiments (Dyson and Haselgrove, 2000, 2001) where it was important to establish an objective basis for devising comprehension questions. The pilot identified the most important 'units' of documents, which provided a criterion for developing questions that addressed the main issues, as opposed to details. On the whole, we would expect questions testing recall of specific information to be answered less accurately than those that are more general, and based on more important units of text (Dyson and Haselgrove, 2000). Cueing may reinforce this difference, having equal effects on the two types of material. Alternatively, as there is more scope for improving the recall of details, differences between the two may be reduced by cueing.

The effect of cueing on recall of non-cued material is also explored in this study as questions address a range of types of material, other than the main facts and details (Dyson and Haselgrove, 2000, 2001).

Finally we vary instruction to see how this may affect the value of cueing (Coles and Foster, 1975).

METHOD

EXPERIMENTAL DESIGN

The experiment compared five cueing conditions: four with cued material and one that served as the control condition, i.e., no text was cued. Two conditions cued text that related to main facts, and the other two cued incidental material. In both cases one document cued phrases and the other cued sentences. All participants received the five cueing conditions (within subject variable), but half were given no prior indication that there would be cued material (no instruction) and the other half were informed that the cued material highlighted answers to some of the questions (instruction).

The time taken to read each text was recorded together with recall scores based on multiple choice questions covering a range of types of material (see below).

All participants started with a practice document. Those who received no instruction regarding cueing received a document identical to the control condition, i.e., contained no cued material. The participants who were given instruction read a practice document which contained four instances of cued material: two phrases and two sentences (in each case with one referring to main factual and one incidental material). The design is summarized in table 1. The pairing of documents with cueing condition and the order of presentation was determined by a Greco-Latin square balanced design.

TABLE 1
Between and within subject variables

BETWEEN SUBJECT	USE OF INSTRUCTION	NO INSTRUCTION						INSTRUCTION					
WITHIN SUBJECT	CUEING CONDITION	No Cueing	No Cueing	Main Factual Phrases	Main Factual Sentences	Incidental Phrases	Incidental Sentences	Main Factual Phrases Main Factual Sentences Incidental Phrases Incidental Sentences	No Cueing	Main Factual Phrases	Main Factual Sentences	Incidental Phrases	Incidental Sentences
	DOCUMENTS	Practice	1	2	3	4	5	Practice	1	2	3	4	5

PARTICIPANTS

Thirty volunteers were recruited from within the Department of Typography & Graphic Communication at the University of Reading, UK. They were either undergraduate or postgraduate students.

MATERIALS

A number of articles that were considered to be of general interest were selected from the magazine *National Geographic*. (Permission was obtained to use these articles.) The documents were edited to be approximately equal length (up to 1000 words) by deleting text from the end, ensuring that the story line remained intact.

Six types of questions were used which appeared to require either recall of specific information (detail or a main fact) and 'higher order' questions (McConkie, Rayner and Wilson, 1973), which required the reader to make inferences about what was read. Five of the six question types were written as multiple choice questions, with three alternative answers. The sixth type of question measured recognition of short extracts (a sentence or the first part of a sentence) from the document.

The questions requiring recall of main facts and incidental details were used to identify which material to cue. In the phrase conditions, the words appearing in the correct answer (within the multiple-choice alternatives) were cued. Where sentences were cued, these incorporated both the question and the correct answer. To maintain consistency across questions and documents, if a sentence incorporated some relevant material, the whole sentence was cued. This resulted in some variation in the number of words cued, but maintained a clear distinction between cueing phrases and sentences.

All question types were applied to each condition to gauge the effect of questions on non-cued material, as well as questions on cued material. There were three main factual (MF) and three incidental (I) questions for each document. There was also one title question (T) asking which of the alternative titles best fit the text; one main idea question (MI) covering one of the main ideas in the text; a structure question (S) asking about the order of items within the text, i.e., what came before or after a particular item; ten recognition questions (R) asking whether the extract had appeared in the text. Recognition questions consisted of ten short extracts, of which five were taken from the text that had been read, and five from the same source material, but from a part that had not been read. This ensured that the theme and writing style of the extracts were similar.

