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THE EFFECT AND AFFECT OF ANIMATED VISUAL CUES
WITHIN A COMPUTER-BASED LEARNING PROGRAM

DISSERTATION

Presented in Partial Fulfillment of the Requirements
for the Degree Doctor of Philosophy in the
Graduate School of The Ohio State University

By
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* * * * *

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ABSTRACT

The purpose of this study was to explore the effect of animated visual cues on students using interactive software learning programs. After viewing a static or animated program that described tasks for using cellular phones, students were asked to perform those same tasks with a cellular phone. In addition, students were given a Productivity and Environmental Preferences Survey to assess learning style preferences, and an additional questionnaire pertaining to their preferences for animated visual cues.

To statistically assess the effect of animated learning materials on students, a logistic regression model was used. This model allowed for the inclusion of other variables, such as "comfort with computers", that could have impacted the outcome of the. Cox’s Proportional Hazards model was used to assess students’ task completion times, taking into consideration the potential complication of repeated tasks.

Results obtained showed that students had greater successful task rates with animated visual cues than with the static cues in their learning programs. Results also showed that students’ successful task completion times with the animated programs were lower than with the static programs. Although some students stated they did not find the animated cues useful, the majority of students found the cues helpful because the animations visualized the process enabling them to remember key parts of the task.

The findings of this study demonstrated support for the use of animated visual cues in learning environments. When properly designed and used, animation has the potential to capture students’ attention, assist them in visualizing content, and decrease task completion times.
Dedicated to
Steven and Alexa Justice
ACKNOWLEDGMENTS

I wish to express my deepest gratitude to Dr. Stephen Acker for his encouragement, inspiration and intellectual insight throughout my graduate study. His support has been a tremendous contribution to my work and life.

I wish to thank Dr. Dale Brashers for his assistance and patience throughout this process. He helped to shape this work. I would also like to thank Dr. Carol Gigliotti for her support of my research direction as well as diversity in academic life. I also thank Dr. Wayne Carlson for his unwavering support of my studies in computer graphics and communication, and of my work in general.

I also wish to thank, Bryce Hooker, for his steadfast programming assistance, Dr. Panickos Palletas for his statistical assistance and Dr. Debra Phillips for her learning styles information and general assistance.

Finally, I want to thank my husband Steven, and daughter Alexa, for helping me throughout this process.
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CHAPTER 1

PROBLEM STATEMENT AND LITERATURE REVIEW

Background

The increase in the hardware and software capabilities of interactive media has facilitated an increase in the use of animated imagery within software learning environments. New software animation programs have been introduced into the market place and are targeted specifically for use on the World Wide Web (WWW) and CD-ROMS. Programmers, designers, and others, who may have little training or experience in developing educational materials, are incorporating animated imagery into interactive content with the use of these programs.

The effectiveness of animated imagery within learning programs has yet to be fully explored (Arnheim, 1974; Laurel, 1990; Shneiderman, 1997), especially in relation to educational programs (Rieber, 1991). Animated imagery allows for more visual stimulation to be present through movement of text, image, and color on the screen. However, little research has been conducted as to whether animated imagery can have beneficial effects on learning, in the educational
environment. Nor has research been conducted to learn about student preferences or aversions for incorporation of animation into their learning programs.

The purpose of this study is to explore the effect of animated visual cues on students in a software learning environment, and the visual preferences of learners. By studying the effectiveness of animated imagery for increases in student learning within educational software, we can discover if visually dynamic imagery helps us retain content or understand concepts. By studying how learners feel about the way content is delivered, we gain insight into visual presentation preferences, which will then assist us in designing and developing effective and positive affective software learning programs.

Animated imagery in interactive content is an inherently different learning tool from the traditional instructional paper book. Our physical interaction with each of these delivery tools is different. We hold a book in our hands as opposed to moving a cursor around with a mouse. While reading a book, we must imagine an image in motion, in our mind's eye, whereas the computer screen can display that image in motion for us. Complex visuals, such as rotating molecular structures or geological formations, may become faster and easier to grasp when presented as three-dimensional models on the computer screen. Our visual perception and understanding are more complete than when we
try to imagine a moving visual in our mind's eye. We have the potential to hear stimuli simultaneously with visual information presented on the computer screen that cannot be communicated with a traditional book format. The value of animated imagery is that it can give us a lot of information in a visually integrated format.

Visually dynamic images can capture our vision and hold our attention. Visually dominant animated images that simply flash on or off, change colors, or physically relocate to another area of the computer screen, captures our attention. Animated images may also simulate three-dimensional shapes and their movement, giving us more information about the content connected to the image as it moves on the screen. A rotating architectural model allows us to envision all sides of the structure as though we were walking around it or walking through it, thus allowing us to process thoughts and feelings about the structure, rather than just processing the image. If properly designed, animated imagery used within an interactive software program can provide a powerful and fertile learning environment for students of all ages and levels.

When animated imagery is placed in an interactive environment, it is used in conjunction with several other types of motion. Video, navigation, pacing, and the programmed tempo of the software program all provide forms of motion for the learner to observe or replicate. Video, which
has been studied extensively in the field of communication, can be used in conjunction with animated imagery. Navigation, or the paths that users take through a software program, allows the user to move in linear or non-linear directions. Some programs give users a choice in navigation, which in turn can affect their pacing throughout the program and possibly their learning.

In addition to navigation and learner pacing is the issue of the effect of animation in a software learning environment. Does moving imagery provide information that cannot be obtained through the combination of static imagery and text, or does it detract from the learning process? Do animations within the interface keep users interested in the content of the program, or are they seen as ineffective and “glitzy”? Do animated images increase user satisfaction through increased visual stimulation and enhanced learning opportunities, or are they annoying and distracting? How do people feel when they are viewing animated imagery? And overall, what do moving images communicate, and to whom?

A wider understanding of animated imagery, and motion in general, is needed to understand how best to use animation within a software interface. In addition, the animation production process is costly and time consuming, compounding the problem if the animations are deemed ineffective or gratuitous. Guidelines for inclusion of animated imagery
would greatly reduce unnecessary and ineffective animation, thus, reducing cost to the producers and frustration for the learners.

Several disciplines, such as art, communication, computer science, design, education, and psychology have provided content on various aspects of motion and animated imagery, but none has amassed a body of research that fully guides the software interface designer with the best methods for application within the interface. Each discipline has something to contribute to guidelines for animation use, but these contributions need to be compared across disciplines.

The following sections of Chapter I explore work done in disciplines which relate to motion, animation and the software learning environment. Educational theories that support the combined use of visual and verbal information in a learning environment will first be addressed, followed by perceptual psychology, cultural, design, and communication studies. Perception studies tell us we are mimicking, not duplicating the human visual perception system and the natural visual world when we view animation on the computer screen. Film, video, design and animation studies provide a cultural viewpoint for assessing animated imagery. Communication and computer science studies focus on imagery and perception of content.

The final section of this chapter will address the recommendation for a study of the effectiveness of animated
imagery within a software-based learning environment. In addition, assessment of learner preferences in relation to animated imagery will be proposed.

LITERATURE REVIEW

Education

The use of software for educational purposes will expand as educators move further toward distance learning, home teaching, and increased use of computers in the classroom. Increased access to computer programs for the production of animated imagery will make it easier to incorporate animated visuals. But why would we use animation in our learning programs? We assume that animated imagery might be useful for visualizing concepts and providing students with additional stimuli that aid learning. This assumption is based on cognitive learning theories.

Cognitive approaches to learning are concerned with perceptions, attitudes and beliefs of the learners (Hill, 1977). Cognitive studies have evaluated the use of nonverbal stimuli, such as pictures, objects, sounds and tactile experiences in the learning environment. Verbal stimuli, such as printed words and speech sounds, also have been studied to assess the effectiveness in a learning environment.
Paivio & Begg, 1981). By the 1970s, Paivio (1978) was conducting studies specific to visual and verbal stimuli, which assumed dual coding of content.

**Dual Coding and Dual Trace Learning Theories**

The dual coding learning theory was one of the first to address the belief that two stimuli, verbal and visual, work together to reinforce understanding. The work of Hilgard and Bower (1975) supported Paivio's studies through work that found that a combination of words and images provides a unique stimulus situation for the learner, even if the images and words are stored differently in memory.

Paivio (1979) found that images taken into the human memory in a synchronous way are recalled in a synchronous way. Words taken into memory in a sequential way are recalled in a sequential way. His results indicate that learners recall pictures in total, while words come back to the learner in stages. This distinction becomes important when addressing the issues of retention in a learning environment. The dual-trace theory, which concerns retention, addresses the use of imagery in educational content, considering visual imagery as one of the more important stimuli.

G.H. Bower (1975) conducted research with a dual-trace hypothesis which states: "there are two distinguishably different forms of representation, the imaginal and the
verbal, and the concepts within these systems are closely connected ... redundant copies of memory trace are laid down" (p. 589). Bower (1975) further explained that:

The redundancy prolongs memory in comparison to abstract items, since the second, imaginal trace is likely to survive after the initial verbal trace has decayed. Not only are there two traces, but the one in the imaginal system seems resistant to forgetting. (p.589)

The value of adding imagery to learning materials is supported by the cognitive learning, dual coding and dual trace theories. Imagery added to learning materials supports the coding of information as well as the recall of the information to be learned. Later studies in education go on to support the inclusion of visuals in educational materials.

In an experiment with kindergarteners and primary grade school children, Wittcock (Williams, 1986) demonstrated that the combination of visual and verbal activities allowed very complex information to be grasped. The children were taught kinetic molecular theory and were introduced to the concepts of “molecules in motion, states of matter, and changes in states of matter” (p. 31). Wittock’s experiment showed that the use of visual imagery, in conjunction with verbal information, was a powerful combination for learning a
complex process. The inclusion of visuals in learning environments was further supported by other education practitioners in the field.

Williams (1983) discussed the introduction of visual thinking. Words are not enough when ideas can be taught more efficiently and more expressively with the use of "pictures, maps, diagrams, charts and mind maps" (p. 30). Her premise was that students of all types benefit from the added stimulation that visual imagery provides.

McKim (Williams, 1983) believed that there are two distinct areas in which teachers should integrate visual representation: 1) presenting and clarifying ideas graphically, and 2) teaching students to interpret and use graphic representation. McKim (Williams, 1983) pointed out that most activities in classrooms are of the presenting and clarifying kind, in which ideas are verbally demonstrated. Visual interpretation and graphic representation, which are used less often, can be valuable learning and retention tools, helping students to visually analyze content and improve general recall.

Many studies in the field of education have reinforced the benefits of using imagery and text (dual coding) within a learning situation, but very few studies have specifically used animated imagery in their experiments. We cannot generalize that animated imagery and text would provide the same benefits for learning as static imagery and text,
because it has not been extensively evaluated. The most focused work in education relating to animated imagery and learning is the work of Rieber.

Animation in Education

Rieber’s (1990) meta-study on animation and learning provides a beginning for the development of guidelines for the use of animation within content. Rieber’s (1990) findings concern student motivation, age, and interactive applications, which also relate to learning styles and learner preferences. Recommendations from Rieber’s meta-study are as follows:

1. Animation should be incorporated only when its attributes are congruent to the learning task.
2. Evidence suggests that when learners are novices in the content area, they may not know how to attend to relevant cues or details provided by animation.
3. Animation’s greatest contribution to computer based instruction (CBI) may lie in interactive graphic applications (e.g. interactive dynamics). (p. 82)

Rieber’s work points to the effectiveness of animation in the use of interactive software applications and the contribution it can make in a learning situation. Rieber
(1990) notes, however, that animations should be used only when appropriate to the content and learning task.

In relation to appropriateness of animated imagery in content, Rieber and Kini (1991) conducted a second meta study based on animated visuals and computer-based learning. Rieber and Kini (1991) found that animation used in computer-based instruction occurs in two ways: 1) presentation strategy, and 2) as a practice activity. The theory of dual-coding supports the study and "contends that pictures and words activate independent visual and verbal codes" (p. 85) leading to better learning and retention, but that the "efficacy of animated presentations appears particularly dependent on task requirements, cognitive load and selective attention" (Rieber, 1991).

Rieber and Kini (1991) expanded their list of the uses of animated imagery to "four basic applications: cosmetic, attention-gaining, presentation, and practice" (p. 86). All of these uses have a different intent and, therefore, require a different development for effectiveness. Rieber and Kini (1991) pointed out that animation can facilitate learning, disrupt learning or have no effect on learning, and that the ability to incorporate animation does not automatically mean that designers have the wisdom to do so appropriately.

In this second meta-study, Rieber and Kini (1991) began to question whether the dual-coding theory can be generalized
to the use of animated imagery in a learning environment. They (Rieber & Kini, 1991) cautioned that the use of animated imagery in these areas may aid learning in some learning situations, but may be a distraction in others. The idea of specialized application for animation in a learning environment emerged from their work, as well as the idea that animation may be a successful learning tool for different learners.

The theory of multiple intelligences concerns the various cognitive differences that may occur in grasping information. Spatial intelligence, an intelligence associated with visual aspects of learning, is listed as one of Gardner’s (1993) seven intelligences. Spatial intelligence is an inherent quality that provides skills for engaging in, and excelling at spatial problem solving. Those who have spatial intelligence excel at activities such as creation in the area of visual arts, chess playing and map reading. Gardner’s (1993) theory of multiple intelligence coincides with learning style preference theories, which purport that students can learn more effectively with a learning style that is tailored to their abilities.

Learning Styles and Learning Style Preferences

While not all learning style methods are the same, they all are similar in assuming that specialized instruction and
presentation methods help a student if the style is matched to his or her particular preference for learning.

There are several learning style inventories and preference tests that are directly related to the use of visuals and animation in learning materials. Torrance's standardized (1983) "Thinking Creatively with Pictures" test is comprised of visual exercises used to evaluate five mental characteristics thought to influence creativity: fluency, originality, resistance to closure, elaboration, and abstract thinking. These mental characteristics in turn allow the researcher to assess student creative strengths, such as emotional expressiveness, movement or action, internal visualization, extending or breaking boundaries, and richness and colorfulness of imagery.

The Torrance test requires each subject to respond to a statement or story by drawing a picture on a page that already has an image. The subjects are supposed to complete the picture, as well as provide a title for the page. The scored tests provide a checklist of creative strengths of the individual tested. These tests are used to identify students who are creatively and visually advanced, so that they can be supported and nurtured in their educational environment.

Dunn and Dunn (1978) have identified four types of learners: visual, auditory, tactile and kinesthetic, and multi-sensory. Visual learners learn from looking at materials such as films, graphs, models and photos. Auditory
learners gain the most information from listening to lectures, tapes, and verbal explanations of written materials. Tactile and kinesthetic learners do best with hands-on activities such as building, constructing or directly manipulating objects. Multi-sensory learners learn best with a combination of two or more stimuli.

The learning styles work by Dunn and Dunn (1978) led them to develop a "Productivity and Environment Preferences" (PEP) survey in conjunction with Price Systems of Lawrence, Kansas. This survey was used to evaluate preferred learning styles for adults and university students. The survey contains 100 questions on preferences that range from audio to kinesthetic learning.

Although there are recommendations for delivering content for each learning style and content may be arranged, prepared and delivered in a particular way, there is no guarantee that students will learn that content. Students need to become aware of the content to learn (Dunn & Dunn, 1978; Williams, 1983).

Computer interface environments are often constructed to mimic the natural world. Images in motion presented on the computer screen are made up of electronic color and movement. Viewing a bird in flight in a natural environment is very different from viewing a bird in flight on a computer screen. Viewing a bird in flight on the computer requires that one be seated in a stationary position and placed directly in front
of the computer screen, rather than outside looking up at the sky or being in motion oneself (walking or running). As more animated visuals are created to replicate and simulate natural motion on the computer screen, it will be important to examine how these images are perceived by the human mind. The following section will cover pertinent issues on human vision, perception and motion.

Perception

The perception of motion occurs in different ways. We can be seated in a stationary position and observe motion (passive), such as looking out a window watching children play. Or we can be engaged in that play (active), moving our bodies and observing our motion, as well as others' motion. Gibson's (1986) study of continuous motion has resulted in the belief that our vision system is much larger than just what our eye perceives; that our "vision is a whole perceptual system, not a channel of sense" (p. 205).

In the past, researchers likened the human eye to a camera with a lens that provided a snapshot of an image that was sent to the brain. Gibson (1986) disagreed with this explanation on several levels. He explained that the visual perception system is integrated into the entire human body; our eyes are in our head, which is attached to our body, which allows us to move about. All of these parts and processes make up the human visual processing system. The
eye and nerves to the brain are only a part of our visual system. Gibson (1986) asserted that the eye does not produce a succession of discrete snapshots, but instead provides an "ambient vision" as we move about. The eye perceives a "flowing array" that continuously captures a "minute inflow of stimulus energy" (p. 58).

