

The Effects of Still Images and Animated Images on
Motion-Related and Non-Motion Related Learning Tasks in
College Students of Different Levels of Field Dependence

Huaiying Gao

Dissertation submitted to the faculty of the
Virginia Polytechnic Institute and State University
in partial fulfillment of the requirements for the degree of
Doctor of Philosophy
in Curriculum and Instruction

Dr. John Burton, Chair
Dr. Mike Moore
Dr. Barbara Lockee
Dr. Ken Potter
Dr. Peter Doolittle

April 18, 2005
Blacksburg, Virginia

Keywords: still images, animated images, Chinese characters, motion-related learning tasks, non-motion related learning tasks, cognitive style

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ABSTRACT

The use of still images in instruction has a long history in the field of education. With the widespread use of microcomputers and the development of graphic software, the ability to create and use animated images has greatly increased; today many people use animated images in their teaching and training activities. Since the use of different types of images in instruction has various influences on students' learning results, the different effects between animated images and still images have been studied widely among researchers. However, the research results are not consistent. Some research results show that animated images are more effective than still images and some show no difference or less effective results.

This experimental study explores the effects of animated images and still images on college students' learning of motion-related tasks and non-motion related tasks, with the students possessing different levels of field dependence-independence. This study found that:

For learning tasks involving motion and/or change, animated images were more effective than still images for college students, and field dependent students benefited more from animated images than did the field independent students. However, for learning tasks that did not involve motion or change, there was no difference in learning results from the use of still images as opposed to animated images. In addition, for such learning tasks, there was no difference in the learning benefits of still images to field dependent versus field independent learners.

Acknowledgments

I had no way to come so far on my academic journey if were not for many people's support and help!

I want to show my greatest appreciation to Dr. John Burton, my advisor and committee chair. Besides everything else, he is the strongest backup that I know I can count on. Whenever I approached him with questions, I would come back with answers and encouragement. No matter how exhausted and desperate I might be, his support would always help me out. His generosity and understanding never let me down. He treats me not just as a student, but also as a whole person.

I also want to extend my thanks to the members of my committee: Dr. Mike Moore, Dr. Barbara Lockee, Dr. Kenneth Potter, and Dr. Peter Doolittle. Dr. Mike Moore helped me a lot with the data analysis and showed a surprising amount of patience with my detailed, sometimes even trivial questions. Dr. Barbara Lockee helped with the preparation of various exam documents. Dr. Kenneth Potter was the person who opened the door for me when I visited the center at the first time. His door never closed since then. Dr. Peter Doolittle gave me enormous help with the Cognitive Load Theory for the literature review. Dr. Cecile Cachaper is not on my committee. However, she helped me very much with the data analysis. Time may pass, but my appreciation never fades.

I am also grateful for the help from the professors and instructors who offered generous help for the data collection. Without their support, this study would not have gotten enough data. These people are: Ms. Aileen Murphy, Dr. Bruce Watson, Dr. Carol Burch-Brown, Dr. Chris North, Dr. Ed Dorsa, Dr. Jim Dubinsky, Dr. Steve Harrison, Dr. Mark Benson, Ms. Mary Verdu, Dr. Paul Heilker, Dr. Peter Schmitthenner, Dr. Scott Chandler, Dr. Scott McCrickard, Dr. Shannon Jarrott, Dr. Steve Harrison, Mr. Steve Kark, Mr. Stuart Feigenbaum, Ms. Tiffany Trent and Dr. Yonsenia White.

My thanks also go to my fellow colleagues and my friends. They helped me during different phases and on various aspects. Dr. Phyllis Newbill, Dr. Miriam Larson, Dr. Ross Perkins and Mr. Jay Swain spent tremendous time editing and proofreading my documents. Dr. Miriam Larson, Mr. Jay Swain and Mr. Terry Burcin helped me with the pilot study and contributed valuable input. Dr. Qi Liu helped to develop part of the instructional instrument using java script and offered great support whenever needed.

I cannot forget the help I got from other members in the college. They are Dr. Glen Homes, Dr. Jennifer Brill, Dr. Kathy Cennamo, Dr. Ireta Ekstrom, Dr. Jamie Little, Ms. Bonnie Guthrie, Ms. Terry Davis, Ms. Lori Harris, Ms. Beth Lawton, and Ms. Emily Bishop.

Finally, it is my family that ever initiated my journey to a higher education and continuously fuels the trip. There is a Chinese proverb: One is wordless when touched by the deepest motion in the most inner part of the heart. I am experiencing the state described in this proverb right now.

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Chapter 1: Introduction

Research on the use of graphic illustrations in instruction has a long history in the field of education. It is believed that to some extent, pictures can motivate learners and improve learning effects as long as they do not interfere with the instructional content. For example, in a meta-analysis of pictures in prose studies, Levin, Anglin, and Carney (1987) delineated five distinct functions of pictures: decoration, representation, organization, interpretation and illustration. These researchers concluded that when used correctly, pictures could greatly facilitate students' learning. Duchastel (1978) believed pictures had three functions in instruction: attentional role, retentional role, and explicative role. Levie and Lentz (1982) suggested four functions of pictorial illustration: attentional, affective, cognitive, and compensatory. Levin (1981) identified five functions: decoration, representation, organization, interpretive, and transformation.

With the spread of microcomputers and the development of graphics software, the ability to create and use pictures in instruction has greatly increased. Some researchers go beyond the use of still images and look at the effects of animated images on people's learning. For example, Rieber (1990a) suggested that "generally, animation has been used in instruction to fulfill or assist one of three functions: attention-gaining, presentation, and practice" (p. 77). Park and Hopkins (1993) identified five important instructional roles of animated images: attention gaining, illustration, representation, an aid to form mental images, and an aid to facilitate learners' understanding of abstract concepts. Baecker and Small (1990) introduced eight situations when animation was needed: identification, transition, choice, demonstration, explanation, feedback, history, and guidance. Bartram (2001) proposed eight functions that animation could offer: awareness,

transition, functional description, emphasis, expression, representation of change, direct visualization and association.

It has been proposed that animated demonstration will add motivational and realism value and provide some beneficial functions to the instruction. However, until now there has been no robust theoretical or empirical evidence to support it. Considering the current enthusiastic application and relatively high cost of developing animated images in instruction, such theory and research is especially needed. Many researchers try to study whether there is a significant increase in learning when using animated images in instruction and if there is an increase, then under what conditions this increase happens.

The purpose of this experimental study is to determine the effects of animated images and still images on college students' learning of motion-related tasks and non-motion related tasks, with the students possessing different levels of field dependence-independence. The study is conducted on the basis of information processing theory (McCown, Driscoll & Roop, 1996), cognitive load theory (Sweller, 1994; Mayer, 2001), Paivio's dual coding theory (Paivio, 1979), learning task classification (Bloom, 1956; Gagné, 1991) and the previous studies concerning the effects of still images and animated images on students' learning, such as Rieber's and Dwyer's work.

In this study, the animated images refer to the pictorial information that demonstrates an object's spatial movement and the change in shape, color or size over time, thus presenting the illusion of motion, trajectory or transformation. The still images refer to the pictorial information that statically represents the objects, concepts or processes with some degree of physical resemblance. The still images in this study do not include charts, table and other arbitrary graphics.

Motion-related learning tasks refer to the learning tasks that involve movement, trajectory, or transformation over time or space, which is similar to the psychomotor domain classified in Bloom's (1956) taxonomy and the motor skill in Gagné's (1991) category. Non-motion learning task refer to the learning tasks that do not involve noticeable movement, transformation or trajectory over time or space, which is similar to the cognitive domain classified in Bloom's (1956) taxonomy and the verbal, intellectual and cognitive skills mentioned by Gagné (1991).

Experimental research should be based on relevant theories. The theories could offer researchers legitimate independent variables to study on and direct the development of the research. There has been quite an amount of research done on still images and animated images, however, the results are conflicting. When analyzing the reasons that why some studies on still images and animated images generate significant difference while others do not, Park and Hopkins (1993) pointed out that:

Probably the most profound discrepancy separating the research is theoretical in nature. One important difference between studies which found significant effects of DVDs [dynamic visual display] and studies which found no such effects is that the former were guided by theoretical rationales which derived the appropriate uses for dynamic and static features of visual displays and their presumed effect. Accordingly, learner variables, the learning requirements in the task, and/or the medium characteristics were appropriately coordinated in most of the studies that found significant effects. (pp. 439-440)

To determine the effects of still images and animated images on college students' learning of different instructional content, one not only needs to develop a set of valid

instrument, but also needs to look through the relevant theories and previous studies first, then decide what factors he or she needs to take into account to lay a good foundation for the study.

Chapter 2: Review of Literature

Information Processing Theory

Information processing theory conceives the human memory working much like the way a computer processor does. It “focuses on how the human memory system acquires, transforms, compacts, elaborates, encodes, retrieves, and uses information” (Moore, Burton, & Myers, 1996, p. 852). The external information is registered by the sensory memory, and then was verbally and/or visually coded into the temporary working memory – short-term memory, and via rehearsal and recoding, the information is stored in the long-term memory, where one retrieves the information when it is needed (Atkinson & Shiffrin, 1968; McCown, Driscoll, & Roop, 1996).

The information process begins with the registration of external stimuli to one’s processing system. At any moment, the amount of information outside of the learners is huge. Not all the information is registered and processed. Only certain information can be selected and enter the system. Fleming and Levie (1978) stated that “each input channel has load limits, and the total information processing capacity from all inputs is limited. The stimulus potential of the environment is great, but the perceiver can attend to only a limited amount at a time” (p. 8). The key for the external stimuli to be registered is attention. “Attention, therefore, plays an important role in selecting sensory information” (Burton, Moore, & Holmes, 1995, p. 351). Attention is “the mental process of concentrating effort on a stimulus or a mental event... [and] the limited mental energy or resource that ‘powers’ the mental system” (Ashcraft, 1998, p. 68).

Attention is limited. G. A. Miller (1956) believed that the attention capacity was about “six objects at a glance” (p. 91). Learners could control their attention and

selectively direct it to certain information. “Selective attention refers to the learner’s ability to select and process certain information while simultaneously ignoring other information” (Driscoll, 2000, p. 81). So how to gain learners’ attention is a major concern for instructors. It is also an important initial event in Gagné’s suggestion for instructional strategies (1985). This encourages many researchers to seek what kind of information is easy to catch the attention of learners. Compared with text, pictures have a better chance to get the learners’ attention “either because of the graphic’s visual appeal or the meaning that the graphic may hold for the learner”(Rieber, 1994, p. 205). After reviewing a series of studies done on the effects of pictures on learning, Samuels (1970), Conannon (1975) and Schallert (1980) concluded that pictures could gain learners’ attention and influence their attitudes. A picture’s attentional role is also identified by Duchastel (1978) and Levie and Lentz (1982). Within the range of pictures, animated images seem to provide a good way to gain and cue students’ attention to the important instructional content because the attributes of motion or trajectory are more likely to catch the learners’ attention. Fleming and Levie (1978) believed that one form of gaining visual attention was “by adding movement” (p. 21) to still images and the change in stimulation will also sustain the attention. Additionally, by directing the learners’ attention to particular attributes of the information, animated images could increase perceptual accuracy, hence improving memory performance (Paivio, 1979). However, some researchers believe that attention gaining does not guarantee better learner performance. For example, Anglin, Towers and Levie (1996) reviewed earlier studies and summarized that “illustration variables (cueing) such as size, page position, style, color, and degree of realism may

direct attention but may not act as a significant aid in learning” (p. 766). What really counts is whether the information is processed and stored in the memory system.

After the information is selected, it needs to be processed in short-term memory and encoded into a recognizable format before it can be stored in the long-term memory. “Unlike the sensory registers, STM [short-term memory] does not hold information in its raw sensory form (e.g., visual – ‘icon’, auditory – ‘echo’), but in its recognized form” (Moore et al., 1996, p. 852).

The short-term memory has both permanence and capacity limits. Only a small portion of perceived information can be processed (Dwyer, 1972; Jacobson, 1950, 1951; Livingstone, 1962). Normally the permanence limit for short-term store is about 20-30 seconds, if no attempt is made to retain the information (McCown et al., 1996) and the memory span in immediate recall averages about 7 ± 2 (G. A. Miller, 1956). G. A. Miller (1956) stated that “there is a finite span of immediate memory and that for a lot of different kinds of test materials this span is about seven items in length” (p. 91). Due to the limits of the immediate memory permanence and capacity, we cannot process all the information that has been selected into the system in the limited time (Baddeley, 1986). Sperling (1960) stated that “more is seen than can be remembered” (p. 1), which implies that there is a memory limit and “more information is available during, and perhaps for a short time after, the stimulus than can be reported” (p. 1). Dwyer (1978) found that “Even though the more realistic visual illustrations contained more information than the less realistic illustrations, the students apparently did not have sufficient time to take full advantage of the information provided by the additional realistic detail” (p. 98). Hsia (1971) stated that “the information processing capacity for any organism is limited

mainly by physiological factors. Of fundamental importance in communication is the limited capacity of the central nervous system and the auditory and visual information processing modalities” (p. 58). Carpenter and Just (1992) proposed that “a key determinant of performance in complex reasoning tasks is the availability of adequate working memory resources both for computing and storing intermediate goals and products during problem solving” (p. 6).

Considering the limited capacity of short-term memory, Perrin (1969) suggested using simple and clear visual stimuli in the instruction and the visual detail presented must be relevant to the learning task. Craig, Gholson, and Driscoll (2002) found that information redundancy interfered with learner performance. When learners encode the external message into their information processing system, they discriminate and eliminate the superfluous and redundant stimuli to accommodate the limited memory span. It would take the learners’ time to do so, therefore, the learning might be slowed down. Instead of adding much redundant information in the instruction, Hsia (1968) suggested reducing the information redundancy to an appropriate level that matched the learners’ processing capacity and maximized their knowledge transfer. Zook (2001) suggested providing as much information as possible to learners, with the prerequisite that the presented information will not overload the learners’ mental capacity.

G. A. Miller believed that there are some ways to overcome the “bottleneck” of the memory span limit. He suggested that the items could be grouped into chunks of information. Although the average number of chunks is still 7 ± 2 , the items stored in each chunk could be expanded. “Since the memory span is a fixed number of chunks, we can increase the number of bits of information that it contains simply by building larger

and larger chunks, each chunk containing more information than before” (p. 93). To attain this expansion of chunks, the learners need to have enough time, effective recoding scheme and sufficient mental capacity. Paivio (1979) believed that “imagery is highly effective both as a memory code and as an associative mediator, consistent with what was assumed in the ancient mnemonic techniques” (p. 296). As a mediator, the imagery could help to organize the information into a recognizable format that the learner will understand. The more concrete the imagery is, the more meaningful structure it could provide, thus the easier the information will be grouped into chunks.

Animated images convey more concrete information than still images when they demonstrate the instructional content. In other words, it involves more realism, which on the one hand will facilitate learning as suggested by Paivio (1979) because of the concrete information it conveys. Extended from G. A. Miller’s theory, animated images also provide a convenient and meaningful structure or recoding scheme to organize the information into richer groups, which expands the chunks. But on the other hand, a realistic animated image may burden the bottleneck of short-term memory and waste the learners’ mental resources if the image does not function as a good organizer. This could happen when animated images are not congruent to the instructional content and are unnecessarily presented to learners. Because recoding or chunking needs attention and mental resources and both of them are limited, if animation is not a critical element in the instruction, then using animation in the instruction will only waste mental resources/effort without doing any good to the learning process. Whether an animated image will do a better job than a still image in helping learners organize the information

to chunks and motivate the learners long enough to finish the processing depends on the specific learning situation.

Besides the influence of selective attention and short-term memory span, animated images and still images also have an effect on the retrieval of learned information.

Before discussing the information retrieval, forgetting needs to be defined. Ashcraft (1998) studied the concept of forgetting and summarized that:

In fact, research on the topic of retrieval since the mid-1960s leads to exactly that conclusion: with the exception of memory loss due to physical, organic factors (e.g., Alzheimer's brain injury), there may be no true forgetting from long-term memory. Instead, the evidence points increasingly toward **retrieval failure**, a loss of access to stored information for some period of time. (p. 158)

This position states that the availability of the information is out of question, so long as it has been stored in the long-term memory. The key point is how to access the information, which directly relates to learner performance. To successfully retrieve the information, the learners need to activate relevant cues. Ashcraft (1998) suggested that “this loss of access will persist until some effective retrieval **cue** is presented, some cue that ‘locates’ the item that can’t be retrieved” (p. 159). What cues can serve as effective retrieval cues then? According to the encoding specificity theory, the best retrieval cues would be the ones that the learners used during the encoding (Thomson & Tulving, 1970; Tulving & Thomson, 1973). Tulving and Thomson (1973) suggested that information was encoded into memory as a set of related entity, not separate items. All the relevant elements are grouped together. So if one is presented a flying plane through animated

images, he or she will probably encode the shape, the color, the moving, etc., into the memory system together. Then, when he or she needs to retrieve the information, the additional cues that have been encoded will help him or her to remember the original item.