EQUIPMENT

A Compaq Prolinea 575 computer was used to present the experimental material on a Sony Multiscan 15sf color monitor with a video image area of 11.25" by 8.5" (14" maximum viewing image). This was set to a resolution of 800 x 600 pixels and 256 colors.

The text was displayed using Microsoft Word for Windows 7 in 10 point Verdana, a sans serif typeface designed for screen. Cued material was displayed in red type, with the remaining type in black on a white background. The interlinear spacing was 12 points with an additional 12 points between paragraphs. The line length averaged 55 characters per line. Figure 1 illustrates the layout of the screen.

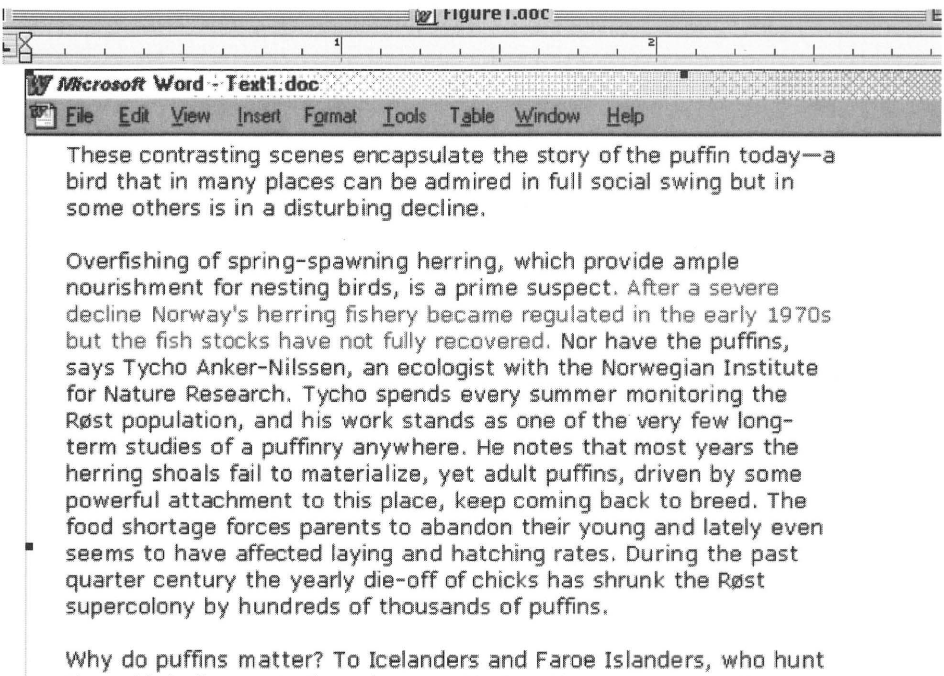


FIGURE 1
Screen layout showing a document with a cued sentence

PROCEDURE

Following initial briefing, a practice trial was given to familiarize participants with the type of questions they would be asked and ensure they knew how to move through documents and call up the next document. They were given the option to scroll through the document with the mouse or use cursor keys.

On completion of the practice trial participants were asked to silently read a series of five documents displayed on screen and the time taken to read each document was recorded.

Nine multiple-choice questions were asked about each document with three alternatives per question, which were answered without referring back to the document. The order of questions and order of alternative answers were randomized for each participant. These questions were immediately followed by ten recognition questions.

After these questions, participants were asked to rate their enjoyment in reading the text, based on the content. They were given a rating scale from 1 (did not enjoy at all) through to 5 (very enjoyable).

On completion of these tasks, participants were asked to fill in a short questionnaire to provide information on their use of computers and reading habits. This asked about their frequency of using computers, reading from screen, word processing and accessing the web (on a scale from 0: not at all to 5: very frequently).

Two further questions explored their attitudes regarding reading from screen, asking them to rate their dislike or enjoyment of reading from screen, and what they did if they found a web page that was of interest to them (e.g., skim and if useful or interesting print out, or read from screen).