As we know, our own movement can vary by degrees. We visually perceive our own movements both externally, by viewing change, and internally, by sensing and perceiving our own kinesthetic movement. Gibson (1986) described three different types of movement in relation to the self as: 1) one's own movement of looking at and looking around, 2) registering of persistent and changing pictures and visual awareness, and 3) motion pictures and visual awareness. The "registry of persistence" and "change" are two distinct types of perceiving (Gibson, 1986). Although related, persistence of vision refers to perceiving objects and environments in a stationary fashion, whereas perception of change begins the flow or optic array.

Our eyes behave in very different ways when we look around our environment, visually perceiving various objects and events. Dodge (Gibson, 1986) listed the different eye movements as: "fixation, saccadic, pursuit (tracking), convergence and divergence, and compensatory movement" (p. 246). All of these eye movements may happen within
microseconds of one other, depending on the objects and events observed and the kinesthetic condition of the human eye.

Our bodies register our movements in relation to our visual kinesthesis Gibson (1986). Gibson suggested that "visual kinesthesis goes along with our muscular kinesthesis" (p. 279). This concept becomes more meaningful when we consider how stationary we are in front of the computer screen, and how active we may be in our natural environments. The computer screen interface becomes the window to the virtual world, requiring little muscular kinesthesis on our part. Without the extra input of our muscular kinesthesis, we may need to present visual stimuli on the computer screen more carefully to compensate for the lessened input.

While the creation of images for an animated event is considered complex, Gibson (1986) provided a provocative thought for our time: "The motion picture is more like natural vision than the still picture, for the latter is an arrested image" (p. 273). When we are engaged in moving about in our daily events, we continually perceive. Our eyes capture movement in the periphery until our full attention is captured (or not captured). But when we perceive the moving images on film, such as a horse running, we are not really viewing the original event; we are experiencing a close representation of the original event.
For Gibson (1986) "there is no such thing as a literal re-presentation of an earlier optic array. The scene cannot be re-established — the array cannot be reconstituted" (p. 279). Although we may understand this concept in a practical sense, that we are not viewing "the real thing," culturally, it is the static, "traditionally" still image that we are most familiar with. We think of moving pictures as special or unusual visuals in relation to still images, which have been with us since the beginning of humankind.

Gibson’s (1986) discussion of the camera movement’s similarity to our own movements supports his statement that the motion picture is the most natural image for us to perceive. But the motion pictures we view today are not really motion pictures in the Gibsonian sense. The single frame stopped-action film that is threaded through the projector is not based on the idea of continuous optic flow, but our perceptions of those “stopped images as motion” capture a continuous array of stimuli, because our natural visual perception system detects motion through persistence of vision.

When we create animated imagery for the computer, we must remember that observers will have stationary posture, and their eyes will be fixated on the computer screen, perceiving through an optic flow of stimuli. The level of kinesthetic stimulation that would occur in our natural environment is, in essence, missing from the stationary event
in front of a computer screen (Gibson, 1986). However, the lack of kinesthetic input in relation to the computer environment may assist us in capturing and holding our visual attention on the computer screen, due to the fact that we are seated in front of the computer screen, much as we are in front of a stage, waiting for the action to begin. The following section explores attention and visual perception of the computer screen.

**Spotlight, Gradient and Noise Theories**

The human eye contains cones and rods, two types of photoreceptors. Cones are receptors in our central vision in the macula, allowing us to perceive detail and color. Rods, which are extremely sensitive to light and motion, lie outside the central macula in the periphery and produce blurred images when motion is perceived. Empirical studies conducted over three decades on visual perception and the physiology of the eye have helped us to understand the human eye and attention.

In the late 1960s and early 1970s, many studies on visual perception were conducted with the computer technology available during that time. Two main theories emerged as a result of these studies: the spotlight theory and the gradient theory. The spotlight theory explained how human
visual perception captures attention and focuses upon visual information. Van Der Heijden's (1992) summarized the spotlight theory:

There is an attentional mechanism limited in its spatial extent that can be likened to a spotlight. The help of this attentional mechanism is needed for rapid detection and identification and therefore for (fast) responding. This attentional mechanism can move its focus just as a spotlight can. (p. 108)

The gradient theory, on the other hand, argues that attention is not as "fixed" as the spotlight theory states, but that perception varies within the attentional field of vision. According to the gradient theory, Humphreys and Bruce (1991) stated that the attentional spotlight at the fovea can narrow, but "it is not a fixed and constant size" (p. 148). When subjects were tested for perception outside of the "spotlight" of attention, findings indicated that subjects were able to perceive visual elements in diminishing degrees outside of the spotlight, due to the partly intermixed cones and rods.

Elements outside of the spotlight and on our periphery capture our attention and require orientation. However, when there are too many elements to perceive, visual noise can occur. Visual noise can cause visual distraction when too
much stimuli demands our attention and continuous re-orientation occurs (Eriksen & Simon, 1993). When visual distractions occur, we tend to not focus for long on any one item, and our attention span decreases.

Our world introduces visual noise and distractions on a continual basis. Busy highways contain a variety of billboards, birds, planes, helicopters, debris and weather elements such as rain or snow, all contributing "noise" to our area of visual perception. In interface design, visual noise is used to attract, and distract, the user. A bouncing, rotating bright shape at the bottom of the screen draws the eye toward the animated shape and away from the top of the screen. Eyes directed toward the top of the computer, searching for specific information, are attracted to the shape at the bottom and distracted from the prior goal of looking at the top of the screen.

Information must be presented in a way that makes it stand out from other stimuli. If information is not presented in a way that garners attention and provides a visual cue, proper attention may not be given to that particular piece of information. A computer interface may have a piece of important information, such as a title, and the interface needs to present that title in an important way. The title may be larger, may be a bright contrasting color, may be placed at the top of the screen, and may have space at the top, sides, and bottom of the words. This is a
visual cue to the reader that these words are important, because they are treated more importantly, and thus demand more attention. If the title visually blends into the crowd of other images, colored letters and numbers, it may go unnoticed, because it was not given a spatial position of visual prominence.

Visual noise can work for us by gaining attention, or against us by creating a visual overload. Full attention is needed in learning situations that require assessing form as well as meaning. Rock and Gutman (1981) found that diverting attention disrupts the cognitive process needed to "describe the spatial relationships that characterize a figure" (p.275). When we are distracted, we do not perceive as readily as we do when our full attention is present.

Age specific cognitive processing often affects perception. The findings of Acker and Tiemens (1981), suggest that children's perceptions of televised images are affected by their age (a correlate of stage of cognitive development), and that they cannot always interpret or discern what is occurring when image transitions such as "zoom" occur. Children may be provided with misinformation through a lack of understanding of their visual perceptions.

In a later study, Acker's (1983) findings indicated that children and adults may perceive visual objects in motion incorrectly due to perspective conflicts created by the type of lens used for photography. Contemporary computer animated
programs are now sophisticated enough to mimic the transitional visual effects, lenses and tools used for television programming. Computer animations may have the same effect on viewers as television programs, in that they can be visually manipulated in several ways.

The type of tool and medium we use to produce visuals affects how we communicate our messages. Although visual perception is rooted in physiology, we are also rooted in a culture that helps us make sense of what we perceive. The following section discusses the mix of physiology, visual elements and meaning.

Perception and Visual Elements in Art and Design

Another reason our attention is turned to motion, beside the input of visual stimuli is because it is linked to our evolution. Arnheim (1974) explained why motion captures our attention:

It is understandable that a strong and automatic response to motion should have developed in animal and man. Motion implies a change in the conditions of the environment, and change may require reaction. It may mean the approach of danger, the appearance of a friend, or of desirable prey. And since the sense of vision has developed as an instrument of survival, it is keyed to its task. (p. 372)
Arnheim's exploration of movement perception provides insight into physiological aspects of movement. Forces upon an object in motion provide a communication that links to the human experience. This communication is recognized as simple or complex, important or unimportant, providing a visual cue to help us ascertain how we should act. The expressive quality of the speed of an object can reflect on the perceived strength or weakness of an object. The more easily an object can retain its size, shape, color and brightness, the easier it will be to perceive (Arnheim, 1974).

Arnheim (1974) described four visual qualifiers of objects in motion: 1) movement, or stasis; 2) flexibility, referring to internal and external parts of the object; 3) the source of locomotion, whether an object can initiate movement; and 4) responsiveness to other forces, the contact an object may have had with another object or force. All of these qualities of motion provide information about the object, to which we then attach meaning from our culture and past experiences.

To fully understand an object in motion, we need to examine the object in context. We may perceive motion of an object while viewing a still image. Arnheim (1974) provided two separate examples of this concept: a blacksmith and a windmill. An image of a blacksmith holding his hammer high above his anvil shows more force of motion than one in which
the hammer is closer to the anvil. The second image is perceived to imply a more quiet motion. We can assess the force of the movement and the sound the hammer might make when hitting the anvil. These assessments are made through our cultural perceptions. If all the elements in the still image of the blacksmith were alien to us, we would not be able to discern the quality of the implied movement. Similarly, if an image of windmills portrays them with arms in horizontal and vertical positions, the windmills are perceived to be at rest. But when the arms are shown as asymmetrical or imbalanced, they appear to be in motion, spinning in the wind. It is our cultural perception of having seen windmills in motion that allow us to consider the potential for movement.

An imbalance or incompleteness can create "visual tension" in an image. It is this incompleteness that provides the illusion of movement for the viewer; our eye wants to right what is wrong, finish what is unfinished, and correct what needs to be corrected. We know that a still image of birds in flight is not real, but we understand that the birds will continue to move in the path shown. We have gathered this knowledge through experience, and we use this knowledge to mentally "complete" the motion. We take the image in as a whole, in order to make sense of the action. The next section describes this whole, or "Gestalt", experience of the viewer.
Gestalt Psychology and Visual Perception

During the early 1900s in Germany, psychologists began to study meaning derived from the "Gestalt", or "whole". Their theory was that the perceived meaning of an object or event could not be obtained from disparate parts, but needed to be complete in order to address the full meaning of the object or event. Gestalt studies brought art and science together, providing an explanation of the "unexplainable." Arnheim (1984) stated that:

For centuries, scientists had been able to say valuable things about reality by describing networks of mechanical relations; but at no time could a work of art have been made or understood by a mind unable to conceive the integrated structure of a whole. (p. 5)

The contemporary partnering of art and science occurs in the design of interactive software. Animation designed for an interactive software learning environment needs to be perceived and understood in the whole. All visual elements must work together to convey a particular communication. Motion is one part of the "whole" and must be perceived and understood within the context of a learning event.

The culture in which we reside also affects the way we perceive and understand objects and events. Perceptions are
often accompanied by thoughts, which in turn are accompanied by feelings and emotions. The next section of this chapter explores the contribution that cultural studies have made to the area of motion perception.

Cultural Aspects of Motion Perception

The subjective role of culture helps us to reflect, define, and understand objects and events through feelings and emotions. It is the whole of the perceptual experience that allows us to respond to objects and events in a meaningful way. The following sections provide an inquiry into cultural literature related to animated imagery and motion through animation, dance, film, theater and video.

Animation History

When we think of traditional animation we often think of those pencil-generated sketches of Disney’s Mickey Mouse. Early animation techniques used hand-generated images drawn on acetate cels, which were painted and photographed separately, then combined in a film strip. The drawn objects appeared to move when, a series of cels, depicting an altered image of the object, was shown in sequence at a rate of 18 or 24 frames-per-second.

In the early 1900s, H. Blackton produced one of the first animated cartoons containing combined movement and caricature. In the 1930s, Walt Disney created the first
version of Mickey Mouse, who underwent several physical iterations before becoming the Mickey Mouse of today. The idea that really came "alive" was that of imbuing a visual element with human characteristics, or personality traits conveyed through movement. A silly Mickey Mouse, with his characteristic hand flourish, and a frustrated Donald Duck, waddling down the road, began to delight viewers around the world, and provide meaning through motion.

Animation is comprised of many parts, aside from image and personality, that need to come together to provide an effective communication. To appear natural, the moving images must convey the forces of gravity upon them or forces that they exert upon other images. For motion to appear realistic, there must be a visually smooth transition between the images. When sound is added it must be synchronized with the moving imagery. The timing and pacing of the overall imagery, as well as the illustration style, all impact the animation. These aspects hold true whether they are applied to traditional animation or computer generated animation graphics.

Other forms of animation are claymation or puppet animations. Claymation refers to clay images created and photographed in minutely varied poses. When all of the captured poses are photographed and run through the projector, the clay figure appears to move on screen. This
photography technique is also used with puppets in varied poses, and each increment of the pose is captured on film.

The Walt Disney Studio perfected two techniques for developing motion (and emotion) on the screen: the storyboard and the pencil test. The storyboard technique came into use as animation production became more sophisticated in the 1940s and 1950s. A storyboard lays out the storyline of an animation and defines the movement of the objects and characters. The storyboard is also a visual tool for helping others understand how the animations will appear, and how lighting and sound will be used.

The "pencil test" used quick sketches of an object or environment in motion. The pencil sketches were created and viewed by manually flipping back and forth to "get a feel" visually for the motion intended. Pencil tests help the animator, and others, perceive the motion of the object without going through the time and expense of painting acetate animation cels. Changes could be costly once an animated sequence was placed on animation cels.

As film-making techniques became more sophisticated, so did the techniques for animation. Better film, equipment, designers, and graphics began to add to the quality of animations. As better animation began to occur, viewers required more sophisticated visuals and storylines to hold
their attention. The next section of this chapter discusses advanced animation techniques and the capacity to hold an audience's attention.

**Computer Generated Animation**

In the 1960s and 1970s computer generated film and animation techniques began to emerge. This meant that film techniques and visual effects such as dissolves, wipes, fades, and could be utilized for animations, as well as films. These computer-generated animations were created using methods that removed the human hand from the project; a visually animated piece could now be produced entirely within the computer system. The 1980s began a new era of computer generated rendering techniques that allowed us to move typography and imagery in new ways (See Figure 1.1).

Computer generated imagery exists primarily in two distinct ways: **vector-based** and **raster-based** (See Figure 1.2). Wireframe visualizations are often vector-based drawings. Vector-based imagery was created in software packages that operated on an intersection system whereby the computer "remembered" particular points of interaction on the computer screen. This type of imagery is processed very quickly by the computer and uses a small amount of computer memory in relation to pixel-based imagery.

Pixel-based imagery, sometimes called raster technology, was created in software programs that created a "blanket of
information” for the screen. Each pixel contains specific information for color or position. These raster-based images allow smoothly gradated imagery in contrast to the hard-edged vector based imagery.

**Typography**

Fig.1.1   Computer-altered typography done in the Illustrator Program

Fig.1.2   Vector-based wireframe by Isaac Kerlow and pixel-based image by Judson Rosebush and Collier Graphic Co. from Computer Graphics for Designers and Artists
Computer graphics systems produce a wireframe image, as well as a rendering capability that allows the animator to produce realistic forms. Lighting and texture are key determinants of the realistic aspects of the image as these qualities place the figure in a ground, and provide a tactile quality we understand. Most computer animation systems allow the creator to specify a beginning image and an end image and the computer will process all of the needed interpolations. Animating these types of images requires huge amounts of computer power by today's standards, though this is rapidly changing with the increase in hardware capabilities.

There are many types of computer graphic applications available today. Two-and three-dimensional graphics packages, hypermedia and interactive graphics, virtual reality graphics, Quick Time Virtual Reality (QTVR) nodes and artificial intelligence related graphics are the major computer applications. Advances in technology have allowed the combination of several of the above-mentioned types of computer graphics.

Two- and three-dimensional computer generated animated graphics can range from graphs and charts to full-length animated features such as "Toy Story." Solomon (1987) linked animated image and filmmaking, citing the increase in technical capabilities during the 1970s that allowed a merging of computer graphics and special effects. The
current film-making practices referred to above are two- and three-dimensional techniques and specialized techniques. Two-dimensional techniques use traditional animation cels or drawings on paper. The three-dimensional techniques use claymation figures or puppets. The specialized techniques refer to computer graphics techniques or drawings made directly on film.

The technical equipment for animation is important in that it provides the means of production for the computer graphic images. However, it is the designer who creates visual qualities for the animation, so that the viewer can perceive the visual communication that is intended.

Whitaker and Halas (1981) discussed the aspect of timing in animation sequences. Good timing is apparent when movements occur smoothly and objects seem to move of their own accord. Forces that affect movement in animation are either gravity acting upon the body of the object, the body working against gravity, or both. The reasons we assign to the movement of objects are derived from our cultural experience. An example of this is the understanding we have of the direction of the ball when it hits a bat. We expect the ball to move away from the bat because of the (implied) force of the bat hitting the ball. Timing and force are combined issues that help us to understand the meaning of a movement.
As in film, there is also the option of camera movement in relation to the movement of the objects to be viewed. Camera movements in animation can be the same as those used in regular film making, providing the animation set-up is conducive to varied camera work. The advent of film and video technology has allowed us to utilize moving images in a way that can communicate in an expansive way. In addition, interactive capabilities, or those that provide navigational abilities, allow us to use varied types of motion within the imagery of our formerly static computer displays.

Hypermedia and interactive media graphics are designed to help the user navigate through the software program. An example of navigation is when the user moves through several computer screens in the same application by clicking on an icon or word or image. Virtual reality graphics are representational and allow the user to interact with the environment by moving through a virtual space, or interacting with a virtual object.

