THE EFFECTS OF IMPLIED MOTION ON SHORT-TERM MEMORY FOR PICTURES

by

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A DISSERTATION

Presented to the Department of Psychology
and the Graduate School of the University of Oregon
in partial fulfillment of the requirements
for the degree of
Doctor of Philosophy

August 1996

"The Effects of Implied Motion on Short-Term Memory for Pictures," a dissertation prepared by Donna M. McKeown in partial fulfillment of the requirements for the Doctor of Philosophy degree in the Department of Psychology. This dissertation has been approved and accepted by:

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An Abstract of the Dissertation of

Donna Marie McKeown for the degree of Doctor of Philosophy

in the Department of Psychology to be taken August 1996

Title: THE EFFECTS OF IMPLIED MOTION ON SHORT-TERM MEMORY FOR PICTURES

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This research examined the effects of motion expectations on memory for static pictures. The central hypothesis was that as implied motion for a picture increases, memory distortions will also increase in the direction of implied motion. A secondary hypothesis predicted that people will find pictures with increased implied motion more interesting than pictures with less implied motion.

Experiment 1 established a methodology for measuring memory distortion in art images. Performance on a "same-different" recognition task measured specific memory distortions for three pictures. In experiment 2, implied motion was varied by using combinations of pictorial devices that imply motion (action lines, posture, orientation, and multiple images). Memory distortion was tested using the methodology established in experiment 1. Participants also rated the amount of implied motion in each picture and level of interest for each picture. Results showed that the more motion devices were contained in a picture, the more memory was distorted in the direction of motion. In addition, as the number of motion devices increased, the amount of

motion and interest rated for the pictures increased. Interest and motion ratings were positively correlated. However, neither motion nor interest ratings were significantly related to performance on the memory distortion task using a correlational analysis across individual pictures.

Experiment 3 used a new set of line drawings of the human body. This set contained more realistic figures, fading action lines and fading multiple images. Participants found this set of pictures more interesting than the previous experiment, but there were no overall differences in motion ratings and memory distortions. However, for particular pictures, differences were found. Thus we can conclude that not all motion devices are alike, and depending on the way they are produced, they can influence perception and memory.

Overall, the results supported the hypothesis that as implied motion increases, memory distortions increase in pictures. Results also provided some evidence that the amount of implied motion in a picture may affect a person's level of interest for the picture. These findings contribute to the growing body of knowledge that expectations about motion affect basic perception and representation of visual pictures.

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ACKNOWLEDGMENTS

The author wishes to express sincere appreciation to Dr. Sarah Douglas, Dr. Douglas Hintzman and Dr. Margaret Sereno for their valuable input and assistance in the preparation of this manuscript. Special thanks goes to Dr. Jennifer Freyd for her guidance, support, and enthusiasm for this research. In addition, thanks goes to John McConnell for his patience with all my computer questions these many years, and to Dr. Kean Chew and Dr. Robert Mauro for their statistical advice.

DEDICATION

This dissertation is dedicated to my parents. Without their help and guidance, I would not have completed this dissertation. My mother taught me the value of an education, how to persevere, and how to always find the positive in the worst of times. My father taught me to think critically and to always ask questions. And from both of them I learned that a sense of humor will take you far in life.

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CHAPTER I

INTRODUCTION

For cognitive psychologists, exploring the capacity and limitations of human memory has been a central topic of study, and in recent years, a growing body of research has been devoted specifically to visual memory. An enormous amount of visual information is always available; however, the architecture of our visual system limits the amount of information we can process. At any moment, the retinal image captures only a small portion of space, yet rarely do we notice this lack of information. One reason we seldom perceive this lack of information is that the visual system has evolved ingenious ways of overcoming such limitations. As the eyes move across a scene, expectations direct our attention to important elements and help us anticipate future events. We may not always be aware that these processing limitations affect our perception, representation, and subsequent recall of visual information. The focus of this research is to explore how expectations influence the representation of visual information.

The role of schemas or organizing frameworks and their effects on memory has been examined extensively (e.g., Bartlett, 1932; Biederman et al., 1982; de Graef, Christiaens, & d'Ydewalle, 1990; Friedman, 1979; Verfaillie & d'Ydewalle, 1991; Bartlett (1932) defines a schema as an active organization of past experience. Research shows that schemas can affect basic object recognition at very early stages of processing (e.g., Biederman et al., 1982; de Graef et al., 1990; Friedman, 1979). If an object in a scene does not fit the overall context of the scene, then eye movements, perception and recall are all affected. Since objects in the world are usually situated in particular contexts, it makes sense that the perceptual system would capitalize on this natural constraint.

Attneave (1954) stated that the visual system takes advantage of the redundancies in information coming from the environment in order to reduce the overall processing load. Since sensory events are highly interdependent in both space and time, some parts of a particular image are highly predictable from other parts. These predictions depend on the previous influx of visual information (e.g., if we see an ear then we can predict that we will also see a nose, eyes, and a mouth, etc.). If in fact the visual system does make predictions based on prior knowledge, then we might expect predictions or expectations about motion to affect the perception of objects that are likely to move.

It has been argued that movement is a fundamental organizing principle of cognition (e.g., Gibson, 1966). Particular objects might be more likely to change positions or move in a particular context than other contexts. For example, a ball in midair might be more likely to change positions than a ball resting on a flat surface. Our experiences with such objects may be stored in memory in the form of a motion expectation. Motion expectations are probably influenced by information about animacy, directionality, time and path of motion (Freyd, 1983, 1987, 1993; Freyd & Finke, 1984; Freyd & Johnson, 1987; Freyd & Miller, 1993; Hubbard, 1995b; Hubbard & Bharucha, 1988; Verfaillie & d'Ydewalle, 1991). Information concerning forces such as gravity, friction, velocity, and acceleration are also likely to influence motion expectations (Bertamini, 1993; Finke, Freyd & Shyi, 1986; Freyd, 1987; Freyd & Finke, 1985; Freyd, Pantzer, & Cheng, 1988; Hubbard, 1995a, 1995b). When activated, a motion expectation may be so powerful that it might even influence our perception of static pictures. This research is specifically designed to explore the issues of how expectations about movement might affect the representation of static pictures.

Gombrich (1968) views perception as a process whereby we continually use schemas to make assumptions about the world and then modify those assumptions in light of experience. He states that artists often capitalize on these expectations or schemas in order to create the illusion of a three-dimensional canvas. It is possible that artists draw upon their knowledge about motion in the real world to activate an audience's implicit motion expectations. They may tap such motion expectations when they wish to add the illusion of movement to stationary works of art and this motion may add aesthetic value or interest to a picture. Dynamic expectations caused by implied motion may be a particular source of aesthetic excitement (Freyd, 1993).

These expectations about potential movement in a visual scene may affect how the scene is remembered. If one expects an object to move in a certain direction, that expectation may influence one to remember the object further along the anticipated path of motion. The present research will address how motion expectations may affect the perception and representation of static pictures.

One of the central questions of this research is whether or not the amount of implied motion in a picture affects the degree to which memory is distorted. If the amount of implied motion correlates with the amount of memory distortion, then we can predict that as activation for a motion expectation increases, memory distortion should also increase. Likewise, as activation for a motion expectation is inhibited, memory distortion is expected to decrease. Another possible outcome is that conscious judgments about motion may not be related to unconscious perceptual judgments. In this case, pictures judged as having more motion may not necessarily produce more memory distortion. Many symbolic ways of depicting motion may not necessarily imply motion in the same fashion as more natural ways of depicting motion. Symbolic ways of depicting motion may a large effect on conscious processing while having little or no effect on unconscious processing.

Another question this research seeks to address is whether or not implied motion affects interest in a picture. Level of interest for each picture will also be measured. A secondary purpose of this research will be to explore possible relationships between expectation, memory distortion, and aesthetic excitement. By measuring how much motion is seen, the memory distortion produced, and how interesting participants find each picture, the underlying relationships may be revealed.

CHAPTER II LITERATURE REVIEW

The Role of Expectation in Picture Perception

When we view a static picture, how is it different from viewing a natural visual scene? One immediate difference is that the picture is 2-dimensional and non-moving, whereas the natural scene is 3-dimensional and usually contains some motion and opportunities for multiple viewpoints. However, as one views the 3-dimensional spatial world, the retinal image is actually 2-dimensional (Helmholtz, 1995; Humphreys & Bruce, 1989) and is used to construct a 3-dimensional representation of the outer world using additional factors such as retinal disparity and motion parallax, etc. Thus, all depth effects in visual experience must be created by our neural networks (Arnheim, 1974). This practice happens automatically. In addition, as moving binocular creatures, we also have supplementary cues which we can use to add information to each incoming 2-dimensional retinal image pattern. Some of these include binocular disparity, motion parallax, and convergence. When viewing a 2-dimensional picture which implies depth, these additional cues conflict with implied depth information. With a 3-dimensional scene, we can move through the space and gather multiple viewpoints. With the 2-dimensional picture, we are limited to only one viewpoint. However, perception of both real scenes and pictorial scenes begins with a 2-dimensional retinal image. Due to this basic similarity, processing static pictures is likely to be very similar to processing natural 3-dimensional scenes.

Gombrich (1968) states that picture representations are compositions of pictorial schemas, which are culturally specific and do not possess object likenesses in the environment. Pictures, as a rule, lack some pieces of information about referents, therefore the viewer must generate and test hypotheses regarding the meaning of a picture before he or she can discover the correspondence between the pictorial and the real image. Thus, picture perception involves schema and correction. We constantly use our schemas to anticipate aspects of the picture and then correct the schemas in light of incoming information to the perceptual system. Gombrich (1982) reminds us that visual perception is a process in time and often occurs very slowly. We have to hold the bits and pieces of each glance together into one coherent representation. Gombrich asserts that if perception did not occur as a process in time, static images would not elicit memories and anticipations of movement. This perception of motion relates to our difficulties holding the representation of all of the elements in our mind as our eyes scan the visual field. Much of what allows us to perceive a picture in its own context lies in the observer and not in the light from the picture.

Since acuity drops off tremendously as one moves away from the fovea, only a small portion of the retinal image is encoded (Hochberg, 1978). The perceptual system must integrate a number of separate glances together into one single coherent picture. To do this, it must encode and store some representation of the scene or picture. Hochberg (1978) calls this representation a schema and defines it as "a structure by which we encode (and can generate or reconstruct) more information than we can retain from individual items" (p. 190). This schema also provides a guiding and anticipating mechanism for what might happen next in the scene. The schema guides the next eye movement to places in the picture where we might test hypotheses or expectations. From Hochberg's and Gombrich's viewpoints, schemas play an integral role in picture perception.

Arnheim (1988) sees the process of picture perception as dynamic and active. He argues that the perceived form, not the material making up the art object, carries visual dynamics which overrule our knowledge about the physical medium. When we perceive objects, we may do more than merely record the shapes, but rather, we dynamically attempt to grasp the structure or event underlying the appearance of the objects (Arnheim, 1974). He states that forms create certain expectations which may influence our perception of the object and subsequent representation. We perceive constellations of forces that are generated from the picture (Arnheim, 1980). However, there is no equivalent of these "forces" or perceptual dynamics in the physical world. These are "forces" which are solely the construction of our nervous system. Due to the flatness of a picture, successful depiction requires such things as portraying objects from their most characteristic aspect or canonical form (Palmer, Rosch, & Chase, 1981). As Arnheim asserts, the artist tries to create experiences. The artist is not trying to recreate the 3-dimensional objects which might possibly give rise to the image, but only the experience which may arise from the image of those objects.

Haber (1980) argues that the pictorial world has a dual reality. On the one hand, we perceive pictures as flat because of head movements and binocular disparity that tell us that the surface lies on one plane (Haber, 1980). On the other hand, we also perceive the picture as 3-dimensional because the momentary retinal patterns to either eye alone provided by the picture are the same as those reflected from the actual scene being represented. Hochberg

(1980) and others suggest that this conflict between the 2-dimensional aspects of a picture and its 3-dimensional perceptual implications might be a source of aesthetic excitement. Likewise, Freyd (1993) has proposed a theory which explains one source of aesthetic excitement that results from conflicts between the retinal image and the underlying representation of the picture.

Freyd (1993, 1987) defines a new class of mental representations in which time is inextricably embedded. These representations are called dynamic because they reflect active anticipation of the immediate future. In this view, the mind does not passively record events taking place in the world, but dynamically organizes and extrapolates forward to future events. Freyd (1983, 1993) asserts that even static pictures can have dynamic qualities that reflect real world constraints. Freyd (1993) proposes that these dynamic pictures can generate aesthetic excitement by producing underlying conflicts between the mental representation and the retinal image. First, a viewer looks at one particular location which induces the representation of movement. The eyes then scan to another part of the picture, as memory for the “moving” part of the picture is unconsciously distorted in a particular direction. Upon returning to the first part of the picture, the viewer now experiences that it is different than he or she remembered. The viewer finds this discrepancy between the remembered and perceived position interesting. The viewer's eyes then scan to a different part of the picture and back again to this “distorted” area, and the process is repeated. These processes are thought to occur without conscious awareness. It may be that these small discrepancies between the actual image and the image stored in one's mind create excitement and interest for the work of art (Freyd, 1993). This theory predicts that pictures with dynamic qualities will be seen as more interesting to viewers than pictures without dynamic qualities.

Research on Picture Schemas

Common ideas among schema theorists are that schemas (a) provide a mental structure for efficient perception and memory for events, (b) generate expectations relevant to a specific event, (c) selectively retain or alter event representations, and (d) are constructed through experience with the world and thus change organization and representation with experience (G. S. Goodman, 1980).

The initial impression of a picture may set up a schema which can influence later perception of the picture (Bruner & Potter, 1964). In a classic study, Bruner and Potter (1964) demonstrated that exposure to an unfocused picture interfered with later recognition of that picture. Adult observers were shown color pictures of common objects slowly coming into focus. The amount of blurriness (degree of focus) at which each picture was initially projected was manipulated across participants. When identical pictures were presented more out of focus (more blurry) initially, participants took longer to recognize the picture content than identical pictures presented less out of focus. The longer the exposure of the blurry image, and the more blurry the image, the greater the effect. Their explanation of this effect is that it may take longer to invalidate an incorrect interpretation than it would to establish a first interpretation. Thus, perception can be influenced by expectations.

Biederman, Mezzanotte, and Rabinowitz (1982) found that schemas or expectations about the relationships between objects in a scene can affect low level bottom-up processing. Individuals searched for a target object in a visual scene displayed for 150 milliseconds. When an object was positioned in an expected location, in an appropriate scene, it was more accurately recognized. If the object was inconsistent with expectations about the appropriate context or position, then recognition was impaired. At the very beginning of visual processing, our expectations about objects and their relationships to other objects in scenes can affect our perception.

More evidence that schemas affect object perception has recently been found by looking at eye movements. De Graef, Christiaens, and d'Ydewalle (1990) noted that the nature of the tasks used in previous studies of schemas might have encouraged participants to use contextual knowledge deliberately. For this reason, they had participants simply count the number of objects in a scene instead of a task which might encourage activation of context-specific knowledge. They measured the amount of time people spent looking at objects which were consistent with the context verses those that were inconsistent with the context. They found evidence that people will gaze longer at objects which are inconsistent (e. g., not in a normal position) with the particular context of a scene. These longer looking times occur during the first eye fixation. Once again, evidence supports the idea that schemas affect early visual processing since these looking time differences were present immediately.

Friedman (1979) also demonstrated the effects of context on recognition memory and eye movements. Participants relied on the context of a scene to detect changes in the pictures (Friedman, 1979). If an unexpected object was in the picture, people looked at it twice as long as they looked at an expected object. Participants also recognized only changes made to unexpected objects. If expected objects were deleted or replaced with different expected objects, the changes usually went unnoticed. Thus the context of the pictures guides eye movement patterns in addition to recognition memory for the details of a visual scene. Friedman presents this as evidence for the idea that the local visual details are not encoded unless they are unusual or unexpected. What does get encoded seems to be information which distinguishes a particular event from others of the same general class.

Evidence suggests that memory for pictures might also be organized around action schemas. G. S. Goodman (1980) found that objects which were highly relevant to a particular action were better recalled than objects of low relevance when participants viewed scenes which depicted a central action. Given that their task was to recognize the presence of particular actions or objects from each picture, one might also argue that the task encouraged this type of organization. When participants were asked to recognize the appearance of the objects, those objects highly relevant to the action were less accurately recognized than objects of low relevance. G. S. Goodman (1980) hypothesizes that the action schema serves as a retrieval framework for object presence but not for the appearance of the objects. Appearance of objects with high relevance would not be retained because prototypical default values for these objects would tend to prevail. Since objects of low relevance are not connected with the action, no default appearance values exist and new representations must be established. Because the action schema is not triggered, their presence is not recalled as well as prototypical items. However, when objects of low relevance to the action schema are recalled, appearance information is recalled in more detail since they are generated from single-item representations. Similar to previous findings, objects which are expected do not get as much processing or attention as unexpected objects because they can fit into the schema structure; however, the action schema can help retrieve expected objects which are important to the action being depicted.

Intraub and Richardson (1989) have shown that memory for photographs can be distorted by expectation. In their studies, people were shown photographs of various objects and they were asked to draw the pictures in a recall test. Participants tended to draw the photographs with information that was not in the original picture and usually extended the scene beyond the boundary of the picture. When given a recognition test that contained original photographs and photographs of the same scene but with extended borders, participants tended to say they had seen the photographs with falsely extended borders, and they often mentioned that original pictures actually seemed "closer up." Intraub and Richardson (1989) demonstrated that effects of expectation on memory can be powerful and predictable. Photographs were remembered with extended boundaries, including what would be expected just outside of the camera's view.

Intraub, Bender, and Mangels (1992) also replicated these results and were able to rule out the hypothesis that participants were merely completing objects since boundary extension occurred when objects were not cut off by the edge of the photograph. They also found that when participants' memory was tested immediately after presentation, close, medium and wide-angle view photographs all produced boundary extension. However, when there was a two day delay from presentation to test, participants tended to remember wide-angle views as slightly closer up instead of farther away (showing a small amount of boundary restriction). This suggests that a prototypical view of the scene may influence memory over the long term. In the short term, our expectations about what lies outside of the camera's view may embellish what we remember.

Even when participants are warned ahead of time about the boundary extension distortion or simply told how they would be tested, the effect is reduced, but never eliminated (Intraub & Bodamer, 1993). Intraub and her colleagues have proposed a perceptual schema hypothesis (Intraub et al., 1992; Intraub & Bodamer, 1993; Intraub & Richardson, 1989). The perceptual schema is a representation of what most likely lies beyond the boundary of a picture. They compare it to a similar schema or mental structure proposed by Hochberg explaining how we integrate successive views during visual perception (e.g., Hochberg, 1980, 1981). Since we cannot focus on all parts of a picture at once, we must integrate different views of the same scene over time. The mental structure or schema activates expectations of the most likely arrangement of objects in a scene as successive views are captured and stored. Intraub and her colleagues propose that when we view a static picture, the same perceptual forces are involved as when we view real world scenes (Intraub & Bodamer, 1993). In the real world, there would be more to the scene than what was revealed in the photograph, so a person would naturally expect the scene to extend beyond the given view and their mental structure would reflect this expectation. Intraub states that the expectation of a scene to continue is so powerful that it actually becomes part of the mental representation of the picture (Intraub & Bodamer, 1993). Thus, simple picture perception is influenced by the expectation of what the next eye movement outside the picture's boundaries might reveal regardless of the content of the picture.

<u>Dynamic Representation of Moving Displays</u>

A person's memory for a moving object is often distorted forward in time along its path of motion. When individuals observe successive orientations of a rotating object, their memory for the final position tends to be displaced forward in the plane of rotation (Freyd & Finke, 1984). This phenomena has been termed "Representational Momentum." Freyd's interpretation of representational momentum suggests that individuals experience a memory distortion in anticipation of future movement (Freyd, 1987; Freyd & Finke, 1984; Freyd, Kelly, & DeKay, 1990).

In subsequent studies, representational momentum has been shown to be influenced by many different factors. If an object moves faster, then the memory distortion is greater (Freyd & Finke, 1985) If an object is accelerating, then the distortion also increases (Finke et al., 1986). If the person is given more time from presentation to recognition, the distortion grows in a lawful manner (Freyd & Johnson, 1987) until around 300 milliseconds where it begins to decrease. If the shape of the items presented changes radically, then the memory distortioneffect disappears (Kelly & Freyd, 1987) suggesting that this distortion is highly related to object perception. The effect is not limited to rotational motion and has been found for horizontal and continuous motion (Faust, 1990), vertical motion (Hubbard & Bharucha, 1988), oblique (diagonal) motion (Hubbard, 1990), spiral motion (Freyd & Jones, 1994) and circular motion (Freyd & Miller, 1993).

Hubbard (1995) has proposed that both boundary extension and representational momentum effects may be special cases of one general extrapolation process. This process distorts memory in directions that concur with past experience. He argues that there are many similarities between the two phenomena. Just as boundary extension extrapolates to the next likely elements lying outside a scene's boundary, representational momentum extrapolates to the next likely position just beyond the object's actual position. Both effects are dynamic and automatic and decline rapidly over a short period of time.

In a review of representational momentum, Hubbard (1995) summarizes the factors which influence direction and size of the representational momentum memory shift. Stimulus characteristics such as direction and velocity of the object affect the shift. The implied dynamics and environmental invariants such as gravity and friction also affect the shift. Memory averaging, a bias to remember a previous location of the object, can influence distortions. In addition, the observer's expectations about future motion and interactions with an objects' surrounding context can affect the size and direction of memory distortions.