RESULTS

SPEED OF READING

There were no statistically significant differences in reading speed across the five cueing conditions and no effect of giving instruction. The average rate was 200 words per minute.

OVERALL RECALL

Scores for recognition questions were adjusted as chance level of performance is 0·5 for these questions and 0·33 for the multiple choice (as three alternatives were available). The adjustment standardized chance level at 0·33 for all questions, so that scores became relative to their distance above or below chance. The answers to all questions were scored as a proportion and transformed (2 arcsin $\sqrt{}$) for statistical analysis. Where scores are a proportion of perfect performance there is a maximum limit and an angular transform is appropriate (Kirk, 1995). Following these adjustments and transformations, chance is equal to 1·57 and a perfect score 3·14 for all question types.

A two-way analysis of variance was carried out on the combined recall scores from the six types of questions with instruction as a between subject factor and cueing condition as a within subject factor. This found a main effect of cueing condition ($F(4,112)=2{\cdot}54$, $p<0.05$). There was no significant main effect of instruction and no interaction between cueing condition and instruction. The data are illustrated in figure 2, averaged across the two forms of instruction. The standard error bars on each data point give an indication of the variability between participants.

Differences among individual means were examined using linear contrasts as not all comparisons between the conditions needed to be tested (Howell, 1982, 276). No difference was found between the four experimental conditions (MFP, MFS, IP, IS) and the control (C) with no cueing suggesting that cueing has not improved overall recall in a simple manner. There was no significant difference between main factual and incidental recall (across phrases and sentences). Cueing of phrases produced significantly better recall than cueing sentences ($p<0{\cdot}025$) although this can be attributed to incidental material. Cueing incidental phrases was better than cueing the whole sentence ($p<0{\cdot}01$), but cueing main factual phrases did not significantly improve recall compared with cueing main factual sentences.

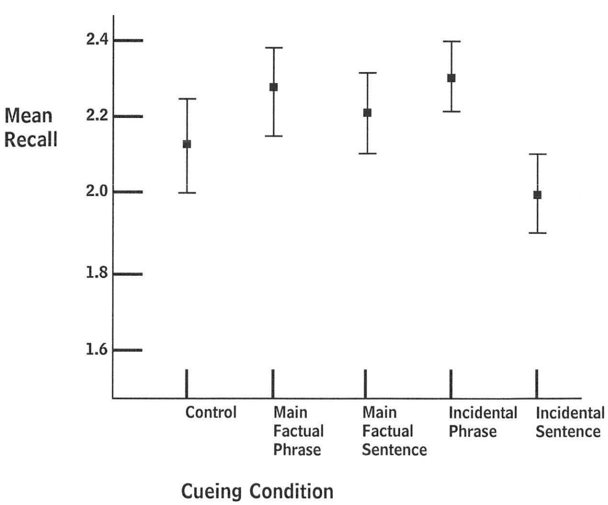


FIGURE 2
Mean recall scores across five cueing conditions.

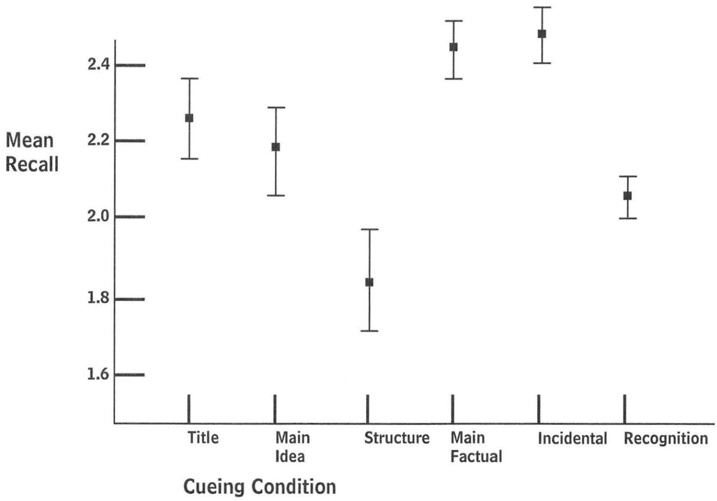


FIGURE 3
Mean recall scores across six question types. T: Title; MI: Main Idea; S: Structure; MF: Main Factual; I: Incidental; R: Recognition