Dancers move through virtual space, often interacting with virtual objects. The field of dance is made up of the combination of movement and emotion. The next section explores the issue of dance, motion, and emotion to explore the communication of motion and the human body.

Dance. The field of dance has been intimately entwined in the relationship between motion and emotion from the first
performance given. Vaughan (1997) borrowed from the field of dance to understand how movement on the computer screen affects its viewers. The power of the abstract movements of dance not only captures our attention, but also conveys messages that pique our emotions, both pleasant and unpleasant. When motion is not used properly, or is not well designed, it creates uncomfortable feelings and miscommunication (Vaughan, 1997). By better understanding the communication and characteristics of movement and the effect that it has, the designer will have the skills needed to design an appropriate piece that communicates what is intended.

Vaughan (1997) relates her work with dance to computer animation by delineating the following categories: "Path (the line the object movement creates), area (the use of space by the object), direction (the direction of the animation), and speed (the speed and tempo of the animated object)” (p. 549). In addition, the duration of time in which a motion occurs also communicates to us. If a slow movement is viewed, it may capture one's attention for quite a while. If the movement is too long or slow, attention may wander unless other qualities begin to emerge. If a short, quick movement is perceived, it may capture our attention until we decide if it is of importance or interest to us.

These aspects of time, motion and emotion are also affected by the culture in which a moving image is viewed.
Does an image move quickly enough for someone who is used to the pace of New York City? Would a quicker pace cause irritation or confusion for someone else? Would an image be moving slowly enough for one who prefers the pace of the countryside? The answers to these questions depend on several factors, culture being one of the major influences, in addition to a viewer's personality and age.

Vaughan (1997) gave an example of the use of an abstract or animated image on a computer screen for capturing attention:

As we know, people don't always read alert messages, and by introducing a simple animation, we can communicate to the user quickly and efficiently how severe the situation is. A simple, organic pattern may convey a mild problem, where a mechanical, fast, irregular movement can show cause for alarm. (p. 549)

The opportunities for communication through motion and emotion on the computer screen are seemingly endless. The combinations of movements with contexts, provides a rich and fertile ground for communication on the computer screen. The motion captures our attention, evokes emotion and engages us to react to what we see. The design of a theater environment is created to draw us in through focusing our attention on
action that occurs before us on the stage. The next section explores the use of theater techniques for computer graphics communications.

Theater Techniques and Computer Graphics

Laurel (1990) examined the computer-human relationship through the eyes of the theater-goer, reflecting that the study of drama can be useful for re-thinking how computer interfaces are designed. By adding a humanistic presence to the interface through the use of agents (computer characters or functions that represent human characters or needs) or through the use of computer environments which contain elements of drama, we can draw people into the computer interface and (hopefully) hold their interest.

Laurel’s (1990) design principles for human-computer activity center on four areas: designing action, designing character and thought, designing language and communication, and designing enactments. Designing action, Laurel states, requires that we “think of the computer, not as a tool, but as a medium” (p.126). “Design enactment” refers to the “sensory modalities” used for human computer interaction. If there is no reason for a computer incident (or event) to occur, it will be perceived as gratuitous (overdone or unnecessary) and distracting (Laurel, 1990). The goal is to engage the user in the computer program in a satisfactory and interesting way.
Designing action and enactments both relate directly to software interface design in that motion can help to communicate qualities that static images can not. Visual, auditory, and kinesthetic modalities can provide the user with a more well-rounded, and possibly, satisfactory computer experience. The more modalities used within computer programs, the easier it is to simulate human interaction within a computer interface.

Just as the dance and theater productions incorporate action to gain the attention of the audience, so does film and video. The next section of this chapter covers the history of film, as well as the technical aspects that allow us to use film to communicate in more sophisticated ways.

Film and Video

The advent of photography soon gave way to moving imagery. Several devices were created in the United States and Europe that showed still images in rapid succession to mimic natural movement. In 1887, Manon Souriau wrote *The Aesthetics of Movement*, an unusual book and topic for its time. Souriau (1887) discussed visual perception, aesthetics, and the effects of viewing motion. Souriau (1887) stated that, at first, works of moving images were pleasing to view, but after a time became visually disconcerting and fatiguing. He assumed this was due to the still images being “put into motion” through succession.
Souriau was reflecting on the fact that although the still, representational images were moving, by being shown in succession, they were still made up of single still images and shown with equipment that was less than sophisticated.

But photography had revolutionized the visual world by providing a realism that was never before seen and sometimes not believed (Crary, 1995; Gibson, 1986). By the late 1880s, images of objects in motion were captured. An American, Eadward Muybridge, and a Frenchman, Etienne-Jules Marey, were the first to capture moving images. By the early 1890s, the camera, film and projector were perfected enough to allow the French brothers Louis and Auguste Lumiere to stage the first public showing of projected motion pictures. This visual revolution was fueled again with the advent of moving images.

By the 1920s, several studios emerged to produce films that were now in great demand by the public. The early films were of scenic places or events. Bordwell and Thompson (1993) explained that “after the initial success of the new medium, filmmakers had to find more complex or interesting formal properties to keep the public’s interest” (p. 454).

The audience was becoming visually sophisticated. They became accustomed to moving images, and integrated complex events that required scripting, and an overall sense of communication on several levels. The combination of visual perception, cultural context and content of the messages provided the “whole” experience of visual communication of
two-dimensional moving images, increasing our visual expectations. Sophisticated imagery also meant sophisticated analysis.

From Monaco’s (1977) analysis came three aspects for comprehending images: physiological, with saccadic eye movements, ethnographical, from experience and, cultural and psychological, from assessing and integrating the meanings of the images. Film and video are designed to provide meaning to us. Some of this meaning is presented through codes, which are culturally derived meanings abstracted from real life and represented in film. Actions and behaviors, such as eating or conversing, may be presented in a specific way to portray a specific feeling. Unique codes in relation to cinema, such as syntax, are needed to tell a story through film (Monaco, 1977).

Zettl (1990) addressed film syntax through the visual effects of time and motion. He described the differences between objective time, which is the actual length of a scene or show, and subjective time, in which the viewer’s perception of time may be altered. Examples of objective time are: spot time, running time, sequence time, scene time and shot time while subjective time can be pace, tempo, rate and rhythm (Zettl, 1990). Although Zettl’s work has been largely connected with film and television, much of it applies to the capabilities of computer systems today and the imagery provided.
Both "slow motion" and "accelerated motion" are useful for communicating a feeling. Viewing a scene produced in slow motion can give us a feeling of unreality, whereas viewing a scene in accelerated motion gives us a hurried and sometimes anxious feeling. The timing and drafting of a scene affects our emotions in different ways, depending upon the context of the scene. Charlie Chaplin's accelerated movements are viewed as funny, within the context of his movies, but the accelerated movements of someone in another context might be viewed as frightening, or perceived as a threat.

Primary, secondary and tertiary motion are three types of motion Zettl (1990) described in relation to filming of objects or environments. Primary motion refers to the actions of an object, whereas secondary motion refers to the movement of the camera in relation to the object. Tertiary motion refers to the development of a sequence, or sequences. Tertiary effects such as the "cut, dissolve, fade and special transitional effects" (p.288) can change our perception of the scene, and are considered editorial decisions.

The creator of imagery can use motion to increase our interest, awareness and attention. The construction software interface that appeals to the interests of a student might keep her or him interested through evoking emotions in reaction to the interface. The added qualities of special effects provide additional stimuli to help us understand, and
sometimes we understand more when we can feel and relate to
the subject matter.

The use of special effects with animated imagery, and also with interactive programs, helps to communicate how to perceive an image or navigate through the content. But regardless of how many tools and effects we employ, the end result will be less than effective if the visual is poorly conceived and executed. It will not capture interest, communicate clearly or help the learner retain information. The following section covers studies in the practice of computer graphics and design, and culminates with design guidelines for incorporating animation into learning environments.

Design Practice

Software interface components, such as layout, navigation, text and image, color, and motion, need to be addressed as a whole (Laurel, 1990), because they combine to make an entire image which is perceived as a whole. The incorporation of animated imagery must be incorporated in a way that is appropriate to the content and cultural communication of the piece. The design of imagery greatly affects the way users interact with the content and the way it is perceived. The following section will cover the design of objects in an environment where motion occurs among the attributes.
Visual Elements in Design

The design of a successful object or computer interface requires an understanding of what visual elements communicate and how to best apply that understanding when creating for others. In his book on visual literacy, Dondis (1973) conducted a study of the cultural aspects of perceiving and understanding visuals. The qualitative nature of his inquiry is revealed in his statement that “mechanical replication of the environment alone does not make a good visual statement” (p. preface). Merely placing elements on a page (or screen) that represents what we already know is not enough. Extra care in placement of the elements can provide a different type of communication to the viewer. Before an entire visual communication can be evaluated, it is important to understand the parts to a visual message.

Dondis’ three levels of a visual message are: representational, abstract and symbolic. These differentiated levels provide us with a way of thinking about the different types of images and help us to define visual concepts that are abstract. Representational images are those that we find realistic enough to recognize. Abstract images are those that have been reduced to a simplified visual structure that communicates an essence or emotion. The symbolic essence of an image is that which relates most to what meaning we give it. Each of these aspects of imagery
communicates a meaning to the viewer that is enmeshed with our visual perception and cultural differences. The Apple Macintosh interface was one of the first software examples that used symbols of our culture to communicate software functions; unused files could be put in the "trash can."

Dondis (1973) listed the elements that make up a visual communication as point, line, plane, color, and movement. Designers use these elements as visual tools to communicate meaning. Each array of images and layouts communicates a mood or expression through the use of these elements. Dondis (1973) reflected that motion, as a visually expressive element, can be useful to provide "compositional tensions and rhythms in visual data" (p. 64). Dondis’ contribution to visual literacy has been to delineate the elements of a visual message, as well as to offer suggestions for communicating various expressions to the viewer.

Wallschlaeger and Busic-Snyder (1992) listed motion as one of the descriptive elements for two- and three-dimensional perception in addition to element size, value, color, perspective, texture, shadow, blurring, transparency and overlap. The "law of closure" (Wallschlaeger & Busic-Snyder, 1992) refers to the motion of the eye to complete a shape. If we viewed a circle, with a small portion of the shape taken away, we would mentally complete the image of the circle, thus experiencing "good continuation." Irregular and complex shapes are more difficult to perceive.
The placement of movement within a visual communication tells the viewer of the importance of the object and the movement. The "hierarchy of information" imparts additional meaning to us (Wallschlaeger & Busic-Snyder, 1992). If a visual element is large, is moving quickly and is at the top left of our computer screen, it will seem more important (and needing more attention) than a smaller moving visual element placed elsewhere on the same screen. The implied importance of objects on a page or computer screen, through prominent placement, are largely culturally derived from our reading patterns. We start at the top of the page and read from left to right. Other cultures may not respond to our implied importance through placement of information on a page or screen if they have different reading patterns.

Although animation may be carefully designed, it does not mean that it will be effective on a cognitive or emotional level. Testing and evaluation of animated imagery is needed to assess the success, or effectiveness, of the imagery. The field of computer graphics and computer human interface has conducted studies over the years on the effectiveness of imagery in software programs. The following section is an overview of the use of animated imagery in interactive software.
Computer Graphics

Very often, it is the "demo disk", or marketing CD-ROM, that is created with the most animation, color, sound and graphics because its main function is to attract an audience (Shneiderman, 1997). These demo disks might have "animated text (words zooming, flipping and spinning), varied transitions, (fades, wipes, mosaics or dissolves), sound effects, and bright graphics," (p. 435) as part of their display to capture the users' interest and communicate a positive product identification (Shneiderman, 1997).

Users have come to expect rich computer graphics and extensive animations in conjunction with marketing. But just because a program may contain a lot of animated imagery and special effects, it does not mean that these are techniques readily transferred to the design of animated imagery in a learning environment.

Shneiderman (1997) discussed motion within the user interface in relation to pacing and guided tours. Users may have the option to press the space bar to move through a computer demonstration, but some may find they move too quickly, speeding through content that might not be absorbed (Shneiderman, 1997). Others may prefer to have a more exploratory experience, not wanting to be led, or paced, through a computer program.

A computer-based learning study by Wiedendeck et al. (1995) suggested that "subjects who carried out online
exercises learned better than those who used only guided exploration" (p.435). The interaction and user experience tied the content to learning. Support for the use of online tutorials also comes from a study by Al-Awar et al. (1981), who believes online tutorials are effective because the user:

- does not have to keep shifting attention between the terminal and the instruction material
- practices skills needed to use the system
- can work alone at an individual pace with out the embarrassment of mistakes made before an instructor or fellow student. (p. 434)

In a study by Baecker et al. (1991) subjects were asked to assess icons in the Hypercard toolbox menu. A designer created two versions of the icons: animated and static. The findings were that the animated icons were more helpful to the users than the static for understanding the task function of the icon.

Baecker and Small (1989) defined animation as "a dynamic visual statement, form and structure evolving through movement over time" (p. 251). They list animation uses as "entertainment, storytelling, drama, identification, persuasion, explanation, and teaching as well as establishing a feeling or mood" (p. 251).
Baecker and Small (1989) examined how our interfaces can communicate visually using options found in cinema. They stated that design for the computer screen could use visual transition techniques such as "the cut, the fade in (fade out), the dissolve, the wipe, the overlay, and the multiple exposure" (p. 252). These techniques provide movement within the interface as well as the opportunity for engaging the viewer. Whenever possible, cinema techniques can be used to describe the computer's functions, thus providing more information for the user.

The usability experiment conducted by Baeker et al. (1991) showed that the animated icons are well-liked, and that users find the animation attributes to be of value. For the experiment, a designer was asked to create a static version and an animated version of a set of icons. One group was asked to use the static set of icons in the software and the other group was asked to use the animated set of icons. The animated icons were very well understood, unlike the static icons. Baeker et al. (1991) stated:

Animated icons can bring life to symbols representing complete applications or functions within an application, thereby clarifying their meaning, demonstrating their capabilities and even explaining their method of use. (p. 1)
Baeker et al. (1991) provided a list of uses for animation, in general, within the user interface. These general uses are: "identification, transition, orientation, choice, demonstration, explanation, feedback, history, interpretation, and guidance" (p. 1). Animation can assist with wayfinding and navigation in a program, or the user's path of motion throughout an interactive program. Navigation interaction exemplifies the activities of user pacing, interaction and flow within a computer program in relation to the content and task objectives. When the user can choose his or her own path or movement through a program, a program gives the user an autonomy that can help to keep his or her interest.

Acker (1992) discussed the idea of movement and navigation within a computer program that uses the hypermedia process. Hypermedia is a computer process that allows text, sound and visuals to be accessed in a non-linear way. Acker (1992) described the possible user actions with the Hypermedia Storyteller's Tool Kit:
The user of the hypermedia program chooses from the database in a self-directed manner. The user’s information selection and sequencing imposes structure on the information and gives it meaning. The designer "writes" by providing original material while the reader "edits" by making connections about the material. (p. 212)

This is a type of movement within the software system that is becoming increasingly used, but Acker pointed out that it can add to the responsibility of the user to conduct certain activities while he or she is engaged in the program.

In an experiment on animated tasks and learning, Palmiter and Elkerton (1991) provided one group with an animated demonstration for learning procedural tasks and another group with textual instructions. Initially the group who had the animated demonstration performed better than the group who had been given text only; but when tested again seven days later, the text group performed at a better rate. This led the experimenters to question the value of animation in relation to retention. However, in the conclusion the authors revealed that the text groups spent more time in training with an instructor than the animated group, who had watched an animated training program in one sitting.

Other outcomes of the Palmiter and Elkerton (1991) research were that the "text only" group would have preferred
more visual demonstrations and did not enjoy their instructions as much as the “animation” group. Palimite and Elkerton’s (1991) conclusions are that the animations should be carefully integrated into the text for optimum demonstration purposes, citing that “the use of animated demonstrations, although seemingly faster at first, may not provide instructions which will be useful for later retention and transfer” (p. 262).

Gonzales (1996) conducted an experiment on animation and decision making using realistic and abstract animations in the software interface, along with different visual transitions and interacting styles. Her findings from this study were that users prefer realistic images and smooth transitions, rather than abstract images and abrupt transitions.

Although Gonzales’ study tracked user preferences, she cited the need for further research after her own literature review of the subject of animation. Gonzales (1996) reported on the lack of research available on animation and interface design:

Animation may make interfaces easier, more enjoyable and understandable. However there is limited theoretically-based empirical evidence to design, use, and evaluate animation for improving human performance. (p. 27)

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Gonzalez’ research is original and helpful in learning about image preferences of users in a learning environment. Her findings of lack of research on animation supports the voices of others in other disciplines, who believe there is a need.

Many design decisions are made for the functionality of just one component of an interface, such as the motion of a window opening on the computer screen. The potential of animation to either aid or frustrate the user is embedded in every design. Shneiderman (1997) stressed that animations can be useful for showing sequences or illustrating a complex task. When incorporating animation in window designs, the direction of arrows and window openings (or closings) are important visual cues for the user. The direction of the movement helps the user discern what is happening within the software and what the next possible action might be.