According to Hubbard (1995), the size and direction of representational momentum effects are consistent with conceptual knowledge of the objects and the context in which the objects are embedded. For example, Hubbard (1993a) looked specifically at the effects of surrounding context on the memory distortions produced in a representational momentum experiment. He embedded a rectangle inside a larger surrounding square which would move in the same direction as the smaller target rectangle or in the opposite direction. When both the rectangle and surrounding square frame moved in the same direction, the memory distortion was greater than when they moved in the opposite direction. The surrounding context influenced the magnitude and direction of representational momentum.

Hubbard and Bharucha (1988) found that expectations about moving targets can also affect representational momentum. If a target typically ricochets off of a barrier, then the effect of representation momentum is decreased near the point where the target bounces off the barrier. If the target is shown to pass through the barrier, then participants always show a robust forward memory shift. Hubbard and Bharucha (1988) conclude that a high-level cognitive mechanism is capable of predicting direction of movement, and this mechanism is involved in the effect of representational momentum. Again, we have evidence that higher level expectations about objects and their motion can influence short-term memory.

Verfaillie and d'Ydewalle (1991) also found that representational momentum is affected by higher level expectations. A motion history is derived from a moving object, and this history affects representational momentum. For instance, when participants view a rectangle that oscillates from a clockwise to counterclockwise direction, the amount of memory distortion is affected by the point where the individuals' memory is tested. If the participants' memory is probed where the rectangle is about to change direction, forward memory distortion is significantly less than if memory is probed during a point where the motion history of the rectangle predicts continuous forward movement. Verfaillie and d'Ydewalle (1991) propose an underlying structure for the perceived events which contains past motion history and affects subsequent perception and memory. Thus, expectations about the path of motion affect memory for position.

There may be many contributing factors to representational momentum. For example, knowledge about the object in motion can affect the magnitude of the representational momentum distortion. Freyd and Miller (1993) found that a bird-like object showed more representational momentum when it was seen to move facing forward rather than facing backwards. Thus, knowledge about the typical motion of creatures and directionality affects how we perceive and represent motion.

In another example, knowledge about an objects' typical motion was shown to influence perception and memory (Reed & Vinson, in press). Two groups of participants were shown the same stimulus in a typical representational momentum experiment, but one group was told that the object was a "steeple" and the other group was told that the object was a "rocket." The "rocket" group produced more of a representational momentum effect than the "steeple" group. Reed and Vinson (in press) concluded that the size of the representational momentum effect is influenced by conceptions about real world object motion. If two objects have similar features in terms of pointiness, but one is drawn as a steeple and the other is drawn as a rocket, the rocket produces more representational momentum (Reed & Vinson, in press). Reed and Vinson (in press) argue that conceptual information from long-term memory about an object's typical motion is recalled and influences the object's short-term memory representation. Thus, the nature of representational momentum depends on knowledge of both typical motions of particular objects and general regularities of motion. These general and specific expectations about motion interact to determine memory for the position of an object.

Freyd and Jones (1994) found that people misremember the motion of a ball exiting a spiral tube in a way that differs from the behavior of physical motion in the world. People show more forward memory shift for the spiral exit path of the ball rather than the physically correct straight exit path. Conceptual knowledge about centripetal forces (knowledge that the ball should follow a straight path when the forces of the spiral tube are no longer exerted) had very little effect on perceptual judgment. Knowledge of typical motion (that objects typically continue in their same path of motion) had more effect on the perceptual judgment. In contrast, when people were asked where the ball would go after exiting the spiral tube, the majority said it will follow a straight path, demonstrating that conceptual knowledge had a greater effect on conscious judgments. These findings demonstrate a dichotomy between explicit conceptual judgments and implicit perceptual judgments.

As more evidence accumulates about representational momentum, the effect appears to be specific to anticipatory computations of objects in motion (Brehaut & Tipper, 1996). Original proposals (e. g., Freyd, 1987, 1993) speculated that the effect may be a more general mechanism for the representation of any changing dimension since it was found present in the auditory domain (Freyd, Kelly & DeKay, 1990; Hubbard, 1995c, 1993b). However, Brehaut and Tipper (1996) recently found no evidence for a forward memory distortion on judgments of luminance change. Future studies may find that other changing dimensions in addition to luminance also do not show the representational momentum effect.

Dynamic Representation of Static Displays

Using a perceptual judgment task, Werner and Wapner (1954) demonstrated dynamic qualities in static stimuli. They showed people pictures with dynamic directional qualities (triangles and profiles of human faces). These pictures were shown slightly to the left or right of a central axis, and participants were asked to place the pictures directly on the center axis. Displacement errors were measured. The direction that the stimuli faced had a significant effect on participants' judgments. If the stimulus was facing to the right, people tended to displace the central axis to the right. If the stimulus was facing to the left, they tended to displace the central axis to the left. In a second study, reversible figures that looked like two birds facing to the left or two airplanes facing to the right were used. Half of the participants were told that the picture was of birds flying and the other half of the participants were told that they were two airplanes flying. More people in the bird group displaced the central axis to the left than to the right, while more people in the airplane group displaced the central axis to the right. These studies provide more evidence that pictures with dynamic directional qualities can influence perceptual judgments. Furthermore, the same stimulus can elicit different perceptual judgments depending on which direction people expect it to face.

Babcock and Freyd (1988) found that from a static sample of handwriting, people are able to explicitly and implicitly detect and use information about the way characters are produced. They exposed two groups of people to the same novel set of characters drawn in different ways. For the implicit task, each group had to produce the same characters. Babcock and Freyd (1988) found that depending on drawing method of exposure, productions of the characters differed significantly for the two groups. For the explicit detection task, participants were asked to speculate on the drawing method used for each character, and there were significant differences in responses for the two groups. Successful use of dynamic information did not depend on conscious awareness. Implicit and explicit performance were not at all correlated with each other. Thus a person could correctly extract and use the dynamic information of how characters were created without any conscious knowledge.

Human observers also have expectations about static displays that have implied dynamics (Freyd et al., 1988). For example, Freyd, Pantzer, and Cheng (1988) displayed a hanging plant or a plant on a stand with a window in the background. The plant was then shown in the same position suspended without support. Immediately following this display, the plant was shown without support in either the same or a different position (which could be displaced downward or upward). Memory for the position of the plant was shown to be displaced downward. Participants seemed to anticipate that the plant would fall and their memory for the position of the plant compensates by remembering the plant as being further down than the original position. In this case, expectations about gravity affected short-term memory for position.

Experiments suggest that observers mentally represent the movement implied in frozen-action photographs (Freyd, 1983). Participants were shown frozen-action photographs and then their memory for the scenes was tested by showing pairs of before and after pictures taken from the same scenes at earlier or later times. After viewing an initial photograph presented using a tachistoscope, participants were presented a second photograph. Participants had to decide if the second photograph was the same or different from the first. The pairs were viewed in either real world order (the second photograph was taken later in time) or backward order (the second photograph was taken earlier in time). Reaction times for correct responses were greater when the pairs were presented in real world order. This increased reaction time implies that the differentiation is more difficult to make when objects move forward in the direction of implied motion. In other words, more time was needed to make the discrimination when comparing the pictures that are in forward than in backward order. Thus, the mind appears to extract information about movement from a photograph, and continue to process this information, perhaps in anticipation of future movement. These findings support Freyd's (1983) hypothesis that mental representations are dynamic. In addition, these findings support the idea that motion expectations influence perceptual judgments.

Futterweit and Beilin (1994) replicated Freyd's (1983) study with children to show that motion extrapolation from static photographs is as prevalent among 8 and 10-year-olds as it with adults. They found that adults and children make more errors on the forward test positions than the backward test positions (reaction times were not reported since the only major finding was that reaction times get faster with age). They also found that in conditions where one should not expect movement (a person lying on the ground in a sideways position), there is no memory bias in any direction (Futterweit & Beilin, 1994). This provides more evidence that motion expectations play a part in the effect of forward memory biases. In the case where a motion expectation presumably should not be activated (since there are no cues such as a leg posture to indicate motion), no directional memory distortion for static photographs were found.

Bertamini (1993) found forward memory distortions for static displays of a ball on an inclined plane. The original display was shown followed by a test display. The task was to judge whether the test display was the same or different from the original display. The test display could show the ball further up the hill, in the same position, or further down the hill. Participants were more likely to respond that the test display with the ball further down the hill looked the same as the original when the incline of the hill was 60 degrees. This forward memory distortion reflects the expectation that in the real world a ball would most likely continue rolling down the hill. As the slope of the inclined plane became steeper, the forward memory distortion increased. In addition, there was a lawful effect of time in accordance with Freyd and Johnson's (1987) findings. As the retention interval increased up to 300 milliseconds, the memory distortion also increases linearly. After 300 milliseconds, the effect decreased and then leveled off. Thus from a purely static display, memory distortions were found. The effects of gravity and the slope of the plane clearly influenced the underlying internal representations. It is likely that an expectation about movement in a particular direction created these memory distortions.

Research demonstrates that static forms and shapes can also induce memory distortions (Freyd, 1990). In a study conducted by Freyd and Pantzer (1995), when participants viewed a series of pictures such as arrows, airplanes or fish, the arrows produced significant memory shifts in the direction which they pointed. These shapes were displayed on a computer screen followed by a retention interval and then a test image. Participants were asked to judge whether the test image was the same as or different from the original image. Neither the fish nor the airplane produced significant memory distortions. These findings provide some support for Freyd and Pantzer's (1995) hypothesis that the representation of shapes with a strong directionality component can be distorted in the direction that the pattern appears to point. Thus, expectations concerning highly directional forms may also influence their representation.

Additional studies have demonstrated that triangles can also produce memory distortions in a predictable direction (Freyd, 1990). In a series of studies conducted by Freyd and Pantzer (1995), memory distortions occurred in the direction that the triangles pointed. When asked, participants responded that the triangles were in the same position when they actually were moved slightly forward (i. e., in the same direction that they pointed) more often than when the triangles were moved backward (the opposite direction of where they pointed). The amount of memory shift was also correlated with the degree of pointiness or angle of the triangles. As pointiness increased (i.e. angle decreased), participants showed more shift in memory for the position of the triangle in the direction that the triangle pointed.

Implied motion in a picture may also affect recall memory. Trotto and Tracy (1994) found that pictures with implied motion were better recalled than pictures with no implied motion when initial presentation of each picture was brief (380 milliseconds). When presentation was longer (5 seconds), this recall advantage disappeared. In addition, pictures with implied motion were more namable than pictures with no implied motion, but only for brief viewing times. Trotto and Tracy (1994) conclude that implied motion enhances the likelihood of recall at short time intervals and they also suggest that information processing models such as dual-coding theory (Paivio, 1990) and others need to incorporate the interaction of motion cues on visual processing.

Methods of Depicting Movement

Studies exploring the perception of motion in static pictures suggest that there are many different ways to depict movement. Friedman and Stevenson (1980) examined the ways in which motion has been depicted across a wide variety of picture types. They gathered 25 paintings, photographs, caricatures, cartoons and diagrams that contained information about movement from each of 13 cultural and artistic periods, and did a content analysis on the use of different types of pictorial movement indicators. From this analysis, Friedman and Stevenson (1980) argue that there may be a continuum of correspondence to the environment for different pictorial devices that indicate movement (Friedman & Stevenson, 1980). At one end of the continuum, the pictorial devices are recognized spontaneously and show close correspondence with the environment. An example from this end of the continuum is the use of posture information to convey motion. These devices are more natural and may be more easily understood since the visual system may process them automatically. At the other end of the continuum, pictorial devices are symbolic and arbitrary and therefore learned by association. Examples from this end of the continuum are action lines or multiple images. These devices may not be understood to represent motion without prior exposure to their symbolic meaning.

Across the 13 cultural periods analyzed, the most commonly used pictorial device to indicate motion was postural deviation from a resting position such as arms raised to indicate hunting (Friedman & Stevenson, 1980). In fact, almost every picture Friedman and Stevenson (1980) surveyed included some postural information to depict movement. Most pictures also used contextual information to convey movement such as a weapon held in addition to an arm raised to indicate hunting. In a review of many experiments, Friedman and Stevenson (1980) found that the effectiveness of pictorial devices for portraying movement varied with age group. In classifying pictures as representing movement, the most effective cue for young children was postural deviation from a resting position. More symbolic devices such as action lines and multiple images were poor indicators of motion to younger children and people of non-European cultures. Differences found cross-culturally and developmentally in pictorial understanding of movement suggest that pictorial devices which correspond to the environment are more easily understood than motion devices which show less correspondence to the environment. More symbolic devices may be less effective in conveying motion since their symbolic connections to motion have to be learned by association.

Newton (1984) found that pictorial devices which do not directly mimic the environment (e.g. more symbolic devices) vary in their effectiveness across different age groups, Older children are more likely to perceive direction of motion and implied speed using devices with no direct correspondence to the environment than younger children. Arrows were more effective at implying direction of motion while "exhaust gases" and multiple lines were more effective conveying speed for older children. In addition, increasing the size or number of devices increased the perception of speed. Younger children were less likely to perceive speed and directional differences.

Russolillo (1986) studied whether or not the perception of motion in pictures was related to intelligence. He used different types of pictorial motion devices: (a) posture [changes in body posture which imply movement], (b) multiple images [multiple body parts used to depict successive positions of a real movement], (c) cartoon cues [such as trailing action lines], and (d) controls [pictures with presumably no implied motion]. Children of various intelligence levels were asked to say which pictures showed motion. Learning disabled children were able to successfully perceive pictures with motion cues as depicting more motion than still pictures (Russolillo, 1986). Those cues that were more isomorphic with the real world (i. e. posture), were more easily identified. Russolillo's (1986) study also suggests that cartoon cues may require more learning than devices which have a closer resemblance to real world motion. Thus, more natural motion devices such as posture might be more closely associated with motion than symbolic devices such as action lines.

Brooks (1977) and others argue that since many of these pictorial devices do not exist in the real world, they have to be learned (Friedman & Stevenson, 1980). Brooks (1977) found that the presence of action lines improved recall memory for older students (ninth graders) but not younger students. Each age level was divided into two groups: one group saw pictures with action lines and the other group saw identical pictures without the action lines. Each picture contained two common objects interacting. Younger students (second and sixth graders) showed no difference in recall for either kind of picture. Older students' recall for pictures without action lines was the same as younger students' recall; however, older students performed better than younger students on pictures with action lines. Brooks (1977) concludes that action lines enhanced comprehension of the pictures for older students.

These motion expectations might be highly specific to the particular context of the picture in consideration. For instance, Carello, Rosenblum, and Grosofsky (1986) found that certain pictorial devices have different effects on what type of action they are depicting. In this study, they looked at five different pictorial devices that were said to show movement (Friedman & Stevenson, 1980). Figure 1 shows the pictures used. Carello et al. (1986) created all possible combinations of these motion metaphors and then asked people to rate how well each of the pictures depicted "moving." Another group was asked to rate how well each of the pictures depicted "running." The most effective device depended on which action (e. g., moving verses running) the person was rating. Devices that highlighted that particular action (such as posture in the case of running) were more effective, regardless of whether or not the device was natural (posture) or more symbolic (such as action lines). In either case, posture was always the best indicator of running or moving. As the number of devices used in a picture increased, the amount of rated motion also increased. Of course, all of the findings are based on the subjective ratings of people viewing the pictures. As has been discovered in the past, there is often a breakdown between what is consciously expressed and what is perceptually found (Shanon, 1976).

Goals of this Research

Expectations actively influence visual perception and representation. This research seeks to examine one type of expectation, namely that which stores information about motion. The first goal of this research is to determine what aspects of a picture might cause implied motion. Participants will view a variety of pictures and rate the amount of

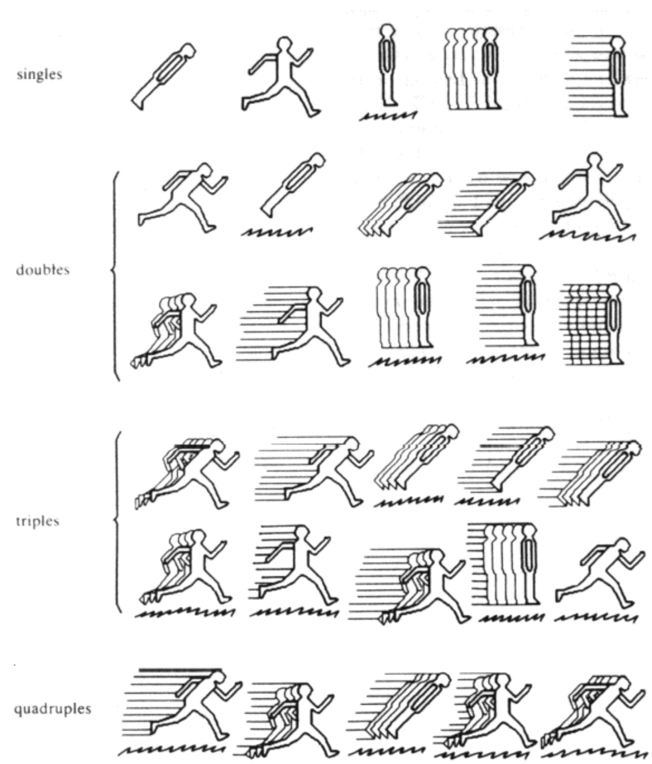


Figure 1. The figures used by Carello et al. (1986). The first row shows single devices of orientation, posture, ground plane, multiple images, and action lines. Rows 2 & 3 show double combinations, followed by rows 3 & 4 showing triple

combinations and then quadruple combinations of the pictorial devices. The standard (not shown) was obtained by straightening the first single, and the complete (not shown) can be obtained by adding action lines to the last quadruple.

implied motion in each. By identifying which pictures cause an increased rating of implied motion, we may be able to identify which pictorial devices might trigger a motion expectation. It is predicted that posture information will cause the implied motion rating to increase since it has been shown to be a very effective motion pictorial device for all age groups in the past. Also, as the number of motion devices are increased in a picture, in accordance with Carello et al. (1986)'s findings, perceived motion is also expected to increase.

The second goal of this research is to measure the amount of memory distortion found in each picture and compare it to the implied motion rating. The prediction is that as the memory distortions produced by the picture increase, the ratings of implied motion will also increase. As we trigger a motion expectation, the underlying representation of the picture may change in anticipation of future motion. Memory for position of an object that triggers a motion expectation may be distorted in the direction of expected motion. In order to test this prediction, a same-different recognition test will be used to determine if there are any memory distortions of position for each picture. Memory distortion for each picture will then be compared to the motion rating for each picture. Given findings that performance on explicit and implicit tasks can deviate (e.g., Babcock & Freyd, 1988; Freyd & Jones, 1994; Shanon, 1976), another possible outcome is that motion ratings will not be related to memory distortion. The motion rating task involves more conscious processing that may be influenced by different factors than the implicit memory distortion recognition task.

The third goal of this research is to test if interest in pictures is related to either the implied motion ratings or the memory distortions found. As implied motion ratings increase, level of interest for the pictures is also expected to increase. Likewise, as the level of memory distortion increases, interest ratings for the pictures are expected to increase. Thus, all three measures should be positively correlated with each other.

CHAPTER III

EXPERIMENT 1: A METHOD FOR TESTING MEMORY DISTORTION

The first step in discovering whether or not motion expectations affect short-term memory is to establish a methodology to measure memory distortions for pictures. The present studies adopted procedures similar to those used by McKeown and Freyd (1992). They found evidence that some images with implied motion indeed produce perceptual differences in the form of small memory distortions. They used a same-different recognition task to test short-term memory. Participants were shown a black and white digital image of a work of art, followed by a test image that could be the same as or different from the original. The images were edited in two directions along a path that was appropriate for the context of the picture. Participants judged whether or not the test image was the same as or different from the originally presented work of art. By looking at the pattern of errors made in response to the different test positions, one can determine whether a predictable memory distortion exists for a particular image.

Method

Participants

Sixteen University of Oregon undergraduate students (ten females and six males) were given course credit for their participation.

Stimuli

Prior to this experiment, a different group of participants (14 graduate students in psychology) were shown 17 different works of art. They were asked whether or not they saw any movement in each picture and what direction this possible movement might occur. Three paintings and drawings were selected from the group of 17 images on the basis that there was almost unanimous agreement on the presence and direction of movement. The works of art were digitally scanned into greyscale format on the computer and edited to create a set of different test positions for each picture. Figure 2 shows the pictures displayed in Experiment 1.

Test positions were determined according to the context of the particular picture. For instance, one picture shows some paint dripping (the image “Brush” in Figure 2) and the test positions show the drip elongated or shortened vertically. For "Pacing", the small man on the right was moved backwards and forwards. For "Drip", a dripping substance was elongated or shortened vertically. Including the original position, there were a total of seven test positions for each picture. The test positions were one, two and three millimeters away from the original position in each direction.