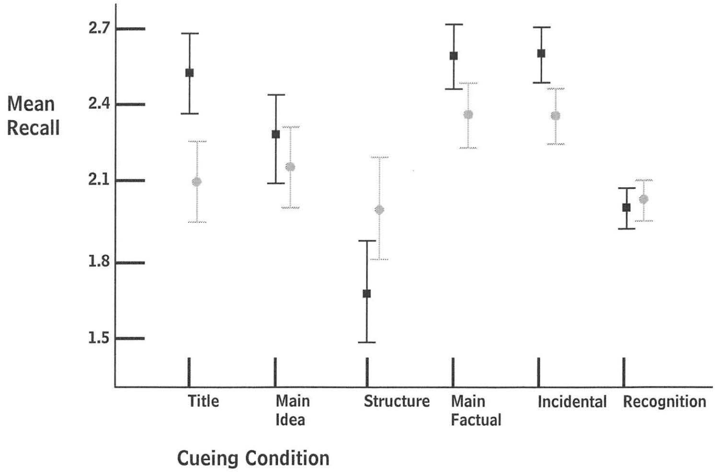
QUESTION TYPES

A second analysis of variance included question type (six levels) and found a significant main effect ($F(5,140)=8{\cdot}42$, $p<0{\cdot}0001$). There are differences in the level of recall depending on question type, which are illustrated in figure 3. Again using linear contrasts, main factual and incidental questions are answered better than all the others ($p<0{\cdot}01$), and there is no significant difference between the two. Structure questions are the most difficult and are significantly worse than all others ($p<0{\cdot}01$).

If the control condition is excluded from the analysis of variance to compare only the experimental conditions, there is a significant interaction between the instruction given to participants and the question type ($F(5,140)=2{\cdot}35$, $p<0{\cdot}05$). Figure 4 shows the recall scores for each type of question with and without instruction. Structure and recognition questions are different from the remaining questions when comparing instruction and no instruction ($p<0{\cdot}01$). When no instruction regarding the cueing is given, performance is superior on title, main idea, main factual and incidental questions, compared with giving instruction. In contrast, structure questions are answered better when instruction is provided, than when it is not; recognition questions are not affected by instruction.

FIGURE 4
Mean recall scores across six question types

■ without instruction
● with instruction



As answers to the structure question seem to be particularly difficult and to be affected in a different way by instruction, compared with other questions, this question type was further explored. Analysis of variance on the answers to this question across the five cueing conditions and two types of instruction produced a significant interaction between instruction and cueing condition ($F(4,112)=2{\cdot}88$, $p<0{\cdot}05$). The data are illustrated in figure 5. The difference between control conditions with and without instruction and experimental conditions with and without instruction is significant ($p<0{\cdot}025$). Instruction hinders participants in answering structure questions when there is no cueing, but has little effect, or helps, when there is cueing. The graph shows that the advantage of informing participants of cueing is associated with incidental material, rather than main factual.

READING PERFORMANCE, ENJOYMENT AND READING HABITS

Pearson's Product-Moment Correlations were computed between individual reading rates on each document, recall and participants' rating of their enjoyment in reading the text. There were no significant correlations so enjoyment did not relate to speed of reading or recall and speed of reading did not correlate with recall.

Correlations carried out to explore possible relationships between reported reading habits and performance (reading speed and recall) found no significant correlations.