In other words, the more effective cues or hints are provided, the more easily the information is retrieved, which echoes to the cue summation theory. Cue summation theory proposes that learning is improved when more cues that are relevant to the task are presented (Severin, 1968). The effectiveness of instruction depends on “the richness of the symbols employed” (Hoban, 1949, p. 9). Besides the same cues provided by both animated images and still images, animated images include a unique cue element, that is, an animation attribute, which can be designed to show direction and change over time or across space. When retrieving such information from the long-term memory, there will be more potential cues used to trigger stored information. However, this does not mean that more potential cues will yield better learning results. Dwyer (1978) believed that “excessive realistic cues within a single-channel may be distracting or even evoke responses in opposition to the desired types of learning” (p. 29). Hartman (1961) stated that “most of the added cues in the mass media possess a large number of extraneous cognitive associations. The possibility that these associations will interfere with one another is probably greater than that they will facilitate learning” (p. 255). When will the cues help to activate the information? Severin (1968) pointed out that to achieve superior learning effects, the presented cues must be relevant to learning tasks, otherwise, it would only bring inferior results. For example, when animated images are used in non-motion related learning situations, embedded motion cues are not closely relevant to the learning

task, thus they will probably interfere with the perception of relevant cues. On the contrary, if used in motion-related learning situation, animated images will help to encode the information and improve learner performance. N. E. Miller (1957) furthered the cue summation discussion:

When cues from different modalities (or different cues within the same modality) are used simultaneously, they may either facilitate or interfere with each other.

When cues elicit the same responses simultaneously, or different responses in the proper succession, they should summate to yield increased effectiveness. When the cues elicit incompatible responses, they should produce conflict and interference. (p. 78)

Extending N. E. Miller's and other researchers' propositions to the practice of using animated images in instruction, it is reasonable to say that even though animated images employ more cues than still images, the use of animated images in instruction does not necessarily improve the learning effects. Only when the relevant cues embedded in animated images, such as color, shape, animation, etc., work cooperatively with the other available instructional cues, can animated images improve learning. On the contrary, adverse effects may occur. For example, Wong (1994) tested the effects of inconsistent animation in a tutorial of teaching simple spatial movements and found that the inconsistent animation hindered the learning. He recommended the designers avoid using poor quality animation in instruction.

In summary, both still images and animated images have the potential of facilitating or interfering in the learning process. The key is how to use them in different learning situations effectively. From the viewpoint of information processing theory, at

least three aspects should be taken into account when considering the use of still images and animated images in instruction: attention gaining, memory capacity and cues retrieval.

Cognitive Load Theory

Based on the information processing theory, especially the limited mental capacity in short-term memory, cognitive load theory (CLT) was generated and developed. Since CLT is closely related to the discussion of still images and animated images in this study, it is separated from information processing theory and discussed in more detail.

The tenet of CLT is that a human being's cognitive processing capacity is limited and the design and development of instructional materials should efficiently use the limited cognitive resources to facilitate the learners' learning activity. CLT is closely related to the short-term or working memory and interacts with the long-term memory via the construction and activation of the schema (Paas & van Merriënboer, 1994; Sweller, van Merriënboer, & Paas, 1998).

As an extension of G. A. Miller's position, CLT proposed that related information can be grouped into single chunk and saved as schema in the long-term memory. "A schema categorizes elements of information according to the manner in which they will be used" (Sweller et al., 1998, p. 255). Schemas are "organized units of knowledge that consist of general categories (or variables) and the relationships between them" (Zook, 2001, p. 208). The schema can be activated, or automated unconsciously, to some extent, from the long term memory to help process the information in short-term memory, thus alleviating the burden of working load in short term memory because the automatically

activated schema do not need much mental effort to process it. But it does take mental effort to construct the schema because the learners will have to gather the relevant information together to mentally build up the schema. Once the schema is generated, it will “increase the amount of information that can be held in working memory by chunking individual elements into a single element” (Sweller, 1994, p. 299). Through this chunking activity and schema technique, the working memory capacity gets expanded and it becomes possible to process more information that seems to exceed the capacity of the short-term memory.

How to help chunk the information and activate the schema is critically important for the improvement of learner performance. CLT states that the construction and retrieval of schema depend on the allocation of learners’ cognitive load.

According to CLT, the cognitive load of any learning task comes from three sources (Sweller, 1994; Sweller et al., 1998). One is from the interactivity of the elements that compose the information. It is called the intrinsic cognitive load “because demands on working memory capacity imposed by element interactivity are intrinsic to the material being learned” (Paas, Renkl, & Sweller, 2003, p. 1). Different learning tasks have different intrinsic loads, which are decided by the learning task itself and the learners’ characteristic, such as prior knowledge. “Intrinsic cognitive load through element interactivity is determined by an interaction between the nature of the material to-be-learned and the expertise of the learner” (Sweller et al., 1998, p. 262). The instructional design really cannot do much with it. The intrinsic load is pre-decided before any instructional strategies come into play. Kalyuga, Ayres, Chandler, and Sweller (2003) believed that when people understood the relationships among the elements, they

would acquire one or more schema that organized all the elements together. The next time when they encountered the same situation, the schema that had been stored in the long-term memory would be activated or automated, and the intrinsic load for such element interactivity would be reduced to quite a low level.

The two other types of cognitive load are from exterior factors, mainly from the instructional design. One is called extraneous or ineffective cognitive load. It is from poor instructional design or unnecessary learning activities that demand the learner spend time and mental effort on activities that are not directly related to the acquisition and activation of schema (Sweller, 1994). The extraneous cognitive load is detrimental to the learning because it is not useful or contributing to the learning, but it will share with and sometimes compete with the intrinsic cognitive load of the limited mental capacity, thus interfering with the generation and activation of the schema. Its adverse effect is especially worse when the intrinsic cognitive load is high.

The other cognitive load is called germane or effective cognitive load. Contrary to the extraneous load, germane cognitive load is from good instructional design and necessary learning activities that will help learners organize the presented stimuli and chunk them into condensed information items, hence assisting the generation and automation of the schema (Gerjets & Scheiter, 2003). Consequently, germane cognitive load will enhance learning. To increase the germane load, explicit instructional strategies should be employed to encourage the learners to engage in the activities that will increase the germane load (Renkl & Atkinson, 2003; Sweller et al., 1998; van Merriënboer, Kirschner, & Kester, 2003).

The intrinsic, extraneous and germane cognitive loads are additive, which means if the total of the three loads exceed the limit of the working memory capacity, the information will not be fully processed and the schema acquisition and automation will not proceed smoothly. When a learning activity happens, the intrinsic cognitive load must be fulfilled, and then the remaining resources could be allocated to the extraneous and the germane load. Reduction of the unnecessary learning activities or irrelevant instructional stimuli, in other words, decreasing the extraneous load, will free the mental capacity to carry more germane cognitive load that will bring effective instructional strategies to prompt the generation and activation of the schema. As a consequence of more available schema, the intrinsic load will possibly decrease, so there will be more cognitive capacity freed, which will leave more space for the germane load, another round of schema generation and activation will begin. If such a learning cycle keeps going, the learning effect will be greatly improved. Otherwise, extraneous load takes too much cognitive capacity, germane load cannot be supported, and the schema acquisition and automation will not be enhanced, thus the intrinsic load will not decrease and no more cognitive space will be freed for further information processing. This condition will not generate effective learning (Paas et al., 2003). The main concern of CLT is to manipulate the instructional design that will maximize the germane load and minimize the extraneous load under the guarantee that the total of three loads will not exceed the cognitive capacity.

One of the effective ways to decrease the extraneous load is to exclude unnecessary and irrelevant information. Mayer and his colleagues (Mayer, 2001; Mayer & Moreno, 2002) proposed a coherence principle that suggests “student learning is hurt

when interesting but irrelevant words and pictures are added to a multimedia presentation” and “student learning is improved when unneeded words are eliminated from a multimedia presentation” (Mayer, 2001, p. 113). The rationale behind it is that processing irrelevant messages takes time and competes for cognitive resources in short-term memory. For example, Rieber (1996) conducted a study to test the distraction effect of irrelevant animation. The research design randomly assigned 364 students learning Newton’s laws of motion to one of three groups: high distraction, medium distraction, and no distraction groups. An animated space ship was displayed on the computer screen during the instructional process. In the medium distraction group, the space ship was moving from left to right at the top of the screen and never overlapped the instructional content. In the high distraction group, the animated space ship was moving at the same direction, but randomly changed its height. Sometimes the graphic overlapped the content. The results found that the learners in the distraction groups did not spend as much time as those in the non-distraction group on the instructional content, which suggests that the learners were distracted by the animated graphic and they spent some time on it, even though they might have noticed its irrelevance. So Rieber suggests the designers should be careful when using irrelevant animated images in the instruction.

Mayer (2001) conducted eleven tests to investigate the influence of irrelevant words, images, or music on student learning. He used simple instructions that encompassed all the necessary message and expanded versions that included interesting but unnecessary messages to teach scientific concepts. Mayer found that learners who received the simple version instructions performed better on both retention test and knowledge transfer test than those who received the expanded instructions. He explained

that the unnecessary message in the expanded instructional materials increased the extraneous cognitive load, thus hindering the learning process. Mayer recommended not adding extraneous words, pictures or music to the presentations and keeping the presented message related to each other and internally coherent.

Another effective way to decrease the extraneous load is to avoid the split-attention effect (Sweller, 1999). Split-attention effect refers to a situation in which learners are “forced to split their attention between and mentally integrate disparate sources of information (e.g., text and diagrams) before the instructional material can be rendered intelligible” (Chandler & Sweller, 1992, p. 233). When the learners have to mentally integrate information in a given task environment, a heavy extraneous cognitive load is possibly imposed on their working memory capacity (Chandler & Sweller, 1992; Sweller & Chandler, 1994). Studies on the split-attention effect show the difference in working memory load between integrated and nonintegrated presentation formats (Cerpa, Chandler, & Sweller, 1996; Chandler & Sweller, 1996; Kalyuga, Chandler, & Sweller, 1999; Yeung, 1999). The integrated instruction format could save the students’ time in processing the information more than the non-integrated instruction (Chandler & Sweller, 1991, 1992). Kalyuga, Ayres, Chandler and Sweller (2003) believed that integrating related instructional elements “reduces the visual search, thus decreasing the burden on working memory” (p. 25).

A direct application of this proposition to instructional design is that the relevant information should be integrated together and presented to the learners to avoid the extraneous load. Empirical data support this hypothesis. Studies show that integrated instructions would be more supportive than non-integrated instructions, and the learners

in the integrated instructions group outperformed the students in the non-integrated instruction group (Carroll & Carrithers, 1984; Leutner, 2000; Mayer & Anderson, 1991; Mayer & Anderson, 1992; Moreno & Mayer, 1999; van Merriënboer, 2000).

For example, Mayer and his colleagues (Mayer & Anderson, 1991; Mayer & Anderson, 1992; Mayer & Moreno, 2003; Moreno & Mayer, 1999) conducted several studies to test the split-attention effect and integrated instruction. They used different version of non-integrated and integrated instructions to teach pump, bike tire pump, car braking system and lightning formation process. The results showed that the integrated instruction helped learners gain better learning results than does non-integrated instruction. The students who took the integrated instruction spent less time finishing the instruction than those who took the non-integrated instruction. Based on their studies, Mayer and his colleagues (Mayer, 2001; Mayer & Anderson, 1992; Moreno & Mayer, 1999) proposed an instructional design principle called the contiguity principle, which includes spatial contiguity and temporal contiguity. This principle suggests that when necessary, related instructional items should be integrated and presented together without being delayed across time (temporal) or separated across space (spatial). Separating related messages will detract learners from the continuity of the message. Presenting related messages near each other spatially and simultaneously will result in better learning than presenting them far from each other in the senses of time or space.

However, to avoid the split-attention effect and facilitate learning, the integrated information must be related and cross-referenced to each other. If each individual item is self-supportive and does not need the other type of presentation to support it, then integrating these items may increase the volume of unnecessary information, thus

increasing the extraneous load and probably overload the working memory capacity. This is called redundancy. Chandler and Sweller (1991) hypothesized that “physical integration is important only where the disparate sources of information are unintelligible unless integrated” (p. 296). If the disparate items are “independently intelligible” (p. 296), then the information presented by these items may become redundant. In this situation, there is no need to physically or mentally integrate these items because integration will increase the extraneous load. If the extraneous load caused by processing the redundant items or mentally integrating them leads to the overload of the working memory capacity, then the learning activity will be inhibited.

For example, Chandler and Sweller (1991) used simple instructional material and redundant instructional material to teach the circuit and flow of blood. The items used in the instructions are self-explanatory and self-supportive. They found that the simple instruction group outperformed the redundant instruction group and the simple instruction group also took less time to process the information. Mayer, Heiser, and Lonn (2001) conducted four experiments in which an animation instruction was presented to college students accompanying with a concurrent narrative explanation on the formation of lightning. When students also received concurrent on-screen text that summarized or repeated the narrative instruction, they performed worse on retention and transfer tests than did students who received no on-screen text. Mayer, Heiser, and Lonn (2001) believed that this redundancy effect was due to the overload on the cognitive capacity. The addition of on-screen text caused learners to split their visual attention in two sources, thus increasing the extraneous load and slowing down the information processing.

Craig, Gholson, and Driscoll (2002) conducted two similar experiments to study the function of agents and redundancy effect in multimedia environments. They used animation with printed text, animation with spoken narration, and animation with spoken narration and printed text to teach the lightning formation. They found that when the same information was presented in different formats, the animation with spoken-narration-only condition outperformed the other two groups, with no differences between printed text and printed text with spoken narration groups. They concluded that unnecessary redundant information would overload the learners' processing capacity and impair the learning effects.

Kalyuga, Chandler, and Sweller (2000) compared the effects of four types of instructional formats in teaching experienced trainees about a cutting machine. The four types of instructional formats are: a diagram with visual text, a diagram with auditory text, a diagram with both visual and auditory text, and diagram-only instructions. The diagram, visual text and auditory text present the same content and are understandable on their own. Kalyuga, Chandler, and Sweller (2000) found that the diagram-only instruction was the most effective instructional material for the experienced trainees. They believed that the diagram was sufficiently self-contained and understandable, so the accompanying texts explaining the diagram did not provide additional information and might be redundant. Based on this belief, they suggested that unnecessary redundant information should be omitted, otherwise the learning would be slowed.

Since CLT has broad implications in multimedia instructional design (Kalyuga et al., 1999; Mayer et al., 2001; Mayer & Moreno, 2003; Moreno & Mayer, 1999; Paas et al., 2003; Paas & van Merriënboer, 1994; Sweller, 1994; Sweller et al., 1998), the

relevant viewpoints of CLT must be taken into account when using animated and still images in different instructional situations.

The first and most important point that needs to be considered is the constraints of cognitive load. According to CLT, the three cognitive loads; intrinsic, extraneous and germane load, are additive. Intrinsic load is not influenced by the instructional design. The other two are, both of which are directly decided by instructional design, the main concerns in the design. Germane load will facilitate learning and extraneous load will be a detriment to the learning. So the instructional design should maximize the germane load and minimize the extraneous load.

When motion is critical to the learning task or instructional objectives, the strategies that help learners understand the motion, in other words, the interactive relationship among the items, will increase the germane load and facilitate the learning. How can learners be helped to understand the motion? A primary step is to show the motion to learners. Compared with still images, animated images will do a better job in presenting the motion to the learners. The motion depicted by animated images will serve as an effective organizer to arrange the information into different schema. For example, when showing learners how to drive a car, each action will involve the cooperation between human body and the car, as well as relate to other actions. When one “starts a car,” he or she needs to make sure no other car or person is in the way, step on the brake, insert the key, and turn the key in the right direction. So one movement, “start a car,” actually organizes a series of cooperative actions into a “start a car” schema. This schema will be stored into long-term memory and automated to working memory as one single item when needed next time. In this way, the working memory capacity gets expanded

and more information can be possibly processed. Using animated images to demonstrate the start-a-car action will smoothen the process and help the learners to connect the sub-actions and generate the mental image of the “start a car” schema.

According to Mayer (2001), the instructional material should be well organized and coherent and the presented message should provide guidance to the learner for how to build the knowledge structure or schema. When instructional content is related to motion or change, animated images can help organize the information and aid learners in building up the schema thus improving the learning effects.