Procedure

Participants were all tested individually in a room lit by a halogen light. To ensure computer accuracy, the timing of the screen presentation was verified by filming the monitor with a time code generator. Figure 3 shows the order of presentation for each trial. Participants initiated each trial by pushing the space bar key on the keyboard. The original work of art (17.8 cm

"Pacing"

"Drip"

"Brush"

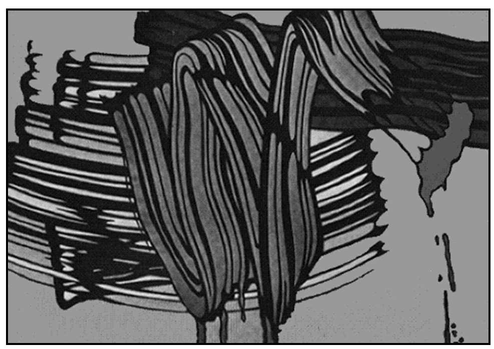


Figure 2. The pictures used in Experiment 1.

in height) was presented on a Macintosh IIci for two seconds (visual angle was approximately 7.2 degrees) with participants sitting approximately 79 centimeters from the screen. Immediately afterwards, a small black cross (cue) appeared for 500 milliseconds in order to direct attention to the area which was edited. After this cue, the original work was displayed again for 250 milliseconds. A 250 millisecond retention interval follows. The final display in each trial was one of seven possible conditions: (a) the original picture, (b) an edited picture 1, 2, or 3 mm in the direction of implied motion, or (c) an edited picture 1, 2, or 3 mm in the opposite direction. Participants were

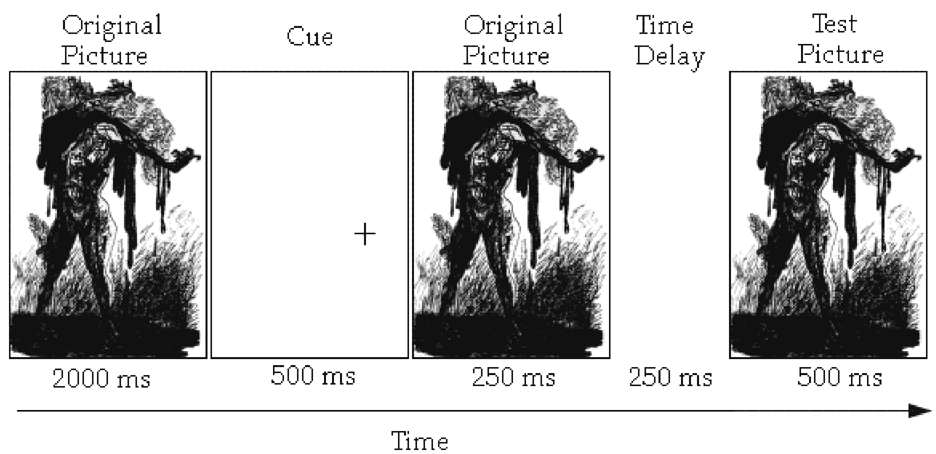


Figure 3. The order of presentation for each trial in the memory distortion task in Experiment 1.

asked to judge whether the test pictures were the "same" as or "different" from the original pictures. After 10 practice trials, participants consecutively viewed a total of 168 trials. Each test position for each picture was shown a total of 8 times. Each picture and its test positions were randomly ordered throughout the experiment.

Results

The results of this study indicated that some images can indeed produce memory asymmetries. For each picture, a weighted mean was calculated to estimate the overall shift. The weighted mean is calculated by taking the sum of the products of the proportion of "same" responses and test positions and dividing it by the sum of the proportion "same" responses. Weighted means have been shown to be a more conservative measure of memory shift than using linear regression (Faust, 1990). Overall, there was no significant memory shift as measured by weighted means [$F(1, 15) = .002$, $p = .97$]. However, Figure 4 shows the significant difference among the three pictures [$F(2, 30) = 3.63$, $p = .039$].

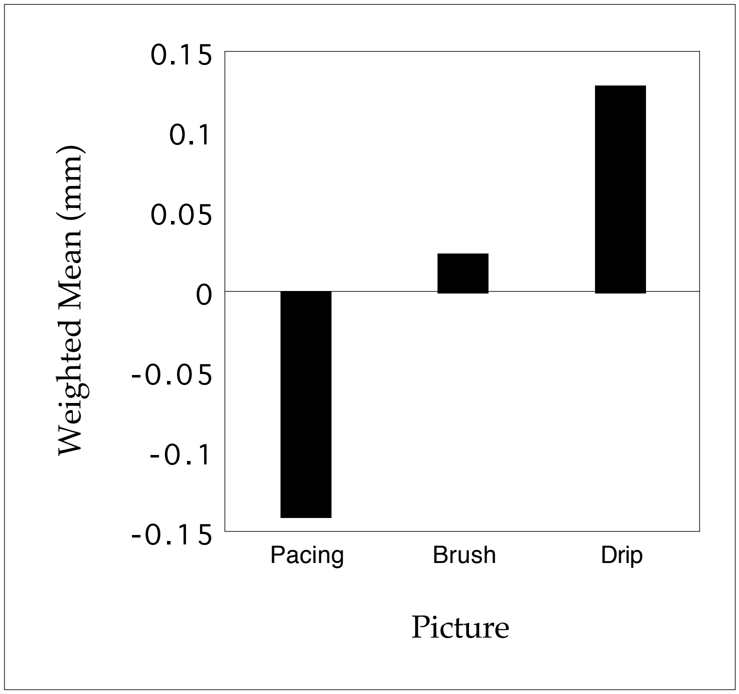


Figure 4. The weighted means for each picture in Experiment 1. Only Pacing showed a significant memory distortion [$t(15) = -2.71$, $p = .016$].

The weighted means were -.15 mm for Pacing [$t(15) = -2.71$, $p = .016$], .13 mm for Drip [$t(15) = 1.50$, $p = .15$] and .02 mm for Brush [$t(15) = .328$, $p = .75$]. Only Pacing showed a significant memory shift using weighted means, and it was in the opposite direction of predicted motion. Since the error rate was below 20% in the tails of the distributions (see Figure 5), the weighted mean may be easily skewed by outliers in the tails since responses are weighted proportionally by test position. Therefore, difference scores between the forward and backward test positions were also used to test for distortions. Significant memory distortions were found for Drip [$t(15) = 2.43$, $p = .028$] and

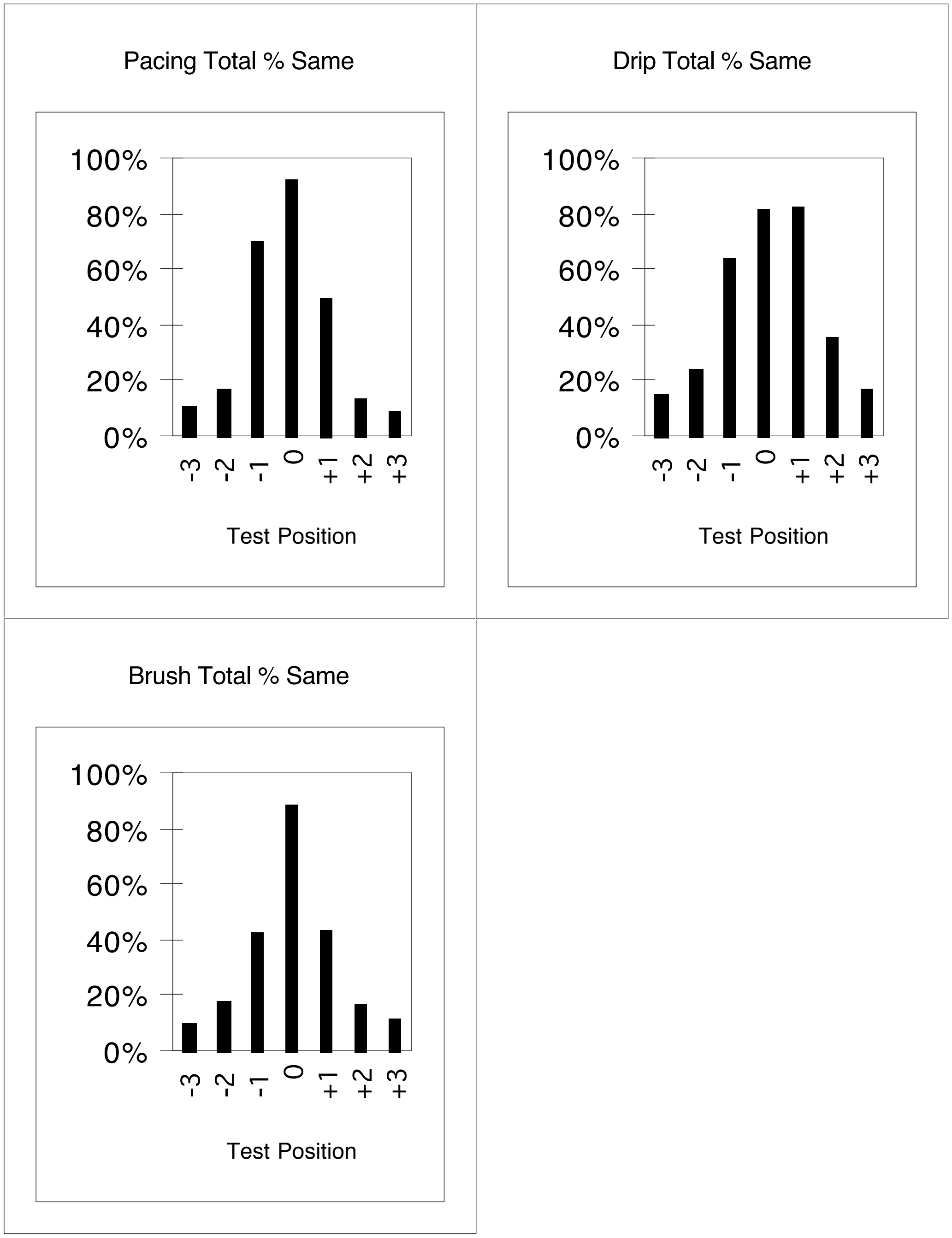


Figure 5. The percent same responses for each of the 3 images in Experiment 1. Test images ranged from 1 to 3 mm backward from the original position (-1, -2 & -3) to 1 to 3 mm forward from the original (+1, +2, & +3).

Pacing [$t(15) = -3.5$, $p = .004$] between the 1 mm forward and 1 mm backward test positions. No significant differences were found in the 2 and 3 mm test positions for any of the pictures using difference scores.

Discussion

The first experiment establishes a methodology by which memory distortions for pictures can be measured. Two out of three dynamic pictures produced significant memory distortions in a particular direction. However, the direction of motion was not always clear. One picture elicited a memory distortion directly opposite of the predicted direction. In addition, many other factors in the picture may have influenced positional judgment. Controlling the context of real art is extremely difficult. Background content might interfere with foreground content. The direction of implied motion may not be clearly defined. Some elements in the composition might be distracting. For this reason, works of art were not used for the remaining experiments.

In order to control for context and discrepancies between the predicted direction of motion and amount of implied motion, a new set of stimuli was needed. A subset of the figures used by Carello et al. (1986) were utilized. There were four distinct advantages in using these figures: (a) they have already been rated as showing motion (b) current results can be compared to their previous motion ratings (c) the direction of motion seems to be clear and obvious and (d) the context of the picture is controlled.

CHAPTER IV

EXPERIMENT 2: LINKING MOTION DEVICES WITH MEMORY DISTORTION

This experiment examined the relationship between implied motion, the number of motion devices, memory distortion, and interest level in pictures. Works of art were not used as stimuli in this experiment because controlling the context and direction of implied motion was impossible. A subset of figures were taken from Carello et al. (1986) which used many different types of pictorial devices also used in works of art. The type of motion device and number of motion devices could also be controlled using this new set of figures. All participants were tested using the memory distortion methodology described in Experiment 1. Afterwards, they also rated how well each picture depicted movement and how interesting they found each picture.

Method

Participants

Sixty University of Oregon undergraduate students were given course credit for their participation. Thirteen left-handers (4 females and 9 males) and forty-seven right-handers (21 females and 26 males) participated. Care was taken to distribute left-handers evenly across conditions where possible.

Stimuli

Eleven different images shown in Figure 6 were tested using various combinations of four pictorial devices. As a control, the upright figure containing no devices and depicting no motion was also used. Four figures contained only one device (singles), and six contained all possible combinations of two devices (doubles). Appendix A shows the actual size of the pictures used in the experiment.

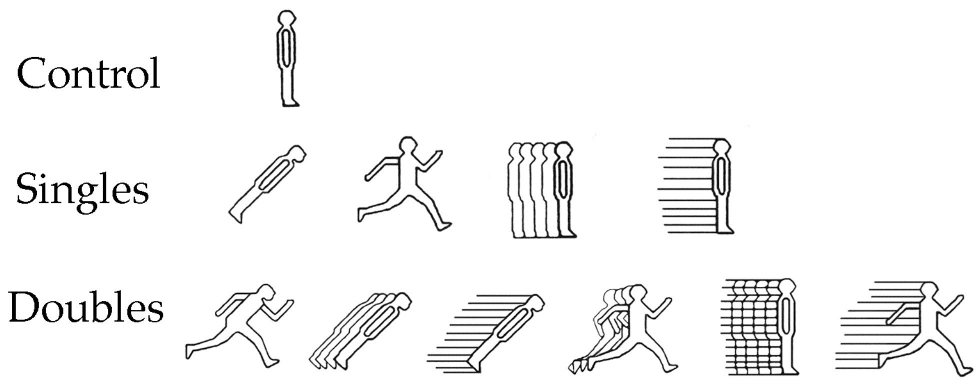


Figure 6. A subset of the Carello et al. (1986) pictures used in Experiment 2. The first row shows the control figure with no movement devices. The second row shows each of the motion devices used singly: orientation, posture, multiple images and action lines. The third row shows all combinations of two motion devices together (see Appendix A for actual size of the pictures during the experiment).

Test positions for each image were created 2 mm (actually 2.1 mm or 6 pixels) and 4 mm (actually 4.2 mm or 12 pixels) from an original position. The original position placed each of the figures in a 525 pixels wide by 315 pixels high (17.8 cm X 10.7 cm) white area in the center of a black screen. In order to control for any differences that might be caused by the direction that the figures in the pictures were facing, half of the participants (30) were shown the images facing to the right while the other half of the participants (30) were shown the images facing to the left. Thus, direction was an additional between-subjects factor.

Procedure

Participants were all tested individually in a room dimly lit by a halogen light. To ensure computer accuracy, the timing of the screen presentation was verified by filming the monitor with a time code generator. Individuals sat approximately 1 meter from the monitor (visual angle of the pictures ranged from .46 to 3.2 degrees in width to 1.8 to 2.2 degrees in height).

Figure 7 shows the order of presentation for each trial. Since all of the pictures were centered on the screen in the same place and changes were all varied around the same position, displaying the original picture before the cue was not necessary. Participants initiated each trial by pushing the space bar on the keyboard.

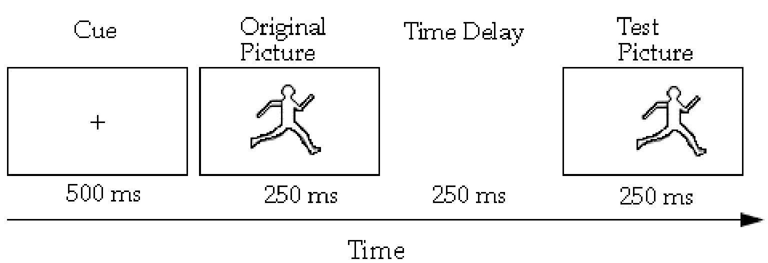


Figure 7. The order of presentation for each trial in Experiment 2.

On each trial, participants first were shown a black cross (cue) in the center of the white screen for 500 milliseconds to direct their attention. Then the original picture was displayed for 250 milliseconds followed by a retention interval of 250 milliseconds. The test image then appeared until participants indicated whether it looked the same or different from the original picture. If the picture looked the same, they were told to press a key marked "S" on the keyboard (actually the "s" key) and if it looked different they were told to press a key marked "D" (actually the "l" key on the keyboard). Participants were also told that they could take a break at any time, since they could initiate each trial by pushing the space bar. There were 11 practice trials followed by 330 real trials (11 Pictures X 5 Test Positions (-4, -2, 0, +2 & +4 mm) X 6 Repetitions for a total of 330 trials).

After the memory distortion task, participants rated each of the 11 images on motion and interest. The image was displayed on the computer screen for a period of 5 seconds. Immediately after, a rating scale appeared below the picture (see Figure 8) and participants were asked to rate "How well does this picture depict movement?" from "Not at all" to "Very well." They responded by sliding a scroll box along a scroll bar scale. The scroll box always appeared in the center of the scale initially.

Figure 8. The rating scale for implied motion used in Experiments 2 and 3.

The scroll box position ranged from 1 (not at all) to 100 (very well) and returned whatever pixel value the scroll box was left on when the subject clicked the continue box. For example, if a person positioned the scroll box in the center of the scale, a value of 50 was recorded. Figure 9 shows the scale for rating interest. Participants were asked "How interesting do you find this picture?" from "Not at all interesting" to "Very interesting." Pixel values were returned from 1 (not at all interesting) to 100 (very interesting).

Figure 9. The rating scale for interest used in Experiments 2 and 3.

In order to counterbalance the design, half of the participants did the interest rating prior to the motion rating task.

Design

The experiment consisted of a 2 X 2 factorial design where direction (right or left) and order of rating (interest followed by motion or motion followed by interest) were between subjects manipulations. Within-subjects factors were image, test position and repetitions.

Results

Memory Distortion Task

For each picture, a weighted mean was calculated to estimate the overall shift. Overall, there was a significant positive forward memory distortion of .14 mm [$F(1, 56) = 7.00$, $p = .01$)]. Figure 10 shows the percent same response for each test position. There was a significant difference among images [$F(10, 560) = 24.87$, $p < .0001$]. In addition, there was a significant difference in the number of motion devices and the amount of memory distortion [$F(2, 112) = 7.85$, $p = .001$)]. Figure 11 shows the average weighted means for the number of motion devices. There was no significant difference between the control picture with no motion devices and pictures

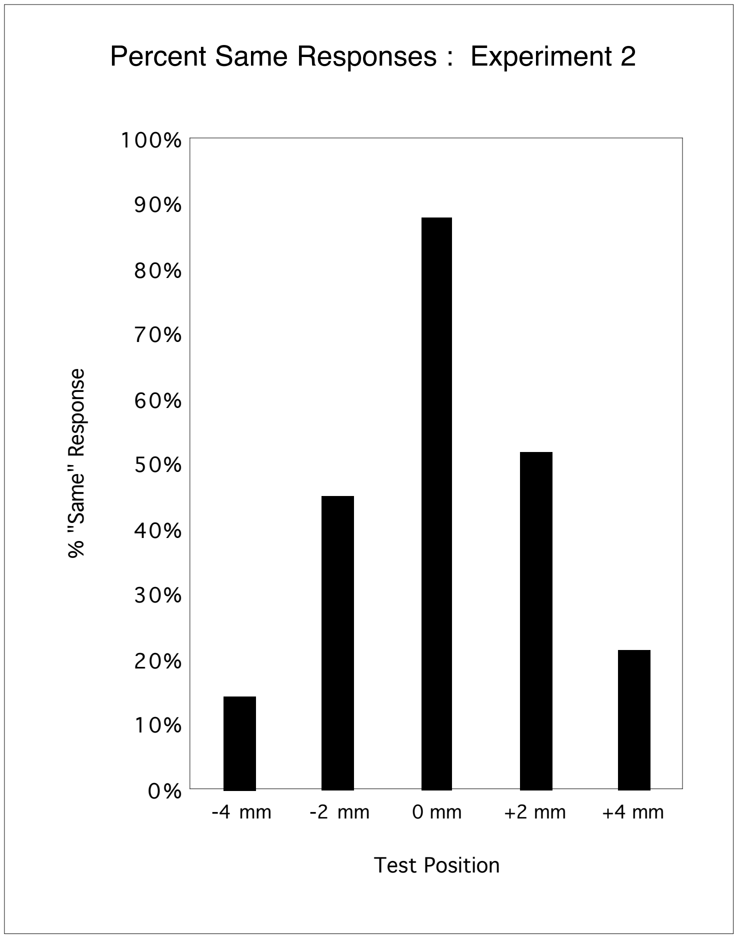


Figure 10. The average percent same responses for each test position in Experiment 2.

with one motion device [$t(15) = 1.19$, $p = .239$]. However, two motion devices produced significantly more forward memory distortion than just one motion device [$t(59) = 3.95$, $p < .0001$]. There was also a significant linear trend across the number of motion devices [$F(1, 112) = 15.08$, $p < .01$]. There was no reliable difference due to direction [$F(1, 56) = .965$, $p = .33$].

However, adding a second motion device does not always increase memory distortion, and the effect of one device (e.g., orientation) might be causing most of the effect across the number of devices. If we compare single motion devices to pictures with two motion devices, memory distortion does

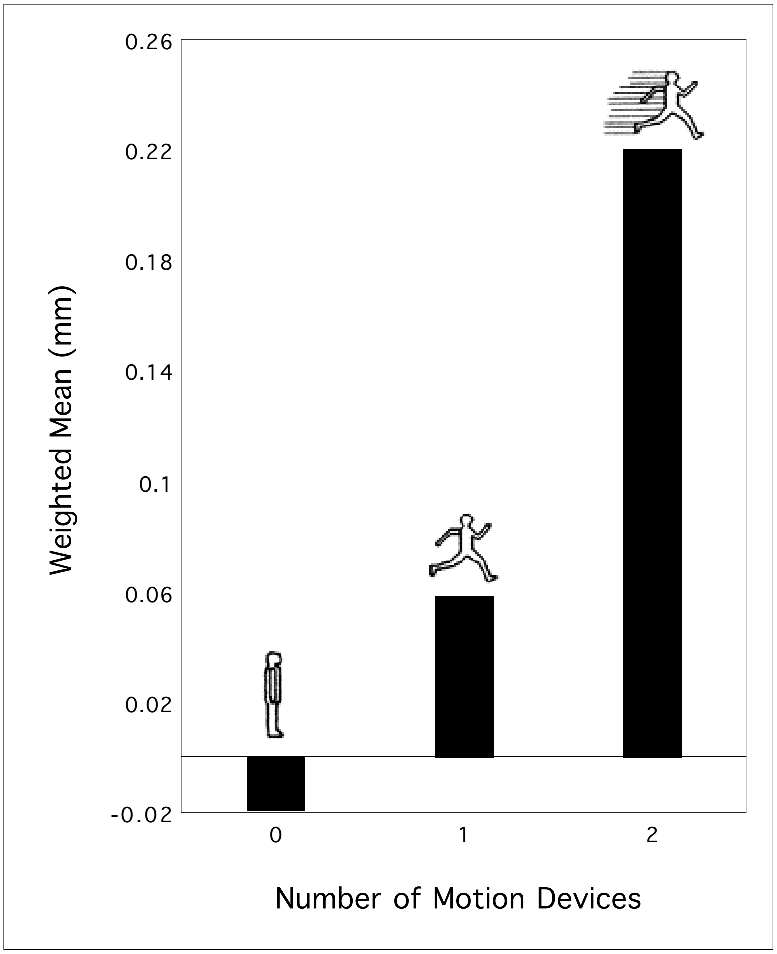


Figure 11. Weighted mean scores as a function of the number of motion devices for Experiment 2.

not always significantly increase. Table 1 shows the average memory distortion values for each individual picture and Table 3 shows the results of *t* tests comparing individual devices to combinations of two. Only 5 out of 12 comparisons (42%) showed a significant forward increase in memory distortion when a second device was added.