That the user knows what to expect in the learning environment may be important (unless surprise is an important element!). The field of product design represents the user by designing for comfort and ease of use. The next section highlights human factor issues in the design of software interfaces.

**Product Design and Human Factors**

In *The Psychology of Everyday Things*, Norman (1990) highlights products and processes that impact our everyday
living and provides several guidelines for producing well-designed hardware and software products.

The constraints of product design that Norman presents are: physical, semantic, cultural and logical. If we relate these constraints to software designs they still apply.

Physical constraints affect the hardware, such as input and output devices, as well as the capacity of the computer system. We may want to show very complex, animated imagery in our interface, but our computer system may not be able to process the images in a timely way.

The semantic constraints Norman (1988) mentioned refer to "the means of the situation to control the set of possible actions" (p. 85). An example of this would be the setting or interface within a software program that affords certain ways of using the program. Suggesting a way of using the software that is outside of the norm for the interface would be going outside of the possible actions that are set up within the interface.

The cultural constraints of our society as a whole, in addition to the "computer culture" that has been created with the different platforms such as Macintosh and IBM, affect how we think about our computer systems. The "Mac" culture was very different from the "IBM" and "Microsoft" culture before "Windows" came along. Loyal users continue to passionately state the finer points of their computer platforms in heated debate.
Logical constraints refer to how we "map" our knowledge to understand functions. If we relate these constraints to software design, a logical mapping of functions will aid the user within the program. Knowledge that the user has about the way things work, must be taken into consideration when designing animated imagery for interactive programs in order to have the user feel comfortable with what he or she already knows in relation to animated imagery. Apple users know that they will need to use the "pull down" menus to access certain functions, as well as double-click on icons to access files.

Norman (1990) believed that we should "use technology to make visible what would otherwise be invisible, thus improving feedback and the ability to keep control" (p.192). He reminded us that computers have powerful graphic displays, and we have the opportunity to provide "good images that provide a mental model of the task." The graphic display, or software interface, can be of great importance when designing a software product that is easy to use.

Knowledge that the user has about the way things work, must be taken into consideration. Norman (1990) referred to this training or knowing as "knowledge in the head." He contrasted this with "knowledge in the world," whereby knowledge is not required and a natural understanding of how things work is taken from outside of the things we already know.
Norman mentioned the potential for different types of errors to be made in relation to product use. These errors are considered either “slips or mistakes” (Norman, 1990). Slips are minor mistakes that result from lack of attention. Mistakes are due to poorly designed functionality of a product or misunderstanding of a product.

Norman’s (1988) guidelines for product design, which aid in keeping the design in the user’s best interest, are listed below and explained in the following paragraphs:

1. Avoid creeping featurism
2. Make systems explorable
3. Simplify the structure of tasks
4. Make things visible
5. Get the mapping right
6. Avoid worshipping false images

Creeping featurism refers to the addition of functions that may not be needed or wanted (Norman, 1990). If we relate this idea to software design, we might not need all of the functions provided by our software packages. A new release may add functions rather than streamlining or refining what is already there. The “more is better” maxim is often applied in software design, but, in many cases, it should be avoided.
"Make systems explorable" refers to keeping systems simple to use by providing functions that are easy to interpret, are easy to find and do not cause confusion or problems when used (Norman, 1990). Users often learn a software program through extensive use of that program. If their explorations within the program became thwarted, or if they become frustrated as a result of poor navigation or cues, they will be less likely to experiment with the software program.

"Simplify the structuring tasks" is an important guideline because of implications for user memory (Norman, 1990). Limitations of our short term and long term memory are directly affected when we interact with overly complex software. Within this guideline, Norman (1990) refers to several approaches, listed below, that can directly apply the use of animation:

1. Keep the task much the same, but provide mental aides.
2. Use technology to make visible what would otherwise be invisible.
3. Automate but keep the task much the same.
4. Change the nature of the task.

The above mentioned guidelines provide support for adding animated imagery to the software program. This ties
into the guideline “making things visible.” An animated “help” sequence provides mental aides by appearing throughout the system to remind, or call attention to specific items. Animation can be used to make ideas visible and provide feedback (Norman, 1990).

Graphic sequences can be used to illustrate and reinforce content concepts. Visible cues can be used to provide feedback to the user. Animation can be used to illustrate autoformatted tasks, as well as indicate what has been changed. If task simplification is a problem, animation can be used to explain. It can help the user to visually grasp the complexities behind what has been simplified. For example, a simple function showing just the numbers for time can be aided by showing a clock face with the hands moving around to indicate how long something will take (Norman, 1988).

“Get the mapping right” refers to the overall use of a product or system and is tied closely to what the user already knows or what seems logical. If a product is designed in such a way that it “goes against cultural convention,” it may seem confusing to the user. Placing buttons that represent a sequence of functions, in an aberrant pattern would confuse the user because the “mapping” would diverge from what is accepted as the norm.

“Avoid worshipping false images” refers to the problems that occur when the image of the product or system is of more
concern than the functionality. The product may look good, but it can be confusing and frustrating to use, rendering it useless. Style is not a substitute for substance.

Norman (1990) believed that animation is under-utilized in software design, and he provided an argument for exploring the use of motion and graphics:

With modern computers and their powerful graphic displays, we now have the power to show what is really happening, to provide a good, complete image that matches the person’s mental model of the task — thereby simplifying both the understanding and performance. Today, computer graphics are used more for show than for legitimate purposes... But there exists great potential to make visible what should be visible (and to keep hidden what is irrelevant). (p. 192).

As a result of Norman’s guidelines, studies in perception and computer graphics, and several expert opinions, guidelines for the incorporation of animation into software interfaces can be supported. The next section will list recommended guidelines.
Guidelines for Incorporation of Animation
Into Software Interfaces

The educational, perceptual, cultural, computer graphics, design and human factors disciplines all contributed to provide a basis for the use of animations within the software learning environment. A list of the potential benefits of animated imagery, culled from this literature review, shows that animated imagery can be used to:

1. capture the viewers' attention (Arnheim, 1974; Gibson, 1986; Humphreys & Bruce, 1991; Rieber)
2. demonstrate an idea (Acker & Tiemans, 1981; Baecker & Small, 1989; Gonzolez, 1996; Rieber, 1990)
3. provide users with visual feedback on functions (Norman, 1990; Schneiderman, 1997)
4. incite emotion (Laurel, 1990; Vaughan, 1997)
5. guide the viewer (Acker, 1992; Zettl, 1990)

The recommended guidelines for incorporation of animated imagery listed above is coalesced from the recommendations and findings of researchers in the various disciplines covered in this chapter. In addition to these guidelines of appropriate use for animation is the need for guidelines for
the design of animated imagery. The following section provides recommended guidelines for the design of animated computer interfaces:

1. Hierarchy of information- showing the most important piece of information first, visually treating it to be the first stimulus that the eye sees. The contents of the program are arranged according to the most important to the least important, and then visually treated to reflect this hierarchy. An example of this would be the visual indication of an important title by making it larger, bolder, in a bright color and placed at the top of the screen.

2. Contrast- the visual elements are clearly distinguishable from one another and visually treated to enhance the differences between the elements. An example is the color, typestyle, and size of a piece of text in relation to the visual field in which it is placed.

3. Layout- the overall composition of text and image. The screen layout would consist of the text, image, underlying grid and space on the computer screen. An example of a layout is the composition of all visible elements in the figure-ground relationship.

4. Grouping laws- the "chunking" of information to make it more easily understood. Grouping can also
indicate the relationship among the separate pieces of information grouped together to appear as a greater whole. An example is a series of sequential tasks that are considered part of a larger function.

5. Legibility- the readability of the typography and images used for screen design. An example of high legibility for a typeface is one that is clearly distinguishable from the background on which it resides.

6. Animation- the use of moving images or text to capture the viewers' attention is appropriate to the content, and not superfluous. An example of an animated visual cue is that of a number, in a sequence of numbers, that blinks on and off to inform the user of its importance in the process.

7. Overall communication- the entire visual treatment of type, image, layout, color, textures, groupings and animations used in the computer program which are appropriate to the target audience. An example of this is a program visual treatment that adheres to its subject, such as muted colors, woodgrain textures, and old western-style typefaces for a program on the Wild West.

As the above mentioned items (1-7) are general guidelines, the final designs should be evaluated for
effectiveness, appropriateness of imagery for content and communication of content.

Summary

The literature review of Chapter I has shown that each discipline has something of value to contribute to the topic of motion within the computer interface. The work of Rieber, Shneiderman, Acker, Gonzolez, Palmite, Elkerton, Baeker and Norman have all indicated the need for more research in the area of animated imagery and perception. In the following section, a recommendation will be made for continued research in the area of animated imagery and learning.

JUSTIFICATION OF THE STUDY

Several disciplines have dealt with the issue of motion: how we perceive motion in our environment and how we understand motion within the confines of our culture. Researchers within each discipline suggested the further study of animated imagery and the potential it has for helping us to see, to learn, to understand and to respond. Since the development of animation in educational software is in the early stages, less is known about how to best incorporate these visuals into our learning materials. Even less is known about the effectiveness of animation within a learning environment.
As our products become increasingly sophisticated, so is the level of learning that must occur with each product. Interactive computer screens have been incorporated into products such as automatic teller machines (ATMs), automobiles, televisions, cameras, microwaves and telephones. Even our coffee machines and low priced children’s toys have had an increase in incorporated software and interactive screens. All of these “smart” products require interaction, but not all of the products are easy to use.

Some products have simple functions, but our VCRs, telephones and automobiles require memory-intensive steps that must be learned in order to use additional functionality of the product. These added functions, coupled with the training manuals provided to the consumer, become confusing and time-intensive to use.

When users are asked to interact with a computer screen or keypad on a product, they are being asked, in essence, to program a part of the functionality of the product for their own use. When we add the numbers, navigation, and specific uses of the products, it may become overwhelming for the user. An average homeowner may have kitchen appliances (stove, microwave, coffee machine, dishwasher, etc.), household appliances (washer, dryer, vacuum, TV, VCR, computer and peripherals, etc.) and other daily living products (heating/cooling system, telephone, automobile, security system, garage door, etc.), which all require
interaction. In many cases, operating the product requires memorization of a code, or interaction patterns on the product interface.

**Purpose and Objectives of the Study**

Research specific to the area of animated visual cues within a learning environment has been limited. The studies conducted are extremely specific to a particular topic, such as icons, or decision-making, and are severely limited for generalizing to a larger community.

While many disciplines have begun the study of motion, none has amassed enough information to truly aid the designer and communicator of educational content. As a result of this, only recommended guidelines coalesced from several disciplines, can be made at this time.

As there has been no extensive testing done on the effectiveness of animated imagery in learning environments, we can say it that is not certain that animated imagery will increase learning and retention. Furthermore, lack of studies done on user preferences for animated imagery, provide us with an unclear picture as to whether users find animated imagery an assistance or a visual diversion.

Due to the above-mentioned lack of research, the objectives of this proposed study are:
1) To gather information from disciplines that have addressed motion as it relates to computer graphics, educational software and cultural considerations;

2) To provide guidelines to graphic, software and content designers for the appropriate incorporation of animated imagery into the software learning environment;

3) To learn the preferences of learners for animated imagery within a software learning environment; and

4) To evaluate the effect of animated imagery on task learning and task completion times.

Guidelines for the use of animated imagery will be grounded in reference after the research for this study is conducted. It is assumed that more knowledge about the effect and affect of animated visual cues will emerge as a result of this study and will inform the process of designing animation for the visual computer interface.

**Testing The Effectiveness of Animated Visual Cues**

As animation is seen as a visual tool to engage the user, this study will test the effectiveness of animation within a software learning environment. If animated visual cues embedded in a software learning environment help the user remember codes and patterns, then it will help users
successfully complete a task with the product, and in less
time.

Two proposed hypotheses are stated below:

H 1: More learning will occur when animated visual cues are
used in the computer learning environment as
demonstrated by higher successful task completion rates
by subjects viewing animated cues compared to those
viewing static displays.

H 2: Animated visual cues within software learning materials
will reduce subject times for completing a task compared
to subjects using static visual cues.

Testing User Preferences

Learning style preferences should be used to assess if users
want animated imagery in their software learning environment
and if there is a relation to task success. Two additional
hypotheses are stated below.

H 3: Subjects will prefer animated visual stimuli in their
software learning environment as compared to static
visual stimuli.

H 4: Subjects preferring animated visual cues will have
higher successful task completion rates, when the
preferred visual cues are used.
Conclusion

The literature review from Chapter I supported the belief that learners may benefit from animated imagery incorporated into their software learning environment. Animation, designed in a way that is easily perceived by the human eye, can capture learner's attention, but works best when it is appropriate to the educational content. Several uses of animation in educational settings were noted. The literature review revealed the paucity of studies in the area of animated imagery in educational environments.

This finding was followed by a recommendation for further studies on animated imagery in educational settings. It is proposed that research be conducted to determine whether animated imagery within the interface increases learning and reduces time-on-task. Chapter II will detail the proposed research method and research design related to animated visual cues.
CHAPTER 2
RESEARCH METHOD AND DESIGN

INTRODUCTION

Chapter II will describe the research design and method used to test the effect and affect of animated visual cues on information acquisition, retention and application within a computer-based learning program. The following sections covered in this chapter are: the research method, research design, sampling plan, instrumentation and data collection, followed by a summary of the chapter. The next section, research method, will cover the selections of variables and the hypotheses.

Research Method

Selections of Variables

To test the effectiveness of visual cues within a computer learning environment, in relation to information acquisition, retention and application, timed tests of specific tasks using a cellular telephone were used. Two computer presentations, one of each task to be
performed were used: one presentation was static and the other was animated.

The independent variable in this experiment is the presence or absence of animation. The dependent variables in this study are (1) time to task completion, (2) accuracy of task performance by subjects in the study, (3) subject satisfaction with animated learning materials, and (4) relationship between preferred learning styles and successful task completion.

To test for preferences of animated visual cues in the learning environment, subjects were asked to complete questions on the perceived value of visual cues in their learning environment and their preferences.

**Statement of Hypotheses**

Based on the literature review of Chapter 1, it is argued that animated visual cues used within the stimulus materials result in greater success rates than stimulus materials without animated cues. Subjects should also have reduced response times for successful task completion after viewing stimulus materials with animated cues. It is also presumed that greater sensory input from animated imagery will result in greater user satisfaction with the software learning materials.
The four research hypotheses are:

**H 1: A Task Completion > NA Task Completion**

- A = Animation
- NA = Not animated

More learning will occur when (A) animated visual cues are used in the computer learning environment as demonstrated by higher successful task completion rates by subjects viewing animated cues.

**H 2: A Time to Completion < NA Time to Completion**

- A = Animation
- NA = Not animated

Animated (A) visual cues within software learning materials will reduce subject times for completing a task compared to subjects using (NA) static visual cues.

**H 3: A Preferences > NA Preferences**

- A = Animation
- NA = Not animated

Subjects will prefer (A) animated visual stimuli in their software learning environment as compared to (NA) static visual stimuli.
H 4: PA successful comp > NPA successful comp

Subjects (AP) preferring animated visual cues will have higher successful task completion rates, when the preferred visual cues are used.

"Successful task completion" refers to the correctness and completion of the task to be completed with the cell phone. One task was to recall, change and store a new number in the cell phone memory (See Appendix A). The other task was to unlock and change the lock code on the cell phone (See Appendix B). Both tasks required several steps and numbers to be entered correctly for the task to be completed. The correct completion of the task resulted in a change in the number on the LED window.

"Time to complete a task" refers to the moment the researcher said "begin" to the subject seated with the actual cell phone, to the moment the subject said "done," which was when the subject felt they had completed the task correctly.

The next section, Research Design, covers the pilot test, sample, apparatus, and experiment procedures.
Research Design

Pilot Test

A pilot test was conducted to practice and evaluate the procedures of the experiment. The pilot test was also used to evaluate apparatus, the wording and visuals of the stimulus materials, the general success rate of the subjects, and the sequencing and timing of the entire experiment.

University students from Communication course 140 were used as volunteer subjects. They were given five extra credit points in their Communication course, as well as five dollars, for participating in the study. They tested over a period of three days in July of 1998.

The first four subjects, who were not told they would be asked to complete cell phone tasks on the actual product, were unable to complete the cell phone tasks. As a result of these failures to complete the tasks, the next six subjects were told they would be asked to perform the two cell phone tasks after they reviewed the software module.

Only one of the next two subjects was able to complete the tasks. However, continuing with the remaining four subjects, two did complete the task, and two were unable to complete the task. Of the final six subjects who were informed they would be asked to complete the tasks, 50% were successful and 50% were unsuccessful. This was deemed
a fair success rate with which to proceed, with the stimulus materials and procedures in place.

The pilot test results prompted a change of wording in the software presentation. An additional screen of text containing information about the tasks was added to the computer screen that provided directions for the subjects. This resulted in less script from the researcher and a more consistent message to the subject.