Animated images are not the only way to present the motion concept. Still images, when designed effectively, can also achieve the effect of motion illustration by leading the learners to imagine the motion. However, it usually needs to have several still images spatially presented to express one motion, sometimes with the aid of arrows or texts. To conceptualize a motion, the learners need to jump from one picture to another, spend time and mental effort to hold the previous pictures in mind, connect them with the following ones and integrate all the images into one action. More often, the learners will have to come back to pick up the missing information. This jumping around and holding images across disparate displays will impose considerable extraneous load on the learners’ working memory capacity, disrupt learners’ attention from the main body of the instruction and possibly slow down the processing activity (Ware, 2000; Woods, 1984, 1991). This is a typical example of split-attention effect. An effective way to avoid split-attention effect is to combine the related instructional information together and present the learners with a whole continuous picture, as suggested by Mayer (2001), to keep the spatial contiguity and temporal contiguity of presented message. In illustrating the motion

concept, animated images can combine relevant items together and present the motion as it is without being separated across space. This physical closeness and meaningful connection will contribute to learning improvement. In this sense, animated image is “perceptually efficient and interpretatively rich” (Bartram, 2001, p. 15). So using animated images to teach motion-related learning tasks will increase the germane load and benefit the learning activity. Using still images in a motion-related instructional environment would have a potential danger of splitting the learners’ attention and aggravate the extraneous load.

On the contrary, in a learning environment where motion is not critical to the learning task or instructional objectives, using animated images will add unnecessary information and put more extraneous load on the processing capacity. In this situation, the animated images demonstrate similar information to the still images, and at the same time, present some unnecessary animation to learners under the circumstance that still images are well understandable on their own. “Attending to unnecessary information requires cognitive resources that consequently are unavailable for the construction and refinement of schemas” (Kalyuga et al., 2000, p. 127). The unavailability of cognitive resources for constructing and refining schema will impede the information organization and cognitive capacity expansion, thus limiting the learners’ ability to improve their learning performance. Mayer and Moreno (2003) suggested eliminating the interesting, but extraneous material to reduce processing of redundant material and free mental resources for learning.

Another drawback of using animated images in non-motion related learning situations is that the movement depicted by animated images will possibly direct the

learners' attention to the irrelevant information, thus splitting the learners' limited attention and wasting their mental effort, which will increase the extraneous cognitive load and interfere with the information processing. Compared with an animated image, a still image does not put more stress on the cognitive processing of the non-motion related learning tasks while visually presenting the instruction to the learners. It is reasonable to hypothesize that still images will be more effective in facilitating non-motion related learning tasks than animated images.

Paivio's Dual Coding Theory

Paivio (1979; 1986) proposed the dual-coding theory and stated that mental representation consisted of two coding systems, one system specializing in language and the other specializing in nonverbal information. The first system was simply referred to as the verbal system and the second one the imagery system.

The verbal system and imagery system are structurally different. The verbal system is basically a serial or sequential process and the visual system is a "parallel processing system in both the spatial and operational sense" (1979, p. 180). The two systems are functionally independent, which means that each system could work individually without relying on the other or they can work simultaneously. Even though they can work independently, their functions are additive, meaning that one system could help to activate the others and the information that is coded verbally could be transferred visually and vice versa.

"Information encoded both verbally and nonverbally should be remembered better than information encoded only one way" (Sadoski & Paivio, 2001, p. 63). Encoding information in both ways will deepen the information elaboration (Purnell & Solman,

1991). The depth to which information is processed is critical to the learning effect (Fleming & Levie, 1978). Paivio called this a “coding redundancy hypothesis” (1979, p. 181): The chance of remembering certain information would be positively related to the number of the available codes. Memory improves directly when the number of alternative memory codes increases “because when one memory trace is lost (either verbal or visual) the other is still available” (Rieber, 1994, p. 113). Mayer and Anderson (1991; 1992), Mayer and Sims (1994) and Mayer (Mayer, 2001) extended Paivio’s verbal and imagery study to narration and animation. They found that when using animation along with concurrent narration to teach students about the formation of lightning, operation of a bicycle tire pump, or operation of a car’s brake system, the students demonstrated a substantial improvement on problem-solving and retention tests, compared with those presented with animation alone, or narration alone, or animation with successive/non-concurrent narration instructions. The result is consistent with Dual-Coding theory that states when learners encode the incoming stimuli through both visual and verbal systems, they will gain a better understanding of the presented content. However, Mayer, Heiser and Lonn (2001) pointed out that the coding redundancy should not exceed the learners’ processing capacity. Otherwise, the learning will be slowed down.

Between the visual or verbal information, Dual Coding theory believes that visual information has a better chance to be dually encoded than verbal information. According to it, pictures will be encoded by imagery system and “are especially likely to be accompanied by language labels or text explanations in literacy situations, giving them a high probability of being encoded both nonverbally and verbally by readers” (Sadoski & Paivio, 2001, p. 104). Concrete verbal information will be likely encoded in both

systems, too, but not as much as the visual information. Abstract verbal information will be mainly encoded only in verbal system because it is hard to generate mental images for it. Based on this assumption and other empirical findings, Paivio suggests that image is superior to language, especially abstract language, in facilitating memory. His hypothesis was supported by many studies on the visual learning (Csapo, 1968; Dilley & Paivio, 1968; Dominowski & Gadlin, 1968; Jenkins, 1968; Lumsdaine, 1949; Paivio & Yarmey, 1966; Rohwer, Lynch, Levin, & Suzuki, 1967; Wimer & Lambert, 1959).

Paivio (1979) believed that imagery concreteness is a good predictor of memory performance and an underlying indicator of the extent to which information is to be coded and processed. He studied recognition memory and free recall memory and concluded that the more imagery concreteness an item conveys, the easier it was to be remembered. Paivio reviewed the studies of Jampolsky (1950), Gorman (1961), and Olver (1965) and found that recognition decreases from pictures, to concrete words, to abstract words. In other words, recognition is positively related to the concreteness of the information. He believed this finding could be explained by the hypothesis that concreteness associated with distinctiveness and differentiation. The more distinctive the information is, the greater the probability it will be recognized. After reviewing several studies regarding the recall memory, Paivio concluded that “Recall for concrete material is typically twice that of abstract material even if imagery is not reported as consciously experienced” (1979, p. 63). Again, the number of items correctly remembered is increased from abstract words, to concrete words to pictures. Besides the processing degree, the effectiveness of concreteness may also relate to the learners’ attention. For example, Keller (1987) believed that concreteness, such as the use of visual illustration, is

a good attention gaining strategy. Zook (2001) believed concreteness could support attention because “they give learners something solid and meaningful to process directly” (p. 298).

Putting the emphasis on comparing image and verbal process, Paivio did not clearly stress the difference between still images and animated images and their influence on the recognition and recall. However, he did point out that images are particularly and “Theoretically coordinated to an abstract-concrete dimension of stimulus meaning or task characteristics. The more concrete or ‘thing-like’ the stimulus or the task situation, the more likely is it to evoke memory images that can be functionally useful in mediating appropriate responses in that situation.” (Paivio, 1979, p. 9)

Besides concreteness, Paivio (1986) also pointed out that imagery vividness “may be an effective attribute of imaginal representation” (p. 83). The learners will be able to dual code the presented items into their processing system when the items are highly imaginable and concrete.

On the one hand, it is obvious that an animated image involves more concrete and “thing-like” information than a still image, and thus helps to generate internal mental images and increases the possibility of encoding information both verbally and visually. Paivio (1986) believed that mental representations are closely related to perceptual, motor, and affective cues when encoding the information. With more available perceptual, motor and affective cues, animated image has a better chance of inducing appropriate responses and increasing memory performance. On the other hand, this does not mean that animated images are absolutely superior to still images in all the situations. Paivio not only talked about the abstract-concrete dimension of the stimulus, but also the

situation of different learning tasks. “The precise effect depending on the nature of the task and the functional utility of imaginal and verbal codes in different tasks” (Paivio, 1979, p. 180), which suggests taking both abstract-concrete characteristics and task situation into account when one discusses the influence of still images and animated images on students’ learning.

Dual coding theory suggests that the learning of facts, concepts, or principles involving motion and/or trajectory should be facilitated by instruction that presents appropriate combinations of visual and verbal representations of these attributes due to increased likelihood of redundant encoding. (Rieber, 1994, p. 116)

When the learning task involves motion and/or trajectory, using animated images will help increase the learning effects. Otherwise, it will distract the learners and impair the learning effects.

Paivio is not the only researcher who studies the information encoding from the viewpoint of concreteness. Dale also bases his classification of the Cone of Experience on the concreteness level of the individual experience.

According to the concreteness level, Dale (1969) classified teaching and learning experiences into three categories and developed the Cone of Experience, a “visual analogy” that described the learning experience “from direct, firsthand participation to pictorial representation and on to purely abstract, symbolic expression” (p. 108). Consequently, instructional methods were categorized into various types and expanded the continuum along the Cone from the bottom of direct purposeful experiences to contrived experiences, dramatized experiences, demonstrations, study trips, exhibits,

educational television, motion pictures, recordings, radio, still pictures, visual symbols and the pinnacle of verbal symbols. The more concrete the information is, the more direct experience it carries. According to the experience continuum, “visual material becomes a necessary component for helping the inexperienced learner bridge the gap between concrete experiences and symbolic representations of real-world phenomena” (H. B. Miller & Burton, 1994, p. 72). Dale (1969) believed that the more realistic the instructional demonstration was, the greater the chance it had for improving the learning.

Dale (1969) pointed out that one of the common dangers “in our teaching is that we may move to generalizations too quickly, without providing a good foundation of vivid, specific experiences. As a result, our students may be confused and perplexed when they confront a new abstraction” (Dale, 1969, p. 101). Even though it is not practical to begin all the instruction with “direct, firsthand participation” (p. 108), it is always nice to give students more possibilities of exploring the concept in an imagery environment. Bruner (1966) also realized the importance and usefulness of imagery on students’ learning of abstract concept. He summarized in one of his study that

While the development of insight into mathematics in our group of children depended upon their development of ‘example-free’ abstractions, this did not lead them to give up their imagery. Quite to the contrary, we had the impression that their enriched imagery was very useful to them in dealing with new problems. (pp. 136-137)

Dale (1969) believed that different learning situations needed different instructional materials. And each kind of instructional material has its most suitable teaching environment and conveys certain message better than others. For example,

“Certain meanings involving motion can best be presented by motion pictures” (p. 390). Besides all the attributes possessed by both animated and still images, animated images have one more characteristic, that is, animation, which puts animated images in a more concrete position than still images in the Cone. According to Dale, animated images “show” motion, and still images just “suggest” motion. The learners need to infer the motion from the still images. “The inferring process requires additional cognitive processes and may not always be accurate” (Park, 1998, p. 48). So animated images have more advantages than still images in representing the motion and showing the invisible. What’s more, “Skillful animation can give a forceful, imaginative quality of an abstract idea, process, or a factual presentation” (Dale, 1969, p. 396). All of these characteristics demonstrate a strong potential of using animated images in instruction.

Cognitive Style

Many researchers have indicated individual differences among learners would influence the learning effects. When one studies the process of teaching and learning, he or she cannot ignore the characteristics of learners. When an instruction involves visual presentation, cognitive style will be an important learner characteristic to be considered. Among the earlier researchers of cognitive style, Witkin, Oltman, Raskin, and Karp (1971) defined cognitive style as “... the characteristic, self-consistent modes of functioning which individuals show in their perceptual and intellectual actives” (p. 3). Goldstein and Blackman (1978) proposed that “Cognitive style is a hypothetical construct that has been developed to explain the process of mediation between stimuli and responses. The term cognitive style refers to the characteristic ways in which individuals conceptually organize the environment” (p. 2). Messick (1993) defined cognitive style as

“characteristics modes of perceiving, remembering, thinking, problem solving, decision making” that were “reflective of information processing regularities that develop in congenial ways” (p. 3).

Learners with different cognitive styles perceive input information in different ways, so their problem solving strategies are various, which somewhat relates to their intellectual performance. However, cognitive style is not a synonym of intellectual competence. It emphasizes how learners perceive the information, instead of whether they are capable of understanding the information once it is perceived. One of the important dimensions of cognitive style is the concept of field dependence-independence, which is believed to be “the most prominent and well-researched dimension of cognitive style” (Waber, 1989, p. 21). Field dependence-independence refers to the extent to which individuals are able to discriminate and select useful information from complicated visual context.

Witkin and his colleagues (Witkin, 1950; Witkin, Dyk, Faterson, Goodenough, & Karp, 1962; Witkin et al., 1954) summarized that individual differences of perceiving visual message could be defined in accordance to the extent to which an individual depends on visual field. If an individual’s

Performance range perception is strongly dominated by the prevailing field, that mode of perception was designated ‘field-dependent’. At the other extreme, where the person experiences items as more or less separate from the surrounding field, the designation ‘field-independent’ was used. (Witkin, Moore, Goodenough, & Cox, 1977, p. 7)

In other words, individuals at the two extremes are considered field dependent and field independent, and the individuals in the middle of the continuum are considered field mixed or field neutral (Liu & Reed, 1994).

To test the level of field dependence-independence, Witkin and his colleagues developed several tests. In their earlier attempt, they developed the rod and frame test, the body-adjustment test and the rotating-room test to examine an individual's perception of the upright (Witkin, Goodenough, & Oltman, 1979; Witkin et al., 1971). Individuals who referred to the external visual cues to perceive the upright were defined as field dependent, and those who perceived the upright depending on the body referents were defined as field independent. It was later found that the ability of perceiving the upright highly correlated with people's "disembedding ability in perception" (Witkin et al., 1979, p. 1129) as measured by the embedded figures test in which the participants need to pick up a pre-listed figure from an embedded picture. Field independent people score higher in the embedded figures test than field dependent people.

Field dependent people depend heavily on the external reference and salient stimuli in the environment (Eagle, Goldberger, & Breitman, 1969; Sherif, 1980), so their perceptual approach is characterized as global versus the articulated approach of field independent people. Compared with field dependent learners, field independent people are good at three aspects: "providing structure for an ambiguous stimulus complex," "breaking up an organized field into its basic elements," and "providing a different organization to a field than that which is suggested by the inherent structure of the stimulus complex" (Riding & Cheema, 1991, p. 198). Moore and Dwyer (1991) further explained the difference as that:

Field-dependence individuals, when presented a visualized presentation tend not to modify the structure but accept and interact with it as presented. They tend to fuse all segments within the visual field and do not view or interact discretely with the visual components. Field-independent persons tend to act upon a visual stimulus, analyzing it when it is organized and providing their own structure when lacking organization. (p. 611)

It may be because field dependent people are less capable of differentiating the critical information from the irrelevant visual message and waste cognitive resources on the increasing demands of processing irrelevant information that they underperform the field independent people in many learning situations (Carrier, Joseph, Krey, & LaCroix, 1983; Descy, 1990; Dwyer & Moore, 1991-1992; Moore & Dwyer, 1991; Reardon, Jolly, McKinney, & Forducey, 1982; Witkin et al., 1977). It is further proposed that field independent people reorganize the relevant information based on their perception, which entails a deeper encoding of the information, thus improving learning results (Carrier, Davidson, Higson, & Williams, 1984).

However, this does not mean that field independent people are more intelligent than field dependent people (Globerson, 1989; Harshway & Duke, 1991; Pascual-Leone, 1989; Witkin et al., 1971). Through his long series of studies, Pascual-Leone (1989) believed that field dependent people had as much mental ability as field independent people. The underperformance of field dependent people was either because “their inadequate executive controls fail to mobilize” (p. 60) their mental capacity well enough, or because they pay too much attention to the irrelevant information, thus wasting the mobilized mental capacity. Globerson (1989) hypothesized three explanations for the

underperformance of the field dependent people: (1) field dependent people were inferior to field independent people in terms of mental capacity, (2) field dependent people were not good at mobilizing their mental capacity and (3) field dependent people were misled by the irrelevant information, thus could not focus on the critical information. His experimental study showed that there was no significant difference found in the mental capacity between field dependent people and field independent people, and field dependent people devoted as much mental effort as field independent people. The only reason for their poor performance lied in the irrelevant cues they detected and input to their information processing system, which implied that a need existed for presenting visual information in certain ways that would help the field dependent people detect relevant information and facilitate their learning.

How to improve field dependent people's learning performance has been a research topic for a long time. Research shows that it is hard to change people's cognitive style (Witkin et al., 1977) and attempts to do so achieved little success (Gill, Herdtner, & Lough, 1968; Lawson & Nordland, 1975; Linn, 1978). However, it is possible, at least for instructors or designers, to construct the learning environment in such a way that will help the field dependent people identify the relevant cues presented in the instruction. With more relevant and critical information detected and input into their processing system, the field dependent people will have a better chance to improve their learning. Some researchers suggest using color coding to improve the learning effects.