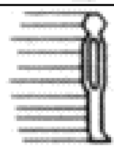
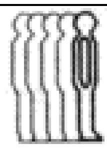
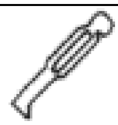
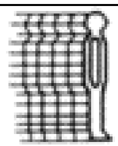
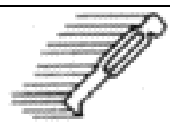
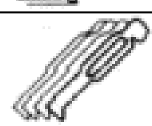
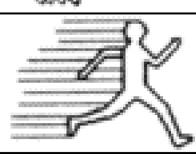
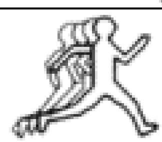
In order to gauge the significance of memory distortions for each individual image, weighted means were tested to see if they were significantly different from zero. Table 1 shows that the orientation device showed a significant positive forward shift, and orientation with action lines, and orientation with multiple images also showed significant positive forward shifts. Surprisingly, action lines, posture and action lines, and posture and multiple images all showed significant negative (backwards) shifts.

Table 2 shows the results of planned contrasts comparing pictures with a particular device to pictures without the device on memory distortion, motion ratings and interest ratings. By comparing all of the pictures with a particular device to all of the pictures which do not have the device, the effectiveness of a particular device can be estimated. The control picture was not used in these comparisons. For example, for the device of action lines, pictures containing action lines, action lines with multiple images, action lines with orientation, and action lines with posture were compared to all other pictures without the device except the control picture. From this analysis, orientation and posture contributed significantly to the overall memory distortion. Action lines and multiple images did not have a significant effect on memory distortion. The residual effects were all significant, indicating that other factors (such as other devices, etc.) besides the particular device being tested were also contributing significantly to memory distortion.

Motion Ratings

Table 1 shows the average motion ratings for each picture. There were significant differences among motion ratings for different images [$F(10, 560) = 52.61$, $p < .0001$]. There was no difference due to the order in which participants did their motion rating (motion then interest verses interest then motion) [$F(1, 56) = 1.20$, $p = .28$]. There were no significant differences in

Table 1. Experiment 2 Summary Table for Individual Pictures

Picture	Device Type	Average Weighted Mean	Average Motion Rating	Average Interest Rating
	Control	-0.108	11.6	21.9
	Action Lines	-0.204 **	43.0	44.1
	Multiple Images	0.024	38.2	47.0
	Orientation	0.506 ***	31.8	31.1
	Posture	-0.094	56.0	40.0
	Multiple Images & Action Lines	0.106	52.7	66.9
	Orientation & Action Lines	0.804 ***	60.9	56.0
	Orientation & Multiple Images	0.594 ***	55.6	55.7
	Posture & Action Lines	-0.164 *	77.0	55.4
	Posture & Multiple Images	-0.174 *	84.0	73.1
	Posture & Orientation	0.156	58.6	44.2

Note. * denotes $p < .05$, ** denotes $p < .01$, and *** denotes $p < .001$ for a t test with 59 degrees of freedom.

Table 2. Results of Contrasts Comparing Pictures Containing a Particular Device with All Others for Experiment 2.

Device	Weighted Mean F (1, 531) =	Residual Weighted Mean F (8, 531) =	Motion Rating F (1, 531) =	Residual Motion Rating F (8, 531) =	Interest Rating F (1, 531) =	Residual Interest Rating F (8, 531) =
Action Lines	.54	29.64***	5.88 *	36.88 ***	20.72 ***	28.50 ***
Multiple Images	.42	29.66***	2.95	37.24 ***	100.62 ***	18.51 ***
Orientation	176.82 ***	7.61 ***	14.16 ***	35.84 ***	24.60 ***	28.01 ***
Posture	69.09 ***	21.08 ***	147.66 ***	19.16 ***	3.94 *	30.59 ***

Note. * denotes $p < .05$, ** denotes $p < .01$, and *** denotes $p < .001$ for an *F* test with the appropriate degrees of freedom for the contrast.

motion ratings for direction (left verses right), [F (1, 56) = 3.01, p = .09]. Replicating the findings of Carello et al. (1986), there was a significant effect of the number of motion devices [$F(2, 112) = 185.20$, $p < .0001$]. Figure 12 shows that as the number of motion devices increased, participants rated the pictures as depicting more motion. Posthoc *t* tests reveal that there was a significant difference between no motion devices and one motion device [$t(59) = 10.73$, $p < .0001$] and a significant difference between one device and two motion devices [$t(59) = 13.10$, $p < .0001$]. Table 3 also shows that for individual pictures, adding a second motion device significantly increased motion ratings in 92% of the cases. Figure 13 shows the interaction between the direction and the number of devices [$F(2, 112) = 5.55$, $p = .005$]. Posthoc *t* tests reveal that the control picture facing to the right had higher motion ratings than the control picture facing to the left

[$t(58) = 2.64$, $p = .01$] but there were no reliable differences due to direction for pictures containing one or two motion devices.

Table 2 shows contrasts comparing each device to all other pictures for motion ratings. Action lines, orientation, and posture all contributed significantly to the motion ratings. Multiples images did not have a reliable effect on motion ratings. The residual effects were all significant, indicating that other factors were also contributing to the motion ratings besides the presence of each device being tested.

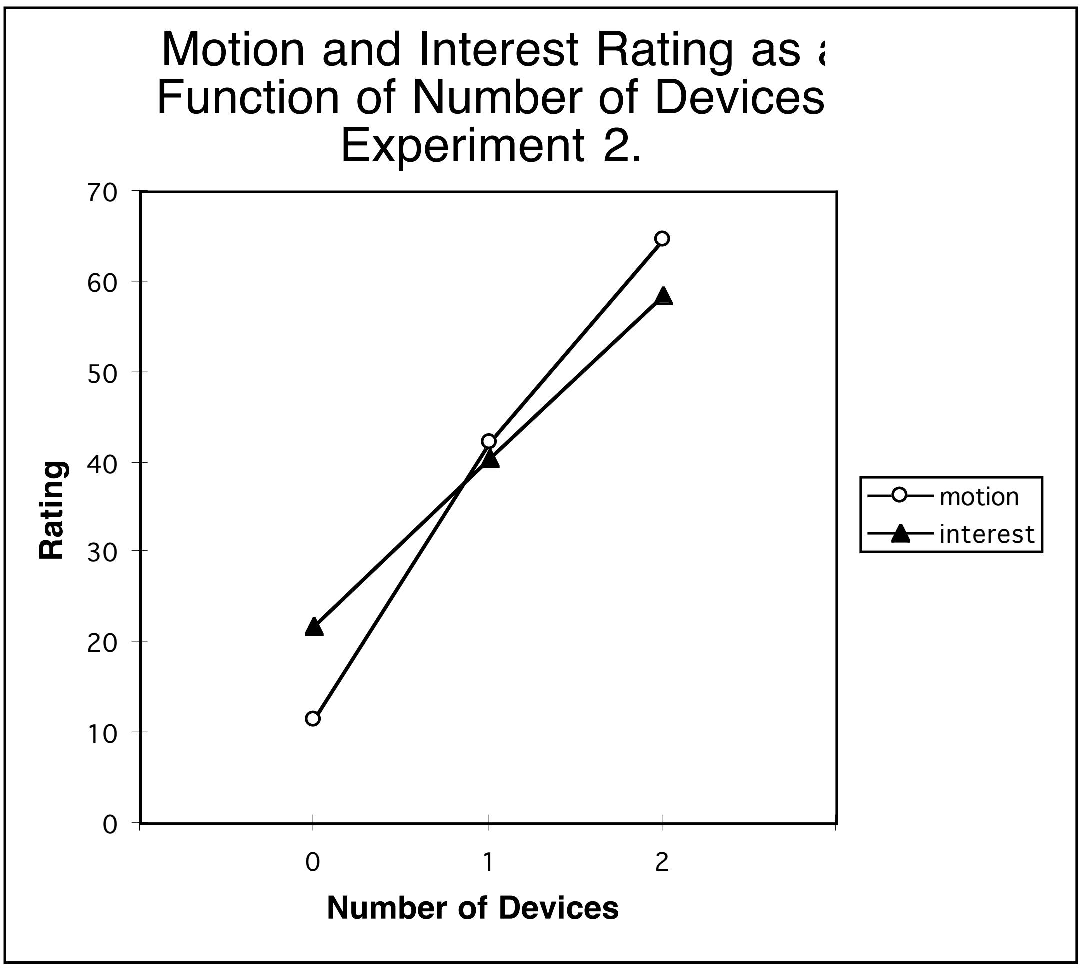


Figure 12. Motion and interest ratings as a function of the number of motion devices: Experiment 2.

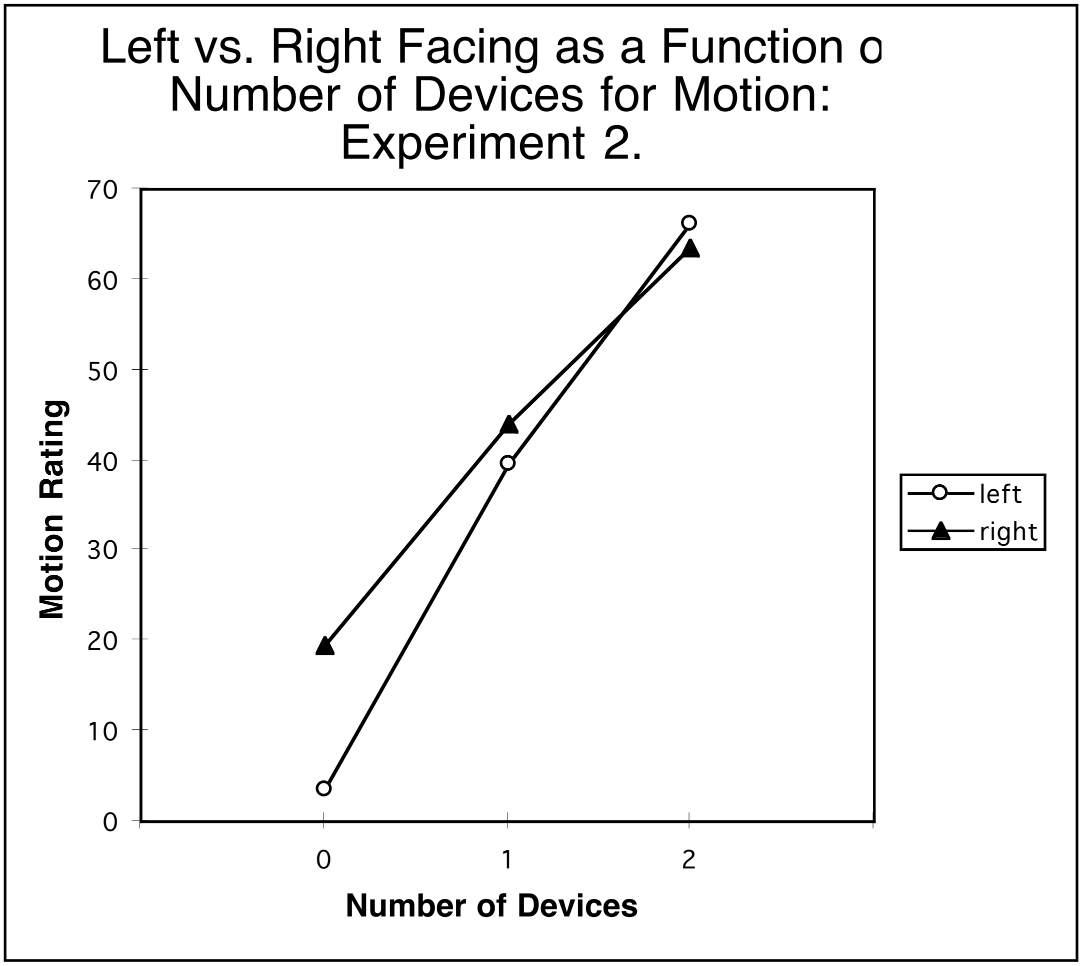


Figure 13. The interaction between direction of facing and the number of motion devices for motion ratings: Experiment 2.

Interest Ratings

Table 1 shows the average interest ratings for each picture. There were significant differences among interest ratings for different images [$F(1, 56) = 36.02$, $p < .0001$]. There was no significant difference due to the order in which participants did their interest rating (motion then interest verses interest then motion) [$F(1, 56) = .001$, $p = .98$]. There were no significant differences in interest ratings for direction (left verses right) [$F\ (1, 56) = .871$, $p = .36$]. There was a significant difference among interest ratings for the number of motion devices [$F(2, 112) = 80.43$, $p < .0001$]. Figure 12 shows that as the number of motion devices increased, participants rated the pictures as more interesting. Posthoc *t* tests reveal that there are differences between the control picture with no motion devices and one motion device [$t(59) = 5.76$, $p < .0001$], and between one motion device and two devices [$t(59) = 9.74$, $p < .0001$]. Table 3 also shows that for individual pictures, adding a second motion device significantly increased interest ratings in 92% of the cases. Overall, participants rated pictures that faced to the right as more interesting than pictures that faced to the left [$F(1, 56) = 4.01$, $p = .05$]. Figure 14 shows the interaction between direction and the number of devices [$F(2, 112) = 4.50$, $p = .013$]. For the control picture, the picture facing to the right is seen as more interesting than the picture facing to the left [$t(58) = 2.65$, $p = .01$] but there were no significant differences between directions for one and two motion device pictures. There was also an interaction between order and the number of motion devices [$F(2, 112) = 4.21$, $p = .02$].

Table 2 shows contrasts comparing each device to all other pictures for interest ratings. Action lines, multiple images, orientation, and posture all contributed significantly to the interest ratings. The residual effects were all significant, indicating that other factors besides the particular device being tested were also contributing significantly to interest ratings.

Correlations

Table 4 shows the correlations between measures in Experiment 2. Figure 15 illustrates the positive correlation between motion ratings and interest ratings [$r = .82$, $p < .002$]. In case ratings might influence each other, just the motion ratings from the group who did motion ratings first were

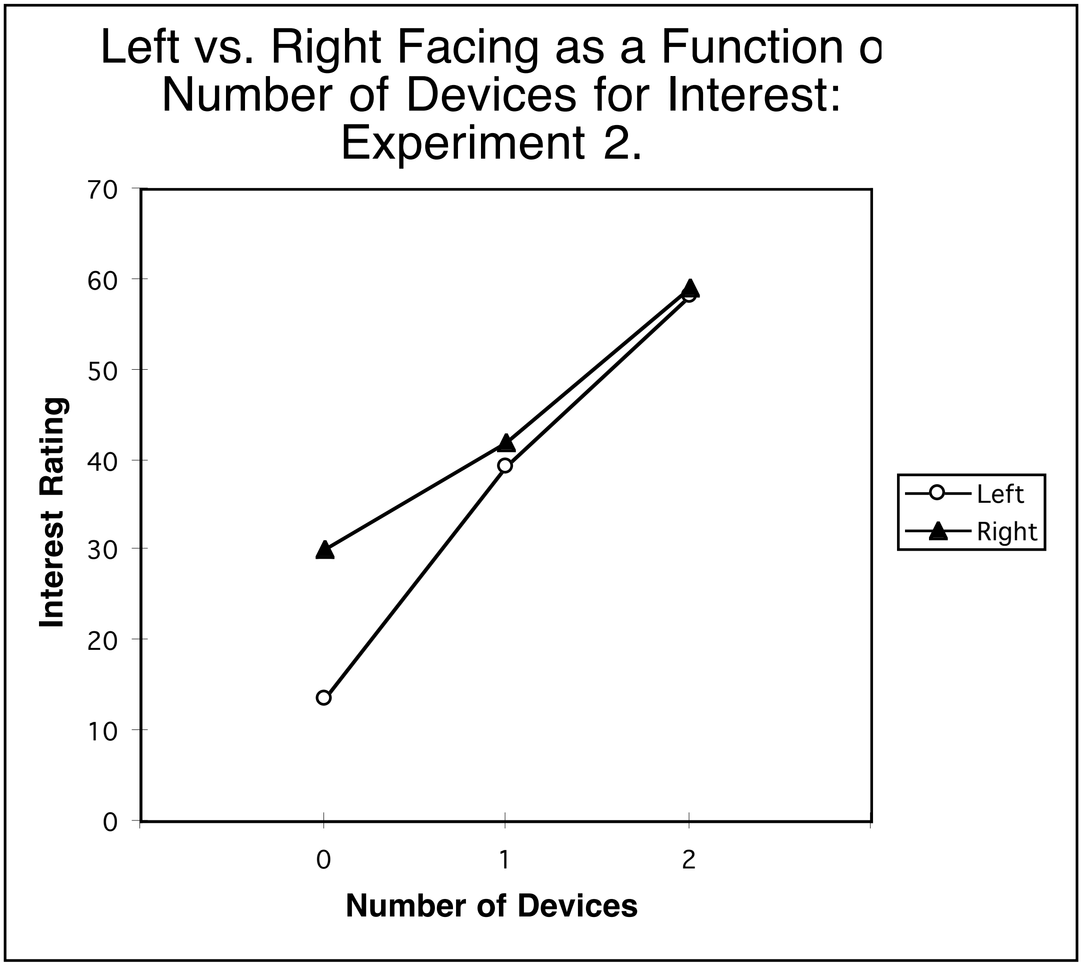
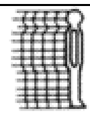
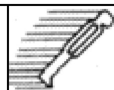
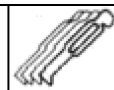
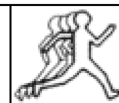
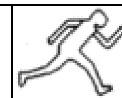
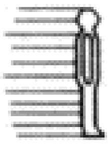
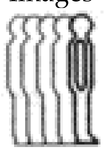
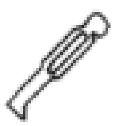


Figure 14. The interaction between direction of facing and the number of motion devices for interest ratings: Experiment 2.

correlated with interest ratings from the group who did interest ratings first and the effect was slightly stronger [$r = .84$, $p < .001$]. Memory shift was not correlated with either motion ratings [$r = -.10$, $p = .76$] or interest ratings across individual pictures [$r = -.01$, $p = .97$]. However, there was a significant positive correlation between the number of devices and motion ratings [$r = .85$, $p < .0009$] and the number of devices and interest [$r = .84$, $p < .0012$]. In addition, both motion ratings [$F(1, 112) = 367.53$, $p < .001$] and interest ratings [$F(1, 112) = 160.85$, $p < .001$] showed significant linear trends across the number

Table 3. *T* Test Table Comparing a Single Device to Combinations with One Other Device for Experiment 2.

Comparison Device	Measure						
		t (59) =	t (59) =	t (59) =	t (59) =	t (59) =	t (59) =
Action Lines 	Weighted Mean:	3.79 ***	8.89 ***	0.45			
	Motion:	2.79 **	4.28 ***	8.54 ***			
	Interest:	6.60 ***	3.66 ***	3.47 ***			
Multiple Images 	Weighted Mean:	0.85			5.74 ***	1.69	
	Motion:	3.87 ***			4.99 ***	10.25 ***	
	Interest:	6.16 ***			2.86 **	7.95 ***	
Orientation 	Weighted Mean:		3.16 **		1.24		3.47 ***
	Motion:		8.21 ***		9.10 ***		6.99 ***
	Interest:		7.31 ***		7.23 ***		3.21 **
Posture 	Weighted Mean:			0.90		1.02	2.45 *
	Motion:			7.60 ***		8.74 ***	1.12
	Interest:			5.66 ***		11.23 ***	1.46

<u>Note</u>. * denotes $p < .05$, ** denotes $p < .01$, and *** denotes $p < .001$ for a t test with 59 degrees of freedom.

Table 4. Correlations Between Measures for Experiment 2.