Sampling Plan

The Ohio State University students who attended sections of the Communication 305 Argument and Debate class during the Autumn Quarter of 1998 were used as subjects. Students from this class were chosen because they were not involved in the production, application or study of technology as a part of their classroom work. The content of this class would not affect their performance on the cellular telephone tasks.

Each class section was given a brief talk on the value of the research to be conducted, where and how the research would be conducted, and that the experiment would take a minimum of 20 minutes.

An in-class sign-up was used to identify willing subjects. A simple random sampling procedure was used for choosing subject names and assigning conditions. From the
randomized list, phone calls were made sequentially until thirty-six subjects were chosen.

Subjects were pre-screened for prior cell phone usage (See Appendix C). Responses were recorded on a sheet with pre-determined questions. No subjects were eliminated from the experiment as the subject cell phone use had been limited to simple calls, even though some had used a cell phone for several years. Students who had performed an extensive amount of functions with a cell phone were excluded from the study. The next section reports the demographic information of the subjects.

Subjects

Demographic Information

A cohort of thirty-six volunteer subjects resulted from the sampling plan. A demographic survey was given to each of the subjects (See Appendix D). Twenty of the subjects (55.6%) were male and 16 (44.4%) were female. Two subjects had never used a cell phone. All others had the same amount of experience.

The ages of the subjects ranged from 17 to 49 years. Five subjects (13%) were in the 17 to 20 age range; twenty-five subjects (69%) were in the 21 to 24 age range; five subjects (13%) were in the 25 to 28 age range and 2 subjects (6%) were in the 29 to 50 age range.

The colleges they were enrolled in were: Humanities at 31%, ASC at 22%, Arts and Science at 11%, Communication at
8%, Pharmacy at 6%, Agriculture at 6%, Business at 6%, ART at 3%, Criminology at 3%, English at 3%, and UVC at 3%.

Of the 36 subjects, 9 (25%) were juniors, and 27 (75%) were seniors.

Their self-reported grade point averages ranged from 2.0 to 3.8. Eight (22%) of the students fell within the 2.0-2.49 grade point range. Seventeen (47%) of the students fell within the 2.50 to 2.99 grade point range. Nine students (25%) of the students fell within the 3.0-3.49 grade point range and two students (6%) fell within the 3.5 to 4.0 grade point range.

When asked about comfort with computer use (1 = uncomfortable and 5 = comfortable), the percentages are as follows: two (5%) students at 1, three (8%) students at 2, seven (19%) students at 3, seventeen (47%) students at 4 and seven (19%) students at 5.

Twenty-five students (69%) preferred animated visual cues as opposed to eleven (31%) students who preferred static screens. Twenty-three (64%) students said the visual cues helped them remember the tasks and 13 (36%) said they did not.

The following section, Apparatus, will discuss the product used in the experiment.
Apparatus

An experiment in which the relationship of animated visual cues and user performance was designed in order to test the hypotheses. A Motorola cellular telephone was the device chosen to demonstrate learning for this experiment. The "cell phone" was chosen as a testing device because it is common to many people, but added software functionality has increased the complexity of its operation (See Appendix E).

The learning modules were presented to the subjects on a Pentium 120, with 32 megabytes of memory resulting in instantaneous screen refresh rate for smooth motion. All four modules, containing both tasks, resided on the PC hard drive. The researcher started the module for the subject, but then the subject used the mouse to navigate through each task in the module.

Experiment Procedures

Thirty-six subjects were selected for this study. Each subject was given one of the four computer modules, containing two tasks to view on the computer monitor. The order of the tasks, whether animated or static, were reversed for each successive subject. This resulted in four sets of differing modules to be used in the experiment. The table for the four sets of modules is represented in Table 2.1.
<table>
<thead>
<tr>
<th>Module 1</th>
<th>Module 2</th>
<th>Module 3</th>
<th>Module 4</th>
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<tr>
<td>Static</td>
<td>Animated</td>
<td>Animated</td>
<td>Static</td>
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<tr>
<td>Task 1</td>
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<td>Task 2</td>
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<tr>
<td>Animated</td>
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<tr>
<td>Task 2</td>
<td>Task 2</td>
<td>Task 1</td>
<td>Task 1</td>
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</tbody>
</table>

Table 2.1: Task Differentiation (animated or static) for Software Modules

The subjects were instructed that they would be viewing a software learning program on cellular telephone functions and would be asked to complete both tasks. The subjects were not told that one task presentation would be animated and the other would be static. Animation was not mentioned throughout the experiment.

**Part One: The software modules and number recollection**

Subjects were asked to view the entire learning presentation module at their own pace, press the "next" button to move to the next screen, and signal when they were finished with the final screen that contained the words "the end."

After the learning modules were viewed, subjects were asked to respond to questions concerning numbers they had viewed in the program. Subjects were asked if they could remember the telephone number to change to, the cell phone
memory location where the number resided, and the six-digit security number and the three-digit security code.

Because the tasks were presented in differing order in the software modules, the questions were asked in accordance with which software module came first. An example: if a subject was given the "changing the electronic lock code" task first, regardless of whether it was animated or static, the questions about the electronic lock code were asked first. Subject responses were recorded for each question. Their responses were recorded on a questionnaire (See Appendix F).

Part Two: Completing the tasks with the cell phone

After completion of the numbers questions, subjects were asked to perform the two tasks in the order that they were presented in the software program. Subjects were instructed to pick up the cell phone and be ready to start when they heard the word "begin". Subjects were timed from the word "begin" and they were asked to say "done" when they felt they had completed the first task. The numbers entered by the subject with the cell phone key pad were checked by the researcher in the cell phone window.

Subjects were asked to do the second task in the same manner. The numbers again were checked in the window of the cell phone to be sure the task had been done correctly. If
the task was done incorrectly, the numbers appearing in the cell phone window would be incorrect.

**Part Three: Questionnaires.** After completion of both tasks, subjects were given a brief questionnaire which contained demographics questions (See Appendix D). This demographic survey, given to each subject, was used to gather information on sex, age, major, grade point average (self-reported) and level of comfort with computer use. The latter part of the survey asked questions on preferences for animated or static computer screens (see Appendix G). After the demographics survey the subjects were given a preferences survey called the Productivity Environmental Preference (PEP) survey (Appendix H), which contained questions on subject motivation and preference for visual, verbal and kinesthetic learning styles. After completion of the questionnaires and survey, the students were debriefed and thanked for their participation.

**Instrumentation**

Several instruments were used throughout the study: the pre-screen test given before the subjects were chosen, the timed test given after the tasks were viewed in the software learning environment, the demographics questionnaire, given after the tasks were completed, and
the Productivity Environmental Preferences Survey, given after the demographics questionnaire.

Two tasks chosen for this experiment were taken directly from the Motorola consumer training manual for cellular phones. The tasks within the training manual range from simple to complex. An example of a simple task with a cellular phone is a normal local call. An example of a complex task is instigating a three-way call from cell phone memory.

Two intermediate difficulty tasks were chosen for the subjects to perform. Both of these task choices were made through an analysis of the entire listing of functions of the cell phone (Appendix E). These intermediate tasks were within the mid-range listing, or of intermediate difficulty, and both had a similar number of steps to complete. The chosen tasks were not commonly performed by the average cell phone user, a point that is addressed in the pilot study, as well as the pre-screen questionnaire for subjects' cell phone usage.

Two computer based learning modules were created for each task: one using animated visual cues and one using static visual cues. Each module was created in the same visual format, with wording taken directly from the Motorola cell phone manual. Subjects received one animated task and one static task.
Demographics and preferences questionnaire

Subjects were asked to complete a questionnaire on major, rank, GPA, and satisfaction with the computer module and learning style preferences.

The format of the questionnaire was in the form of both closed-ended and open-ended items. The user satisfaction portion of the questionnaire was in the form of semantic differential questions, and open-ended questions. The semantic differential question used a scale of 1 through 5, with 1 being strongly agree and 5 being strongly disagree.

Productivity Environmental Preference Survey

The Productivity Environmental Preference (PEP) survey was chosen as a test that addressed specifically the issues of visual materials in a learning environment. The PEP is geared for adult and university students, is standardized, and could be administered within the design of the experiment.

The PEP survey is an inventory for the identification of individual adult learning style preferences in a working or learning environment (Price, 1996). The survey is based on the work of Dunn and Dunn (1978), whose studies have ranged over several decades. Their experiments (Dunn & Dunn, 1978) have identified four types of learners: visual, auditory, tactile and kinesthetic and multi-sensory.
Price's (1996) description of the PEP survey is that it "does not measure underlying psychological motivation, value systems or a quality of attitudes. It yields information about learners that show a pattern through which the highest levels of productivity tend to occur" (p. 5).

The PEP survey is used to show how an adult learner or student prefers to produce or learn, not the skills or particular intelligences needed to perform a task. Of the twenty areas that the PEP survey assessed, four were chosen as important to this study. They are motivation, visual preferences, tactile preferences and kinesthetic preferences, consistent with the research results of Dunn and Dunn. "Motivation" describes the way assignments should be structured. For standard scores of 40 or less, meaning lower motivation, assignments should be short, simple and uncomplicated. For scores of 60 or more, self-designed assignments allowing self-pacing and low supervision are recommended.

The "visual preferences" category states that subjects with standard scores of 40 or less, prefer more multi-sensory activities, such as model building, real life activities, and listening to tapes. Those learners with scores of 60 or higher do well with films, charts, maps, diagrams and other visual materials such as computer graphics. Visual learners would like visual demonstrations
of how things work. They would want to see someone operating the cell phone and would look for visual cues to let them know what is occurring.

The "tactile" learners with scores of 60% or higher want to touch and interact with objects. These types of learners would want to pick up the cell phone and test the buttons, rather than just look at a computer screen or hear a lecture.

The "kinesthetic" learners with scores of 60% or higher enjoy real life experiences. These learners would want to use the phone in actual practice, calling another party to see if their actions were correct.

Several learning style preferences surveys were evaluated, but most were ruled out for this study for several reasons. The most common reason was that the surveys were not standardized, and were difficult to ascertain if the scores were reliable. The second most common reason a learning style survey was rejected was that they were geared for schoolchildren, rather than adults. The third most common reason for rejection was that the test was set up in such a way that made it difficult or impossible to administer in a university setting. In addition, several of the learning styles tests did not test specifically for visual preferences, but rather personality differences, which were deemed unusable.
The next section will discuss the stimulus materials, and the expert design and review of stimulus materials.

Stimulus Materials

As stated earlier, the stimulus materials consisted of four learning modules, each containing two tasks. The animated and static versions of each task were exactly the same in content and imagery, except that one contained animated visual cues and the other had none. The content of the computer-based learning modules was based on the Motorola consumer cell phone training manual. The user tasks for operating the Motorola cellular phone were broken into simple numbered steps in the modules.

The visuals for the software learning modules (See Appendixes A and B) were created with the Java programming language and then presented in an html software environment. The next section reviews the visual design of the modules.

Expert Design of Stimulus Materials

The four software learning modules were designed according to interface guidelines suggested in the literature review in Chapter I. The overall screen design resulted in a very simple, straightforward visual presentation of the tasks. Several animated cues were used within the software learning modules. These
recommended uses were: "text reveals", "flying numbers and buttons", and "animated cell phone activity".

"Text reveals" refers to text that emerged on the computer screen in steps, in order to capture user attention and lead the eye through the hierarchy of information on the page.

"Flying numbers and buttons" were used to highlight various pieces of information. Functions using the "save" and "clear" buttons, were taken directly from the text on the left and "flown" into position on the phone keypad to the right of the screen. Red numbers were taken from the line of text on the left and moved to the image of the phone keypad. This animation was used to guide the viewer's eye to the correct spot on the phone keypad.

The other form of animation used was the visual effect for the image of the cellular phone, which mimicked the exact visual experience with the real, 3-dimensional cell phone. Blinking color buttons, codes and text that appeared in the actual cell phone window were created for the software version.

The software screens for each task were designed to be similar: the opening screen contained blue background for a "welcoming" color field, the "working" screens contained a red title to highlight the task to be done, and black letters signaled a seriousness for the task to be done. Helvetica type, with a large X height, was used to provide
heightened legibility, and red numbers and buttons were used for increased visibly while they were moved across the computer screen in each of the modules.

It was important to show an image of the cell phone along with the animated visual cues from the text. The visual cues that were in motion were numbers to be remembered for the task, or buttons that needed to be pushed. The numbers and buttons moved from their position of the wording on the left to their correct position on the keypad of the phone on the right.

Since subjects were to complete the same task that was demonstrated in the software presentation, it was important that the visual "activity" on the phone image on the computer screen occurred exactly as it did when the subject completed the task with the actual phone. This meant that the visual activity of numbers and messages in the actual phone window, and which seemed random at times, would show up in the phone window on the computer screen.

Although the modules were designed in accordance with recommendations from the literature review, an expert review of the materials was conducted.

**Expert Review Stimulus Materials**

Before the pilot test was given, three local designers were asked to review the four learning modules. All three designers were familiar with animation, the design of
computer interfaces, as well as recommended guidelines for design of animation in the software interface presented in Chapter One.

The designers also were informed of the visual objectives of the experiment, which was to provide a straightforward visual interface, with minimum visual "noise" and extraneous design elements, so as not to distract from the animations that would occur in one of the two software modules. An overly designed interface could confound the responses of the subjects if they were overwhelmed by visual stimuli in the modules.

The expert reviewers were asked to provide a critique of the stimulus materials, pointing out which areas of the screen layout could be improved. After their input, images were changed to increase contrast, text was made larger and visual consistency of the screens was implemented.

The following section describes the setting in which the stimulus materials were presented.

Setting

The timed tests and surveys were conducted in room 375B Hopkins Hall on the OSU campus. The well-lit room contained a Dell computer with the four software programs (modules) resident on the hard drive. The subjects, who were tested individually, were seated at a table which contained the computer, the cell phone and the surveys.
After the computer module was started, the subjects operated the computer on their own. The researcher stayed in the room, within hearing distance, but was visually removed from the subject's view.

The entire testing procedure for each subject took approximately 25 minutes. The thirty-six students were scheduled at various times of the morning, afternoon, and evening, within a week's time. The following section describes the data collection procedures during and after the subject's responses.

Data Collection

The subject's successful or failed task completions, as well as the amount of time for the completion of each task, were recorded by hand.

Data Analysis

After data collection, trained coders were given direction as to the possible categories of subject responses. Coders were trained by showing them sample statements and indicating within which category the statement should be placed. They were then given additional sample statements and asked to decide within which category the statements should go. When the coders understood the process, they were allowed to proceed.
The coded data was entered in a Microsoft spreadsheet that was used in conjunction with the SAS software program and a GLIMMIX macro. The data in the spreadsheet was verified by a graduate student in the statistical consulting group at the Ohio State University.

**Task success or failure analysis.** A logistic regression model was used to determine if the probability of completing a task depended on animation being present in the software modules. Since the data were presented as binomial data, we were not modeling the mean, but the probability of the success of a subject using animated imagery. Therefore, a logistic regression model was needed.

Letting \( p \) represent the probability with which a person will succeed in completing the task in question, we needed to identify the factors that may have an effect on \( p \); thus making it more or less likely to complete the task successfully. The logistic regression model provides this means to do so by modeling some function of \( p \), namely the \( \log(p/(1-p)) \), as a linear combination of the controlled explanatory factors. More specifically, the model we obtained has the form:

\[
\log(p/(1-p)) = \beta_0 + \beta_1 \text{Method} + \beta_2 \text{Task} + \beta_3 \text{Period} + \beta_4 \text{Compcomf}
\]
where,
Method = 0 for not animated, and Method = 1 for animated
Task = 0 for task 1, and Task = for task 2
Period=0 for first trial, and Period=1 for the second trial

The method, or whether the task was animated or static, was of most importance for considering Hypothesis 1. The task was also of importance because of the possibility of one task being simpler than the other. The period was important because of the possible effect of task order. Finally, computer comfort was an issue because of the impact it might have on users viewing and learning from the computer program, as well as the effect with programming a cell phone.

Survey analyses. Content analysis was used for the open-ended items in the questionnaire. The closed-ended questions were analyzed for simple frequency scores.

The PEP survey was sent to Price Systems, Inc., in Lawrence, Kansas. The PEP surveys were analyzed in the Scan & Score program using a 7000 NCS series scanner in conjunction with an IBM computer. The data from the scan was fed to the Productivity Style Report (PSR) software which generated individualized scores for each subject (See Appendix I). The standard score ranges from 20 to 80 with a mean of 50 and a standard deviation of 10. The standard
score is based on a random sample of 1000 subjects from the national data base who have taken the PEP survey. Scores of 60 or higher in a particular area show a propensity toward a particular learning style (such as visual or kinetic), while those of 40 or less may require another style or a mix of styles.

Summary

In summary, this experiment tested the effect and affect of visual cues within a software learning environment. Students from The Ohio State University population were chosen to test with the actual device, a cellular phone, after viewing learning modules. Subjects' success rates, and times for task completion were compared, as well as their attitudes toward animation and learning preferences. The following chapter will discuss the findings of the study.
CHAPTER 3
FINDINGS

Introduction

This chapter will present findings from the data collection and analysis described in Chapter II. Logistic regression and Chi-Square statistical models were used for the data analyses for the hypotheses. The following sections will discuss findings for each of the four hypotheses presented in Chapter II.