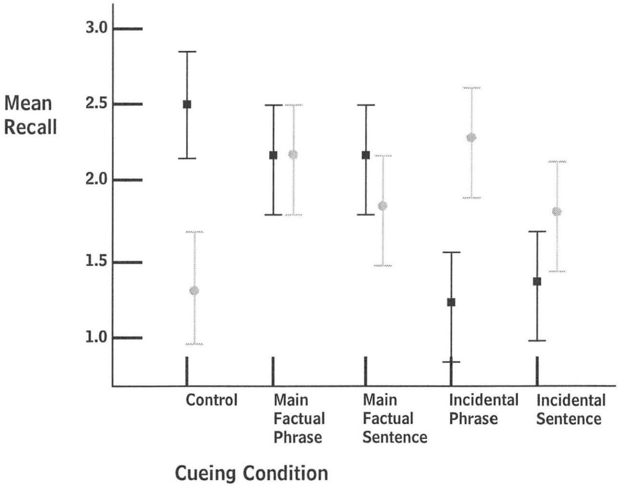


FIGURE 5
Mean recall scores for structure questions across five cueing conditions

- ■ without instruction
- ● with instruction

However, the pattern of reading habits appears logical. Frequency of computer use correlates with frequency of screen reading ($R=0{\cdot}4$, $p<0{\cdot}05$), so those who report using computers more often also report reading from screen more often. Frequency of screen reading also correlates with enjoyment of screen reading ($R=0{\cdot}66$, $p<0{\cdot}0001$) and with what participants say they do with a web page that is of interest to them. Those who read from screen more frequently are more likely to read the web pages on screen, as opposed to skimming and then printing out.

DISCUSSION

The results provide no support for a general improvement in immediate recall of material read from screen that is cued in red. However, cueing of phrases produces better recall than cueing whole sentences, particularly when incidental details are cued. Therefore the suggestion reached by Marks (1966), that more discriminate use of cueing is preferable, may also apply to reading from screen. The confounding factor in the Marks study was removed in the current experiment which used the same cueing devices for both phrases and sentences.

This experiment, however, does not establish whether the advantages of cueing less material are due to identifying more specific items (with phrases) or simply cueing fewer words. Cueing sentences increases the density of cueing (Crouse and Idstein, 1972), so that a greater proportion of material is cued. An alternative way to increase this proportion would be to cue a greater number of phrases, but this was outside the scope of the current study.

The larger difference in recall between incidental sentences and phrases, compared with main factual sentences and phrases, suggests that a greater density of cueing may not be a sufficient explanation for poorer recall. Both the amount and type of cued material seems to be relevant. A specific detail, unlike a main fact, may be conveyed in a few words and if the whole sentence is cued, identification of the detail may be obscured.

The lack of a difference between the recall of main factual and incidental material may be due to a ceiling effect in recalling more important information. This is the material that tends to be recalled more accurately without cueing (Dyson and Haselgrove, 2000, 2001). Cueing incidental details may have focused participants' attention on them and thereby improved their recall to the level of the more important units (main factual). This works more effectively when only phrases are cued.

In this study, there appears to be no adverse effect of cueing on the recall of non-cued material. Although the main factual and incidental questions are answered better than all other questions based on non-cued material, this is the case with or without cueing. There is no interaction between cueing condition and question type.

Introducing cueing also had no effect on reading speed, as reported by Hershberger and Terry (1965). The average reading rate falls within the range of other studies that have measured speed of reading from screen (Muter and Maurutto, 1991; Dyson and Haselgrove, 2000, 2001). There appears to be no trade-off between speed of reading and recall, nor a tendency for faster readers to have higher levels of recall (Dyson and Haselgrove, 2001).

Instructing participants that the cued material highlights answers to some of the questions does not improve overall recall. As with the Coles and Foster (1975) study, it may be necessary to go further than a simple instruction and suggest a specific reading strategy. However, the introduction of instruction does interact with the type of question, suggesting some form of strategy may have been adopted.

Recognition questions are unaffected by instruction, perhaps because a rather different type of recall is being measured. Recognition questions do not require understanding of the text, but memory for specific wordings. As these particular extracts are not cued (and participants may have realized this as the experiment progressed) instructions regarding cueing, or even cueing itself, may be irrelevant. This is supported by very similar recognition scores across all five conditions.

The difficulty of structure questions is consistent with earlier studies (Dyson and Haselgrove, 2000, 2001) and in this experiment instruction differentially affects recall of structure depending on whether or not cueing is applied. Due to instruction, participants may have decided to use the sections in red type as reference points, thereby using the cueing to help locate items. The extremely poor recall (worse than chance) with no cueing, when instructed, may possibly be due to a reliance on the red, which is not available in the control condition. Participants were not informed that one document contained no cued material.