Variable	1	2	3	4	5
1. Number of Devices	--				
2. Motion	.85	--			
3. Interest	.84	.82	--		
4. Weighted Mean	.27	-.10	-.01	--	
5. Absolute Value of Weighted Mean	.39	.15	.14	.89	--

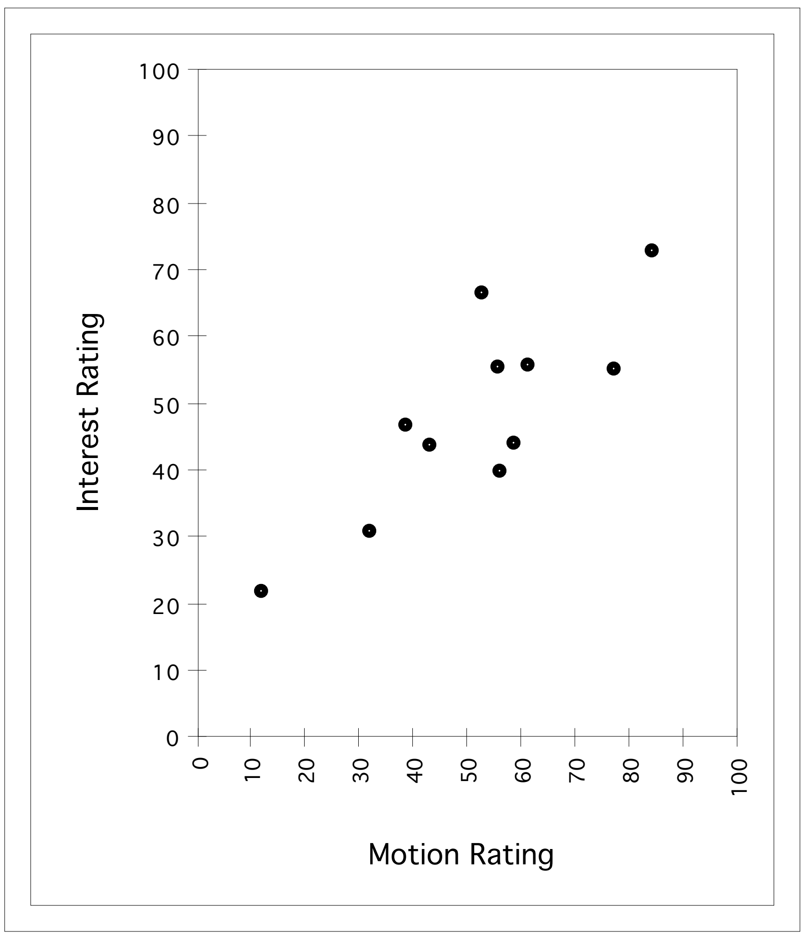


Figure 15. The relationship between ratings of motion and interest [$r = .82$, $p < .002$] for all 11 pictures for Experiment 2.

of devices. However, the correlation between amount of memory shift and the number of memory devices was not significant [$r = .27$, $p = .42$]. Since some of the memory distortion values were negative (indicating backwards memory shifts), the absolute value of the weighted means was also tested for correlation with the other measures. Although the relationship was slightly stronger, the correlation between the absolute value of the weighted mean and the number of devices was also not reliable [$r = .39$, $p = .24$].

Discussion

There was an overall significant forward memory distortion in the direction of implied motion. We can conclude that expectations about motion can cause memory distortions. As the number of motion devices increased, the amount of memory distortion increased overall; however, this effect can be explained by the strong influence of the orientation motion device. For one motion device, orientation is present in 25% of the data (1 out of 4 pictures), and for two motion devices, orientation is present in 50% of the data (3 out of 6 pictures). The increase in memory distortion due to the number of devices may be due to an increasing proportion of devices with orientation. Table 3 shows that only 1 out of 6 combinations of two devices that did not include orientation actually increased significantly with a second motion device (action lines alone compared to multiple images with action lines).

Pictures that were rated as having more motion were also seen as more interesting. Likewise, interest for the pictures increased as the number of motion devices increased. However, individual pictures with more memory distortion were not necessarily rated as having more motion. Thus, there was no evidence for a relationship between a person's subjective ratings of implied motion and the memory distortion produced for a picture. In addition, pictures with more memory distortions were not necessarily seen as more interesting. Orientation had the greatest influence on memory distortion while orientation, action lines, and posture all had effects on motion and interest ratings. Multiple images also affected interest ratings. These findings also suggest that the conscious ratings of motion and interest may be unrelated to the perceptual memory distortion task.

What was not predicted was the significant negative memory shifts found for particular pictures. The pictures that had negative memory shifts were: action lines, posture and action lines, and posture and multiple images. One potential problem with the action lines device from the Carello et al. (1986) figures is that the lines did not gradually fade away. They were sharp lines that extended several centimeters back from the figure (see Appendix A for full-size depictions of the Carello et al. figures). One observation made by a participant was that the action lines appeared to be rubber bands pulling the figure backwards. In addition, the posture device also caused negative memory shifts. This picture was not drawn in an anatomically correct way and may have also produced an ambiguous interpretation of which direction it would move next. These factors may have contributed to the backward memory distortions that were found.

Experiment 3 was designed to test the effects of variations on the same pictorial motion devices. By using action lines and multiple images that fade gradually and a more anatomically correct posture figure, it was expected that the memory shifts would be significantly more positive.

CHAPTER V

EXPERIMENT 3: A TEST OF THE NEW MOTION DEVICES

In order to test the effects of variations on particular motion devices, a new set of stimuli was created for Experiment 3. Experiment 3 was designed to further explore the nature of some of the backwards memory shift findings from Experiment 2. More realistic figures were used to depict motion. In addition, action lines and multiple images were gradually faded backwards away from each figure to test the effect of fading.

For the original upright control picture, a photograph of a person standing sideways was digitally scanned (see Muybridge, 1955, plate 3). Figure 16 shows the pictures used in Experiment 3 (see Appendix B for actual size of the pictures). For the posture device, a photograph of a man running was digitized and outlined to create a more human-like figure whose direction of motion was more clearly defined due to limb position (see Muybridge, 1955, plate 22). For the action lines, the lines were gradually faded backwards behind the figure. For multiple images, the figures also gradually faded using the same gradation rate as the action lines. Orientation remained the same except that new human-like figures were used for all of the pictures. As reported by Carello et al. (1986), for orientation, figures were rotated 30 degrees clockwise from the upright position. (Upon closer examination, the Carello et al. (1986) orientation figures that were used in Experiment 2 actually appear to be rotated 45 degrees and not 30 degrees as they reported. However, the reported 30 degrees was used for orientation in Experiment 3.)

Method

Participants

Sixty University of Oregon undergraduate students were given course credit for their participation. Five left-handers (3 females and 2 males) and fifty-five right-handers participated (32 females and 23 males). Care was taken to distribute left-handers evenly across conditions where possible.

Stimuli

Eleven different images shown in Figure 16 were created using various combinations of four pictorial devices. As a control, the upright figure containing no devices and depicting no motion was also used. Four figures contained only one device (singles), and six contained all possible combinations of two devices (doubles).

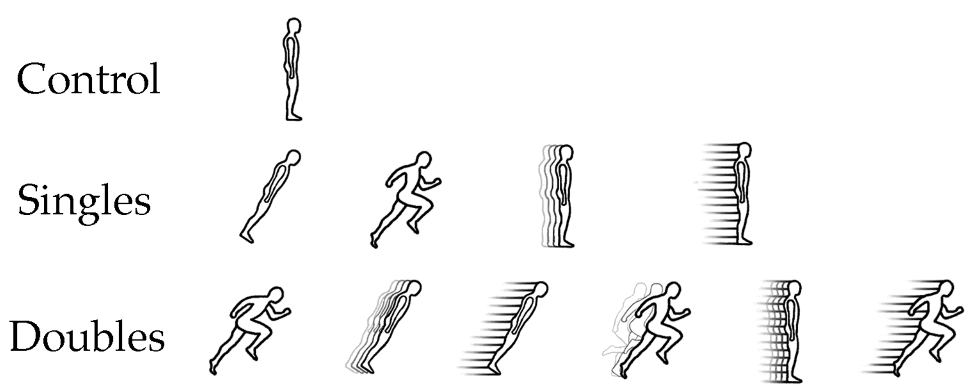


Figure 16. The pictures used in Experiment 3. 1st row: control figure with no motion devices. 2nd row: each motion device used singly (orientation, posture, multiple images, action lines) 3rd row: all combinations of two motion devices together (see Appendix B for the actual size of the pictures).

Procedure

Procedures for Experiment 3 were identical to Experiment 2. Visual angle of this set of pictures ranged from approximately .46 to 2.1 degrees in width to 2.1 to 2.4 degrees in height.

Results

Memory Distortion Task

For each picture, a weighted mean was calculated to estimate the overall shift. Overall, there was a significant positive forward memory distortion of .144 mm [$F(1, 58) = 12.852$, $p = .001$)]. Figure 17 shows the average percent same responses for each test position. There were significant differences among images [$F(10, 580) = 8.296$, $p < .0001$]. There was no significant effect of the number of motion devices on the amount of memory distortion [$F(2, 116) = 1.929$, $p = .15$]. There was a marginally significant linear trend [$F(1, 112) = 3.84$, $p < .06$] across the number of motion devices. There was a significant effect of direction [$F(1, 58) = 5.364$, $p = .024$] such that the figures facing to the left showed more memory distortion (.24 mm) than figures facing to the right (.06 mm). Figure 18 shows the average weighted means as a function of the number of motion devices.

If we compare single motion devices to a pictures with two motion devices, memory distortion does not always significantly increase. Table 7 shows the results of *t* tests comparing individual devices to combinations of two. Only 3 out of 12 comparisons (25%) showed a significant forward increase in memory distortion when a second device was added (see Table 5 for the average memory distortion values for each individual picture). The

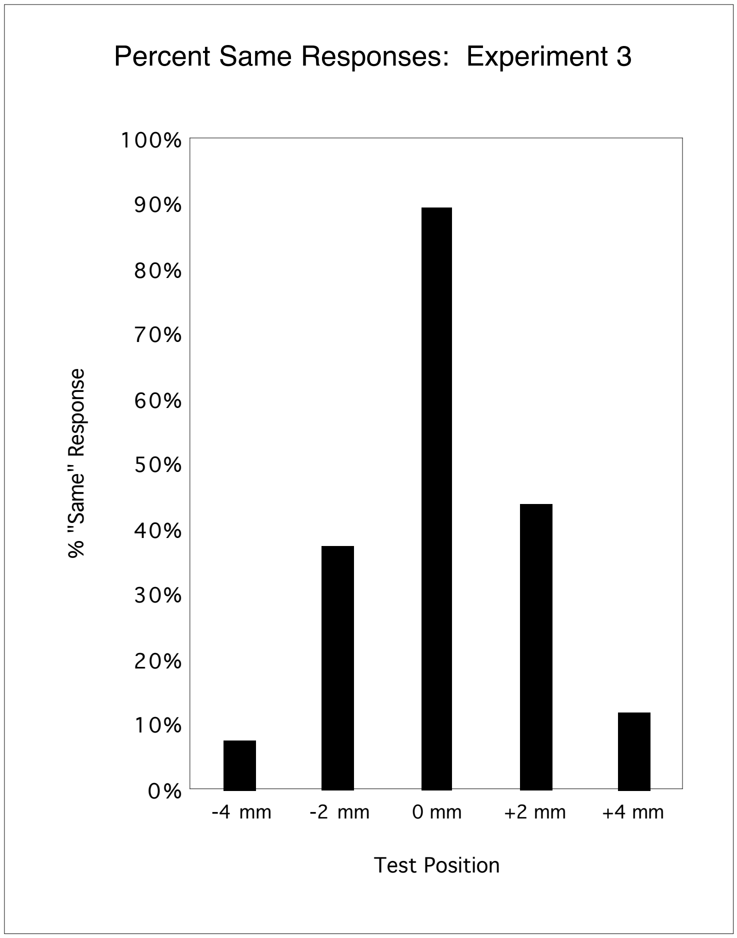


Figure 17. The Average Percent Same Responses
for Each Test Position in Experiment 3.

strong influence of orientation may be distorting the effect of the number of motion devices (orientation is present in 25% of pictures with single devices and 50% of pictures with two motion devices).

Table 6 shows contrasts comparing each device to all other pictures for memory distortion. Action lines, multiple images, and orientation all contributed significantly to the memory distortion. Posture did not have a reliable effect on memory distortion [$F(1, 531) = 2.94$, $p < .10$]. The residual effects were all significant, indicating that other factors were also contributing to memory distortion besides the presence of each device being tested.

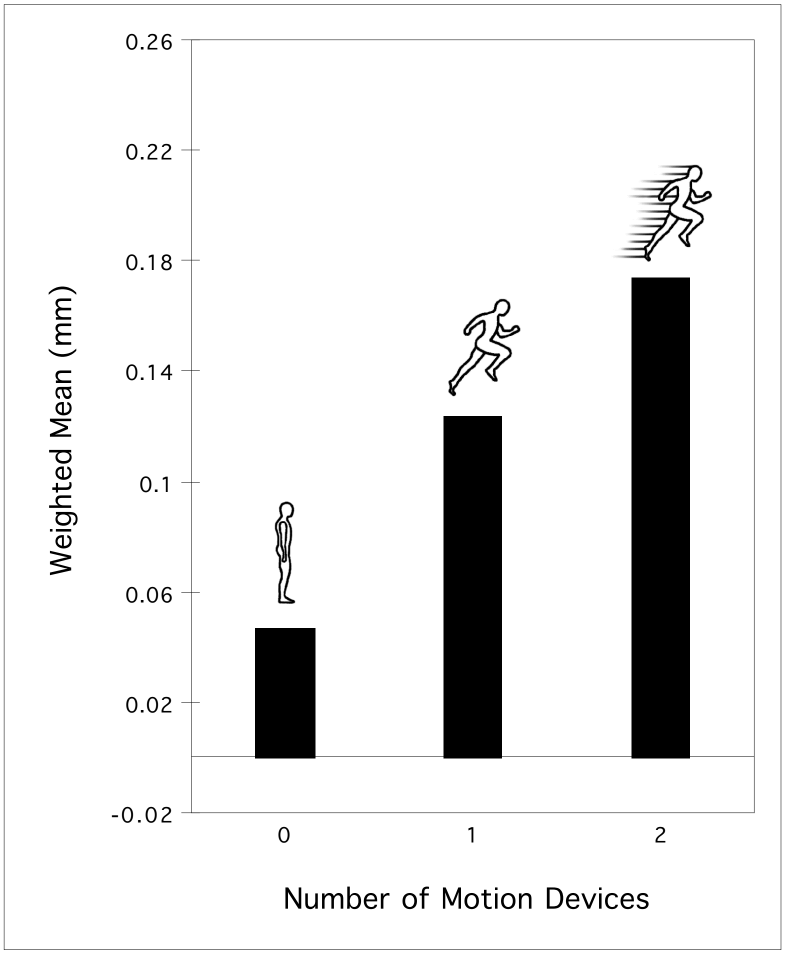


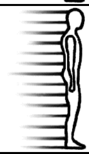
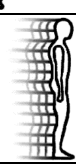
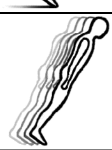
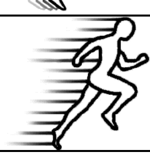
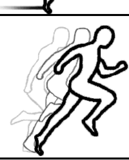
Figure 18. Weighted Mean Scores as a Function of the Number of Motion Devices for Experiment 3.

For each individual image, weighted means were tested to see if it was significantly different from 0 in order to gauge memory distortion. Table 5 shows the results for each picture.

Motion Ratings

Table 5 shows the average motion ratings for each picture. There were significant differences in the motion ratings among pictures [$F(10, 560) = 71.697$, $p < .0001$]. There was no difference due to the order in which participants did their motion rating (motion then interest verses interest then

Table 5. Experiment 3 Summary Table for Individual Pictures

Picture	Device Type	Average Weighted Mean	Average Motion Rating	Average Interest Rating
	Control	0.046	6.6	15.9
	Action Lines	-0.002	42.6	49.7
	Multiple Images	-0.024	41.3	48.8
	Orientation	0.400 ***	31.2	36.0
	Posture	0.119	61.8	49.4
	Multiple Images & Action Lines	-0.064	47.0	65.0
	Orientation & Action Lines	0.419 ***	67.3	61.0
	Orientation & Multiple Images	0.351 ***	65.0..........	64.6
	Posture & Action Lines	0.006	84.1	69.3
	Posture & Multiple Images	0.158 *	83.3	75.4
	Posture & Orientation	0.173 *	59.9	50.3

Note. * denotes $p < .05$, ** denotes $p < .01$, and *** denotes $p < .001$ for a t test with 59 degrees of freedom.

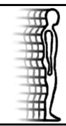
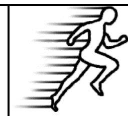
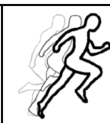
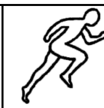
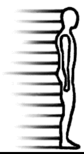
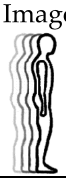
Table 6. Results of Contrasts Comparing Pictures Containing a Particular Device with All Others for Experiment 3.

Device	Weighted Mean F (1, 531) =	Residual Weighted Mean F (8, 531) =	Motion Rating F (1, 531) =	Residual Motion Rating F (8, 531) =	Interest Rating F (1, 531) =	Residual Interest Rating F (8, 531) =
Action Lines	7.56 **	9.42 ***	3.38	49.25 ***	20.01 ***	23.69 ***
Multiple Images	4.40 *	9.81 ***	.59	49.60 ***	45.56 ***	20.50 ***
Orientation	61.91 ***	2.62 **	5.85 *	48.94 ***	17.10 ***	24.05 ***
Posture	2.94	10.00 ***	181.63 ***	26.96 ***	18.72 ***	23.85 ***

<u>Note</u>. * denotes $p < .05$, ** denotes $p < .01$, and *** denotes $p < .001$ for an F test with the appropriate degrees of freedom for the contrast.

motion) [$F(1, 56) = .892$, $p = .35$]. There were also no differences in motion ratings for direction of figures (left verses right) [$F(1, 56) = 1.702$, $p = .20$]. Replicating the findings of Carello et al. (1986), there was a significant effect of the number of motion devices [$F(2, 112) = 236.459$, $p < .0001$]. Figure 19 illustrates that as the number of motion devices increased, participants rated the pictures as depicting more motion. Posthoc t tests revealed significant differences between no motion device and one motion device [$t(59) = 13.96$, p < .0001] and one motion device and two motion devices [$t(59) = 12.98$, p < .0001]. Table 7 shows that 9 out of 12 pictures (75%) were rated as having more motion when combined with a second device. Table 6 reveals that only orientation and posture contributed significantly to the motion ratings. The residual effects were all significant, indicating that other factors besides the

Table 7. *T* Test Table Comparing a Single Device to Combinations with One Other Device for Experiment 3.

Comparison Device	Measure						
		t (59) =	*t* (59) =	*t* (59) =	*t* (59) =	*t* (59) =	*t* (59) =
Action Lines 	Weighted Mean:	0.83	5.28 ***	0.09			
	Motion:	1.43	7.09 ***	11.63 ***			
	Interest:	4.89 ***	3.73 ***	6.19 ***			
Multiple Images 	Weighted Mean:	0.51			4.85 ***	2.18 *	
	Motion:	1.68			6.31 ***	9.64 ***	
	Interest:	4.47 ***			4.82 ***	7.16 ***	
Orientation 	Weighted Mean:		0.25		0.58		2.45 *
	Motion:		9.63 ***		10.54 ***		7.17 ***
	Interest:		8.75 ***		8.28 ***		3.61 ***
Posture 	Weighted Mean:			1.58		0.58	0.60
	Motion:			6.95 ***		6.15 ***	0.68
	Interest:			6.95 ***		7.85 ***	0.342

Note. * denotes $p < .05$, ** denotes $p < .01$, and *** denotes $p < .001$ for a *t* test with 59 degrees of freedom.

particular device being tested were also contributing significantly to motion ratings.

Interest Ratings

Table 5 shows the average interest ratings for each picture. There were significant differences in the interest rating for each picture [$F(1, 56) = 45.535$, $p < .0001$]. There was no difference in the order in which participants did their interest rating (motion then interest verses interest then motion) [$F(1, 56) = 2.379$, $p = .13$]. There were also no differences in interest ratings for direction of figures (left verses right) [F (1, 56) = .523, p = .47]. There was a significant difference in the number of motion devices [F(2, 112) = 181.251, p < .0001]. Figure 19 shows that as the number of motion devices increased, participants rated the pictures as more interesting. Posthoc t tests revealed that there was a significant difference between no motion devices and one motion device [t(59) =10.77, p < .0001] and one motion device and two motion devices [t(59) = 10.31, p < .0001]. Table 7 shows that 11 out of 12 pictures (92%) were rated as more interesting when combined with a second device. Table 6 reveals that action lines, multiple images, orientation and posture all contributed significantly to interest ratings. The residual effects were all significant, indicating that other factors besides the particular device being tested were also contributing significantly to interest ratings.