Research Hypothesis 1

H 1: A Task Completion > NA Task Completion

More learning will occur when animated visual cues are used in the computer learning environment as demonstrated by higher successful task completion rates by subjects viewing animated cues.

The findings for Hypothesis 1 showed that more learning occurred for subjects who had animation present in their learning materials. This learning was demonstrated through
higher successful task completion rates by subjects who viewed animated cues, rather than static cues, in their software modules.

In order to statistically assess the effect of animation on the success of students who performed the tasks, a logistic regression model was used to model the data. The logistic regression model allowed the reacher to account for possible peripheral effects that other issues, such as comfort with computer use, may have had in the study. Table 3.1 gives the information obtained as a result of fitting the aforementioned logistic regression model to the data.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>DF Estimate</th>
<th>Std Err</th>
<th>ChiSquare</th>
<th>Pr&gt;Chi</th>
</tr>
</thead>
<tbody>
<tr>
<td>B0 INTERCEPT</td>
<td>1</td>
<td>0.2930</td>
<td>1.3730</td>
<td>0.0455</td>
</tr>
<tr>
<td>B1 METHOD</td>
<td>1</td>
<td>2.7036</td>
<td>0.7917</td>
<td>11.6610</td>
</tr>
<tr>
<td>B2 TASK</td>
<td>1</td>
<td>-1.6384</td>
<td>0.7467</td>
<td>4.8149</td>
</tr>
<tr>
<td>B3 PERIOD</td>
<td>1</td>
<td>0.1544</td>
<td>0.6827</td>
<td>0.0512</td>
</tr>
<tr>
<td>B4 COMPCOM</td>
<td>1</td>
<td>-0.4659</td>
<td>0.3531</td>
<td>1.7417</td>
</tr>
</tbody>
</table>

Table 3.1: Analysis of Parameter Estimates for Animation Effects
In the context of the above analysis, testing the hypothesis: Ho: no animation effect vs Ha: there is a definite animation effect that amounts to testing:

\[ Ho: \beta_1 = 0 \text{ vs Ha: } \beta_1 \text{ not equal to 0} \]

The test statistic for this is a Chi-Square (with 68 df). The observed Chi-Square is 11.6610, which corresponds to a p-value <0.0006. Thus, we can reject the null hypothesis \( Ho \), to conclude that there is a significant positive animation effect at the .0006 significance level.

In exploring the findings in relation to Hypothesis 1, Table 3 shows the structure for the four program modules and two periods of the experiment. Each of the four program modules consisted of an animated task and a static task. Two periods of testing occurred, one for each task. Subjects were randomly assigned to one of the following program sequences as shown in Table 3.2.

<table>
<thead>
<tr>
<th>Periods</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Program Modules</td>
<td>T2A</td>
<td>T1NA</td>
</tr>
<tr>
<td>1</td>
<td>T1NA</td>
<td>T2A</td>
</tr>
<tr>
<td>2</td>
<td>T1A</td>
<td>T2NA</td>
</tr>
<tr>
<td>3</td>
<td>T2A</td>
<td>T1NA</td>
</tr>
<tr>
<td>4</td>
<td>T2NA</td>
<td>T1A</td>
</tr>
</tbody>
</table>

Table 3.2: Structure for Animated and Non-Animated Program Modules and Periods in Which They Occurred
Table 3.3 shows the animated and non-animated periods and success rate responses for the experiment overall. Nine subjects were used for each of the four periods.

<table>
<thead>
<tr>
<th>Program Modules</th>
<th>Successful Responses</th>
<th>Total Subjects</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1 T1NA T2A</td>
<td>(1,1)(0,1)(1,0)(0,0)</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>2 T1A T2NA</td>
<td>1 1 7 1</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>3 T2A T1NA</td>
<td>0 2 3 4</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>4 T2NA T1A</td>
<td>1 6 0 2</td>
<td>9</td>
<td></td>
</tr>
</tbody>
</table>

Table 3.3: Success Rate Responses for the Four Program Modules and Two Task Periods

In period 1, 11 of the 18 students (61%) who received animated learning materials successfully completed a task as opposed to 2 of the 18 (11%) percent of the students who received static learning materials. This represents a difference of 82% percent.

At period 2, 11 of the 18 (61%) students who received animated materials successfully completed a task as opposed to 3 of the 18 (17%) students who received static learning materials. This represents a 70% difference in success rate.

The variables of task order, task difficulty, and comfort with computers were used to assess the impact
they might have on the outcome of the subject responses. There is a statistically significant effect with task
difficulty as one task was easier than the other. "Changing
a number in cell phone memory" had more successful
completions (18 successes) than "changing the electronic lock
code" (9 successes). Subjects task successes are shown in
Table 3.4.

<table>
<thead>
<tr>
<th>Task</th>
<th>Success</th>
<th>No Success</th>
<th>Total Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phone Mem.</td>
<td>18</td>
<td>18</td>
<td>36</td>
</tr>
<tr>
<td>Elec. Lock</td>
<td>9</td>
<td>27</td>
<td>36</td>
</tr>
<tr>
<td>Totals</td>
<td>27</td>
<td>45</td>
<td></td>
</tr>
</tbody>
</table>

Table 3.4: Table of Subject Task Completion Successes Delineated by Task

The students’ "comfort with computer" scores averaged
3.67 in a range of 1 to 5 (5 = most comfortable). "Comfort
with computers" was added into the regression model to assess
the impact of this variable on successful task completion
with animation. Had subjects been extremely uncomfortable
with computers, their learning in this experiment might have
been affected. An uncomfortable learning environment could
have caused them to miss several of the visual cues and steps
needed for successful task completion. Conversely, extremely
high scores for "comfort with computers" might have made the
tasks appear easier than they were, and the students could lose interest, missing several important visual cues.

The PEP Survey in relation to the study

The PEP survey was used to determine if the subjects had extremes in preferences for learning styles and motivation. The student scores for areas pertaining to the study (visual, kinesthetic, and motion) fell within the midrange areas of 40 to 60 on a scale from 1 to 100, which was determined by the PEP Survey system. There were no extreme preferences recorded by the subjects.

The average student score for visual preferences is 48.56. The average score for kinesthetic preferences is 52.56. The average score for motivation is 51.39. Since the scores of the students were at mid-range for the PEP survey, the subject sample was not excessively skewed toward high or low preferences for visual, kinesthetic or motivational learning styles.

In the motivation category, an average score purports that the subjects prefer neither total autonomy or total assistance during tasks. The average scores for the motivation category fit well with the self-guided computer learning materials prepared for this experiment, because the cell phone learning materials are packaged and presented in short modules that allow the subjects to learn on their own.
Research Hypothesis 2

H 2: A Time to Completion < NA Time to Completion

Animated visual cues within software learning materials will reduce subject times for completing a task compared to subjects using static visual cues.

The findings for Hypothesis 2 showed that student’s task completion times were aided by animation present in their computer learning modules. This was demonstrated by the reduced task times for those students who used animated tasks and increased times for static tasks.

To test this hypothesis, Cox’s proportional hazards model was used to model the data on times to complete the tasks. To avoid the complication of the repeated measures (i.e., the fact that each student performed two tasks), a more conservative approach was followed to test the hypothesis for the two tasks (first versus second task performed) separately. Students’ times, for those who did not successfully complete the task, were treated as censored observations, meaning that we assume that they were not able to complete the task successfully within the time taken. Table 3.5 shows the time averages for completion of animated and non-animated tasks.
Successful Task Completions

<table>
<thead>
<tr>
<th>Average Times</th>
<th>Static</th>
<th>Animated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seconds</td>
<td>72.4</td>
<td>62.3</td>
</tr>
</tbody>
</table>

Table 3.5: Table for Subjects’ Average Completion Times for Static and Animated Tasks

In the context of the model, the effect of animated visual cues was found to be significant in both cases. Table 3.6 shows the results of animation (method 1) used for tasks one and two.

First task performed:

<table>
<thead>
<tr>
<th>Variable DF</th>
<th>Parameter Estimate</th>
<th>Standard Error</th>
<th>Wald Chi-Square</th>
<th>Pr &gt; Chi-Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>METHOD 1</td>
<td>2.069044</td>
<td>0.83779</td>
<td>6.09908</td>
<td>0.0135</td>
</tr>
</tbody>
</table>

Second task performed:

<table>
<thead>
<tr>
<th>Variable DF</th>
<th>Parameter Estimate</th>
<th>Standard Error</th>
<th>Wald Chi-Square</th>
<th>Pr &gt; Chi-Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>METHOD 1</td>
<td>1.469786</td>
<td>0.66499</td>
<td>4.88515</td>
<td>0.0271</td>
</tr>
</tbody>
</table>

Table 3.6: Analysis of Data From Student’s Completion of Tasks Using Animation in the Computer Module

For the first task, the observed Chi-Square is 6.0008 with a p value of .0135. For the second task the observed
Chi-Square is 4.88515 with a p value of .0271. Consequently, the null hypothesis should be rejected in favor of the alternative. The effect of animated visual cues in the cell phone training materials had a significantly positive influence on task time, as opposed to static visual cues in the cell phone training materials.

Research Hypothesis 3

H₃: A Preferences > NA Preferences

Subjects will prefer animated visual stimuli in their software learning environment as compared to static visual stimuli.

The findings for Hypothesis 3 showed that more students preferred animated visual stimuli in their learning materials than static visual stimuli. This is demonstrated through the increased numbers for students who stated they prefer animated cues, as well as the open-ended statements of the number of students who found the animations in the learning materials helpful.

The stated preferences of students for static or animated cues in their learning environment are shown in
Table 3.7. Twenty-six students, of a total of 36 students, preferred animated visual cues as opposed to ten students who preferred static materials.

<table>
<thead>
<tr>
<th>Static Cues</th>
<th>Animated Cues</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student Preferences</td>
<td>10</td>
<td>26</td>
</tr>
</tbody>
</table>

Table 3.7: Preference Sample Frequencies for Static or Animated Visual Cues in Learning Materials

The estimate for the proportion of those preferring animation is $p = 0.7222$ or 72.2%. An exact hypothesis test (using a Binomial test statistic) for:

$$H: p = 0.5 \quad \text{versus} \quad A: p \neq 0.5$$

yields a p-value equal to 0.0113. Hence the hypothesis $H: p = 0.5$ can be rejected in favor of the alternative, at any significance level larger than 0.0113 (e.g., $H$ rejected at 0.05): $P_{\text{observed}} = 0.0113 < P_{\text{critical}} = 0.05$. Restated, a 95% confidence interval for the proportion preferring animation is $(0.5481, 0.8580)$, does not include the value 0.5.

Of the thirty six subjects who were asked to comment on animated visual cues, 21 (58%) of them made entirely positive statements about animated visual cues in the learning software, citing "easier visualization", "helpfulness", and
"creating more interest" as the major values of animated visual cues (See Appendix L). Representative subject responses are presented below:

"They helped to show the right way to do a task."

"They were helpful, especially when they showed buttons being pushed."

"More interesting than the static screen. Liked the color change/button icon."

"They helped when I was using the actual cell phone."

Ten subjects (28%) had mixed reviews, citing "easier visualization", "helpfulness" and "creating more interesting visuals" as positive responses to animation. Representative mixed review comments are listed below:

"They helped me visualize the task much easier, even though I forgot how to accomplish it."

"They were nice but I put more emphasis on the animation rather than trying to learn the material that was animated."

"Less boring than reading the words. The words were what I focused on, though."

"I learn better through verbal instruction and trial and error. However, the visual cues were not bad."

Five (14%) subjects recorded negative comments about
animated visual cues. Three subjects (.08%) thought the animations were "distracting" and two subjects (.06%) thought the animations were "boring or uninteresting" as problems with the visual cues. Representative comments are listed below:

"Threw me off of my thinking process."
"Took too long to cue up, lost interest."
"The animated cues distracted me from reading the computer screen. They got in my way."

The findings for this hypothesis are that the majority of the subjects preferred animated cues in their learning materials. The statistical analysis supporting preferences for animated visual cues, as well as student comments that animated visual cues were helpful for learning, indicates strong support for Hypothesis 3.

Research Hypothesis 4

H 4: PA successful comp > NPA successful comp

Subjects preferring animated (PA) visual cues will have higher successful task completion rates, when the preferred visual cues are used.
This hypothesis was used to evaluate student preferences in relation to their performance with animated visual cues and static cues. This hypothesis was also used to begin an inquiry to learn if students know what types of visual cues will help them. Students may prefer static or animated cues, but their preferences may not be in line with how well they actually perform when the preferred cues are used.

The findings for Hypothesis 4 showed that students who preferred animated visual cues, and received animated visual cues in their learning, had significantly higher task success rates than students who preferred static visual cues and received static visual cues. Table 3.8 indicates the numbers of students who preferred static or animated cues, and their success rates.

<table>
<thead>
<tr>
<th>Table</th>
<th>Pref. Static</th>
<th>Pref. Animtn</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>succeeded</td>
<td>2</td>
<td>18</td>
<td>20</td>
</tr>
<tr>
<td>failed</td>
<td>8</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td>TOTAL</td>
<td>10</td>
<td>26</td>
<td>36</td>
</tr>
</tbody>
</table>

Table 3.8: Frequencies for Student Preferences for Static or Animated Visual Cues and their Success Rates.

A formal statistical comparison between the success rates corresponding to animation and static when each subject used their preferred type of materials, yields an estimated difference of 0.4923, with a 95.00% confidence interval given by (0.1206, 0.7952), which means the difference is
statistically significant at the 0.05 significance level. The actual p-value based on an exact Binomial test is 0.0108. The analysis for the difference of two binomial proportions can be seen in Table 3.9.

Statistic based on the observed 2 by 2 table:
Binomial proportion for column <Pref. Static> : \( \pi_1 = 0.2000 \)
Binomial proportion for column <Pref. Animtn> : \( \pi_2 = 0.6923 \)
Difference of binomial proportions: \( \Delta = \pi_2 - \pi_1 = 0.4923 \)
Standardized diff. of binomial proportions: \( \Delta / \text{Stdev} = 3.165 \)

Results:

<table>
<thead>
<tr>
<th>Method</th>
<th>P-value(2-sided)</th>
<th>95.00% Conf. Interval of Delta</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exact Test</td>
<td>0.0108</td>
<td>(0.1206, 0.7952)</td>
</tr>
</tbody>
</table>

Table 3.9: The Difference of Two Binomial Proportions for Static and Animation Preferences

Consequently, the conclusion is that subjects preferring animated visual cues have higher successful task completion rates at a statistically significantly level than subjects preferring static visual cues, even when the preferred visual cues are used by all. The overall conclusions here can be summarized as follows:
1.) those who prefer animation do very badly (success rate 11.54%) when they are presented with static materials
2.) those who prefer static cues also do badly (success rate 20%), when they are presented with static materials
3.) those who prefer static actually do better (success rate 40%), when they are presented with animated materials
4.) those who prefer animation when presented with animated materials do best (success rate 69.23%), far better than under any other circumstances.

Hypothesis 4 is supported by the task success of students who preferred animation in their learning materials, as well as the lack of success of students who preferred static materials and then performed unsuccessfully.

Summary
The findings presented in Chapter III support Hypotheses 1, 2, 3 and 4. The findings for Hypothesis 1 showed that animated visual cues increased learning, as demonstrated by successful task completion rates. Animated cues in learning materials did have a significant positive effect on time reduction for completion of tasks, and Hypothesis 2 was supported. There was evidence that subjects preferred animated visual cues in their learning materials and found
them helpful, which supported Hypothesis 3. Hypothesis 4 was supported by the positive relationship between preferences for visual cues and task success rates.

Chapter IV will discuss the findings in relation to the use of animated visual cues and guidelines for the design of animation in learning materials.
CHAPTER 4
DISCUSSION

This study began with the assumption that animated visual cues, which provide additional stimuli, would be helpful to students in a software learning environment. The experiments tested whether students would learn more and perform better when animated cues were used to train them for use with an actual product. The data supported that students prefer animated visual cues because the cues helped retain their interest in the content and visualized the learning process.

This chapter provides a discussion on the major findings of the effectiveness of animated visual cues, the preferences of animation in learning programs, and the design of animated cues within the learning environment.
Effectiveness of Animated Visual Cues

Hypothesis 1

More learning will occur when animated visual cues are used in the computer learning environment as demonstrated by higher successful task completion rates by subjects viewing animated cues.

Subjects, regardless of task order, task difficulty, and comfort with computers performed better on the tasks that used animated visual cues, as opposed to static cues. A majority of positive responses to the inquiry of whether or not animated cues were helpful also supported the usefulness of animation. Students commented that the cues helped them visualize the task before they were asked to perform. Student comments were straightforward in their preferences for animated visual cues, and they found value in having cues incorporated into their learning program.