Color could function as an attention-gaining tool and, at times, add realistic attributes to the message, thus improving the learning effects. Dwyer (1978) believed that:

The effectiveness of color in visual illustrations in facilitating student achievement of different educational objectives may be explained by the fact that the realistic detail in the visuals was accentuated by color; thus, the students were better able to make the appropriate discriminations and obtain the information necessary to achieve on the different criterion measures. (p. 135)

However, color's beneficial function does not exist all the time. Dwyer and Lamberski (1982-1983) reviewed studies concerning the effect of color coding on learning and concluded that color coding facilitated learning only when the color was closely related to the instructional objectives. Gibson and Mayta (1992, August) warned that instructors or designers should use color to help learners focus on the critical information and that it should never malfunction, becoming a distracter.

Dwyer and other researchers conducted several studies regarding color coding and field dependence. In some of the studies, they did not find that color coding would help the field dependent people improve their learning. The results show that field independent learners outperformed field dependent learners when presented with either black and white or color coded information (Dwyer & Moore, 1991; Moore & Dwyer, 1994; Worley, 1999). However, in other studies, it was found that color coding helped the field dependent learners improve their learning results. When students received color coded information, there was no significant difference in the achievement between field dependent and field independent students. When black and white coded information was presented, a significant difference existed between the achievement of field dependent students and field independent students (Dwyer & Moore, 1991-1992; Moore & Dwyer, 1991).

Adapting the same instructional unit to his study, Ogle (2002) investigated the effects of static image treatment and virtual environment (3-D) treatment on recall in participants of differing levels of field dependence. The results showed that there was no significant difference in recall test scores between virtual environment treatment and static image treatment. There was also no significant difference in test scores for field dependent participants who received the virtual-environment treatment versus the static image treatment.

Some researchers explored the influence of animation on field dependent people. An advantage of animation is that it can be applied to stimuli that have already employed color or shape attributes, which actually helps to disembed the relevant information from the background visuals (McLeod, Driver, & Crisp, 1998; Nakayama & Silverman, 1986). Witkin, Moore, Goodenough, and Cox (1977) found that field dependent people were more prone to attending salient cues than relevant cues. So an effective way to improve the field dependent people's perception is to present the relevant cues saliently.

Applied to instructional design, designers should emphasize the relevant information and draw learners' attention to it. When related to the instruction, animation can present the critical message in a more salient way to the learners, thus helping the field dependent people detect and pick up the useful information. But there is also a potential danger in using animation. That is, the animation may add more superfluous cues to the instruction, especially when the animation is not a critical element for the message, thus distracting learners and placing more stress on field dependent learners because they have to separate the relevant information from the confounding visual context. For example, the study of Sperling, Seyedmonir, Aleksic, and Meadows (2003)

“partially supported that animation can facilitate selection and organization and that some distraction may result from the use of animation” (p. 213). Since there are both advantages and disadvantages in using animation with the purpose of facilitating a field independent person’s learning, the research results are inconsistent.

Packard, Holmes, Viveiros, and Fortune (1997) conducted a study to test the relationship between learners’ cognitive style and various computer-assisted instructions for mathematical and statistical concepts. Participants were assigned to text-only, text and static graphic, and text and animated graphic presentation modes. The experimental procedure includes tests to determine the cognitive style, a pretest of statistical knowledge, instructional presentation, immediate recall test and delayed recall test. Results suggest that text-only presentation was significantly different for students with various levels of field independence, which suggests that static graphic and animated graphic presentations modes are helpful in decreasing the difference between field dependent and independent learners’ perception of presented content. However, the researchers did not specify any difference between the static and animated graphics on the learning results.

Another study was conducted by Carpenter and Just (1992). In this study, they used static display and animated display to teach a mechanical system to learners with different cognitive styles. They found that “animation improved the ability of lower knowledge subjects to answer questions about the motion of a component or component at a joint that were explicitly mentioned by the text” (p. 13). “But animation alone did not entirely compensate for the subject’s difficulty in identifying relevant features and ignoring irrelevant features” (p. 1). The animation they used in the study was not an

animated graphic presentation, but more like self-control learning material. What they did was to “limit what parts of the display are visually available and allow the subject to determine when and where to move to the next part” (p. 13). The participants could select “which portion they saw by moving a mouse pointer into the region of the display screen associated with the portion” (p. 13). But the participants could not decide where to go absolutely on their own. They had to follow the flow instructed in the accompanying text. What the learners could do is to decide how long they want to spend on each specific part of the graphics. This animated display does not use animation as a presentation tool, but as a self-control technique.

H. L. Lee (1997) investigated the influence of visual displays on learners with different field dependent levels. He employed animated visual, still visual and no-visual instructions to teach the concept of a cube and the relationship of the volume of a cube to its edge. He found that for field dependent learners, there is no significant difference between animated and still visual presentations, but both of the visual presentations scored higher than the non-visual instruction. For field independent learners, all the three presentation formats generated similar learning results. The results suggested that the visual display helped field dependent learners to isolate the related information from the presentation, but did not make much difference for field independent learners. In this study, there was no benefit of using animated presentation. This may be because the instructional content, the cube, does not involve any motion or trajectory, thus the advantage of animated images cannot be reflected. In other words, since there is no motion involved in the learning task or the instructional content, still images and

animated images are functioning similarly with regard to helping the learners discriminate the relevant information from the embedded environment.

S. Lee (1996) explored the effectiveness of animated presentation in improving problem solving ability and retention of mechanical device knowledge across learners with different cognitive styles. He used animated images and still images to teach the operation of a bicycle tire pump including handling the inlet valve, outlet valve, the cylinder and the hose. The results showed that participants who received the animated presentation performed significantly better than those receiving the still graphic presentation on the problem solving test. Field dependent participants in the animation group generated approximately 40% more correct solutions to the problem-solving test than those in the still image presentation group. This study suggests that the animated graphics may help the field dependent learners to acquire and process relevant information, thus improving knowledge transfer and problem solving ability.

Smith (1984) stated that part of the reason for inconsistent and inconclusive results concerning cognitive style and visual demonstrations is that the studies did not address the difference of “information processing requirements of a particular task, and the accommodating mediation of the treatment” (Smith, 1984, p. 7). Future research should include these two variables into consideration.

Task Classification

According to different criteria, human performance and learning tasks can be classified into different categories and requires corresponding capacity to fulfill them. The classification has significant implication for instructional design, such as clarifying the learning objective, employing the instructional strategies, selecting the instructional

media, etc. All of these have direct influence on the learning effects, which prompts the researchers to explore the classification of learning tasks and human performance.

Two well-known classifications of human performance and learning tasks are Bloom's three learning domains and Gagné's five categories.

Bloom and his colleagues (Bloom, 1956; Krathwohl, Bloom, & Masia, 1964) classified the human performance into three domains: cognitive, affective, and psychomotor. The cognitive domain "includes those objectives which deal with the recall or recognition of knowledge and the development of intellectual abilities and skills"(Bloom, 1956, p. 7). The affective domain "includes objectives which describe changes in interest, attitudes, and values, and the development of appreciations and adequate adjustment" (Bloom, 1956, p. 7). The psychomotor domain includes "objectives which emphasize some muscular or motor skill... they were most frequently related to handwriting and speech and to physical education, trade, and technical courses" (Krathwohl et al., 1964, p. 7).

Gagné (1991) developed a taxonomy of five categories: verbal information, intellectual skill, cognitive strategy, attitude, and motor skill. Verbal information refers to "the performance of stating, in the form of meaningful propositions, names, facts, sentences, and passages of connected sentences" (p.131). Intellectual skill is demonstrated by "the application of regular symbolic relationships (procedures) to specific instances" (p. 132). Cognitive strategy "refers to an internally organized cognitive skill by means of which learners are able to control their own processes of learning and thinking" (p. 132). Attitude "is an acquired mental state that influences the choice of personal action towards some object, person, or event" (p. 133). Motor skill

“consists of the execution of goal directed muscular movements, characterized by smoothness and precise timing” (p. 133).

In this study, the learning task is divided into two categories: motion-related tasks and non-motion related tasks. Motion-related learning tasks refer to tasks that involve movement, transformation, or trajectory over time or space, which is similar to the psychomotor domain classified in Bloom’s taxonomy and the motor skill in Gagné’s category. Non-motion learning tasks refer to tasks that do not involve noticeable movement, transformation or trajectory over time or space, which is similar to the cognitive domain classified in Bloom’s taxonomy and the verbal, intellectual and cognitive skills mentioned by Gagné’s.

Different types of learning tasks need different consideration in the instructional design, especially the selection of instructional media. For example, Fleming and Levie (1978) stated that “instruction dealing with some action or motion was best depicted by full demonstration of motion (live or with motion media, e.g., film and TV)” (p. 87). Obviously, animated image is one type of the “full demonstration of motion”. Morrison, Ross, and Kemp (2003) suggested that motion demonstration was often required for the psychomotor procedures learning, especially for complex psychomotor tasks or naïve learners. Studies such as the ones conducted by Roshal (1949), Silverman (1958), and Gropper (1968) showed that motion presentation helped to elicit better performance on the procedural learning. Some early studies on the effect of dynamic visuals of films suggested that animated illustration was effective when motion is a critical attribute of the presented concept and the learning objective was related to procedural task (Lumsdaine, Sultzer, & Kopstein, 1961; May & Lumsdaine, 1958; Weber, 1926).

Milheim (1993) suggested using “animation that related directly to important objectives or features within an instructional lesson” (p. 174) and using “animation when the instruction includes the use of motion or trajectory” (p. 174) such as simulating the orbiting of planets. Rieber (1990a) opined that “animation should be incorporated only when its attributes are congruent to the learning task” (p. 79). Given the dynamic nature of an animated image, it not only involves a particular set of static images but also depicts the motion embedded in the series of the static images. When motion is critical to the learning task, animated images act as a pointer directing the learners’ visual attention to next step.

In Dwyer and his colleagues’ series of systematic and extensive visual research, they tested the effects of visual presentations with various realistic levels on the students’ achievement in different learning tasks, which were called educational objectives in the studies. These learning tasks were measured by four criterion tests: drawing test, identification test, terminology test and comprehension test. Dwyer and his colleagues (1978) found that not all types of visual presentations have the same effect in improving the students’ achievement in all kinds of educational objectives. For a specific educational objective, some visuals with certain realistic details may add little or actually decrease learning effects, while the same visuals may work great for another kind of educational objective. The effectiveness of visual presentation is dependent upon, at least in part, the type of educational objectives. Dwyer (1978) stated that:

One of the basic criticisms leveled at media related research is the contention that researchers do not adequately specify the type of learning tasks students are expected to achieve. This in turn prevents researchers from generalizing results

obtained from individual studies and probably explains why some studies using media achieve significant results while other obtain insignificant result. One possible explanation for these contradictory findings may be that specific types of visualization may function very well in facilitating student achievement of specific types of educational objectives while for other types of educational objectives visualization may not be necessary or may actually function to inhibit learning. (p. 42)

Basing on these findings, Dwyer suggested including the type of visual presentation and the type of educational objective as two important variables in the visual study.

Van Mondfrans and Houser (1970) developed a paradigm for selecting appropriate media to teach different types of concepts. They suggested that instructors or designers first need to determine the “defining attributes” of the concepts to be presented, then they would select the appropriate media that will meet the requirement of the attributes. According to this paradigm, Wells, Van Mondfrans, Postlethwait, and Butler (1973) studied the effectiveness of three visual media and two study formats in teaching different concepts. The three visual media were sequential still photographs, slides, and motion pictures. The two study formats were timed and non-timed instruction. The presented concepts involved time, space, and motion. They found that in teaching concepts involving time, motion presentation led to better learning results than the sequential slides and sequential still photographs. In learning concepts involving motion, the participants in motion pictures and slide treatment groups scored better than those in the sequential still photograph treatment group. The similar effectiveness of slide and

motion picture in teaching motion-involved concepts may be explained by the possibility that the constantly changing slide generates an illusion of motion since the pictures in slides and motion presentation are quite identical. In teaching concepts involving space, there was no significant difference among the three presentation formats.

The results of this study suggest that certain visual media are more effective than others in presenting concepts involving time, motion, or space. Of the three visual media used, motion pictures were more effective for presenting concepts involving motion; and sequential still photographs and slides appeared more effective than motion pictures in presenting concepts involving space. (Wells et al., 1973, p. 240)

Another important finding of this study is that when combining all the test scores for the three concepts of learning into a composite score, there was no significant difference among the three presentation modes. This could explain why some of the visual studies could not find significant difference between still images and animated images on students' achievement. The reason probably lies in the fact that these studies did not differentiate the learning tasks.

Spangenberg (1973) conducted a study to test the effectiveness of motion demonstration in procedural learning. He used both motion visuals and still visuals to demonstrate the disassembly of an M85 machine gun. He found that the learners who took the motion presentation spent less time to process the information and scored higher in the performance test than those who were presented the still demonstration. The overall error rate was "6.5 percent for the motion sequences and 23.8 percent for the still sequences" (p. 424). Spangenberg also studied the effectiveness of cueing arrows. He had

four treatment groups in the study: motion presentation, motion with arrow presentation, still presentation, and still with arrow presentation. The conclusion is that there is no significant effect due to the use of cueing arrow, even though it was hypothesized that arrows would direct learners' attention. This result is similar to Dwyer's (1969) study of motion as an instructional cue with the finding that when motion is not critical to the learning task, animated cue is not that effective in improving student performance.

Spangenberg (1973) concluded that:

Motion presentations are superior to still when: 1) the activity requires simultaneous motion in different direction; 2) the activity is unfamiliar to the subject; or 3) the activity has a low verbal codability (it is not readily described accurately with words). (p. 433)

Rieber (1990a) believed that still images and animated images had different functions and should be used only when there is an external need for them. He (1994) proposed that still images "would be sufficient for tasks that only require learners to visualize information" (p. 117) and "animated graphics are probably better at communicating ideas involving changes over time because of their ability to show motion" (p. 116). He believed animation could help to present instructional content "more concrete and spontaneous by providing the motion and trajectory attributes directly to the learners" (p. 117). If no external needs existed, designers should not incorporate still images or animated images in the instructions (Rieber, 1990a).

Anglin, Towers, and Levie (1996) concluded that one of the reasons that an animated image did not make a significant difference on students' learning in many studies was because the investigators did not determine whether

There was a need for external visuals, static or dynamic. Perhaps reading text alone is adequate. In addition, many of the investigators did not provide a rationale for why motion is needed to either indicate changes over time or changes in direction. Text or text-plus static graphics may be the optimal treatment if motion is not required. (p. 768)

So they recommend that future studies on animated images should “include content for which external visual information is needed and which requires the illustration of motion or the trajectory of an object” (p. 768).

Levie and Dickie (1973) stated that a “basic postulate for a technology of media selection is that the nature of the learning task and the nature of the objectives associated with a unit of instruction should be determinants of the medium used to provide the instruction” (p. 859). They believed that animated visuals like film and television were especially useful when motion and change were critical for the learning task. They reviewed earlier studies concerning the visual presentations, such as the ones conducted by Houser, Houser, and Van Mondfrans (1970) and Allen and Weintraub (1968), and concluded that motion visuals were superior to static visuals when the presented concepts were related to motion or change.

Woods (1984) stated that the visual display must be relevant to the learning tasks and highly identifiable. He discussed the visual and interface design from the viewpoint of visual momentum that “captures knowledge about the mechanisms that support the identification of ‘relevant’ data in human perception so that display system design can support an effective distribution of user attention” (p. 229). He proposed that when the learner scanned a visual illustration, he or she looked for relevant information. If the

relevant information was easy to obtain, then the learners did not need to input much mental effort in the searching, which resulted in higher visual momentum since the amount of visual momentum was adversely proportional to the devoted mental effort of searching. When the visual display provided a functional perceptual cue “that describes the relationships among data points as well as the data points themselves, the viewer’s attentional mechanisms can identify highly ‘informative’ areas (high visual momentum)” (p.233). The perceptual cues must be relevant to the learning task; otherwise, it will demand more mental effort to process the irrelevant cues, thus increasing the workload and decreasing the visual momentum, which describes the case when animated images are used in the situation that motion is not related or critical to the learning task. The low visual momentum will in turn result in low attention, and decrease the overall problem solving performance. One of the techniques that Woods suggested on improving the visual momentum was to offer perceptual landmarks, “features that are visible at a distance and that provide information about location and orientation” (Hochberg & Gellman, 1977, p. 23). Obviously, in motion-related tasks, animation will be an effective visual landmark to help the learners locate the information, group relevant data together, and distinguish relevant from irrelevant data.