Correlations

Table 8 shows the correlations between measures in Experiment 3. Figure 20 illustrates the positive correlation between motion ratings and interest ratings [r = .91, p < .0001]. In case ratings might have influenced each other, just the motion ratings from the group who did motion ratings first were correlated with the group who did interest ratings first and the effect was again slightly stronger [r = .95, p <.00001]. Motion ratings and the amount of memory distortion (as measured by the weighted mean) were not significantly correlated with one another [r = .15, p = .65] and neither was the interest ratings and the amount of memory distortion [r = .02, p = .95]. The correlation between the number of devices and the weighted mean was not

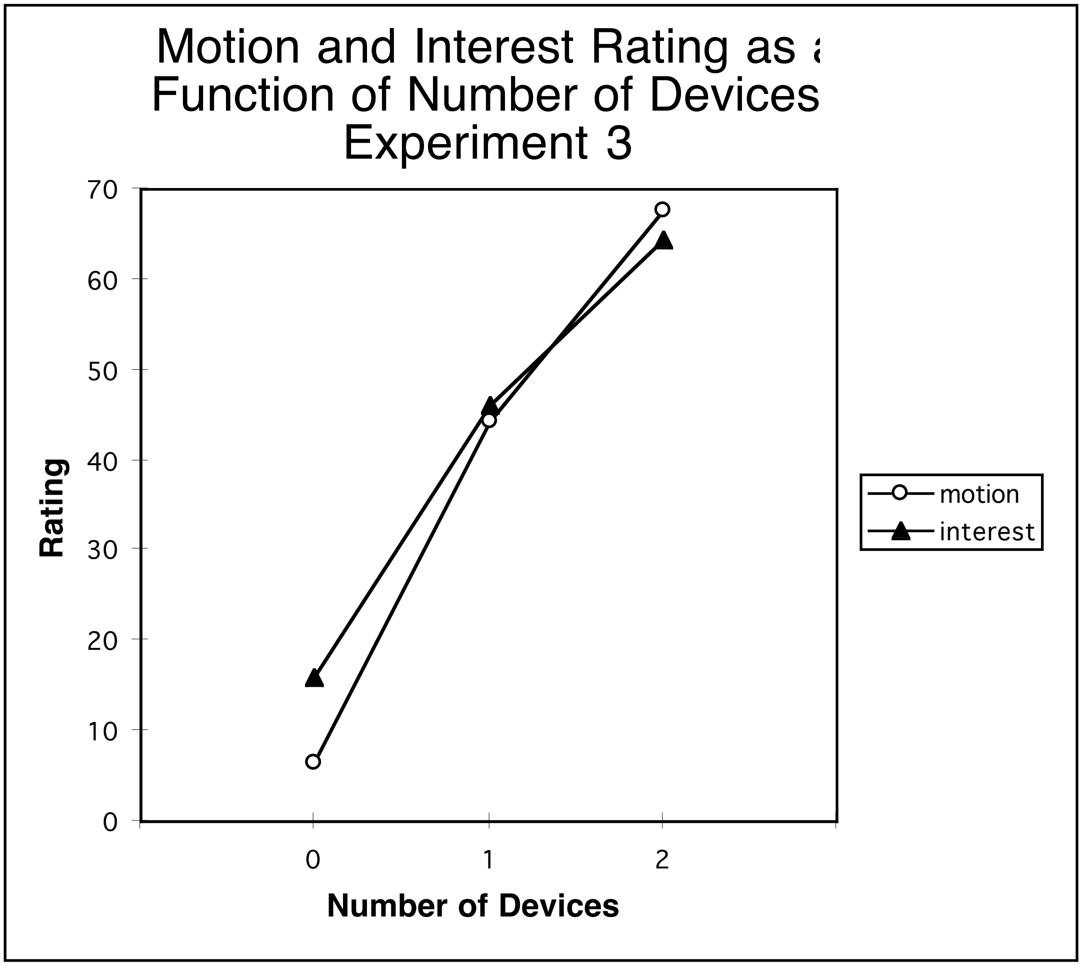


Figure 19. Motion and interest ratings as a function of the number of motion devices for Experiment 3.

significant [$r = .23$, $p = .50$]. However, there was a significant positive correlation between the number of devices and motion [$r = .84$, $p = .0014$] and the number of devices and interest [$r = .90$, $p = .0002$]. Both motion ratings [$F(1, 112) = 464.76$, $p < .001$] and interest ratings [$F(1, 112) = 355.54$, $p < .001$] also showed significant linear trends across the number of devices. Since some of the memory distortion values were negative, the absolute value of the weighted means was also tested for correlation with the other measures. The correlation between the absolute value of the weighted mean and the number of devices was also not reliable [$r = .30$, $p = .38$].

Table 8. Correlations Between Measures for Experiment 3.

Variable	1	2	3	4	5
1. Number of Devices	--				
2. Motion	0.84	--			
3. Interest	0.90	0.91	--		
4. Weighted Mean	0.23	0.15	0.02	--	
5. Absolute Value of Weighted Mean	0.30	0.13	0.07	0.98	--

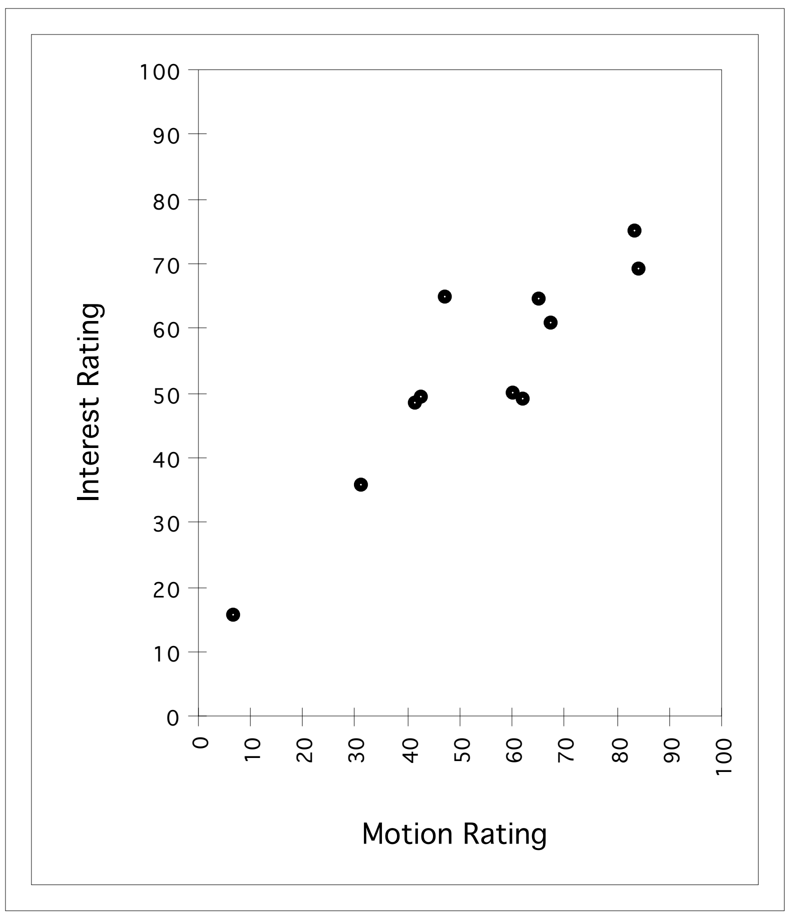


Figure 20. The relationship between ratings of motion and interest [$r = .91$, $p < .0001$] for all 11 pictures in Experiment 3.

Comparing Experiment 2 and Experiment 3

An ANOVA with experiment, picture, and direction for each of the measures was calculated. There were no significant differences between Experiment 2 and Experiment 3 on overall memory distortion [$F(1, 116) = .004$, $p = .948$]. There was variation between individual pictures [$F(10, 1160) = 29.383$, $p < .0001$] and also a significant picture by experiment interaction [$F(10, 1160) = 5.608$, $p < .0001$]. Thus, Experiment 3 pictures did produce different effects than Experiment 2 pictures (see Table 9 for details about each picture). There was also a significant effect of direction [$F(1, 116) = 4.831$, $p = .03$]. Overall for both experiments, figures facing to the left (.22 mm) had a higher memory distortion than figures facing to the right (.07 mm). No other effects or interactions were significant. An ANOVA with experiment, number of devices and weighted means was also calculated and there was no difference in the experiments. There was a highly significant main effect of the number of devices [$F(2, 236) = 8.23$, $p < .0001$]. The effect of the number of devices is distorted since only 33% of the pictures across both experiments showed a significant increase in forward memory distortion when a second device was added (see Tables 3 and 7). As noted previously, the effect of the number of devices can be explained by the increasing presence of the orientation device in both experiments.

For motion ratings, there were no significant differences between Experiment 2 and Experiment 3 [$F(1, 116) = .704$, $p = .403$]. There was a difference between pictures [$F(10, 1160) = 121.90$, $p < .0001$], but there was no significant picture by experiment interaction [$F(10, 1160) = 1.601$, $p = .101$]. All other effects and interactions were not significant. An ANOVA with experiment, number of devices and motion ratings was also calculated and there was no significant difference between the experiments. However, there was a highly significant main effect of the number of devices [$F(2, 236) = 409.33$, $p < .0001$] which was also linear in nature [$F(1, 236) = 404.27$, $p < .001$].

Experiment 3 pictures were rated as more interesting (53.2) than Experiment 2 pictures (48.7), [$F(1, 116) = 4.244$, $p = .042$]. For interest ratings, There were differences among pictures [$F(10, 1160) = 79.47$, $p < .0001$] and an interaction between pictures and experiment [$F(10, 1160) = 2.428$, $p = .007$]. There was also a triple interaction between direction, picture and experiment [$F(10, 1160) = 2.475$, $p = .006$]. An ANOVA with experiment, number of devices and interest ratings was also calculated and there was no significant difference between the experiments. However, there was a highly significant main effect of the number of devices [$F(2, 236) = 227.23$, $p < .0001$] and an interaction between the experiment and the number of devices [$F(2, 236) = 5.58$, $p = .004$]. As the number of devices increased, the amount of interest increased in a linear fashion [$F(1, 236) = 225.64$, $p < .001$].

Table 9 shows how Experiments 2 and 3 compare to each other on each individual combinations of motion devices. *T* tests were used to compare weighted means, motion, and interest ratings in Experiments 2 and 3. The new posture image elicited more forward memory distortion [$t(118) = 2.17$, $p = .03$], along with a higher interest rating [$t(118) = 2.45$, $p = .02$] in Experiment 3. Posture in combination with multiple images also produced more forward memory distortion in Experiment 3 [$t(118) = 3.08$, $p = .003$]. Posture with action lines showed a more forward trend, [$t(118) = 1.75$, $p = .08$] produced a higher motion rating [$t(118) = 1.99$, $p = .05$] and a higher interest rating [$t(118) = 3.54$, $p = .001$] using the new devices. The new orientation motion device produced less memory distortion in Experiment 3 than 2. One explanation is that the degree of rotation for the original Carello et al. (1986) figures was not 30 degrees as reported, but rather closer to 45 degrees (see Table 9). The increased rotation may have produced more distortion in Experiment 2. For orientation with action lines [$t(118) = -3.48$, $p = .001$] and orientation with multiple images [$t(118) = -2.06$, $p = .04$], the forward memory shift was greater using the Carello et al. (1986) figures. Despite showing less memory distortion, the new figure using orientation with multiple images was rated as having more motion [$t(118) = 2.18$, $p = .03$] and being more interesting [$t(118) = 2.33$, $p = .02$]. Although still slightly negative (-.002), the new action lines showed less of a backwards trend than the old action lines, [$t(118) = 1.93$, $p = .056$].

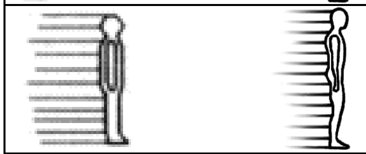
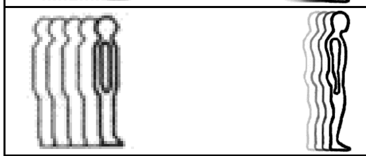
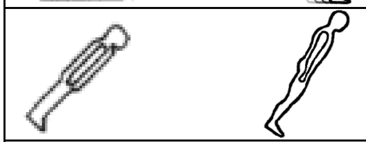
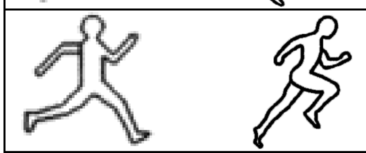
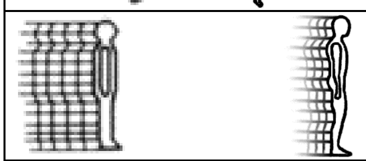
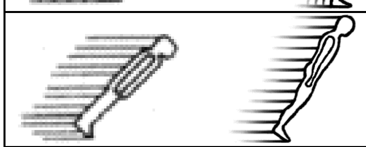
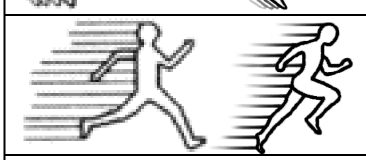
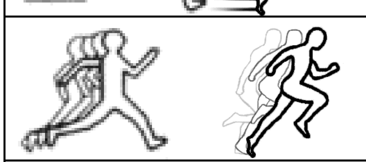
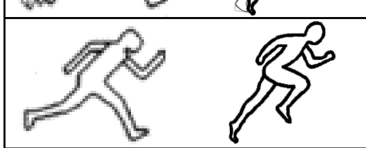
The number of devices was also correlated with motion ratings ($r = .80$) and interest ratings ($r = .70$) across both experiments. Weighted means were not as highly correlated overall ($r = .16$) with the number of devices. Motion and interest were also correlated with each other overall ($r = .71$) When the three measures (memory distortion, motion ratings and interest ratings) are correlated between the two experiments, the measures themselves are very highly correlated with one another. Table 10 shows the correlations between measures from both experiments. For weighted means, Experiment 2 and Experiment 3 showed a positive relationship ($r = .84$, $p = .0012$). In addition motion ratings ($r = .98$, $p < .0001$) and interest ratings ($r = .95$, $p < .0001$) were very highly correlated between Experiment 2 and Experiment 3. Thus the measures used in Experiments 2 and 3 show a large amount of agreement with each other. This finding is in contrast with the lack of relationship between weighted means and interest and motion ratings within each experiment. The memory distortion task may be tapping into processes that are not under conscious control. With the phenomenon of representational momentum, participants were not able to control the forward memory bias even with feedback and instruction (e.g., Finke

& Freyd, 1985). Some aspects of representational momentum are thought to be automatic and not under conscious control (Finke & Freyd, 1989). Similar phenomena may be happening here as well.

Additive Effects Analysis

One question of interest is whether or not the motion devices are additive in nature. Because only limited combinations of devices were used, we cannot statistically test if the devices might be additive. However, in order to estimate how well the pictorial devices conform to an additive model, the actual score of a combination of devices was compared to the idealized score which would occur if the devices were perfectly additive. The average deviation from the idealized score estimates how close the data conform to an additive model. The idealized score was calculated by adding up the actual scores of each device alone. For example, to get the idealized score for multiple images with action lines, the actual scores for each device alone were added (.0248 + -.204 = -.18) The deviation score was calculated by subtracting the actual score for the combination of devices (e. g., .107 for multiple images with action lines) from the idealized score (e. g., -.18 - .107 = .287). For Experiment 2, weighted means ranged from -0.20 to +0.80 with an average deviation score equal to +0.104 above the idealized score (10% of the range). Motion ratings ranged from 11.6 to 84.0 with an average deviation equal to 19.7 below the idealized score (27% of the range). Interest ratings ranged from 21.9 to 73.1 with an average deviation score equal to 22.6 below

Table 9. Results of *T* tests Comparing Experiments 2 and 3.

Comparison Pictures	Device Type	T for Weighted Mean	T for Motion Rating	T for Interest Rating
	Control	.62	-1.22	-1.46
	Action Lines	1.93	-.089	1.41
	Multiple Images	-.39	.62	.44
	Orientation	-.83	-.14	1.11
	Posture	2.17 *	1.32	2.45 *
	Multiple Images & Action Lines	-1.70	-1.12	-.44
	Orientation & Action Lines	-3.48 ***	1.45	1.25
	Orientation & Multiple Images	-2.06 *	2.18 *	2.33 *
	Posture & Action Lines	1.75	1.99 *	3.54 ***
	Posture & Multiple Images	3.08 **	-.18	.58
	Posture & Orientation	.15	.29	1.51

Note. * denotes $p < .05$, ** denotes $p < .01$, and *** denotes $p < .001$ for a *t* test with 118 degrees of freedom.

Table 10. Correlations Between Experiment 2 and Experiment 3 Measures.

Variable	1	2	3	4	5	6	7
1. Motion: Experiment 3	--						
2. Interest: Experiment 3	.91	--					
3. Weighted Mean: Experiment 3	.15	.02	--				
4. Motion: Experiment 2	.98	.92	.07	--			
5. Interest: Experiment 2	.76	.95	-.07	.82	--		
6. Weighted Mean: Experiment 2	-.02	.00	.84	-.10	-.01	--	
7. Number of Devices	.84	.90	23	.85	.84	.27	--

the idealized score (44% of the range). For Experiment 3, weighted means ranged from -0.02 to +0.42 with an average deviation score equal to -0.07 below the idealized score (17% of the range). Motion ratings ranged from 6.6 to 84.0 with an average deviation score equal to 20.6 below the idealized score (27% of the range). Interest ratings ranged from 15.9 to 75.4 with an average deviation score equal to 27.6 below the idealized score (46% of the range). Weighted means come the closest to being additive; however, all three measures largely deviate from a purely additive model and are based on a limited number of cases (n=6).

Discussion

Using a different set of stimuli, Experiment 3 replicated many of the findings of Experiment 2. Experiment 3 replicated the overall forward memory distortion using the new set of pictures. The largest memory distortions were found for the orientation device. Additionally, pictures with more implied motion as measured by the number of motion devices were rated as depicting more motion and being more interesting. There were significant differences found on the memory distortion task, interest ratings and motion ratings between individual pictures in the two experiments. When combinations of two motion devices were used, interest ratings and motion ratings increased, but not necessarily memory distortion. No reliable relationships were found between conscious motion ratings and interest ratings with the perceptual memory distortion task.

In Experiment 2, posture proved to be a much more effective motion device than in Experiment 2. Comparing Experiments 2 and 3, the new posture device produced more forward memory distortion in Experiment 3. Posture with multiple images showed significantly more forward memory shift than this combination in Experiment 2. Although not significant by itself, in combination with orientation and multiple images, posture elicited significant forward memory shifts in Experiment 3. In most cases, posture also produced greater ratings of motion and interest using the new figure. Posture with multiple images in Experiment 3 showed significantly more forward shift than this combination in Experiment 2. In comparison with the posture device in Experiment 2, the posture device in Experiment 3 is more tilted. This slight tilt in orientation might be contributing to the greater forward memory distortion in Experiment 3 since it is evident that orientation has a strong an influence on memory distortion. The new posture device might be more effective because it is oriented at a slight angle.

In contrast with Experiment 2, there were no significant negative shifts in Experiment 3. Thus the negative effects of the action lines were reduced when the lines were gradually faded and shortened. However, using symbolic pictorial devices such as action lines and multiple images did not produce forward memory shifts individually. Overall, action lines and multiple images did significantly contribute to memory distortion, however; their effect may be negative in some cases (see Tables 1 and 5).

In addition, orientation continued to produce the strongest forward memory shifts. The shift for orientation was not as strong in Experiment 3 as it was for Experiment 2. One explanation for this effect is that although Carello et al. (1986) reported that for orientation they rotated the control figure 30 degrees, it appears that the figures were actually rotated closer to 45 degrees (see Table 9). This added degree of rotation may contribute to the increased memory shift.

Participants found the figures used in Experiment 3 to be more interesting than the Carello et al. (1986) figures. Using more realistic pictures may add to the interest value of the picture. Another source of interest may have been that the fading gradation in the action lines and multiple images produced more interest than just regular line depictions of these devices. A more carefully controlled experiment could test each device individually and vary several aspects (length, intensity, fading ratio, etc.) of each device in order to see which changing dimension adds the most interest, implied motion, and memory distortion.

CHAPTER VI

GENERAL DISCUSSION

Knowledge and experience continually influence our perceptions and representations of pictures. Clearly, knowledge about motion affects how we perceive visual information. The expectation that a figure in a picture will move changes the representation such that the figure is recalled farther forward in position. Gombrich and others believe that expectations and schemas are a necessary and integral part of perception, and this study illustrates how the expectation of motion can influence perception and recall of visual information. Often times, we may not be aware of the extent to which prior knowledge and experience influences what we see and how we represent the world. Participants in these studies were often quite surprised to see the patterns of errors in their data since most of them were not conscious of these memory distortions.

Experiment 1 was designed to establish a methodology for measuring memory distortion in static pictures. Three different works of art with implied motion were used in a "same-different" recognition task. Two of the three pictures produced significant memory distortions. However, one picture produced a memory distortion opposite from the predicted direction. For this reason, a more controlled set of pictures was used for the last two experiments.

Experiment 2 was designed to test the relationship between memory for position, motion ratings and interest ratings for pictures. A subset of the stimuli from Carello et al. (1986) depicting combinations of four different motion devices was used. Overall, there was a significant forward memory distortion for the pictures. Orientation produced the most significant forward memory shifts. A few devices produced negative distortion effects (e. g., action lines, posture with action lines, and posture with multiple images). Each motion device was unique in the amount of memory distortion produced and the level of motion ratings and interest ratings elicited. For individual pictures, motion and interest ratings were positively correlated. As the number of motion devices increased, motion ratings and interest ratings increased in a linear fashion. However, the correlation between memory distortion and motion and interest ratings was not significant across individual pictures. The conscious rating tasks and the more implicit memory distortion task may be influenced in different ways by the different motion devices. While action lines affected motion and interest ratings, they did not have any reliable effect on memory distortion. Multiple images had no effect on motion ratings or memory distortion, but did significantly affect interest ratings. The memory distortion task may be affected by more natural devices that are more closely linked to real motion such as posture and orientation, while the ratings tasks may be affected by both symbolic and natural devices.

Experiment 3 was designed to test a new set of stimuli which varied the way in which Experiment 2 motion devices were depicted. The same design as Experiment 2 was used and many of the findings replicated. Once again, there was a significant overall forward memory distortion for the pictures with orientation having the strongest effect. Some of the new devices produced significantly different memory distortion, motion ratings and interest ratings from Experiment 2. For example, posture did not produce backwards memory distortions in Experiment 3 as it did in Experiment 2. The new posture device was tilted slightly forward and this slight orientation may have contributed to greater forward memory distortion. Action lines which were shorter and gradually faded had a significant effect on memory distortion and no longer produced any significant backwards memory distortions. Thus, the exact depiction of a motion device and its context can affect the perception and representation of motion in a picture. As the number of motion devices increased, motion ratings and interest ratings increased. Motion and interest ratings were positively correlated, but no relationship was found between memory distortion and motion and interest ratings for individual pictures. Thus, the lack of correspondence between conscious ratings and memory distortion is also replicated in Experiment 3.

This research supports the idea that motion expectations exist and can trigger representation changes. Performance on a "same-different" recognition task demonstrated that memory for the position of the pictures was distorted in a forward direction. This result supports the hypothesis that participants' short-term memory for position changes as a result of implied motion in the pictures. Whether long-term memory for the picture has been distorted is not addressed in this research. Further research should test these distortion effects over longer periods of time to estimate their duration.

The Dichotomy Between Conscious Ratings and Memory Distortion

The study did not support the hypothesis that conscious motion ratings are related to performance on the memory distortion task. As more motion devices were added to a picture, people reported that the image depicted more motion. Tables 3 and 7 show that adding a second device significantly increased motion ratings the majority of the time. In contrast, memory distortion did not always increase when a second motion device was added, motion ratings did not significantly correlate with memory distortions. One example of this dichotomy is the orientation device. Orientation produced the most significant forward memory shifts in both studies, but not necessarily the highest motion ratings. Posture seemed to contribute more to the subjective ratings of motion, yet it produced backwards memory distortions Experiment 2. Action lines contributed significantly to motion ratings but not significantly to memory distortion in Experiment 2. Furthermore, the devices were more additive in the memory distortion task than they were for motion and interest ratings.