Of interest and importance was that the students knew what benefited them in their learning materials. This self-assessment of what was needed to learn may indicate that our students know which types of learning materials are effective for their type of learning. Students at the university level have insight into their preferred ways of learning. Students at a much younger level might not have the insight and self-assessment skills that the university students have and might
not know how they benefit the most from different styles of learning. It is recommended that students in K through 12 be offered content in various styles so they can start the self-assessment process for learning styles.

Although the students did not have the option of practicing the task before performing with the cell phone, the task visualization in the computer module helped them “mentally rehearse” the task through visualization. The steps for operating the phone and performing the tasks were carefully and visually constructed for the students with animation emphasizing which buttons needed pressing. Taking them through the process “virtually” was, in essence, training them before they had to perform.

Animation in learning materials is still new to students, although the use of animation is increasing in other areas such as film and video and the Web. Several students reported that visual cues helped them remain interested in the task they needed to learn. The bright red colors and moving numbers helped students keep their attention on the tasks. The additional stimuli provided by the animated cues was helpful to the students for this short-term memory task. Students were able to view the task and then perform the task immediately after viewing.

What is not known is whether or not animations would have helped students remember the task over the long term. To test for long term success of the animated cues, students
would need to be tested immediately after viewing the cues, as well as at later intervals, such as one week and two weeks after the time of the initial experiment. Different information designs using animation may assist with tasks needed for short term or long term memory.

Not all students successfully completed the tasks. Five of the thirty-six subjects indicated in their survey comments that animated visual cues were not effective and felt the animations were "distracting," "confusing," or "boring". Although these students expressed little support for animated cues, the majority of the students were able to successfully complete the tasks with animation added. It may be that learning preferences and successful task completion are not always related issues, and while students may not prefer animation, it may still assist them in learning.

**Hypothesis 2**

Animated visual cues within software learning materials will reduce subject times for completing a task compared to subjects using static visual cues.

The rationale for Hypothesis 2 was that those who had animated cues in their learning program would be able to perform the cell phone tasks faster because they were given more stimuli through visualization of the tasks. In the context of the model used for analysis, the effect of
animated visual cues was found to be significant in helping reduce the task times. The result from this experiment was that subjects were better able to learn with animated cues.

The design of the task, in relation to the animated parts of the training program, provided a "chunk" of information for the students to learn. The animated cues within the training modules were used to highlight important pieces of information related to task completion. The motion was used to capture the student's attention and reinforce parts of the module that were deemed important enough to be animated.

Other tasks that may benefit from animated cues and show a difference in performance times are those that require assembly, such as with children's toys or motor parts. These tasks could be scientific experiments or cooking procedures, which have longer time periods for completion than the operation of a cellular phone, and may show a greater indication of time saving with tasks.

**Hypothesis 3**

Subjects will prefer animated visual stimuli in their software learning environment as compared to static visual stimuli.

The majority of students supported this hypothesis through their comments on the value of the animated cues, their stated preference for animated cues and their
indication that animated cues were more helpful than the static cues. The students stated that the cues helped keep their interest. The moving red letters and buttons captured the student's visual attention and the cues kept bringing the students back to the task with every movement. Their attention was focused again and again on the movement of the items on the screen. Since the movement was continual with every new step of the task, they remained interested until the end of the task. This repetitive type of animation (movement for each part of the task) kept the students engaged. Any "down time" in the animation may allow the student's interests to wander and it might be harder to get their interest back, once the students have become disengaged from the task. Keeping the attention of the students is needed in order to have them process and evaluate the content. Animation can be used to keep drawing the student's attention back to the content to be learned.

Of the subjects commenting on the positive aspects of visual cues, most said that the cues helped them visualize the task. It is easier, in some cases, to have our tasks laid out before us and know exactly what is required of us. When students are in pressured situations, or when emotions play a force in the success or failure of a task, such as testing, pre-visualizing what is required will reduce anxiety and allow them to assess what they need to do to successfully complete the task. When tasks are presented with a situation
that creates pressure or uncomfortable emotional situations, animation may help students to relax and learn.

Another major benefit of animation in student learning materials is when the content is visually “explained” so that it becomes meaningful for them. Animation draws attention to the most important parts of what should be learned and emphasizes the content through the additional stimuli of movement color and form. Using motion to highlight the important parts of a piece of music to be performed can emphasize the difficult parts and assist in evaluation. The animated visuals take the content a step further so that the student can more readily understand what is being taught.

Students of today are accustomed to sophisticated visual imagery. Content is delivered in a multitude of formats, which are all increasing in technological sophistication, as well as media formats. Television, computer games, visually complex movies and interactive appliances are available to most students in the United States. Students have become accustomed to the World Wide Web and the rapid change that it represents. We may need to rely on animation to draw students in and to keep them interested in the content.

Two male students felt that the animations in the program were either too slow or boring. The design of the animations used in the program were purposely designed to be “simple” in nature, and not overwhelm students with too much visual stimuli or movement. These student comments provided
insight into the levels of movement, color and visual stimulation that are of acceptable levels for the students.

Variations of pacing may be needed for different students. Some tasks may be best shown at a very fast pace, so that students can quickly get an overview of the process, but then slowed down so that they can learn the process step by step. Animation for a chemistry project might first show an overview of the reaction of various chemicals and processes in an accelerated visual, but then show an animated breakdown of each of the steps required to produce the desired end result.

Just as we know the pacing for animated learning materials may need evaluation, so does the level of visual sophistication. Moviemakers who employ special effects firms know that a high level of visual sophistication is expected. This sophistication holds true for our learning materials. Quality learning materials will assist in engaging the students and imparting the content that needs to be learned. We need to reach the level of sophistication required to reach our audience: students prefer additional, meaningful stimuli in their learning materials. The level of sophistication of computer games is one for comparison for learning materials. This level of sophistication can be enhanced in multi-media learning applications, in which the content can be separately accessed in each media. Some
students may want to just listen to content, others may want to have the content visualized, and others may want a combination of voice and image.

Hypothesis 4

Subjects preferring animated visual cues will have higher successful task completion rates when the preferred visual cues are used.

This hypothesis begins to address user preferences in relation to performance. It is not known for certain that student preferences are an indication of how well they will do with a particular learning style, but the students who preferred animated cues had a higher success rate than those who preferred static cues. This hypothesis was supported by the high task success rate of students who preferred animated visual cues.

Students who did not prefer animated cues but had animated cues in their task, also did well in their learning. It was the students who did not prefer animated cues, and did not receive animated cues, who had the least successful rate of task completion. It may be that the cell phone tasks were well suited to animated cues.

Content may need to be treated in a particular way, regardless of student preferences. The task of memorization of poetry might be simply read aloud or combined with imagery
and words. These are options for the information designer, but further testing of a wide variety of problems and audiences is needed.

Experimental Design Issues

The design of this experiment dealt with several issues such as task order and difficulty and student comfort with computers. The testing of animated stimuli in conjunction with the use of an actual product was new, and several factors needed to be carefully considered.

Task Order and Difficulty

Issues related to task choice were: number of steps required, complexity of tasks, subject familiarity with tasks and the appropriateness for incorporating the content into a computer program module. Although much thought went into the choice of tasks for subjects to perform, "changing a number in cell phone memory" was easier than "changing the electronic lock code." And even though both functions were explained to the students before they completed the tasks, the "cell phone memory" task may have been easier for the students because the concept, perhaps, is better understood than that of changing an electronic lock code on the phone.
Student Comfort With Computer Use

The majority of the students recorded they were above average in their level of comfort with computer use. The students did not record or express negative feelings in relation to computer use, which might have affected how they felt about using the computer to learn tasks. The students high levels of comfort with computer use did not statistically affect the significance of the task success rate for animated computer programs, but even higher scores might have had a confounding effect.

Future experiments may need to pre-screen subjects to find those students who are at mid-range comfort level with computers. Students who are not entirely comfortable with computing may dislike an abundance of animation and interactivity with the computer, which could impact scores. Students who are required to take computerized tests and are uncomfortable with computers may find their scores are lower due to their emotions regarding the testing format. Subjects who are not accustomed to computers may require lower levels of animation and interactivity within software programs. Conversely, those students who are very adept at computing could handle higher levels of animation and interactivity within learning materials.
Productivity and Environmental Preferences Survey

The PEP survey was used in this experiment to assess the learning preferences of the students who would complete the tasks. The auditory, kinesthetic, and visual preference averages for the students were at mid-range. This meant that the students who performed the tasks did not have uncommonly high or low preferences for auditory, kinesthetic, or visual learning. The student motivation scores were also at mid-range, indicating that the sample was not requiring extreme amounts of attention or inattention in order to learn the tasks. Had the students all scored highly on the motivation, they might have preferred to study the cell phone information on their own at varying times, and then demonstrate that they knew the material, as opposed to viewing a prepared computer program. Average motivation scores also mean that the tasks prepared for learning should be short, structured tasks. The computer modules fit the motivational levels of the students. Had the students scored low on motivation, the program could have implemented a drill and practice session in the program.

Affect of Animated Visual Cues Within

The Learning Environment

The affect, or feelings stirred by the use of animated imagery, was evident in the comments made by the subjects on their surveys. The students had a strong preference for
animated cues, believing that cues helped them visualize a process and keep them on track. One student said that although she had focused on the words, she could see how “visual learners” might prefer the animated cues.

The animation presented in the learning modules was of a low level (straight line movement, simple images). Had the screens been designed in a more visually enhanced way, the satisfaction levels would have probably increased due to something that seemed “better” and of higher quality. The screens for the experiment could have included animation in the title, a character could have pointed at areas of the screen. A color “wipe” could have appeared before the main image of the cell phone appeared and color cycling could have occurred throughout the text. But more movement is not always better, and the combination of the added animation might have distracted from the task of learning the steps to operate the cell phone. An increase in the color, shapes and movements on the screen might have seemed more important because more was going on, but it could also be overwhelming or unnecessary in a learning environment. The amount of animation needed for different learning situations requires further testing.

Not all students preferred animated cues and responded by saying they felt “confused”, “distracted”, and “bored” by the animations used in the learning materials. The students who were confused and distracted by the animations would
require even lower levels of motion, slower motion or no motion, to satisfy their preferences for visuals in learning materials. They should be given a choice in an interactive learning program to have text available to them instead of imagery. The student who was bored might benefit from an abundance of multi-media opportunities in his learning programs, helping him learn in different formats. Animation in content must affect the learner in a positive, meaningful way. Animation, just for the sake of motion, may at first attract the student's attention, but if the motion is not attached to a meaning, the student may become confused and frustrated.

Animation influences our emotions. We respond to movement. This premise is carried out continually in the animated feature movies available to us today. Animation is meant to inspire, astound, and engage the viewer. Our learning materials can benefit from this same practice. When our emotions are involved, our awareness may be heightened, and more learning may occur.

Diverse learning situations

Although the use of animated visual cues was supported at a statistically significant level, the individual responses to questions indicated that not everyone preferred animated visual cues. The responses to the PEP Survey, which
indicates the preferences for learning materials, did not indicate a strong response for any particular learning style preference. Had there been an overwhelming number of subjects scoring highly in the visual or kinesthetic category, we might have expected to see a higher demand for more imagery (visual) and more “hands on” activities.

Many preferred the animated visual cues and even requested more, better and faster animations. Others, however, would find this learning environment uncomfortable and should not be forced to use materials that are a hindrance. Materials must provide a variety of stimuli, prepared in a way that complements, integrates, and adapts stimuli and the content of what is to be studied.

It is recommended that content be provided in a variety of ways, so that the learner can choose the way she or he would like the information presented. Students entering a learning environment must first be made aware that they have options in viewing the material in various multi-media formats. They should be allowed to easily choose any or all media environments, experimenting with whatever seems the most helpful. Students should also be provided with a way to evaluate what they have learned to make sure they grasped the content.

If a student is learning geology, he or she might want to first read about changes in the earth’s crust and then see an animated recreation of the formation of the different
layers, complete with dramatic sound effects. A student learning astronomy might have fun manipulating the paths of the planets and seeing what happens as a result. He or she may then want to look up a particular myth that is related to the planets and constellations. Animation and interactivity may have an added benefit that provides learners with some control over how they are taught. The main point is that content should be presented in a multi-sensory way and designed to incite interest in the learner through the use of meaningful delivery.

The Design of Animation in Content

The design of animation in content is a relatively new practice that requires thoughtfulness, planning, visualization skills, and knowledge of technologies.

The Visual Design of the Stimulus Materials

The computer software program modules used for my experiment were presented in a visually straightforward manner, with no extra design elements or overly sophisticated visual treatments. The modules were designed to communicate what was needed to complete the tasks and not impart any "extra" communication through the use of visual elements. The task text directions, an image of the cell phone, and moving numbers and buttons were presented on a plain colored background in the learning modules prepared for the students.
Overly designed computer screens that contained visual noise might have distracted the students and resulted in confounding the study. An example of an overly designed screen might have included more images, flashing text and titles, a wide array of colors and an exorbitant amount of movement of the different elements. What would occur, in this case, is a distraction from one visual element to the next. The eyes would be unable to focus quickly on each element, which could block or lessen the impact of the visual stimuli that need to be perceived for learning. The screen would be visually overwhelming, with the eye not resting long enough to take in the message.

Overly designed messages may communicate more than the content of the subject matter. The visuals may communicate haphazardness and provide an overall negative feeling toward the piece to be learned. If the visual is overwhelming, or a clear message is not presented, the communication may be perceived as visually dissonant (not visually cohesive and causing confusion), and it will not be perceived in the way it was intended. The viewer may become disengaged with the message presented.

If a piece is designed with many visual elements incorporated into the message, the experiment would require testing on the "comfort level" of design to discern if the number of elements within the communication has a positive or negative impact on the subjects' learning. As a result of
the possible complications of adding more imagery and movement to the computer screens for this experiment, the animations were kept to a minimum.

Guidelines for Use of Animation Revisited

A synthesis of research from the various disciplines, expert evaluation and design practice, as well as the results of this experiment, allowed the formation of guidelines for the use of animation within training and learning materials. Training for a specific task may require different types of animations, such as short visual cues, whereas learning complex concepts may require more in-depth animated visuals. The decision to animate or not to animate a visual element within a software program can be discerned through practice, feedback and systematic inquiry, and familiarity with the types of content that will be animated.

Uses of animation, visual treatment, and the evaluation of animation must be considered together. The use and design of animation in learning materials may not be a linear process, but a circular and synthesized process. A decision may be made to animate an image because it seemingly will enhance the content to be studied, but unless the treatment is correct, it will be a hindrance to learning.
Guidelines for use

The list of the potential benefits of animated imagery in learning materials is presented below:

1. Capturing the student’s attention.
   An appealing opening animated sequence of images will capture the student’s attention long enough to engage him or her in the content matter to be presented. Within a learning program, an animated visual cue can be used to recapture a student’s attention. A small child may watch a butterfly animate across the screen and land on a word that he or she is to learn.

2. Adding meaning to the content.
   Animation can be used to highlight content that needs explanation. Math formulas can “come alive” when the formulas are illustrated in conjunction with imagery.

3. Inciting emotion.
   Motion can induce excitement and amazement with subject matter if the animations are of quality and used appropriately. Getting the rules right for a sports game might be punctuated with an animated cheering section.

4. Guiding the student through navigation paths.
   A student might benefit from being led to important pieces of information. The English student might enjoy having an animated flashlight move him or her
through the murky computer screens of a mystery story.

5. Providing practice for the student.
Some tasks benefit from practice and drill techniques. Students in lifesaving classes might want to practice steps on a computer "dummy" before moving to the real thing.

6. Visualizing an idea or steps in action.
Students may benefit from seeing an entire task completed and then returning to more detailed steps. A computer program might show how a computer is assembled, and then have separate modules with more detailed, animated information on the computer components.

7. Providing feedback to the student.
Animation could help the student know where something is appropriate and where it is not. Medical students could perform a virtual surgery and have vital signs of the patient available in "real time," indicating when the patient is in "danger."

8. Providing physical involvement and interaction with the student.
Some students might stay involved in the content if they are required to perform functions in the program. Rather than passively watch how a garden
would grow, young students might be asked to “plant” the seeds and cover them up, giving them a feeling of helping with a project.

After several evaluations of animation within the learning environment, the designer will become more aware of the best practices for incorporating animation in learning content. When evaluating animation, we need to ask designers, teachers, students and communicators to offer their expertise and opinions. Animation can be costly and time consuming, so planning needs to occur through storyboards and informal meetings with students. A prototype should be used to help evaluate the effectiveness of the animation.

Deciding whether content should be animated is only part of the process. The design of the animated visuals is just as important and requires expertise that is acquired through experience.

**Guidelines for the Visual Design of Animated Cues Revisited**

The guidelines of appropriate use for animation, revisited from the literature review in Chapter 1, are presented below:
1. Examine the relationship of content to animation. Ask if the content would benefit from being animated. Is the communication of a visual imparting more information through motion?

2. Examine the appropriateness of motion in relation to individual learning preferences. How could the animation be presented to engage the most learners in the most appropriate way? Is only part of something animated or all of it?

3. Create a hierarchy of motion. Show the most important piece of motion first, visually treating it to be the first piece of stimulus that the eye sees. The contents of the program should be arranged from the most important piece of information to the least important, and visually treated according to this hierarchy.