Previous research of visual effects on students’ learning has provided inconsistent and inconclusive results. Some studies show that animated images facilitate learning better than still images (Baek & Layne, 1988; Hays, 1996; Mayton, 1991; Park & Gittelman, 1992; Rieber, 1990b, 1991a; Szabo & Poohkey, 1996; Williamson & Abraham, 1995), other studies suggest the opposite results, or no difference between still images and animated images on students’ learning (Al-Saai & Dwyer, 1993; ChanLin,

1999; Lai, 1998; Lin, 2001; Rieber & Hannafin, 1988; Towers, 1994; Wilson, 1998). One of the main reasons for the inconsistent results is that some studies employed motion-related learning tasks, while others did not. When the learning tasks involve motion or change, animated images are probably more effective than still images. Otherwise, still images will be more effective than animated images.

Mayer and Gallini (1990) conducted three serial studies concerning how different instructional presentations influence the students' learning of scientific device working principles e.g., how a brake, a pump, and a generator works. The participants were randomly assigned to four groups: text only group (control group), static demonstrations of the device with labels for each part, static demonstrations of the device with labels for each major action, or dynamic demonstrations showing the "off" and "on" states of the device along with labels for each part and each major action. The results indicated that the dynamic demonstrations "consistently improved performance on recall of conceptual information and creative problem solving" (p. 715), but not on the verbatim retention test, and "these results were obtained mainly for the low prior-knowledge (rather than the high prior-knowledge) students" (p. 715). Based on these results, Mayer and Gallini (1990) suggest that future studies should pay attention to demonstration formats, learner characteristics, and appropriate tests.

Park and Gittelman (1992) believed that animated graphics facilitated learning only when its "attributes are applied in congruence with the specific learning requirements of the given task" (p. 28). They conducted an experimental study to investigate the effects of animated graphics and static graphics in teaching electronic circuits and trouble shooting procedures. Both of the learning tasks involved movement

and change. The results show that the college students who took the animated graphic demonstrations experienced significantly fewer trials than those in the static graphic group, which supports their hypothesis.

Craig, Gholson, and Driscoll (2002) integrated still images and animated images in a multimedia instruction that teaches students the formation of lightning, which involves motion and transformation of the objects. They found that animated graphic demonstrations better facilitated the students' understanding of the presented concept than did the still image demonstration. They also found that when the color in the still images changes along with the spoken narrative, the students' learning is also improved than when the same still image presentation was used, but without color change. They conclude that the animation and color change help the learners to direct the learners' attention to relevant information, thus helping to improve the learning effects, while the still image presentation left the learner on his or her own to find the relevant information.

Poohkey and Szabo (1995) did a comparison study in which they used animation, still images and text-only instruction to teach students how to use a compass to create triangles. The results showed that the students who were presented with animated instruction scored significantly higher than those who were presented with still images or text-only instructions. Students' attitudes toward animated and still graphic instructions were higher than towards the text only instruction.

Justice (1999) tested the effects of animated visuals and still visuals by teaching students how to use cellular phones. The results showed that the students who viewed the animated visuals had greater performance than those who viewed still visuals. It was also found that the animated visual group spent less time than the still visual group to

complete the learning task. The students revealed that the animated graphics helped to visualize the process and enabled them to remember the key cues of the learning content.

ChanLin (2000) studied the difference of three presentational modes on students' learning of descriptive and procedural knowledge. The three presentational modes are text only, static graphics with text, and animation with text presentations. "The descriptive knowledge refers to knowledge that can be communicated through recital of facts or the description of objects or events" (p. 231). For example, a definition is considered descriptive knowledge. "The procedural knowledge refers to learning and construction of the problem-solving procedures related to physics concepts" (p. 231). For example, to figure out how much force is needed to move a cart weighing 20 kg upward, four steps are necessary: Identify two force vectors, identify the angle, calculate the two vectors, and get the amount of force to pull the cart upward. The results indicated that for descriptive learning, there is no significant effect for visual treatments. For procedural learning, a significant effect for visual treatment was found. Students presented with animation and static graphics outperformed those presented with text-only instruction. But there was no significant difference between static graphics and animation groups. Since motion, trajectory or transformation is not critical for both of the descriptive and procedural knowledge involved in this study, there is no external need for animated demonstration. It is understandable there was no difference between static graphic and animated presentation because the advantage of animated presentation will not be achieved if it is not necessary for the learning tasks.

Lai (1998) investigated the effects of three types of visual demonstrations in teaching basic computer programming language through analogy. The three types of

visual presentations are text-only, text with static graphics, and text with animated graphics. The results showed that the students who received the text with static graphic instruction outperformed those in the two other groups. The students' attitudes were not affected significantly by the types of visual display. The animated graphics used in this study did not "directly represent the real process that happens in a computer. It was an animated analogy which required students to build connection between the base analog and the target domain" (p. 158). The learning task did not involve any motion either, so the animated presentation is not critical for the learners' comprehension, which may explain the ineffectiveness of animated graphics in this study.

Wilson (1998) examined the effects of different visual presentations, including static and animated images, in facilitating students' learning of the parts and function of human heart and found that there was no significant difference in student achievement between and among the visual treatments.

Lin (2001) explored the effects of varied visual enhancements on students' learning of factual, conceptual and problem solving information about the human heart. The treatments included static graphic instruction, animated graphic instruction, animation with advance organizers and animation with adjunct questions and feedback. The results showed that there was no significant difference among the four groups. Even with advance organizers or adjunct questions and feedback included in the instructions, the animation was still not more effective than the still graphic instruction. Lin believed that one of the reasons for no difference finding was that the content used in this study was well developed and highly organized. More importantly, the learning task was not

related to motion. The still graphics also used arrows to demonstrate the direction, so the advantage of animated images might not be proved in the study.

However, not all the studies concerning the human heart generate no significant difference between animated and still graphic presentation. Mayton (1990) conducted a study to investigate the effects of animated images on students' learning of dynamic process, in this study, the structure and function of human heart. He found that learners who viewed the animated graphic presentation significantly outperformed those who viewed the static graphic presentation, both on recall tests immediately after the treatments and the test conducted one week later. This study supports the use of animated images on dynamic learning.

Francis Dwyer's Studies

One of the most prolific researchers in visual study is Francis Dwyer. He and his colleague conducted a series of extensive and systematic research known as the "Program of Systematic Evaluation" (Braden, 1994, p. 196). Most of their visual studies are related to the instruction of the human heart. In their experimental studies, they use the treatments of simple line drawings (black and white); simple line drawings (color); detailed, shaded drawings (black and white); detailed, shaded drawings (color); heart model photographs (black and white); heart model photographs (color); realistic heart photographs (black and white); and realistic heart photographs (color). The control group is the oral/print presentation. The students in each group received a pretest, participated in the study, and then received four separate criterial tests. Scores of the four tests were then combined together into a composite of the 78-item total criterial test score that was used to measure the learners' general understanding of the presented concepts. The four

criteria tests were the drawing test, the identification test, the terminology test and the comprehension test. Even though their study mainly focuses on the oral/print presentation and still image illustration, their conclusion is more about the general visual design principle that could be applied to the use of animated images and other visual presentation formats. One important conclusion of their study is that:

The realism continuum for visual illustrations applied to externally paced instruction is not an effective predictor of learning efficiency for all types of educational objectives. An increase in the amount of realistic detail contained in an illustration will not produce a corresponding increase in the amount of information a student will acquire from it. (Dwyer, 1978, p. 96)

Dwyer defined realism in the visual presentation as “the amount of stimuli available to convey information to student” (p. 5), which is similar to Levie and Dickie’s understanding that the dimensions of pictorial realism are “the amount of detail shown (line drawings versus detailed drawings versus photographs), chroma (color versus black and white), and the presence or absence of motion cues” (1973, p. 873). From the studies, Dwyer found that not all types of visual presentations were equally effective in helping students’ learning, which can partly be explained by the realistic information that each visual format contains. Too much or too little realistic information will both impair the learning. Dwyer (1978) stated that

Highly realistic illustrations may contain so many stimuli that the student will experience difficulty in identifying those essential learning cues with which he should interact, and also since there is a great deal of stimuli in the visual he may experience difficulty attending to and interacting with the essential learning cues

for the amount of time necessary to achieve understanding of the information being presented. In this case the students' behavior might be described as depicting the scanning syndrome – a constant surveillance of the entire perceptual field while not focusing or interacting with any specific stimuli. At the other extreme are the simple line illustrations containing very little instructional stimuli. Students receiving these illustrations are at a disadvantage since the visuals are limited in the amount of information they are capable of transmitting to the students regardless of how long the students are permitted to view and interact with the illustrations. (pp. 5-6)

Dwyer cited information processing theory to explain the “curvilinear,” not “linear” relationship between the learning effect and the realistic information contained in the instruction: “There are limits to the amount of information a learner can process. Therefore, it is necessary that the information to be transmitted is appropriately limited prior to transmission in order to reduce the processing demands made upon the learner” (p. 26). Similar to Dwyer's opinion, Feigenbaum and Simon (1963) and Broadbent (1965) believed that too much information will interfere with the learners' perception and performance. Travers (1964) suggested using simplified presentation because:

Through providing simplified presentations of the environment in learning situations, the teacher can be sure that the compression process is effective. When this is done, the separation of the important elements in the message from the less important elements and the noise in the message is not up to the learner who may fail to separate them. The separation is made for him. (p. 380)

According to their propositions, instructors or designers should avoid adding irrelevant or unnecessary stimuli to the instruction and limit the use of redundant information, so that the learners will not need to spend time and mental capacity to separate the irrelevant from the relevant and locate the critical information.

Dwyer (1978) conducted several studies regarding the externally-paced versus self-paced instruction and found that, “the amount of time students are permitted to view and interact with their respective presentations determines the kind of visualization which is most efficient in facilitating student achievement of specific kinds of educational objectives” (p. 73). If students only have limited time to process input information, which often happens to them, then there will be an optimal level for the amount of realistic presentation to be efficiently processed by the students in the fixed time. To optimize the beneficial function of visual presentation, images must be properly related to instructional objectives and learning content and help focus the students’ attention on the relevant information because “for a student to learn optimally from a visualized presentation he must be able to locate, attend to, and interact with the relevant instructional stimuli while ignoring or minimizing the effect of the competing irrelevant stimuli” (Dwyer, 1978, p. 156). Compared with still images, animated images contain more realistic details, which in one way may facilitate the learning activity because they offer more perceptual cues. However, in another way they have a possibility of competing with the processing of relevant information due to the limited mental capacity and processing time. The point is how to use the animated images so that it will maximize the learning effect without taking too much of the time and mental effort for the learners to process the visual stimuli.

Although most of Dwyer and his colleagues' studies are about the effects of still images with various levels of realism on students' learning of different learning objectives, Dwyer did test the effect of motion on students' learning. Dwyer (1978) believed that there were two basic cueing strategies, which also applied to the use of motion picture:

The first consists of providing students with additional relevant stimuli to improve and make more complete their understanding of the information they are receiving ... The purpose of this type of cueing is to systematically increase the amount of stimuli contained in the visualization, the assumption being that students' subsequent achievement will increase as the amount of stimuli contained in the visualization increase... The second type of cueing does not provide additional information to the students but functions primarily to ensure that the intended instructional stimuli are emphasized in such a way so that they will be quickly perceived from among all stimuli in the student's total perceptual field... In this type of cueing the cues are used to reduce the total number of errors students make when initially exposed to new information and to reduce the amount of time necessary to acquire the desired information. Such cues are considered to be external stimuli whose primary function is the gaining and directing of students' attention so that they will be able to quickly identify that which is to be learned. (p. 158)

In an earlier study, Dwyer (1969) tested the effect of motion picture as an instructional cue. The study determined whether motion picture was effective in facilitating student achievement on the five criterion tests. In his study, Dwyer used

arrows plus motion in the visual illustrations with the attempt to focus students' attention on relevant information. The arrow and the motion have nothing to do with the specific instructional content. This animation belongs to the second type of cueing strategies defined by Dwyer. The result of the study suggests that

The use of motion as an attention gaining cue is not an effective instructional technique for improving student achievement when the instructional presentation utilizes the more realistic type of visuals and the students are limited in the amount of time they can interact with the visual information. (Dwyer, 1978, p. 91)

On one hand, the result shows that motion picture may not be an effective attention-gaining cue in all the situations. On the other hand, it proposes a question: Whether motion images facilitate learning if they are not used solely as an attention-gaining cue, but also as an informative instructional visual.

To answer this question, Wilson and Dwyer (2001) conducted another study which tested the effect of motion picture as a presentational tool to depict the instructional content and provide students with additional relevant information. Wilson and Dwyer used still graphics, progressive reveal graphics, animation graphics, and animation and progressive reveal graphics to teach the learners the terminology and function of various parts of human heart. The still-graphics group served as a control group. Progressive reveal graphics were a "dynamic visual enhancement that entailed a sudden color change in, or a sudden addition of graphic elements" (p. 162). Animation graphics simulated the real world situation and presented the activity of the heart. Animation and progressive reveal graphics combined both animation and progressive reveal graphics. Wilson and Dwyer also took instructional time as another independent

variable. The students were randomly assigned to one of two timing treatments: One was self-paced instruction, and another one was external timed control instruction. The results showed “insignificant difference in achievement among the visual treatments. Significant differences in favor of the self-paced treatments were found to exist on the Drawing ... and total Criterion Measures” (p. 166). The researchers did not find significant interactions “between the visual treatments and time on all criterion measures” (p. 166). The results indicated that the type of graphic presentation did not influence the students’ achievement on the five criterion tests. At least in this study, the still graphics were as effective as animated graphics.

Wilson and Dwyer suggested the reasons of insignificant results might be because the students were not ready for the animated graphic presentation, the students were cognitively developed enough to deal with the instructional content when presented with still images, and the animation “employed may not have been sufficiently intense so as to instigate the levels of information processing necessary to move the information from short term into long term memory” (p. 166).

Another possible reason that has been ignored may be that there is no external need for the animated graphic presentation as related to the learning tasks in this study. The learning tasks and criterion tests focused more on the terminology and function of the various parts of the heart, rather than the motion or trajectory, which are “distinguishing perceptual attributes of animation” (Rieber, 1994, p. 149). If there is no need for external animated graphic demonstration, the use of animated images in instruction will not generate significant differences in learning achievement than still images.

Lloyd Rieber's Studies

Rieber is another researcher devoted to visual research. If Dwyer focused on the study of static images and text, Rieber spent his time on the study of how animated images can be used to influence learning. He conducted a series of studies concerning the effects of animated images on learners in different age groups and summarized important principles for visual design.

Rieber (1994) believed graphics had five functions in instruction. They are cosmetic, motivation, attention-gaining, presentation, and practice. Cosmetic, motivation and attention-gaining functions sometimes overlap with each other. On the one hand, graphics can motivate learners and direct their attention to relevant information. Gaining attention is critical for learners to take external stimuli into processing system. Research has shown that visual attributes, such as color, animation, etc, are fundamental to the learners' perception. On the other hand, there is a potential danger of distracting the learners' attention from some important information and wasting the learners' time to process the irrelevant visual presentation (Rieber, 1996). Rieber stated that "distraction is the nemesis of instructional graphic design" (p. 47) because the learners spend limited capacity of short-term memory on unnecessary stimuli, thus cannot process the relevant information effectively. When used in practice, graphics can be displayed as a visual feedback. With the development of computer techniques and authoring languages, graphics can be designed to simulate the situation depending on the learners' input.

Graphics, both still graphics and animated graphics, are more used as presentation tools in instruction. They try to represent the realistic situation and offer learners rich information. This has been called "learning-by-viewing approach" in instructional design

(Reed, 1985, p. 297). When supplemented with text, graphics prove to be helpful in improving learning effects. They can serve as organizational tools to aid the learners in processing the information, thus helping to group the input stimuli into memory chunks and expand the memory capacity. Besides, well-organized information is easier for the learners to understand, so it will save the information processing time, too.