N. Goodman (1976) asserts that a picture is entirely symbolic and involves no overlap with existing perceptual processing. The findings in this research suggest a different view: there may be some motion devices which are purely symbolic, but other devices relate more to natural motion. There is more support for the view that a continuum of correspondence to the environment exists where one end of the continuum is purely symbolic and arbitrary and has little or no overlap with existing perceptual processing. The other end of the continuum contains motion devices which are closer to how real motion is depicted in the environment and the processing of these devices probably overlaps with perceptual processing.

Subjective ratings do not always reflect perceptions. In many cases, people are able to make correct visual judgments concerning physical events, but often lack the correct underlying conceptual model (Shanon, 1976). Given this dichotomy, the subjective motion ratings and performance on the memory distortion task in the present research may have their basis in different mental mechanisms.

The Relationship Between Motion and Interest

There seems to be a strong relationship between interest and perceived motion in a picture. Both Experiments 2 and 3 demonstrated very good support for this relationship. As the number of motion devices increased from 0 to 1 to 2, motion and interest ratings both increased in a linear fashion. An interesting experiment would be use the full set of Carello et al. (1986) pictures and examine memory distortion, motion ratings and interest ratings as one increases the number of devices up to five. It is likely that the motion and interest ratings will level off after a certain number of devices.

Why do people find pictures with more motion more interesting? Gombrich (1968) might say that motion cues add to the overall illusion of the picture. All good art is about creating illusions. The artist relies on the assumptions of the individual viewing the work of art. As a person views the picture, they are sorting, comparing, and classifying the elements of the composition. Just as perception is about schema and correction, audiences viewing a picture rely on assumptions, test out hypotheses about what the picture portrays, and correct their hypotheses in terms of the incoming information. While viewing a picture with motion, a likely assumption that a person could make is that the elements in the picture will move. However, according to Gombrich, that assumption has to be continually corrected since the picture is obviously not moving. Freyd (1993) would also add the idea that the underlying representation of the picture actually changes in anticipation of the motion. In turn, the underlying representation now conflicts directly with the incoming information from the picture. This expectation and correction processing may be more interesting than processing for pictures which do not have to be "corrected" in any way.

Moving objects in our environment often require us to respond in some fashion. For example, the motion of an approaching car necessitates that we move out of the way. If we do not respond, our lives may be in danger. Thus, motion may heighten our awareness and attention (Goldstein, 1996). By increasing our attention to an object, it may cause our level of interest to increase. Thus the presence of implied motion may act in a similar fashion to real motion, directing our attention and influencing our subsequent interest for a picture.

Of course, there will always be some question as to whether or not asking a person to rate their interest level is really the best way to measure interest. Interest may be an unconscious dimension and not easily quantifiable. Perhaps physiological measures might be more accurate if people are not the best judges of their own level of interest. In addition, this experimental setup may provide demand characteristics which encourage people to respond in such a way that they think they are supposed to increase their rating of interest as the amount of motion or number of motion devices increases. A naturalistic field study of preferences for pictures might be a more accurate test of the relationship between increasing motion and interest. Other measures of aesthetic excitement need to be explored besides a single interest rating.

Other factors may also be influencing interest level. As the number of motion devices increases, the complexity in the pictures is also increasing. Berlyne (1974) and others have found that more complex patterns are rated as more interesting than less complex patterns. Berlyne's (1974) idea is that arousal potential, which might arise from such factors as novelty or complexity, is really what is affecting "interestingness." In these studies, the pictures with increased motion may also happen to be more complex, and the increased motion may have nothing to do with increased interest. A new set of equally complex pictures with varying amounts of implied motion should be tested in order to understand the influence of both motion and complexity on level of interest.

The Influence of the Motion Devices

Both orientation and posture showed a strong effect on memory distortion, motion ratings and interest ratings in Experiments 2 and 3. These devices can be considered more natural since they show a closer correspondence to the environment than symbolic devices. More symbolic devices such as action lines and multiple images were not the most effective source of motion information. Action lines and multiple images were not rated as highly as posture for how well they depict motion. In addition, they were not as effective in producing forward memory distortions by themselves. In conjunction with orientation, action lines did increase memory distortions slightly in Experiments 2 and 3 (see Tables 1 and 5). However, with posture, action lines did not significantly increase memory distortion in either Experiment 2 or 3. The multiple images device varied in how much it affected memory distortions, depending on which device it was coupled with. In combination with orientation, multiple images increased the forward memory distortion only in Experiment 2 (see Tables 3 and 7). However, in combination with posture, multiple images did not add significantly to memory distortion in Experiments 2 or 3 (see Tables 3 and 7). For both experiments, multiple images did not have any reliable effect on motion ratings (see Tables 2 and 6). This finding relates to Friedman and Stevenson's (1980) finding that metaphorical or symbolic devices are poor motion indicators for young children and people in non-European cultures. Perhaps those devices which we must learn about through culture are less compelling.

However, Kennedy and Gabias (1985) found that the blind matched metaphoric motion devices to types of motion in the same fashion as adults with normal vision. They concluded that in adults, metaphoric motion devices are widely understood without prior exposure since the blind participants, presumably having had no experience with these motion devices, performed like sighted adults. Kennedy and Gabias (1985) argue that children have difficulty with metaphoric motion devices not because they have to be taught, but because they lack a particular kind of comprehension. Perhaps the processing needed in comprehension of symbolic motion devices is separate from processing needed for naturalistic devices.

The exact depiction of a motion device can make a tremendous difference. Even though Experiments 2 and 3 used the same motion devices depicted in slightly different manners, results showed that there were significant differences between images in each experiment. For example, the posture device used in Experiment 3 was tilted slightly forward and produced more forward memory distortion than the posture device used in Experiment 2. Since orientation had the most powerful influence on memory distortion, the greater tilt on the new posture device may be causing the larger forward memory distortion in Experiment 3. In addition, the new posture figure may have had a more clearly defined future direction of motion than the posture device used in Experiment 2.

In another example, the degree of rotation for orientation made a difference. As the degree of rotation increased from upright, memory distortion increased. This effect may be due to an added awareness of gravity. Perhaps there is a sense that human figures with greater rotation are more likely to fall than human figures with less rotation (closer to an upright standing position). The greater likelihood of falling for the more rotated figures may increase the forward memory distortion. An interesting experiment would compare these human figures with inanimate objects with the same degrees of rotation from upright. If an inanimate object did not show the same effect as the human-like figure, we could conclude that knowledge of the normal upright positions of humans might also be contributing to the effect. If there were differences with inanimate objects as well, then perhaps a greater angle of slant might make gravity more salient under certain conditions. Indeed, Bertamini (1993) found that a ball on a hill showed increased memory distortion with increasing angle of slant. In addition, a future experiment should test the set of figures used in Experiment 3 with an orientation of 45 degrees instead of the 30 degrees as reported by Carello et al. (1986) in order to make a more direct comparison between the sets of figures.

Not all of the devices were equally effective in producing higher motion ratings. Carello et al. (1986) believed that motion devices that highlight the particular action are the most effective. This study showed similar results for motion ratings for the Carello et al. (1986) set of figures, but a different pattern with the new set of depictions. In addition to the particular action being highlighted, we now have evidence that the characteristics of the device itself will also influence the amount of implied motion seen in a picture.

Conclusions

Expectations can have very powerful influences on the way people process information about the world. In particular, expectations about motion can affect the way we process visual information in static pictures. If there is implied motion in a picture, people are likely to show memory distortions in predictable directions. People are more likely to misremember the picture in the direction of implied motion. Using implied motion devices in pictures can add to the perception of motion and the amount of memory distortion produced. Using combinations of motion devices adds to the conscious perception of implied motion as well as interest expressed for a picture. More motion may be perceived unconsciously for more natural devices (e. g., orientation and posture) than for symbolic devices (e. g., multiple images and action lines) and produce more forward memory distortion.

The exact manifestation of particular motion devices makes a tremendous difference in how much memory distortion is produced, how much motion is consciously implied and how interesting a picture looks. It is not enough to just add motion devices. The exact depiction of a motion device is critical. For example, the posture device used in Experiment 3 was oriented slightly forward with a more clearly defined future direction of motion and produced more forward memory distortion than the posture device used in Experiment 2. Greater degree of rotation in orientation can cause more forward memory distortion than less rotation.

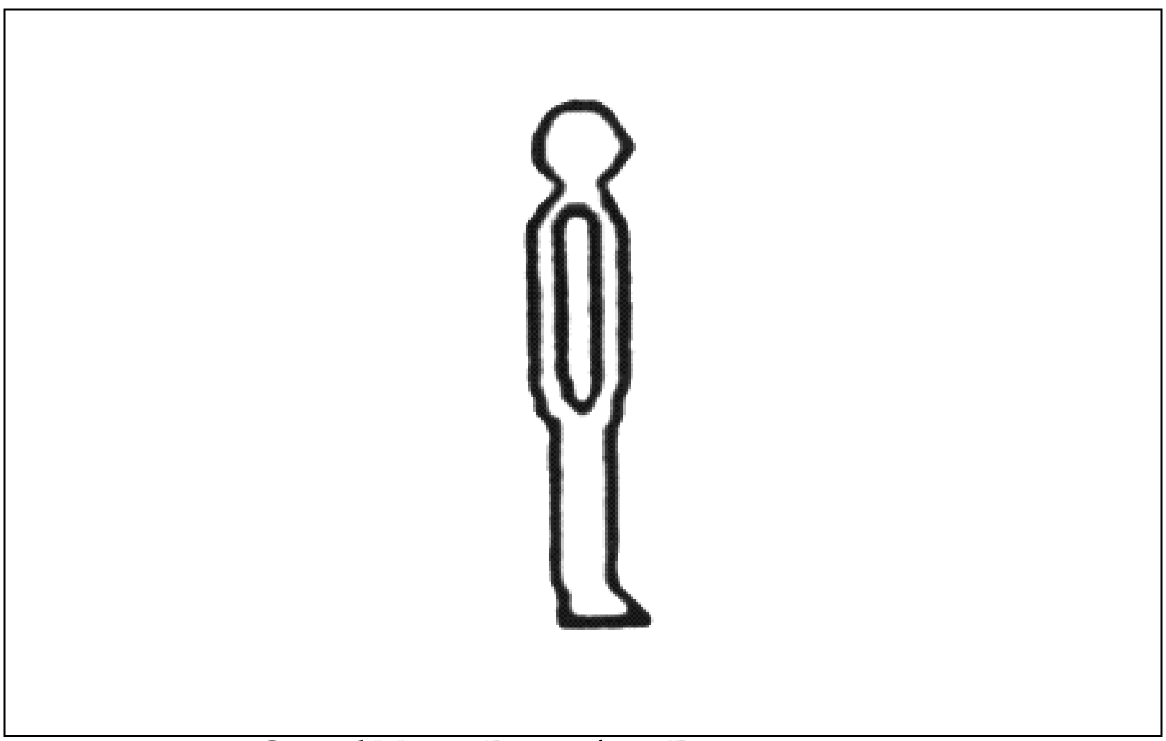
Future experiments should explore other kinds of variations of motion devices. Perhaps there are canonical forms for motion devices which represent the ideal form for depicting the most motion in a particular context. Future studies should also try to use an increased number of test positions which are closer together in order to more clearly define where the forward shift in memory resides. It is likely that more pictures from the last two experimental sets might have significant memory shifts using a more accurate measure since many pictures had forward trends that were not significant. In addition, this research only addresses distortions over a very short period of time and further research is needed to determine the duration of these distortions. We assume that the representation has changed and therefore the long term storage of the picture has also changed. However, these effects may in fact be only very short-lived and over longer periods of time may not be present in the underlying representation.

Other kinds of contexts should be tested as well. For instance, these motion devices might differ in effect when in combination with inanimate objects verses human-like figures. Other kinds of actions should also be tested since Carello et al. (1986) found evidence that motion devices that emphasize a particular action caused higher motion ratings than devices that did not emphasize the action. Memory distortion may also be affected if different actions are depicted with different motion devices. More naturalistic stimuli such as real works of art should be tested in the future in order to see if these findings also generalize to real works of art. However, selecting works of art so that the direction of implied motion is clearly defined can be problematic as demonstrated in Experiment 1. Other measures of interest and motion should be explored in conjunction with memory distortion. Lastly, eye tracking experiments would reveal where people look in pictures with implied motion. Perhaps certain devices direct the eyes to particular parts of a picture and thus affect attention and subsequent recall.

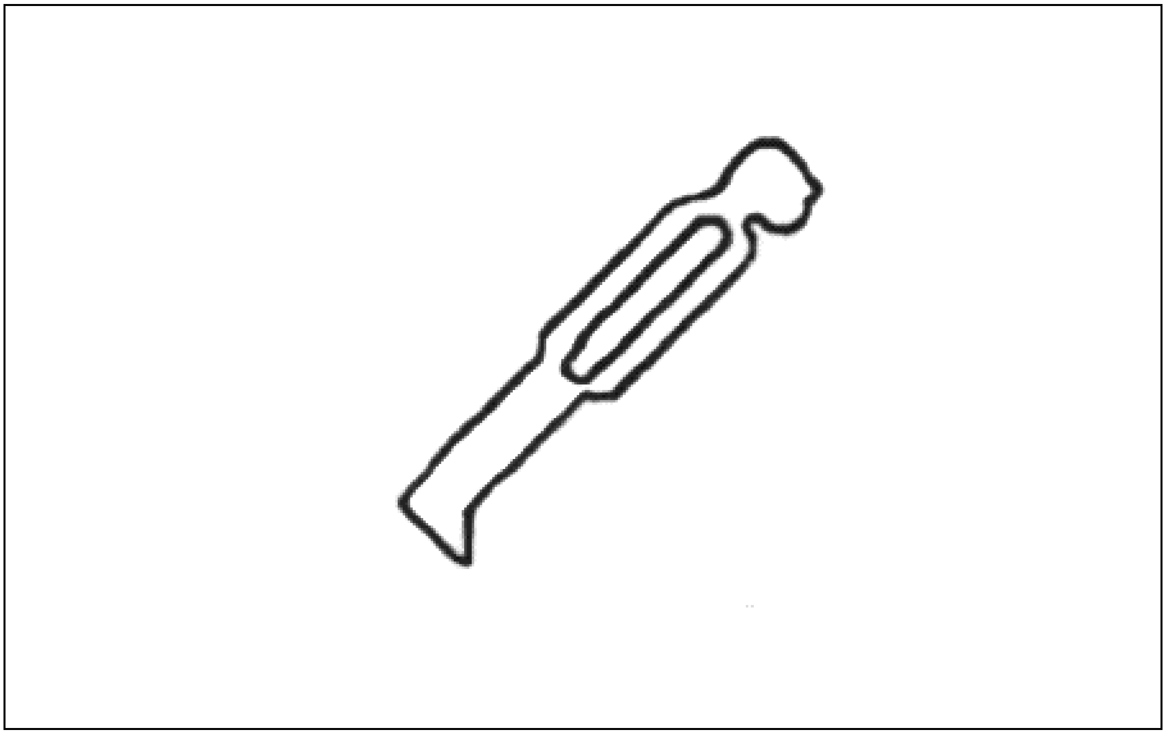
APPENDIX A THE

PICTURES USED IN EXPERIMENT 2

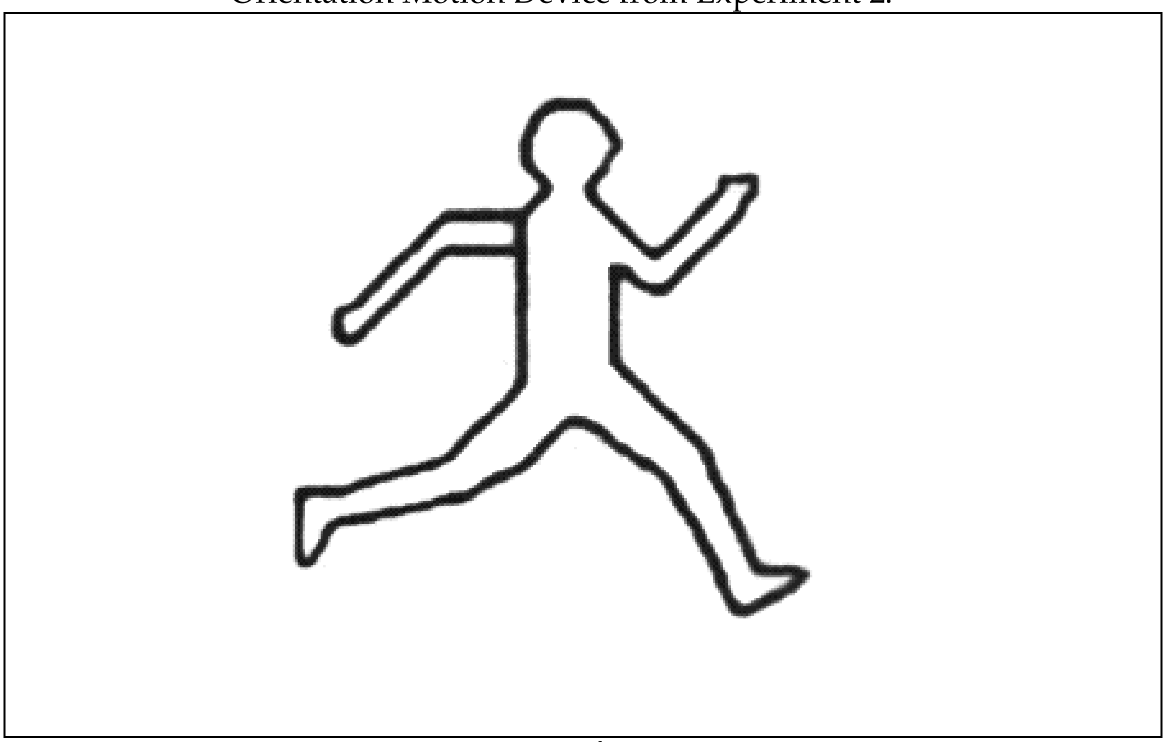
These are the pictures used in Experiment 2. These pictures are the actual size of the pictures used in the experiment. However, the frame around the pictures was one inch wider and one-half inch taller on the screen during the experiment.



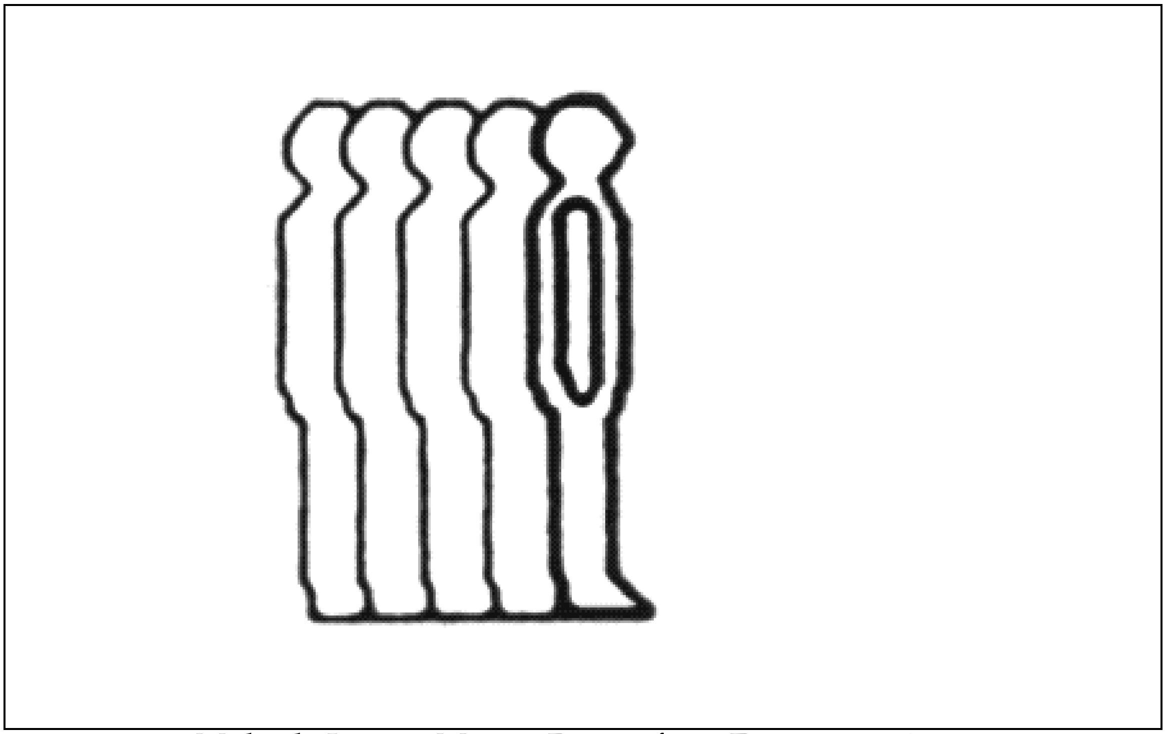
Control Motion Device from Experiment 2.