4. Consider motion throughout the entire layout. Assess the quantity and quality of animation and motion throughout the overall composition of text and image. Still images need to be assessed along with the animated imagery.

5. Use motion and animation for contrast. Motion and animated elements can help to clearly distinguish visual elements and text from one another. The contrast in elements will aid in legibility of imagery and clarity of importance in content.
6. Use motion to group elements. Animated images moving together, in the same direction, help to “chunk” the information to make it more easily understood. Grouping can also enhance the relationships among other visual elements on the computer screen by indicating which content is related.

7. Make the motion “legible.” The motion of the element should appear to be clear and not leave the viewer wondering what the motion is supposed to “represent.” In addition, elements in motion (unless unwanted) should maintain a visual sense of definition and clarity to be more easily grasped by the viewer.

8. Use pacing wisely. This refers to the speed of animated objects within the learning program. Evaluations of elements should occur to determine if they are moving too quickly or too slowly. Proper animated rates need to be tested on an audience. In addition, if too many elements are moving, and at differing speeds and directions, it may introduce a visual dissonance (uncomfortable or incongruous visual experience) for the viewer.

9. Consider the direction of the motion. The elements in motion should move in a way that keeps the viewer’s eyes on the screen. Motions that move the eye away from the screen may distract the viewer from the content.
10. Consider the overall communication of motion. This refers to the overall visual treatment of the content in relation to learning. Does the motion communicate something that it should not? Is an erratic blinking object gaining attention or annoying the viewer? Does it seem to hurry the learner, when in fact the learner should stay at a screen and practice a skill? Does the motion engage the viewer or put them off in some way? The overall communication of the motion of the piece can also indicate whether the piece is sophisticated or not. The overall motion needs to communicate a particular “feeling” to the viewer.

The above-mentioned guidelines are recommendations for the visual design of motion and animation within the learning environment. As with guidelines, they should serve as a framework for evaluation.

The Design of a Training Module

The design of a training module should first be evaluated for the most important pieces of information or concepts that need to reach the student, as well as the overall goals of the training module. It is the most important areas of content that first need to be considered for animation. A hierarchy of items for motion should ensue,
according to importance and the value that animation can play in imparting information.

After the hierarchy decisions are made, the general look and layout for the content and motion need to be addressed as an overall communication issue. As the pieces are designed and assembled, a prototype should be tested with students, and then evaluated for communication of content and pacing of elements. Each individual element that is animated needs to be evaluated for contribution, legibility, direction and emotion.

Visual cues might be needed to draw further attention to visual elements and navigation paths. After a more refined prototype is completed, it should be evaluated again to make sure it is not visually overwhelming, but is still capturing student’s attention and communicating important concepts.

It may be important to offer traditional text, with no visual embellishments, in all of the training programs for purposes of printing and reference. Each training piece should also give the student the option of accessing information in as many ways as possible. The physical environment should be conducive to the use of multi-media training modules.
Summary

The support for animated visual cues in learning materials was supported through the performance and preferences of the subjects. The use of animation in learning experiences of all types needs to be evaluated in several ways to be sure we are providing meaningful content in ways that are useful to students. New uses and guidelines for animated imagery in learning materials were presented, along with the recommendation of student and expert evaluations throughout the process.
CHAPTER 5
SUMMARY AND CONCLUSION

This study examined the use of animated visual cues within the software learning environment. This study specifically addressed the effectiveness of animation for learning tasks, and assessed user preferences for animation within learning environments.

The following sections of this chapter will cover a recapitulation of the major findings and limitations of this study, as well as recommended directions for future research.

Recapitulations of Major Findings

This study used four hypotheses that provided the basis for inquiry into animation. The materials were designed, produced and placed in software modules for use by the students. The study used four computer modules with variations of animated and static cell phone tasks. Each subject was shown two tasks, one animated and one static, and was then asked to perform the tasks with the actual cell phone. The findings of this study supported all of the hypotheses presented. The students who participated in the
study had no extreme preferences for specific learning styles, but were above average in their comfort with computer use.

Hypothesis 1 stated that animated visual cues in the software learning environment would be more effective than static. Students who viewed the animated cues had a greater success rate with cell phone tasks than the subjects who viewed static visual materials. Greater learning occurred through the use of animated visual cues that emphasized important information through movement for completion of the tasks. The steps of the task and the numbers needed to operate the cell phone were highlighted through animation.

Hypothesis 2 stated that subjects who viewed animated visual cues would have shorter task completion times when performing the task with a real cell phone. Hypothesis 2 was supported as the study results indicated there was a difference in successful task completion times for animated and static tasks.

Hypothesis 3 stated that users preferred the use of animated visual cues within their software learning environment. This hypothesis was supported by the majority of subjects who indicated animated cues helped them to visualize and remember tasks, as well as hold their interest in the content. Five of the thirty-six students wanted more,
faster and better animations in the software modules, even though the learning materials were purposely designed to reflect average designs.

Hypothesis 4 stated that users who preferred animated visual cues would perform better when they were presented with their preferred cues. This hypothesis was supported by the higher task success rate of those who preferred animated cues. The subjects who preferred static cues did not perform as well with static task materials, even though they preferred them.

Although there was support for animated visual cues within a software learning environment, not all students preferred animations to help them learn. Learning materials should be offered in several formats in order to accommodate the various types of learners.

Limitations of This Study

Although this study was carefully planned, there are several issues that are considered limitations of this study. The sample makeup, task difficulty and learning preferences all have issues worth noting in relation to generalizations and experiment repetitions.

The student subjects used for this study consisted of university students who were comfortable with computers. The average (self-reported) comfort with computers was 3.75 on a scale of 1 (not comfortable) to 5 (comfortable). As it
occurred, the design and delivery of the learning materials seemed well matched to the type of sample used for the study in relation to comfort with computers.

Since the sample is not representative of the greater population, the generalizability of the study is restricted. Cell phones are used by the young and old, the intelligent and the mentally challenged, and by people from all cultures. We cannot say that these students, and their learning outcomes, were represented in this study.

Another limitation of this study may be the choice of tasks and the order in which the tasks were presented. One task was easier than the other, although this was not determined until after the study was complete. Future experiments with tasks should be designed to account for differences in difficulty.

Another limitation of this study may be that the subjects were asked to perform the task after they had viewed the modules rather than asked to perform or practice the task while viewing the modules. Although, performing the task after viewing the modules was a more stringent test of the learning that occurred, some students need to perform the task to learn it more effectively. A different type of study would be needed to properly assess that style of learning environment. The learning materials were taken directly from
the Motorola manual, which were designed for use with the cell phone. The materials were then broken into steps easy to memorize.

The learning style preferences survey used for this project was one of the only surveys found on the market suitable for this study. It is standardized, addresses the issues such as visual preferences, and is prepared for adults and college students. The scores were self reported preferences, however, and may or may not indicate how the students actually learn the best. Learning style preferences are not always an indication for how students learn and respond to visual information.

Direction for Future Research

The directions for future research can be focused in several areas. Levels of acceptable animation, new areas of testing and evaluation, and retention studies and learning styles, are needed to expand our understanding of the effectiveness of animation in learning materials.

The use of animation within learning environments will require new ways of testing the effectiveness of animation and new ways of evaluating the affect that animation communicates through computing. The use of a variety of studies, combining quantitative and qualitative measures may be needed to evaluate the use of animation in a more robust
way. We want to find what will help students perform better, as well as what will motivate them in a learning environment.

Several types of retention studies would be useful to assess the effects of animation on short term and long term retention. If a task is more easily learned and remembered with animation, it may be that it will be retained for a longer period of time due to the dual coding and enhanced retrieving that visual stimuli can provide. Specific types of learning may be enhanced with animation for long-term memory, while others may not.

Additional study is needed in relation to animation and improved ways of determining learning styles. This study assessed the effectiveness of animated cues and learning preferences to ascertain if there was a majority of learners who preferred a particular learning style. But asking students for their preferences is not the same as testing for their strengths and weaknesses with particular learning styles. Students may prefer visual stimuli, but find they need auditory and kinesthetic stimuli to truly learn a task. A larger, longer study might include testing students of a particular age for learning styles, and then designing various tasks with differing learning styles for their use in their studies.

Students may not know what makes them learn more efficiently. They may believe they need to physically perform a task (kinesthetic) but find in practice that they
need to listen to directions first. Frustration levels in learning may be eased, just by delivering information in different ways.

The effect and affect of animations may vary with age. What is appealing to children in animation may not be appealing to adults. Brightly colored, quick and haphazard movements may be appropriate for children (as are animated cartoons), but they may not be attractive to adults in learning situations, who may prefer more subtle coloring and sophisticated, detailed imagery.

The use of three-dimensional animations may not be needed in particular areas of learning where two-dimensional animations may suffice. The use of three-dimensional animations may be required to communicate particular pieces of information and may impart more three-dimensional knowledge in a learning situation. The use of three-dimensional animations is more costly, in most cases, than two-dimensional animation, because of the production methods.

Comfort levels with animation may also vary from person to person. If the image is appealing to learners, it will draw them into the content. If the image is unappealing, it may repel the interest levels of the learners. Evaluations of comfort levels with pacing and amounts of animation need to be addressed. A simple animation in learning materials may be quite enough for someone who is trying to grasp the information, whereas another learner may feel that there is
not enough to capture his or her interest. What is the appropriate amount of animation within a learning program? When is it too much or too little, and what are the guidelines for each?

Additional research is needed in relation to appropriate speeds for animation. What is considered fast or slow for animated imagery in a learning environment? This situation is similar to assessing rides in an amusement park and deciding whether a particular ride is too fast for an individual’s comfort or too slow to be considered fun.

Very little research has been conducted on animation combined with additional types of stimuli. Animation used with sound has not been fully assessed for effectiveness. Do we really know if sound and animation complement each other, and when does that become apparent? The appropriateness of additional stimuli and the choices of stimuli to enhance content is often difficult to discern, because the methods are still new to our list of tools that aid learning.

The study of the effect of animation on emotions in learning has not been extensive. Can animation help to intensify emotions that will assist learners? Can students be influenced by imagery that produces emotion that keeps them enthralled in the message or the content for the period of time needed to learn?

In addition to the above-mentioned issues related to the further study of animation within the learning environment
are the cultural aspects of motion. Are the effects of our culture evident in the way animation is used? Is there a difference in how animation may be used from culture to culture? Are there preferences we are not aware of? Aside from the visual representational aspects, is the communication of motion universal to all cultures? Little research has been conducted in this area.

The study of animation within learning environments is new and much research needs to be conducted for us to understand the benefits of motion within content. This research is needed so we can be assured of the benefits of animation, before going to the time and expense of creating the visuals. It is through years of research and practice on animation in the learning environment that accepted and appropriate uses of animation will become apparent.

Conclusions

The findings of this study showed support for the effectiveness of animated visual cues within the learning environment and the enhancements they can bring to learning materials. When used properly, animation can assist learners in visualizing tasks and can keep them interested in the content. In this study, animation helped decrease time performing tasks and enhanced the students' learning experience.
Limitations of the study included a restriction in the generalizability of the study to the larger population, as well as an indication that the subjects were above average in their comfort with computer use, which the general population may not be at this point in time.

Recommendations for future research included the further study of the effectiveness of animation in learning materials on retention, as well as the emotion induced by animated imagery and its affect on retention of content.
Appendix A

Storing, Recalling and Changing Phone Numbers
You will be viewing a presentation on cellular telephone functions. Please view each screen carefully. Press the "Next" button to move to the next segment. Keep moving forward until you reach the screen that says "The End."
Storing, Recalling and Changing Phone Numbers in Cell Phone Memory

The cell phone provides memory for frequently called or important phone numbers. Each number is stored at a two-digit "location" in the memory area such as 01, 02 or 03. The Motorola cell phone will store up to 16 phone numbers. Numbers in memory locations may be changed according to need and amount of use.

You will now watch a presentation describing how to store, recall and change a number in the cell phone memory. Press "Next" when you are ready to start.
Storing, Recalling and Changing Phone Numbers in Cell Phone Memory Location

Storing Numbers in a Memory Location

1. Turn the phone on by pressing 📞.
2. Enter a phone number.
   Use 1(614)292-6836 for this exercise.
3. Press 📞.
4. Enter a two-digit location number (01, 02, etc.)
   Use 07 for this exercise. You must enter the location number within 8 seconds of pressing 📞 or the operation will cancel.

Press button when you are ready to proceed
Storing, Recalling and Changing Phone Numbers in Cell Phone Memory Location

Recalling a Phone Number from Memory

1. Press 📞.
2. Enter the two-digit memory location number.
   Use 05 for this exercise.
3. Press 📞 again to review the complete number.

Press button when you are ready to proceed
Storing, Recalling and Changing Phone Numbers in Cell Phone Memory Location

Changing a Phone Number in Memory

1. Press $ and the two-digit number to display the number to be changed. Use 07 for this exercise.
2. Press and release $ to back out each of the digits displayed.
3. Enter the new number. Use 1(614)451-6203 for this exercise.
4. Press $ and the two-digit location number. Use 07 for this exercise.

Press button when you are ready to proceed
Locking, Unlocking and Changing the Lock Code on Your Cell Phone

Lock codes prevent unauthorized use of the cell phone. When the phone is locked, all incoming and outgoing calls are disabled. Lock codes should be changed from time to time for security purposes.

You will now watch a presentation describing how to place and change an electronic lock on the cell phone. Press "Next" when you are ready to start.
Locking, Unlocking and Changing the Lock Code on Your Cell Phone

Placing an Electronic Lock

1. Turn the phone on by pressing ON.
2. Press FCN.
3. Then press and hold 5.
   The phone will display LOC ?
4. Press STD to lock the phone.
   The phone will display Lock'd and the green indicator will light steadily.

To Unlock

1. Enter your three-digit unlock code.
   Use 123 for this exercise.

   Press button when you are ready to proceed
Locking, Unlocking and Changing the Lock Code on Your Cell Phone

To Change an Unlock Code

1. Press 2.
2. Enter your six-digit security code.
   Use 123456 for this exercise. The security code is not displayed.
3. Enter the new three-digit unlock code.
   Use 456 for this exercise.
4. Press button when you are ready to proceed.
The End

Thank you for viewing the presentation. You will now be asked to perform two tasks and complete a questionnaire.
Appendix C

Pre-Screen Interview
Pre-Screen Questionnaire

Name

1. Have you worked in the field of telecommunication? Y N
   If yes, for which company?

2. Have you used a cellular telephone before? Y N

3. Which functions on the cellular phone have you used?

4. How long have you used a cellular phone?
Appendix D

Demographics Questions
Demographics Questions

Name__________________________________________

1. Age: ________

2. Sex: M F

3. In which college are you enrolled at OSU?____________

4. What is your grade point average (GPA) ________

5. Please circle your grade level:
   Freshman  Sophomore  Junior  Senior

6. Comfort with computer use:
   1=uncomfortable,  5=comfortable
   1  2  3  4  5
Appendix E

Motorola Cellular Phone Functions
Motorola Cellular Phone Functions

1. Placing a call
2. Correcting an error
3. Recalling a number longer than 7 digits
4. Automatic redialing
5. Receiving a call
6. Absence indicator
7. Changing the code
8. Displaying the battery voltage meter
9. Adjusting the earpiece volume
10. Adjusting the ringer volume
11. Muting the microphone
12. Displaying own phone number
13. Switching to a second phone
14. Storing numbers to a memory location
15. Changing entry in memory location
16. Recalling number from memory
17. Scrolling in memory
18. Recalling a prefix
19. Emergency dialing
20. Speed dialing
21. Scratch pad memory
22. Tone dialing
23. Memory linking
24. Pin code activation
25. Disable audio notification
26. Call timer
27. Call timer (set, reset, cumulative)
28. Electronic lock
29. Display lock code
30. Change lock code
31. Outgoing call restrictions
Appendix F

Task Success and Time Record Sheet
Task Success and Time Record Sheet

Name________________________

Program # 1 2 3 4

Success/Failure:

Task 1

(Circle one)

A (animated)

NA (not animated)

Task 2

(Circle one)

NA (not animated)

A (animated)

Task times:

Task 1

Start time: ____________________________

End time: ____________________________

Task 2

Start time: ____________________________

End time: ____________________________
Appendix G

Preference questions
Preference questions

Did you prefer the animated visual cues or static computer screens?

Please circle: Animated  Static

Did the animated cues help you to remember the tasks?

Please circle: Yes  No

What did you think of the animated visual cues?
Appendix H

Productivity Environmental Preferences Survey Areas
Productivity Environmental Preferences Survey Areas

1. Sound
2. Light
3. Warmth
4. Formal/Informal Room Design
5. Motivated/Unmotivated
6. Persistence
7. Responsible
8. Structure
9. Learning alone/Peer-oriented
10. Authority-oriented learner
11. Several ways of interacting
12. Auditory preferences
13. Visual preferences
14. Tactile preferences
15. Kinesthetic preferences
16. Requires intake
17. Evening/morning
18. Late morning
19. Afternoon
20. Needs mobility
References