Although graphics have so much potential benefit to the learning, whether the benefit could be actually fulfilled depends on how we use the graphics in the instructional design. Numerous researchers have done many studies on this subject. Levin, Anglin, and Carney (1987) conducted a meta-analysis of these studies and generated ten commandments of picture facilitation to instruction:

Pictures shalt be judiciously applied to text, to remember it wholly... Pictures shalt honor the text ... Picture shalt not bear false fitness to the text ... Pictures shalt not be used in the presence of 'heavenly' bodies of prose ... Pictures shalt not be used with text carvin' for images ... Pictures shalt not be prepared in vain ... Pictures shalt be faithfully created from generation to generation ... Pictures shalt not be adulterated ... Pictures shalt be appreciated for the art they art ... Pictures shalt be made to perform their appropriate function. (pp. 73-76)

Rieber (1994) proposed that "before any graphic offers the potential for increased learning, a need for external aids to visualization must be established" (p. 147). If text alone is sufficient to elicit an internal image, there is no need to include graphics in the instruction. Because unnecessary graphics will take the information processing time and learners' mental capacity, both of which are quite limited according to information processing theory. Even worse, the unnecessary graphics may distract the learners and be

detrimental to the learning. Though there is a need for the external visuals, the graphics must be congruent with the instructional content. Otherwise, they still cannot help to improve the learning effects. The same opinion is also supported by Levin and Lesgold (1978) and Levin, Anglin, and Carney (1987).

After talking about the situation when graphics should be used, Rieber (1994) further discussed the specific conditions under which animated images and still images should be differentiated. “Although animated visuals can be viewed as a subset of instructional visuals, to what extent does the research on static visuals extend to animated visuals? Put another way, what distinguishes learning from static versus animated visuals” (p. 147)? Rieber believed that as two major types of visuals, animated images and still images would best contribute to the learning in different situations.

Rieber proposed that still images “would be sufficient for tasks that only require learners to visualize information” (1994, p. 117). For example, when the learners first study a jet plane and have no idea what it looks like, then a still image will be sufficient to help the learners visualize the jet plane. But when the learners try to learn how to fly a jet plane, which requires the learners understand the operation of the internal mechanic system, the static image is not enough for this learning task. Instead, an animated image plays a better role here because “animated graphics are probably better at communicating ideas involving changes over time because of their ability to show motion” (1994, p. 116) and animated graphics are good at depicting the change in direction which is defined as trajectory (Klein, 1987, November). When a static image is used in a learning task that involves motion and trajectory, it probably represents “at best, visual ‘snapshots’ of such ideas and are often accompanied by abstract symbols, such as arrows and dotted lines”

(Rieber & Kini, 1991, p. 86). One can only hope that the learners will generate the mental image for the motion and trajectory on their own. According to the dual coding theory and information processing system, learners will take more time to generate the image and may have a hard time retrieving the information. “However, animation makes this cognitive task more concrete and spontaneous by providing the motion and trajectory attributes directly to the learners” (Rieber, 1994, p. 117) and “animation triggers the automatic ability of the visual system to induce apparent motion, thus freeing short-term memory for other task” (Rieber & Kini, 1991, p. 86). If there is no motion or trajectory involved in the learning task or the two attributes are not critical for the student’s understanding of the presented concept, then using animated graphics in instruction will have a potential of distracting the learners, thus impairing the learning effects. At the same time, it is a waste of time and money to develop animated graphics.

Rieber conducted a series of studies regarding the effect of animation on students’ learning. He used animated images to teach Newton’s laws of motion because they involved motion and trajectory, the two “distinguishing perceptual attributes of animation” (1994, p. 149). In the earlier studies, he did not find a significant difference among the effects of textual material, still images and animated images on students’ learning. He concluded that it was either because the instructional content was too difficult for the learners to understand, which resulted in the students’ failure of attending to the animation, or the animation was only used as an attention gaining tool so that the learners actually did not fully process the information embedded in the instruction (Rieber, 1989; Rieber & Hannafin, 1988). After adjusting the instructional materials according to the lessons taken from the previous studies, Rieber conducted several other

studies (Rieber, 1990b, 1991a, 1991b; Rieber, Boyce, & Alkindi, 1991; Rieber, Boyce, & Assad, 1990) and found that younger learners (fourth, fifth and sixth graders) “receiving animated graphic presentations learned more than students receiving static graphics or no graphics” (Rieber, 1994, p. 158) when the presentation was accompanied with practice. Such results were not found on adult learners. But the adult learners who received the animated graphic instruction spent less time taking the post-test than those who received still graphic instruction or all-text instruction. “This suggested that the animated presentations may have encouraged mental organization of the material as it was being learned. Increased mental organization of the content should result in faster, more confident, responses” (p. 158). In his study, all the lesson objectives are related to attributes of motion and trajectory and require the students to visualize the motion and trajectory. To assure the students attend to the animation effectively, Rieber broke down the instructions to proper chunks and cued the students’ attention to motion and trajectory details embedded in the animated images.

Rieber (1994) recommended four general instructional design principles concerning the use of graphics in presenting the instruction:

1. There are times when pictures can aid learning, times when pictures do not aid learning but do no harm, and times when pictures do not aid learning and are distracting. This is the ‘first principle of instructional graphics’.
2. Select the type of visual based on the needs of the learner, content, and the nature of the task. The type of visual used (representational, analogical, arbitrary), as well as the instructional function it serves (cosmetic, motivation, attention-gaining, presentation, practice), should be selected and designed based on the

interplay of three variables – learner, content, and task ... Different content or domains (i.e., the materials to be learned) demand different considerations when it comes to visuals. Also, the nature of the task, as defined by one or more strategies suggested by Gagné's events of instruction, and the delivery system (i.e., individual, small group, large group, distance learning, etc.) must be taken into account. All of these instructional variables, of which visuals only contribute to, must be congruent and consistent with one another.

3. Graphics should not distract attention from the lesson goals or objectives.
4. Graphics should be designed carefully to serve their appropriate function ... deliberate attention should be given to what type of graphic is chosen and the function it serves as it relates to the overall design. (pp. 202-203)

Summary and Hypotheses

Even though researchers try to make reasonable recommendations for using images in instruction, the research results are not congruent. At times the research shows a promising future for using animated images in instruction. Sometimes the effects are not superior to other illustration formats. When comparing the effects of still images and animated images, the results are even more conflicting and the amount of research effort is relatively small. However, the availability of new techniques and the educational development demand that researchers further study the effects of visual presentations and generate more reliable foundations for practical purpose. Anglin, Towers and Levie (1996) concluded that:

While some progress had been made, it is apparent that we know very little about the effect of dynamic visual displays on student learning. Given the proliferation

of visual information in instructional material, it is imperative that the most effective strategies for using animated visuals be determined. Relative to the production of static visuals and text materials, the cost of producing animated sequences is high... many additional theory-based studies, including a range of content areas, audiences, treatment conditions, and learner characteristics, are needed. (p. 768)

This study is conducted in response to this research call.

From both theoretical viewpoints and previous studies, it seems reasonable to say that both animated and still images will motivate learners, help gain their attention, and realistically represent the instructional content (Duchastel, 1978; Levin, Anglin, & Carney, 1987; Park & Hopkins 1993). However, attention and motivation are not equal to learning results. Realism will not necessarily increase the learning effect, for example Dwyer believed that “increases in realism, that is, density of instructional stimuli in visualization, and the level of student achievement do not appear to be a straight line function” (1978, p. 5). To get the maximum learning effect, “Pictures shall be made to perform their appropriate function” (Levin, et al., 1987, p. 76). Levin and Lesgold (1978) suggested that pictures would benefit the students’ learning when they overlapped the instructional content. Park and Hopkins (1993) proposed that dynamic visuals could be used as effective aid for illustration to represent movement and action in certain domain knowledge. More specifically, Rieber (1994) concluded that when there was no motion or change over time or across space in the instructional content, the ineffectiveness of animated images would occur. Therefore, animation should be incorporated only when its attributes are congruent to the learning tasks.

Besides the influence of specific types of learning tasks, researchers also suggest including the learner characteristics into consideration. For example, Reiser and Gagné (1982) suggested taking learner characteristics and domain tasks as part of the primary factors in media selection. Levie and Dickie (1973) believed that when selecting media for an instruction, designers need to consider both the learning tasks and the learner characteristics. The first question is “what media attributes are appropriate for the given task-learner situation” (p. 861). In other words, “what media attributes will facilitate learning for what kinds of learners in what kinds of tasks?” (p. 877). As one of the important learner characteristics, field dependence-independence plays a critical role in visual learning. When using visual display in instruction, the learner’s field dependence-independence level must be taken into account. Witkin, Moore, Goodenough, and Cox (1977) suggested using salient cues to help the field dependent people differentiate the relevant information from the background image. Pascual-Leone (1989) proposed using relevant cues to help the learners with relatively low field dependence levels detect the critical instructional content. At the same time, Gibson and Mayta (1992, August) pointed out that caution should be employed when using cues to direct learner attention. They believed irrelevant cues had a danger of distracting the learner from the main instructional content and should be avoided. Rieber (1994) believed that when related to learning task, animation was a good way to direct the learners’ attention to important information and helped to improve the learning effect. However, when the learning task was not related to motion or animated images were not congruent with the learning content, the use of animated images would distract the learner and decrease the learning effect.

Based on the previous studies and relevant theories, the research questions for this study are: For non-motion related learning tasks, will still images and animated images have different effects on college students' learning if the images are relevant to the instructional content? For motion-related learning tasks, will still images and animated images have different effects on college students' learning if the images are relevant to the instructional content? In both situations, if there is difference between still images and animated images on the learning effects, which kind of images has a better learning effect? Will animated images help the field dependent people improve their learning if the learning task is related to motion? Will still images help the field dependent people improve their learning if the learning task is not related to motion?

The research hypotheses for this study included:

H₁: For college students, still images will be more effective than animated images in the learning tasks that do not involve any motion or change.

H₂: Field dependent college students will benefit more from still images than field independent students in the learning tasks that do not involve any motion or change.

H₃: For college students, animated images will be more effective than still images in the learning tasks that involve motion and/or change.

H₄: Field dependent college students will benefit more from animated images than field independent students in the learning tasks that involve motion and/or change.

Chapter 3: Research Methodology

The purpose of this experimental study was to determine the effects of animated images and still images on college students' learning of motion-related tasks and non-motion related tasks, with the students possessing different levels of field dependence-independence. The Group Embedded Figures test (GEFT) was used to assess participants' levels of field dependence-independence. The main instruments were two sets of Chinese character tutorials that used still images and animated images to teach the meaning and the writing of 25 Chinese characters. The participants' performance was evaluated by a post-test that included two parts: Test A and Test B. The tests covered both the meaning and the writing of the characters that were taught in the tutorials.

Research Design

This study employed two 2 x 3 post-test-only designs. The independent variables were the types of visual displays (still images, and animated images), and the levels of field dependence-independence (field dependent, field neutral and field independent).

The dependent variable was the participants' post-test scores.

<i>Types of Visual Displays</i>	<i>Field Dependence-Independence Level</i>		
	Field Dependent	Field Neutral	Field Independent
Still Image			
Animated Image			

Figure 1. 2 x 3 experimental design.

Since there was no pre-test in this study, the participants only took a post-test that consisted of two parts: Test A and Test B.

Test A included 25 fill-in-the-blank questions that were used to evaluate the participants' recall level of the characters' meaning, a type of non-motion related task.

Test B was a writing test that asked the participants to actually write seven characters and demonstrate the way they wrote them by using lines, arrows and numbers. Test B was an example of a motion-related learning task.

Participants

The participants of this study were Virginia Tech undergraduate students from the colleges of Liberal Arts and Human Sciences; Agriculture and Life Sciences; Architecture and Urban Studies; Pamplin Business; Engineering; and Science.

To recruit participants, around 80 Virginia Tech instructors were contacted first and asked to disseminate a recruiting message. These instructors were randomly selected from the university course registration list. A follow-up message was sent out to these instructors two weeks later. Detailed information about the study and sign-up method were included in the recruiting message. The instructors were asked to forward the messages to their students and encourage their students to sign up for the study. Due to limited access to each individual student, the study could not get a random sample directly from the whole student body university-wide. This is a limitation of the study.

There were 197 students who registered for the study and 181 students who actually took the study. Of the 181 students, 19 were excluded from the data analysis because they were familiar with Chinese characters to some degree, thus having more prior knowledge than other participants. Therefore, test results from a total of 162 participants were included in the data analysis.

Participants in the study were volunteers. The participants could withdraw from the study at any time without penalty by simply walking out of the computer lab or not showing up.

Instruments

Group Embedded Figures Test. The Group Embedded Figures Test (GEFT) was used to assess participants' levels of field dependence-independence. GEFT is an adaptation of the Embedded Figures Test that measures a person's "disembedding ability in perception" (Witkin, et al., 1979, p. 1129) by requiring them to trace and map a pre-listed figure from an embedded visual context.

When taking the GEFT test, participants had two minutes to practice seven items first, and then they had 10 minutes to take 18 items for actual test. Each test would be scored individually using the scoring key provided with the test booklet. The total GEFT score ranged from zero to 18. According to Witkin, et al., the GEFT has a reliability of 0.82 (1971).

Participants who scored one-half standard deviation above the mean score were classified field independent and participants who scored one-half standard deviation below the mean score were considered field dependent. The other participants whose scores fell in the range of the mean score plus and minus one-half standard deviation were considered field neutral (Dwyer & Moore, 1991-1992).

Chinese character tutorial. Two sets of online Chinese character tutorials were designed and developed for this study: Type I Tutorial and Type II Tutorial. Chinese characters were chosen for the content of the instrument because the form of these characters is closely related to their origin and the development. Learning the meaning of Chinese characters is a type of non-motion related learning task, and learning to write Chinese characters is a type of motion-related learning task. In addition, since only a small number of college students at Virginia Tech study Chinese, the use of Chinese

characters for the content of the instrument made it easier to obtain suitable study participants.

The two sets of tutorials taught the same 25 Chinese characters. Each tutorial had two parts: an instructional part and a test part.

In Type I Tutorial, the meaning and the writing of the 25 characters were demonstrated in still images. In Type II Tutorial, the meaning and the writing of the same 25 characters were demonstrated in animated images.

The tutorials taught both the meaning and the writing of the characters. The meaning demonstration was created in Macromedia Flash MX 2004 software and the animated writing demonstration was created in Java Applet. The meaning and writing demonstrations were put together using Macromedia Dreamweaver software. The tutorials were computer-based in a web-ready format.

Procedure

There were 12 pre-arranged time slots for the study. Each time there were about 20 participants taking the study. All the participants signed up for one of the appointment time slots and the study was carried out in a computer lab in Virginia Tech.

Each participant was randomly assigned a number ranging from 1 to 200 when they entered the computer lab. This number served as an identification code for the GEFT and the two-part post-test.

Participants took the GEFT to assess their level of field dependence-independence. They had two minutes to practice the GEFT, and then 10 minutes to take the actual test. Standard oral instructions for the GEFT, as provided by Witkin, et al. (1971), were announced to ensure that each participant received the same message.

After the participants finished the GEFT, they were randomly assigned to one of the two tutorials: Type I Tutorial or Type II. Each participant was given an answer booklet for the post-test. They were also asked to write down their identification code and tutorial type on the cover sheet of their answer booklet.

In Type I Tutorial, the participants learned the meaning and the writing of 25 characters from still images. Then they took a post-test with two parts: Test A and Test B. Test A evaluated the participants' recall level of character meaning, a type of non-motion-related task. Test B evaluated the participants' writing performance when drawing the characters, a type of motion-related learning task.

In Type II Tutorial, the participants learned the meaning and the writing of the same 25 characters from animated images. Then they took the same post-test that was administered to Type I Tutorial participants.

Once the participants finished the post-tests, they were asked to turn in their answer booklets prior to leaving the computer lab. There was no time limit set for completion of the post-test. On average, it took participants approximately 60 minutes to finish the entire study.

Testing

A two-part posttest was used to assess the participants' understanding of the meaning and the writing of the Chinese characters that were covered in the instructional tutorial. Test A included 25 fill-in-the-blank questions that focused on evaluating the participants' recall of the characters' meaning, a type of non-motion related task. Each item scored one point credit if the participant wrote down the correct answer. Incorrect answers or missing items were not credited with any points. Test B was a writing test that

asked participants to actually write seven characters and demonstrate the procedure they used with lines, arrows, and numbers. The construction of the seven characters required a total of 41 strokes. The correct writing of each stroke in a character was scored as one point credit. Half a point was awarded for executing the stroke in the correct order (as indicated by the number of the stroke), and half a point was awarded if the participant drew the stroke in the correct direction (as demonstrated by the arrow). Full credit for writing all six characters totaled 41 points.

Pilot Study

Prior to administration of the experiment, a pilot study was conducted to evaluate the appropriateness of the general procedure and the content. Seven graduate students participated the pilot study. In general, pilot study participants felt the instructions were easy to follow and the content was clear to understand. However, they also had some suggestions. Their suggestions for modifications to the testing procedure and tutorial design were incorporated into the final study design, and are detailed as follows.