When cueing is applied to incidental material, especially phrases, informing participants of the relevance of the cueing to the follow-up tests may have increased their attention to what were otherwise seemingly unimportant details. These appear to have been used to improve the recall of the order of items (structure questions). Performance on incidental questions does not show a similar improvement with instruction, but the level of recall is generally much higher for these questions (with or without instruction).

Although this study has produced no clear evidence that typographic cueing on screen improves the recall of cued material, we cannot conclude that these results differ from those for print. The literature on cueing in print was used to inform and direct suitable hypotheses for testing on screen, and the experiment was not designed to compare the two forms of reading. The results suggest that further exploration of the use of cueing on screen would be useful, looking specifically at facilitating the location of items within a narrative, a particular problem when reading from screen (Dyson and Haselgrove, 2001).

References

Ausubel, D.P., J.D. Novak and H. Hanesian. 1978. *Educational Psychology: A Cognitive View*. 2nd ed. New York: Holt, Rinehart and Winston.

Backman, J., I. Lundberg, L.G. Nilsson and K. Ohlsson. 1984. Reading Skill and Text Structure. *Educational Communication and Technology Journal*, 32:1, 51.

Beck, C.R. 1984. Visual Cueing Strategies: Pictorial, Textual and Combinatorial Effects. *Educational Communication and Technology Journal*, 32:4, 207–216.

Beck, C.R. 1991. Strategies for Cueing Visual Information: Research findings and Instructional Design Implications. *Educational Technology*, XXXI:3, 16–20.

Britton, B.K., S.M. Glynn, B.J.F. Meyer and M.J. Penland. 1982. Effects of Text Structure on Use of Cognitive Capacity during Reading. *Journal of Educational Psychology*, 74, 51–61.

Bruce, M. and J.J. Foster. 1982. The Visibility of Colored Characters on Colored Backgrounds in Viewdata Displays. *Visible Language*, 16:4, 382–390.

Cashen, V.M. and K.L. Leicht. 1970. Role of the Isolation Effect in a Formal Educational Setting. *Journal of Educational Psychology*, 61, 484–486.

Coles, P. and J. Foster. 1975. Typographic Cueing as an Aid to Learning from Typewritten Text. *Programmed Learning and Educational Technology*, 12:2, 102–108.

Cory, K.A. 1994. Effective Video Screen Displays: Cognitive Style and Cueing Effectiveness. *SIGCHI bulletin*, 26:1, 51–55.

Crouse, J.H. and P. Idstein. 1972. Effects of Encoding Cues on Prose Learning. *Journal of Educational Psychology*, 63:4, 309–313.

Dillon, A. 1992. Reading from Paper Versus Screens: A Critical Review of the Empirical Literature. *Ergonomics*, 35:10, 1297–1326.

Dyson, M.C. and M. Haselgrove. 2000. The Effects of Reading Speed and Reading Patterns on Our Understanding of Text Read from Screen. *Journal of Research in Reading*, 23:1, 210–223.

Dyson, M.C. and M. Haselgrove. 2001. The Influence of Reading Speed and Line Length on the Effectiveness of Reading from Screen. *International Journal of Human-Computer Studies*, 54, 585–612.

Dyson, M.C. and G.J. Kipping. 1998. The Effects of Line Length and Method of Movement on Patterns of Reading from Screen. *Visible Language*, 32:2, 150–181.

Foster, J.J. 1979. The Use of Visual Cues in Text. In Kolers, P.A., M.E. Wrolstad and H. Bouma, editors. *Processing of Visible Language* Vol. 1, 189–203. New York: Plenum Press.

Foster, J.J. and M. Bruce. 1982. Looking for Entries in Videotex Tables: A Comparison of Four Color Formats. *Journal of Applied Psychology*, 67:5, 611–615.

Fowler, R.L. and A.S. Barker. 1974. Effectiveness of Highlighting for Retention of Text Material. *Journal of Applied Psychology*, 59:3, 358–364.

Glynn, S. 1978. Capturing Readers' Attention by Means of Typographic Cueing Strategies. *Educational Technology*, 18:11, 7–12.

Gould, J.D., L. Alfaro, V. Barnes, R. Finn, N. Grischkowsky and A. Minuto. 1987. Reading Is Slower from CRT Displays than from Paper: Attempts to Isolate a Single-variable Explanation. *Human Factors*, 29:3, 269–299.

Hansen, W.J. and C. Haas. 1988. Reading and Writing with Computers: A Framework for Explaining Differences in Performance. *Communications of the ACM*, 31:9, 1080–1089.

Hershberger, W.A. and D.F. Terry. 1965. Typographical Cueing in Conventional and Programmed Texts. *Journal of Applied Psychology*, 49, 55–60.

Howell, D.C. 1982. *Statistical Methods for Psychology*. Boston, Massachusetts: Duxbury Press.

Jackson, M.D. and J.L. McClelland. 1979. Processing Determinants of Reading Speed. *Journal of Experimental Psychology: General*, 108:2, 151–181.

Jorna, G.C. and H.L. Snyder. 1991. Image Quality Determines Differences in Reading Performance and Perceived Image Quality with CRT and Hard-copy Displays. *Human Factors*, 33:4, 459–469.

Kirk, R.E. 1995. *Experimental Design: Procedures for the Behavioral Sciences*. Pacific Grove, USA: Brooks/Cole.

Marks, M.B. 1966. Improve Reading through Better Format. *Journal of Educational Research*, 60:4, 147–151.

McConkie, G.W., K. Rayner and S.J. Wilson. 1973. Experimental Manipulation of Reading Strategies. *Journal of Educational Psychology*, 65:1, 1–8.

Muter, P. and P. Maurutto. 1991. Reading and Skimming from Computer Screens and Books: The Paperless Office Revisited? *Behaviour and Information Technology*, 10:4, 257–266.

Oborne, D.J. and D. Holton. 1988. Reading from Screen Versus Paper: There Is No Difference. *International Journal of Man-Machine Studies*, 28, 1–9.

O'Hara, K. and A. Sellen. 1997. A Comparison of Reading Paper and On-line Documents. In S. Pemberton, editor. CHI 97 Conference: *Human Factors in Computing Systems*, 335–342. Reading, MA: Addison-Wesley, ACM Press.

Reynolds, L. 1980. Teletext and Viewdata—A New Challenge for the Designer. In J. Hartley, editor. *The Psychology of Written Communication*: *Selected Readings*, 207–224. London: Kogan Page.

van Nes, F.L. 1986. Space, Color and Typography on Visual Display Terminals. *Behaviour and Information Technology*, 5:2, 99–118.

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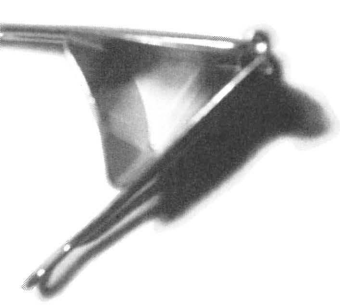

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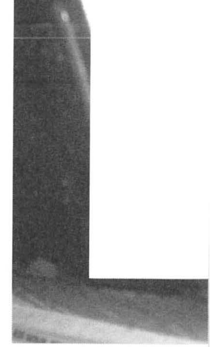

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Foreign Institutional 3 YEARS **$246**
Foreign subscriptions include additional postage ($21 per year).

Canadian Individual 1 YEAR **$44**
Canadian Individual 2 YEARS **$83**
Canadian Individual 3 YEARS **$108**

Canadian Institutional 1 YEAR **$74**
Canadian Institutional 2 YEARS **$142**
Canadian Institutional 3 YEARS **$210**
Canadian subscriptions include additional postage ($9 per year).

Prepayment is required. Make checks payable to **Visible Language** in U.S. currency only, foreign banks need a U.S. correspondent bank.