Test A originally used 15 multiple-choice items to test the meaning of the characters. There were four options to each question and only one of them was the correct answer, which was also the only one that had ever appeared in the tutorial. The other three options had never been mentioned in the tutorial. Participants indicated that they could easily identify the correct answer without actually knowing the meaning of the character, because they could tell right away there was only one option that had ever appeared in the tutorial. Pilot study results showed that participants had, indeed, scored full credit on the character meaning test. This would seriously influence the reliability of the instrument. Test A was modified and all four options were changed to the ones that

had appeared in the tutorial. Two participants took the revised tutorial and they both scored full credits for Test A. Test A was changed again and the question type became fill-in-the-blank format, instead of multiple-choice.

The research design was also changed as a result of the pilot test feedback. The original design randomly assigned the participants to one of two tutorials: Type I and Type II Tutorial. Type I participants learned 15 characters in still images, took a test, and then learned another 15 characters in animated images, and took a second test. Type II participants learned the first 15 characters in animated images, took a test, and then learned the other 15 characters in still images and took a second test. The rationale for this design was that by having each participant take both the still image and animated image tutorials, it would be easier to compare the different effects between types of visual displays. However, this design ignored the possible effect generated by the order of the two types of visual displays. Even though it was hard to statistically prove the order effect from the pilot study because of the limited number of participants, pilot study participants indicated that they felt more comfortable when they took the second part of the tutorial. This was because they learned what they would be tested on from the first part of the tutorial and they were thus sensitized to the underlying principle of Chinese character writing.

To eliminate the possible order effect and to minimize the difficulty in the future data analysis, the study was re-designed. Each participant only took either the still image tutorial or the animated image tutorial, and participants were randomly assigned to one of the two tutorials that were notated as Type I Tutorial and Type II Tutorial. In Type I Tutorial, participants learned 25 characters in still images, and then took a post-test. In

Type II Tutorial, participants learned the same 25 characters in animated images and then took a post-test.

Some lexical and grammatical modifications were also made in order to help the participants to better understand the study and the tutorials.

Institutional Review Board Approval

The researcher applied for and obtained exempt status for the study from the Virginia Tech Institutional Review Board (IRB). An amendment approval was requested and obtained on August 17, 2004 due to changes made based on the results of the pilot study. A copy of the IRB approval is included in Appendix A.

Data Analysis

Data for this study included GEFT scores and post-test scores, both of which were recorded and stored in paper format. Each participant was given an identification code, which enabled the researcher to link participants' GEFT and post-test scores.

According to their GEFT scores, participants were categorized into three groups: field dependent, field independent, and field neutral. The post-test scores consisted of two parts: the Test A recall scores of character meaning, and the Test B production scores of character writing. Each set of scores were recoded and analyzed separately.

To reiterate, the purpose of this study was to explore the effect of still images and animated images on college students' learning of motion-related tasks and non-motion related tasks, with participants who possessed different levels of field dependence-independence. The hypotheses for this study included:

H_1 : For college students, still images will be more effective than animated images in the learning tasks that do not involve any motion or change.

H₂: Field dependent college students will benefit more from still images than field independent students in the learning tasks that do not involve any motion or change.

H₃: For college students, animated images will be more effective than still images in the learning tasks that involve motion and/or change.

H₄: Field dependent college students will benefit more from animated images than field independent students in the learning tasks that involve motion and/or change.

SPSS statistical analysis software was used to analyze the test score data. A descriptive analysis was first conducted to generate detailed information, including means, standard deviation, and frequency data. Cronbach's alpha analysis was then used to test the reliability of the GEFT.

Finally, for each set of test scores, character meaning recall scores and character production scores, a two-way ANOVA was conducted to test the four hypotheses. The alpha level for all analyses was set at .05 ($p \leq .05$).

- For Hypothesis One, “still images will be more effective than animated images in the learning tasks that do not involve any motion or change”, the character meaning recall score (Test A) was used as the dependent variable, and the main effect of types of visual displays was analyzed.
- For Hypothesis Two, “field dependent college students will benefit more from still images than field independent college students in learning tasks that do not involve motion or change”, the character meaning recall score (Test A) was used as the dependent variable, and the interaction effect between types of visual displays and field dependence – independence levels was analyzed.

- For Hypothesis Three, “animated images will be more effective than still images in the learning tasks that involve motion and/or change,” the character production score (Test B) was used as the dependent variable, and the main effect of types of visual displays was analyzed.
- For Hypothesis Four, “field dependent college students will benefit more from animated images than field independent students in learning tasks involving motion and/or change”, the character production score (Test B) was used as the dependent variable, and the interaction effect between types of visual displays and field dependence – independence levels was analyzed.

Chapter 4: Results and Discussion

In this part, a general description of the data is reported first. Then the results of two two-way ANOVAs are presented, followed by discussions and conclusions.

This study employed GEFT to determine the participants' field dependence-independence level and used Dwyer and Moore's method (1991-1992) of categorizing the participants. According to Dwyer and Moore (1991-1992), participants who scored one-half standard deviation above the mean score were classified field independent and participants who scored one-half standard deviation below the mean score were considered field dependent. The other participants whose scores fell in the range of the mean score plus and minus one-half standard deviation were considered field neutral. The mean of GEFT scores in this study was 13.111 and the standard deviation was 4.247. Of the 162 participants, 47 were categorized field dependent (scores were equal to or below 11), 50 participants were categorized field neutral (scores were between 12 – 15, including 12 and 15), and 65 participants were categorized field independent (scores were equal to or above 16).

Of the 47 field dependent participants, 29 took the still image tutorial and 18 took the animated image tutorial. Of the 65 field independent participants, 29 took the still image tutorial and 36 took the animated image tutorial. Of the 50 field neutral participants, 21 took the still image tutorial and 29 took the animated image tutorial. In all, 79 participants took the still image tutorial and 83 participants took the animated image tutorial. The details of the data for each group are shown in Table 1.

After running a reliability test, the Cronbach's Alpha of the 18 GEFT items was .873, which suggested relatively high and satisfactory consistency of the test items.

Table 1

Means and Standard Deviations for the Group Embedded Figures Test

Group	Sample Size	Mean	Standard Deviation
Still Images	79	12.468	4.540
FD	29	7.241	2.029
FN	21	13.381	1.687
FI	29	17.035	.865
Animated Images	83	13.723	3.877
FD	18	7.722	1.873
FN	29	13.138	1.457
FI	36	17.194	.786
Total	162	13.111	4.247

Note. FD = Field Dependent; FN = Field Neutral; FI = Field Independent.

Results of Analysis

The dependent variable for Hypothesis One and Hypothesis Two was the character meaning test score. The mean score for this test of all 162 participants was 16.043 and the standard deviation was 5.910. The details of the character meaning scores for each group are shown in Table 2.

A two-way ANOVA was run to test the first two hypotheses. The ANOVA test results are detailed in Appendix B. The rejection level, also known as alpha, was set at .05. A Levene's Test of Equality of Error Variances was conducted to test whether the data met the homogeneity requirement of running ANOVA analysis (Howell, 2002). Results of the Levene's test were insignificant, which suggested that all three groups – field dependent, field neutral, and field-independent had roughly the same variance in the character meaning test scores and met the homogeneity requirement.

Table 2

Means and Standard Deviations for the Meaning Test

Group	Sample Size	Mean	Standard Deviation
Still Images	79	15.937	5.671
FD	29	15.345	5.087
FN	21	15.048	6.778
FI	29	17.172	5.326
Animated Images	83	16.145	6.161
FD	18	14.000	7.284
FN	29	16.207	6.821
FI	36	17.167	4.742
Total	162	16.043	5.910

Note. FD = Field Dependent; FN = Field Neutral; FI = Field Independent.

Hypothesis One: For college students, still images will be more effective than animated images in the learning tasks that do not involve any motion or change.

When comparing the mean scores of the character meaning test, results showed that the participants who took the still image tutorial actually scored lower ($M = 15.937$, $SD = 5.671$) than those who took the animated image tutorial ($M = 16.145$, $SD = 6.161$) (Table 2). However, this difference was not statistically significant. The results of the ANOVA failed to indicate that there was a main effect of the types of visual displays, $F(1, 156) = .004$, $p > .05$, $MSE = 34.804$ (see Appendix B). The analysis showed that there was no significant difference between the mean character meaning scores for the two treatments, therefore, Hypothesis One is not supported by the results of this study.

Hypothesis One was based on the assumption that when the learning task was not related to motion or change – in this case when the task is to learn the meaning of a

character – the use of animated images will distract the learner, add irrelevant information to the instruction, increase the extraneous load, and thus influence the learning effect (Gibson & Mayta, 1992; Mayer, 2001; Rieber, 1990a, 1994, 1996). For such a learning task, there is no external need for animated images, and still images should do a better job than animated images in promoting people's learning. However, the results of the study failed to support this assumption. There was no significant difference in the mean character meaning test scores of the still image tutorial and the animated image tutorial. This finding is consistent with previous research such as the studies conducted by H.L. Lee (1997), Wilson (1998), ChanLin (2000), and Lin (2001).

Hypothesis Two: Field dependent college students will benefit more from still images than field independent students in the learning tasks that do not involve any motion or change.

To test this hypothesis, mean scores from the character meaning test were compared. For field dependent participants, the still image treatment group scored 1.345 points higher than the animated image treatment group. However, for field independent participants, the still image treatment group scored only 0.005 points higher than the animated image treatment group. The results of the ANOVA failed to indicate that there was an interaction effect between the types of visual displays and the levels of field dependence-independence, $F(2, 156) = .523, p > .05, MSE = 34.804$ (see Appendix B). In other words, the effect of one variable did not depend on the level of the other variable. For situations in which motion or change was not involved, the differences of field dependent and field independent groups' meaning scores were not contingent or

dependent on the difference of visual display type. So Hypothesis Two was not supported by the results of this study.

Research shows that field dependent people have a relatively lower capacity to discriminate and select relevant information from a visual environment than do field independent people (Dwyer & Moore, 1991, 1991-1992; Witkin, Moore, Goodenough, & Cox, 1977). From this, it would seem that less distraction in an instructional tutorial would make it easier for a field dependent person to pick up important information from the visual context. In a learning situation where motion or change is not relevant, the use of animated images may add more superfluous cues to the instruction, thus distracting the learner and loading more difficulty on field dependent learners when they try to separate the relevant information from the confounding visual context. Hypothesis Two predicted that in a learning situation where motion is not relevant, field dependent learners would benefit more from a still image than would field independent learners. For this hypothesis, even though the mean character meaning score showed a slight difference, it was not significant enough to support Hypothesis Two.

However, there is an interesting finding from this study. That is, there was no main effect of the levels of field dependence-independence in the character meaning test $F(2, 156) = 2.484, p > .05, MSE = 34.804$ (see Appendix B). The mean scores of the character meaning test were not significantly different between field dependent participants and field independent participants. Usually, field independent people perform better in visual-related learning situations than do field dependent people (Carrier, Joseph, Krey, & LaCroix, 1983; Descy, 1990; Dwyer & Moore, 1991-1992), but this was not confirmed by this study.

The dependent variable for both Hypothesis Three and Hypothesis Four was the test score for character writing. The mean character writing score of the 162 participants was 27.636 and the standard deviation was 8.057. The details of the character writing score for each group are shown in Table 3.

A two-way ANOVA was run to test the last two hypotheses, and details are provided in Appendix C. Again, the rejection level, also known as alpha, was set at .05 and Levene's Test of Equality of Error Variances was conducted to test whether the data met the homogeneity requirement of running ANOVA analysis (Howell, 2002). Results of the Levene's test were insignificant, which met the homogeneity requirement (Howell, 2002).

Table 3

Means and Standard Deviations for the Writing Test

Group	Sample Size	Mean	Standard Deviation
Still Images	79	24.405	8.258
FD	29	18.448	6.042
FN	21	25.810	7.123
FI	29	29.345	7.329
Animated Images	83	30.711	6.556
FD	18	30.667	7.863
FN	29	29.345	6.526
FI	36	31.833	5.809
Total	162	27.636	8.057

Note. FD = Field Dependent; FN = Field Neutral; FI = Field Independent.

Hypothesis Three: For college students, animated images will be more effective than still images in the learning tasks that involve motion and/or change.

From the comparisons of the mean scores of the writing test, the participants who took the animated image tutorial scored higher ($M = 30.711$, $SD = 6.556$) on the writing test than those who took the still image tutorial ($M = 24.405$, $SD = 8.258$) (Table 3). The results of the ANOVA showed that there was a main effect of the types of visual displays, $F(1, 156) = 31.796$, $p < .05$, $MSE = 44.651$ (see Appendix C). The data indicated that there was a significant difference between the mean writing scores of the two treatments. The animated image treatment group scored significantly higher than the still image treatment group. So Hypothesis Three is supported by the results of this study. A power coefficient of 1.000 was observed, suggesting that there was about 100% chance of yielding a statistically significant difference between the two groups. The partial eta squared value of .169 suggested that almost 16.9% variation in writing test scores could be explained by the differences between still images and animated images (Trusty, Thompson, & Petrocelli, 2004).

Some researchers believe that animated images should be used in instruction when motion or change is relevant to the learning task (Fleming & Levie, 1978; Levie & Dickle, 1973; Levin, Anglin, & Carney, 1987; Klein, 1987; Park & Gittelman, 1992). For example, Rieber suggested that animated images should be used only when there is an external need for them (1990a). Park and Hopkins (1993) proposed using dynamic visuals to represent movement and action. There are also some studies showing that animated images generate better results than still images (Baek & Layne, 1988; Craig, Gholson, & Driscoll, 2002, Hays, 1996; Justice, 1999; Mayton, 1991; Park & Gittelman, 1992; Rieber, 1990b, 1991a; Szabo & Poohkey, 1996; Williamson & Abraham, 1995). This study hypothesized that when the learning task was related to movement and/or

motion, such as when learning how to write a Chinese character, then animated images would do a better job at facilitating learning than would still images. This hypothesis was supported by the research results. The participants who took the animated image tutorial performed much better than the participants who took the still image tutorial. The results are also consistent with the previous studies cited previously.

Hypothesis Four: Field dependent college students will benefit more from animated images than field independent students in the learning tasks that involve motion and/or change.

A comparison of the mean scores for the character writing test shows that the field dependent participants in the animated image treatment group scored 12.219 points higher than the field dependent participants in the still image treatment group. This is much greater than 2.488, the mean score difference of field independent participants in the animated image treatment group over those in the still image treatment group. The results of the ANOVA indicated that there was a significant interaction effect between the types of visual displays and the levels of field dependence-independence, $F(2, 156) = 7.770, p < .05, MSE = 44.651$ (see Appendix C). A significant interaction shows that the effect of one variable depends on the level of the other variable. In this study, it shows that for situations when the learning task requires motion and/or change, as controlled in this study, the differences between field dependent and field independent groups' writing scores were dependent on the difference of visual display type. Therefore, Hypothesis Four was supported by the results of this study. A power coefficient of .947 was observed, suggesting that there was about 94.7% chance of yielding a statistically significant interaction between the visual display type and field dependence-

independence level. The partial eta squared value of .091 suggested that almost 9.1% of the variation in writing test scores could be explained by the interaction (Trusty, Thompson, & Petrocelli, 2004).

Figure 2 graphically illustrates the interaction effect between the types of visual displays and the levels of field dependence-independence. The differences between field dependent and field independent participants in the animated image treatment were less than the differences in the still image treatment. In other words, differences between the two image treatments were less extreme for the field independent participants than for the field dependent participants.

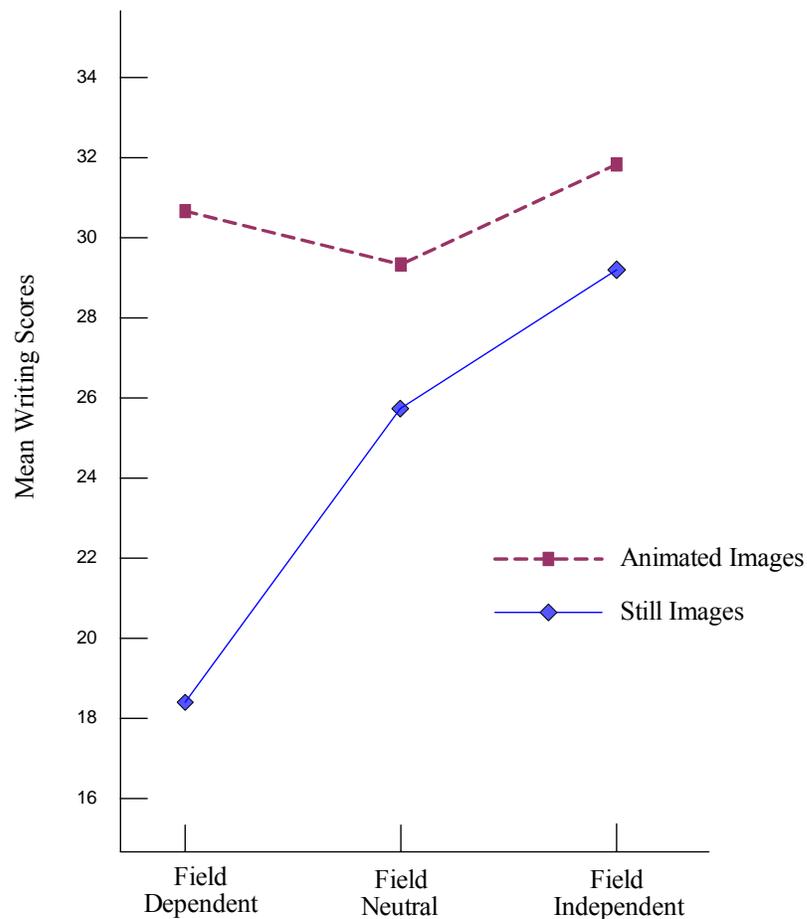


Figure 2. Interaction effect between the types of visual displays and the levels of field dependence-independence in the writing test.

Several prior studies show that field independent people perform better than field dependent people on visually related learning tasks (Carrier, Joseph, Krey, & LaCroix, 1983; Descy, 1990; Dwyer & Moore, 1991-1992; Moore & Dwyer, 1991; Reardon, Jolly, McKinney, & Forducey, 1982; Witkin et al., 1977). To help field dependent learners, Witkin, Moore, Goodenough, and Cox (1977) suggest using salient cues to help them to differentiate the relevant information from the background images. Researchers believe that these cues must be relevant to the learning task in order to facilitate learning (Gibson & Mayta, 1992; Pascual-Leone, 1989). When a learning task is related to motion or movement, animation can be an effective and salient cue to help the field dependent learners. Based on these suggestions, Hypothesis Four predicts that field dependent participants will benefit more from animated images than field independent participants in the learning tasks that involve motion and/or change. The results of this study support this hypothesis and indicate that the field dependent participants' writing scores increased much more from the animated image tutorial than did the scores of field independent participants. This finding provides support for the use of animation as an effective cue to help field dependent learners in a visual learning environment when the learning task is related to movement and/or change.

This study also finds that in the writing test, there was a significant main effect of the level of field dependence-independence $F(2, 156) = 10.812, p < .05, MSE = 44.651$ (see Appendix C). This is consistent with previous research results suggesting that field independent people usually outperform field dependent people (Descy, 1990; Dwyer & Moore, 1991-1992; Moore & Dwyer, 1991; Reardon, Jolly, McKinney, & Forducey, 1982; Witkin et al., 1977).

Since the data do not violate the homogeneity of variance, a Tukey Post Hoc test was run to further analyze the results. The results revealed that the writing scores of both the field neutral and the field independent groups were significantly higher than the scores of the field dependent group (see Table 4). The difference was only found in the writing test. Such a difference was not found in the character meaning test, though.

Table 4

Multiple Comparisons of the Mean Writing Scores

FDI (I)	FDI (J)	Mean Difference (I-J)	Standard Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
FD	FN	-4.732(*)	1.358	.002	-7.945	-1.520
FN	FI	-2.863	1.257	.062	-5.837	.111
FI	FD	7.595(*)	1.279	.000	4.568	10.623

Note. FDI = Field Dependence-Independence Level; FD = Field Dependent; FN = Field Neutral; FI = Field Independent.

* $p < .05$

Discussion

Even though images have been used in instruction for a long time, the effects of still and animated images are not quite clear. Many studies have been conducted, and the results are not consistent or conclusive. Some studies show that animated images facilitate learning better than still images (Baek & Layne, 1988; Hays, 1996; Mayton, 1991; Park & Gittelman, 1992; Rieber, 1990b, 1991; Szabo & Poohkey, 1996; Williamson & Abraham, 1995), other studies suggest the opposite results, or no difference between the effects of still images and animated images on students' learning (Al-Saai & Dwyer, 1993; ChanLin, 1999; Lai, 1998; Lin, 2001; Rieber & Hannafin, 1988; Towers, 1994; Wilson, 1998). After reviewing the previous studies on images,

Anglin, Towers, and Levie (1996) pointed out the necessity of conducting more “theory-based studies, including a range of content areas, audiences, treatment conditions, and learner characteristics” (p. 768). Park and Hopkins (1993) suggested that to study the effect of visual presentation, “learner variables, the learning requirements in the task, and/or the medium characteristics” must be taken into account (pp. 439-440).

Based on the previous research results and suggestions, this study explored the effects of still and animated images with a focus on the different learning tasks and different field dependence-independence levels that learners possess. The types of learning tasks for the study included motion-related and non-motion related learning tasks. The learners’ field dependence-independence level was categorized into three groups: field-independent, field-neutral, and field-dependent.

Different types of learning tasks necessitate different considerations in instructional design, especially with respect to the selection of instructional media.

Rieber (1990a) noted that still images and animated images have different functions and should be used only when there is an external need for them. He (1994) proposed that still images “would be sufficient for tasks that only require learners to visualize information” (p. 117) and “animated graphics are probably better at communicating ideas involving changes over time because of their ability to show motion” (p. 116). He believed animation can help to make instructional content “more concrete and spontaneous by providing the motion and trajectory attributes directly to the learners” (p. 117). If no external needs exist, designers should not incorporate still images or animated images in instruction (Rieber, 1990a). Anglin, Towers, and Levie (1996) also believed that when using still images or animated images in instruction, there must be “a

need” (p. 768) for doing so. Morrison, Ross, and Kemp (2003) suggested that motion demonstration is often required for psychomotor procedures learning, especially for complex psychomotor tasks or naïve learners.

This study supported these claims. The results showed a significant difference in test scores between participants who took a still image tutorial and those who took an animated image tutorial when the learning tasks involved motion and/or change, such as Chinese character writing. The animated image tutorial group scored significantly higher than the still image tutorial group. For the learning tasks that do not require motion or change, the study showed no significant difference between test scores for still image tutorial participants and animated image tutorial participants. The data showed that the participants in the still image group actually had slightly lower mean scores than the animated group in the character meaning test, even though the difference was not significant.

The results of this study suggest that a conclusion about the effects of still and animated images cannot be simply drawn without considering the specific demands of the learning task. When learning tasks involve motion and/or change, animated images tend to facilitate learning better than still images. However, when the learning tasks do not involve motion or change, learning results are not necessarily increased by the type of visual display used (still or animated).

In addition to the types of the learning task, instructional designers should also consider learners’ field dependence-independence level when designing visual instruction.

Field dependence-independence level is believed to be “the most prominent and well-researched dimension of cognitive style” (Waber, 1989, p. 21). Field dependence-independence refers to the extent to which individuals are able to discriminate and select useful information from complicated visual contexts. In many studies, field independent people were found to perform better than field dependent people in many learning situations (Carrier, Joseph, Krey, & LaCroix, 1983; Descy, 1990; Dwyer & Moore, 1991-1992; Moore & Dwyer, 1991; Reardon, Jolly, McKinney, & Forducey, 1982; Witkin, Moore, Goodenough, & Cox, 1977). However, this does not mean that field dependent people are less intelligent than field independent people (Globerson, 1989; Harshway & Duke, 1991; Pascual-Leone, 1989; Witkin et al., 1971). Through a long series of studies, Pascual-Leone (1989) found that field dependent people have as much mental ability as field independent people. He suggested that the poorer performance of field independent learners was either due to the fact that they failed to fully “mobilize” (p. 60) their mental capacity, or they wasted their mental effort by paying too much attention to irrelevant information.

For many years, researchers have investigated ways to improve the learning performance of field dependent learners. Some researchers explored the influence of animation on field dependent people’s learning (Carpenter & Just, 1992; McLeod, Driver, & Crisp, 1998; H. L. Lee, 1997; S. Lee, 1996; Nakayama & Silverman, 1986; Packard, Holmes, Viveiros, & Fortune, 1997; Sperling, Seyedmonir, Aleksic, & Meadows, 2003). When used appropriately, animation can present critical messages in a more salient way, thus helping field dependent learners detect and apply useful information. But there is also a potential danger in using animation. That is, the animation may add more

superfluous cues to the instruction, especially when the animation is not a critical element for the message, thus distracting learners and creating more cognitive load for dependent learners when they attempt to separate relevant information from a confounding visual context. Since there are both advantages and disadvantages to the use of animation in instruction, instructional designers should carefully consider the specific learning situations and the learners' characteristics.

This study explored the effects of using still images and animated images to help field dependent learners and predicted that:

Field dependent college students will benefit more from still images than field independent students in the learning tasks that do not involve any motion or change, and

Field dependent college students will benefit more from animated images than field independent students in the learning tasks that involve motion and/or change.

The results of the study did not support the hypothesis that field dependent college students would benefit more from still images than field independent students in the learning tasks that do not involve any motion or change. As the data show, the mean scores increased by the field dependent participants in the still image group than in the animated image group was slightly higher than the mean scores increased by field independent participants in the still image group than in the animated image group. However, the difference was not significant enough to support the hypothesis, which means, the effect of still images did not depend on the level of field dependence-independence in this specific learning situation.

In terms of the learning situation where motion is involved, the study supported the hypothesis that field dependent college students benefited more from animated

images than field independent students in the learning tasks that involve motion and/or change. As the data show, the mean scores increased by the field dependent participants in the animated images group than in the still images group was higher than the mean scores increased by field independent participants in the animated images group than in the still images group. The results of the ANOVA indicated that the increase was significantly different. In other words, in a specific learning situation where motion was involved, the differences of field dependent and field independent groups' writing scores were contingent and dependent on the difference of visual display type. The differences between field dependent learners and field independent learners in the animated image group were less than their differences in the still image group. This finding has an important impact on the effort of improving field dependent students' learning because it suggests a possible way of using animated images to improve field dependent students' learning when the learning task involves some motion and/or change.

The results of the study indicate that instructional designers should consider using animated images when motion and/or change is involved in or a demand of the learning tasks, especially when they have a concern for improving field dependent people's learning results because these learners would benefit more from the use of animated images in such learning tasks than field independent people.

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Appendix A: Institutional Review Board Approval



Institutional Review Board

Dr. David M. Moore
IRB (Human Subjects) Chair
Assistant Vice Provost for Research Compliance
CVM Phase II- Duckpond Dr., Blacksburg, VA 24061-0442
Office: 540/231-4991; FAX: 540/231-6033
email: moored@vt.edu

DATE: March 16, 2004

MEMORANDUM

TO: John K. Burton Teaching and Learning 0313
Huaiying Gao T&L 0313

FROM: David Moore 

SUBJECT: **IRB Exempt Approval:** "The effects of still images and animated images on motion-related and no-motion related learning tasks in college students of different levels of field dependence" IRB # 04-139

I have reviewed your request to the IRB for exemption for the above referenced project. I concur that the research falls within the exempt status. Approval is granted effective as of March 12, 2004.

cc: File
Department Reviewer Barbara Locke T&L 0313 ✓

Appendix B: Summary ANOVA Table for Meaning Test

Source	DF	Sum of Squares	Mean Square	F	Sig.	Partial Eta Squared	Observed Power ^a
Visual Type	1	.156	.156	.004	.947	.000	.051
FDI	2	172.920	86.460	2.484	.087	.031	.493
Visual Type * FDI	2	36.435	18.218	.523	.594	.007	.135
Error	156	5429.401	34.804				
Corrected Total	161	5622.698					

Note. FDI = Field Dependence-Independence Level.

^a Computed using alpha = .05

Appendix C: Summary ANOVA Table for Writing Test

Source	DF	Sum of Squares	Mean Square	F	Sig.	Partial Eta Squared	Observed Power ^a
Visual Type	1	1419.697	1419.697	31.796*	.000	.169	1.000
FDI	2	965.532	482.766	10.812*	.000	.122	.989
Visual Type * FDI	2	693.849	346.924	7.770*	.001	.091	.947
Error	156	6965.514	44.651				
Corrected Total	161	10452.512					

Note. FDI = Field Dependence-Independence Level.

^a Computed using alpha = .05

* $p < .05$

Curriculum Vita

Huaiying Gao

Education

Ph.D. Curriculum and Instruction, May 2005

Virginia Polytechnic Institute and State University (Virginia Tech), Blacksburg VA.

M.A. History, July 1998

Liaoning University, Shenyang, Liaoning, P.R.China

B.A. History, July 1995

Liaoning University, Shenyang, Liaoning, P.R.China

Work Experience

Graduate Teaching Assistant, Instructional Technology Master's Degree Program (ITMA), Virginia Tech, (2002 - 2004)

Designed ITMA online courses

Graded ITMA online students' assignments

Instructional Designer, *Digital History Reader* Project, History Department, Virginia Tech (2003 - 2004)

Used Macromedia Flash and Dreamweaver to design and develop online teaching modules for the *Digital History Reader* Project sponsored by a grant from the National Endowment for the Humanities (NEH)

Instructor, Faculty Development Institute, Virginia Tech (2003 - 2004)

Taught Macromedia Dreamweaver, Adobe Acrobat 6.0, Online Survey Tool sessions

Coordinated the Photoshop, Blackboard and iMovie training sessions

Instructor, Blacksburg Summer Youth Technology Workshops (Summer 2003 and 2004)

Taught and helped more than 60 middle-school students to use digital video cameras and iMovie software to videotape and edit short movies

Taught the students to use Macromedia Dreamweaver to create their own web pages

Technical Support for Faculty and Staff within College of Liberal Arts and Human Sciences (2001 - 2002)

Worked as a consultant to help maintain computer hardware and software belonging to the College

Traveled to departments to solve computer problems

Training Assistant, Faculty Development Institute, Virginia Tech (Summer 2002)

Provided training assistance to faculty at Macromedia Dreamweaver and Blackboard Training Sessions

Graduate Teaching Assistant, Humanities Department, Indiana State University, Terre Haute, IN (2000 - 2001)

Presented lectures to classes of 20-30 students and graded quizzes
Helped students with research interests concerning Chinese policy issues

Faculty, History Department, Liaoning University, Shenyang, Liaoning, P.R.China (1998 - 2000)

Taught undergraduate courses

Teacher (Part-Time), No. 5 Zhujiang Elementary School, Shenyang, Liaoning, P.R.China (1995 - 2000)

Taught English to more than 200 elementary school students

Publications

Gao, H. (2003). Application of Bruner's Cognitive Development Theory to Language Teaching in an Asynchronous Environment. *Society for Information Technology & Teacher Education (SITE) 2003 International Conference proceedings*

Hicks, D., Sears, P., Gao, H., et al. (2003). Preparing Tomorrow's Teachers to Be Socially and Ethically Aware Producers and Consumers of Interactive Technologies. *Society for Information Technology & Teacher Education (SITE) 2003 International Conference proceedings*

Gao, H. (1998). Relationship between Tax Regulations and Census Registers in Ancient China. *Liaoning University Journal*, 5.

Gao, H. (1997). Development of the Chinese Archives Law. *Shenyang Archives*, Summer.

Gao, H. (1997). Social Nature of Archives. *Lan Tai World*, 9.

Gao, H. (1997) Virtual Documents and Virtual Archives (Translation). *Shenyang Archives*, Winter.

Presentations

Gao, H. Still Images and Animated Images, Is there a Better Option? Presented at E-Learn 2004 International Conference

Gao, H. The Alternative Higher Education in a Chinese University. Presented at Association for Educational Communications and Technology (AECT) 2004 International Conference

Gao, H. Adjusting to New Technology: Chinese Students in US. Presented at AECT 2004 International Conference

Gao, H. A 4-D Online Teaching Program Model. Presented at AECT 2003 International Conference

Gao, H. Using Animated Image and Human-Computer Interaction to Teach PH value. Presented at AECT 2003 International Conference

Spielman, L., & Gao, H. Understanding Relationships Between Professionalism and Teaching Practice. Presented at American Association for Teaching & Curriculum (AATC) 2003 Conference

Gao, H. Using Image to Teach Chinese Character in an Online Tutorial. Accepted by International Visual Literacy Association (IVLA) 2003 Conference

Gao, H. Application of Bruner's Cognitive Development Theory to Language Teaching in an Asynchronous Environment. Presented at Society for Information Technology & Teacher Education (SITE) 2003 International Conference

Sears, P., Gao, H. et al. Preparing Tomorrow's Teachers to Be Socially and Ethically Aware Producers and Consumers of Interactive Technologies. Presented at SITE 2003 International Conference

Professional Memberships

AECT (Association for Educational Communications and Technology)
ACE (Association for the Advancement of Computing in Education)