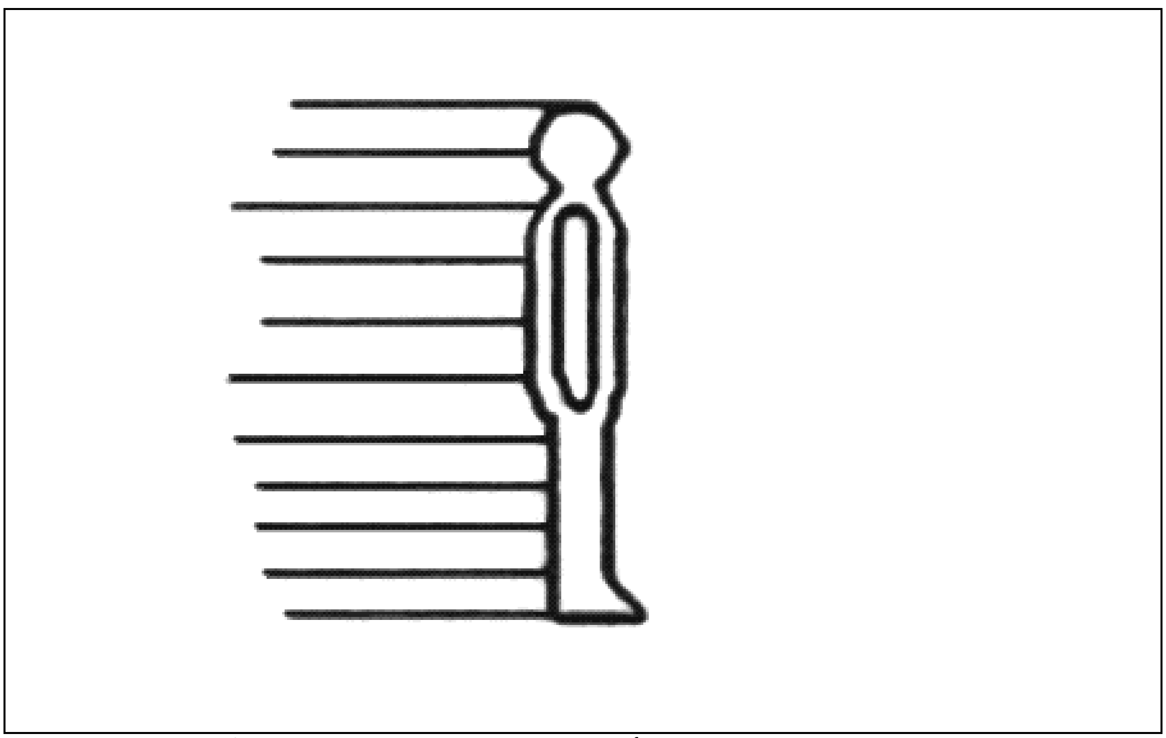
Orientation Motion Device from Experiment 2.



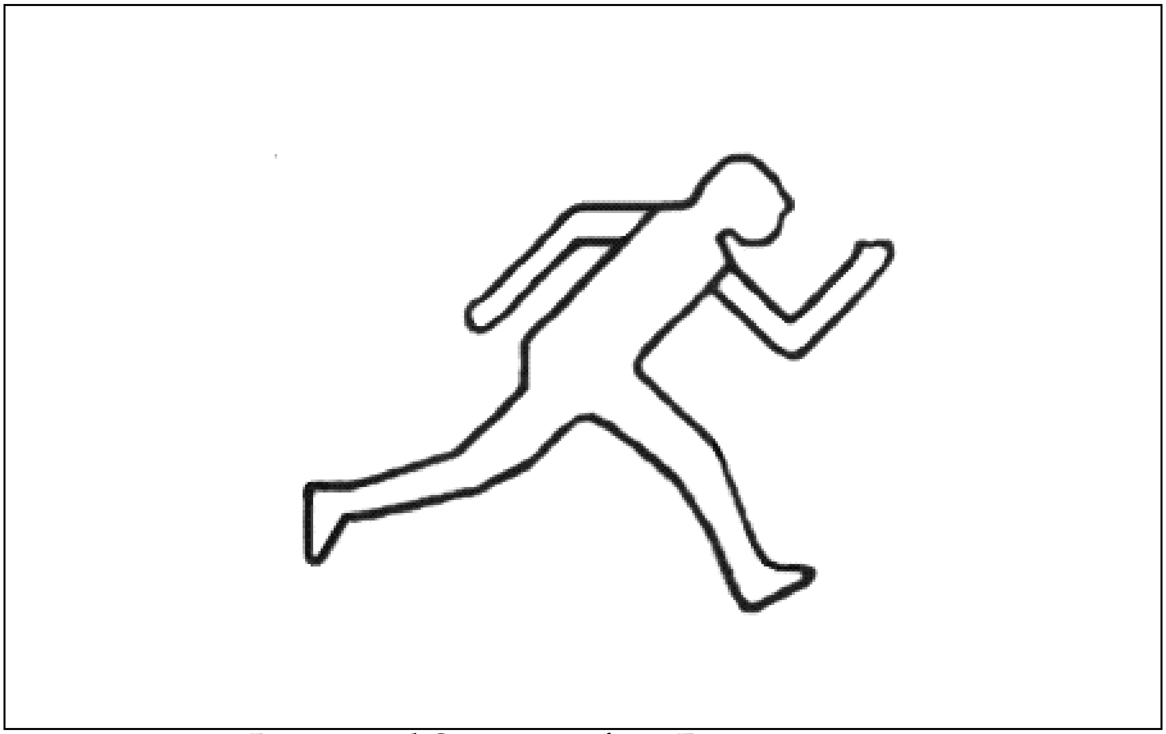
Posture Motion Device from Experiment 2.



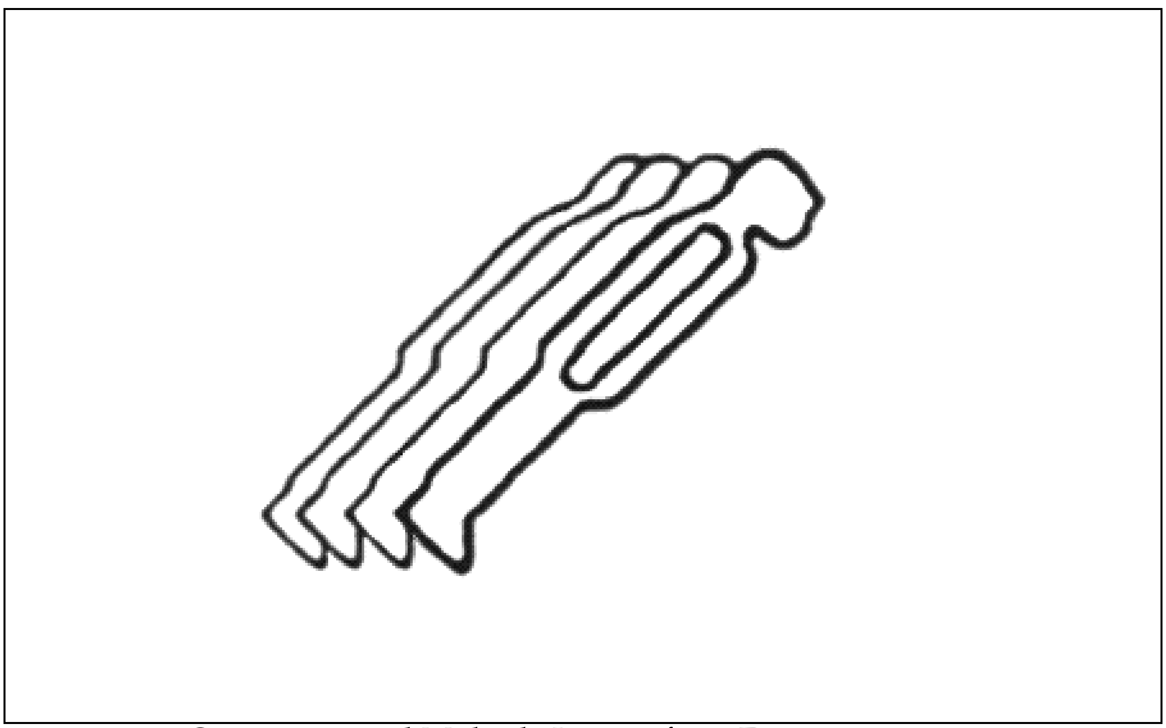
Multiple Images Motion Device from Experiment 2.



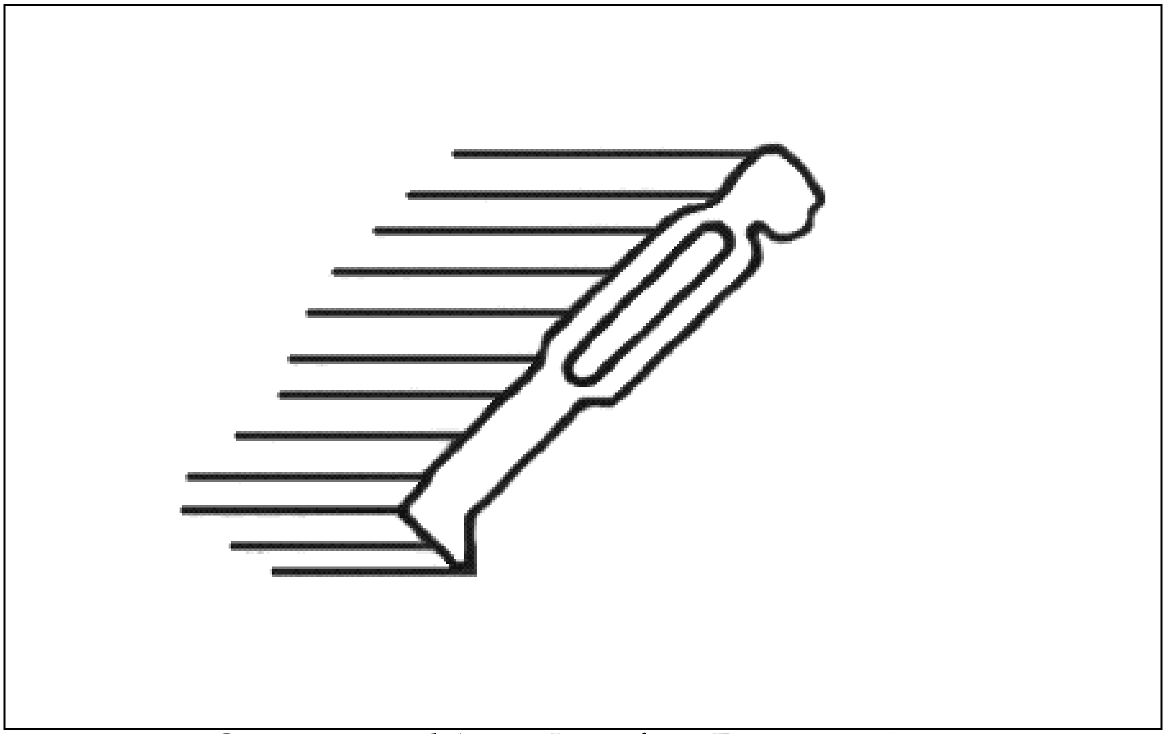
Action Lines Motion Device from Experiment 2.



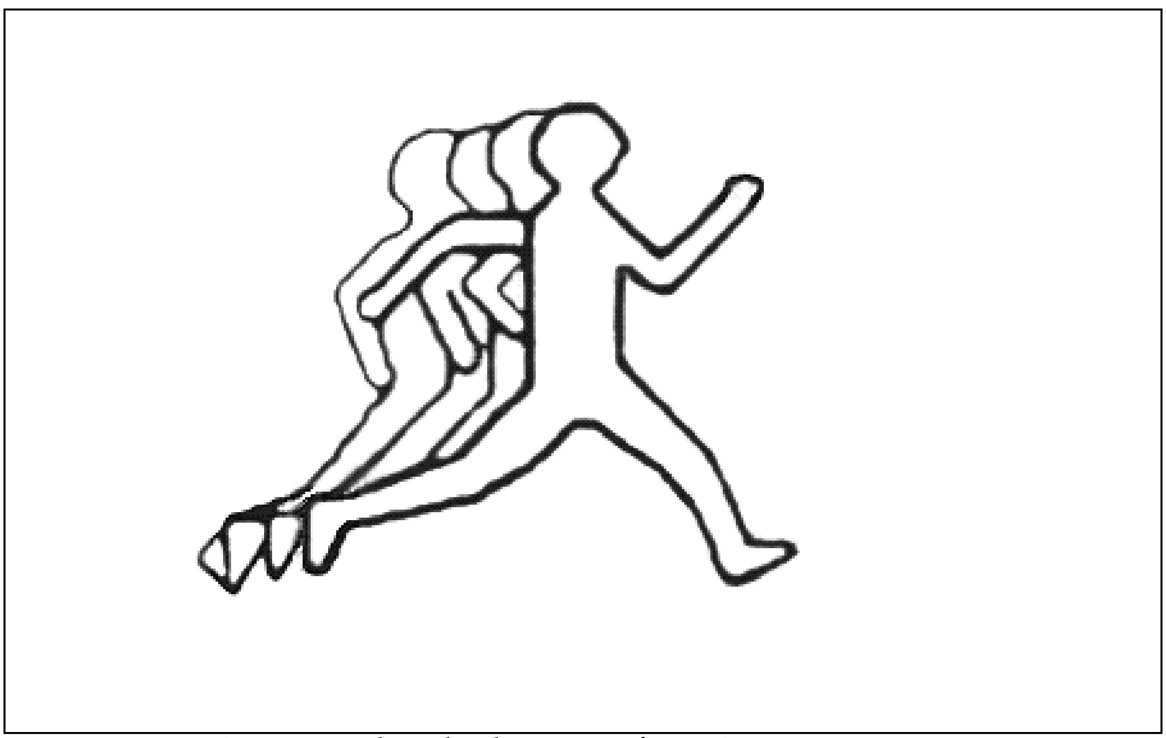
Posture and Orientation from Experiment 2.



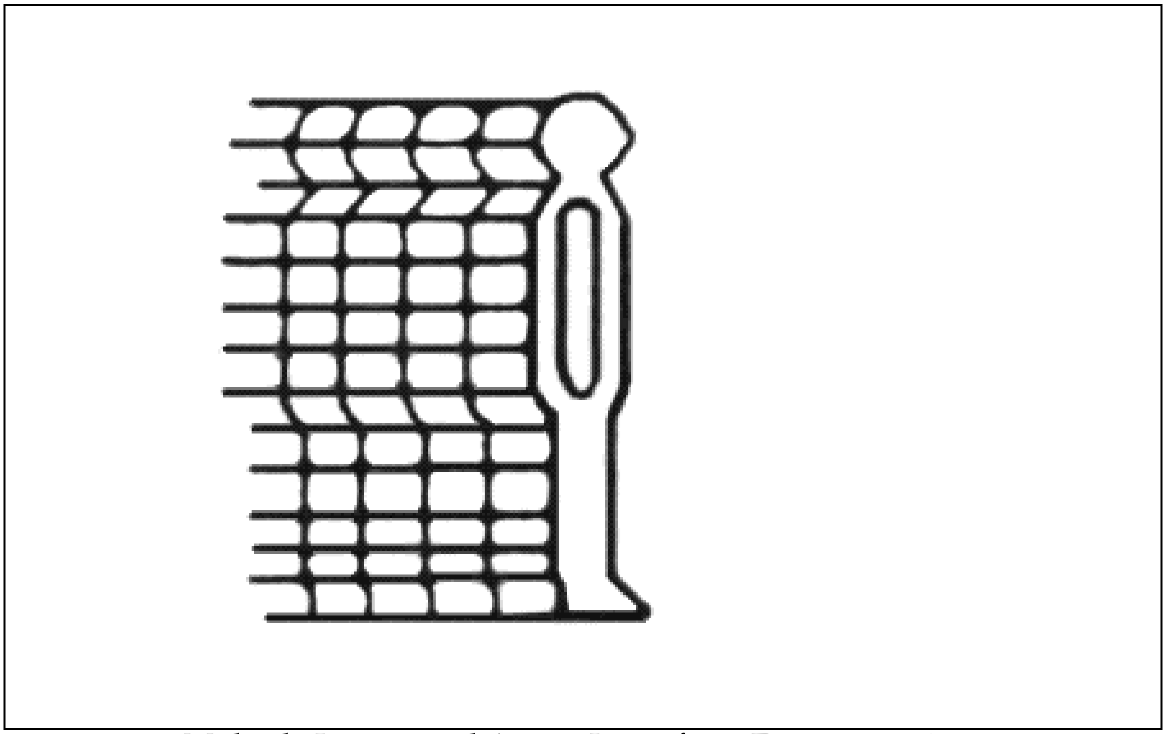
Orientation and Multiple Images from Experiment 2.



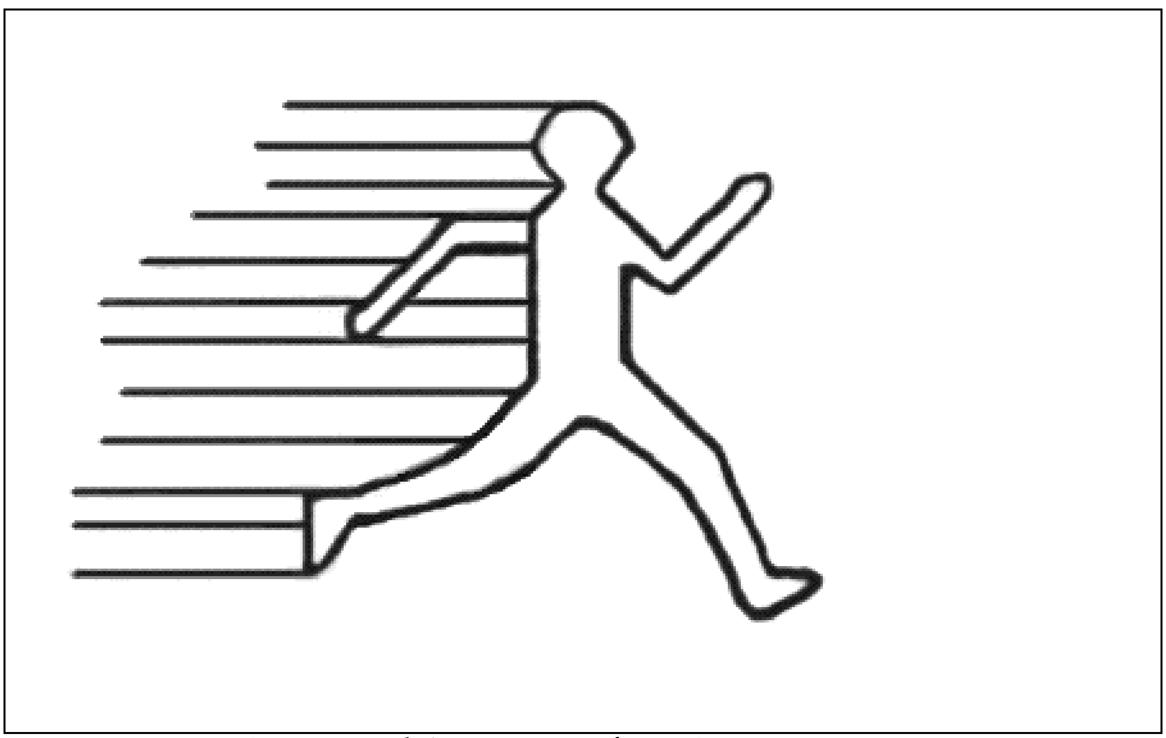
Orientation and Action Lines from Experiment 2.



Posture and Multiple Images from Experiment 2.



Multiple Images and Action Lines from Experiment 2

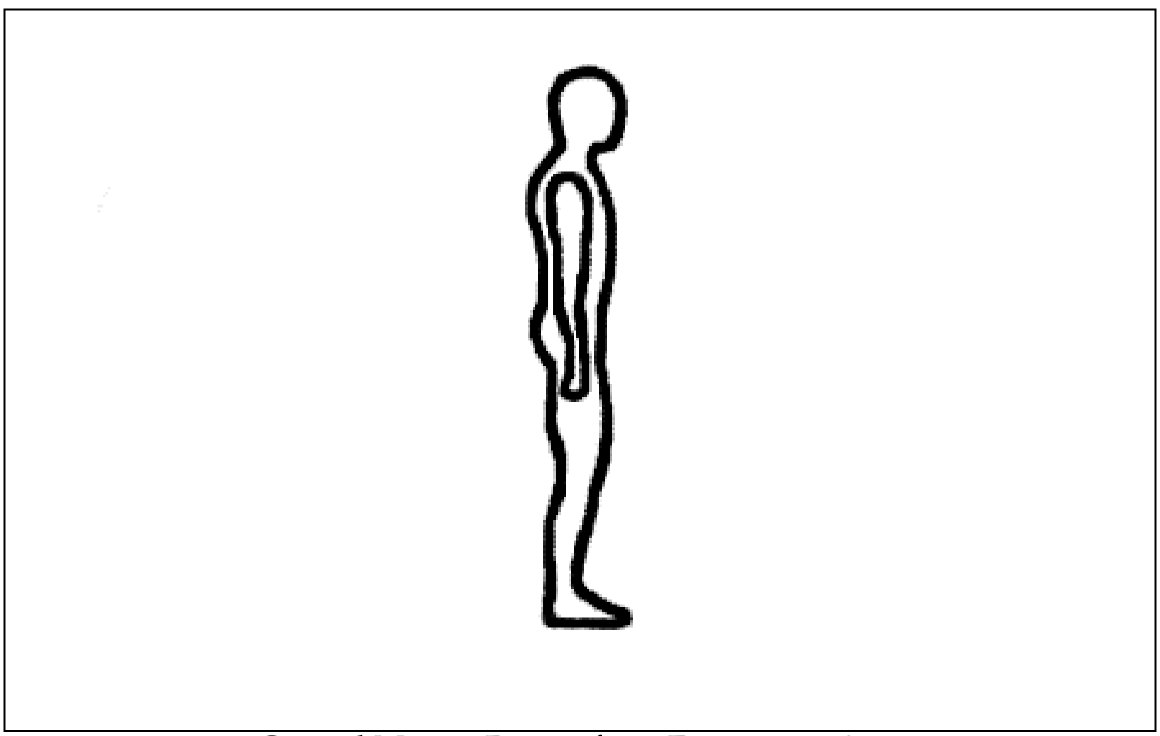


Posture and Action Lines from Experiment 2.

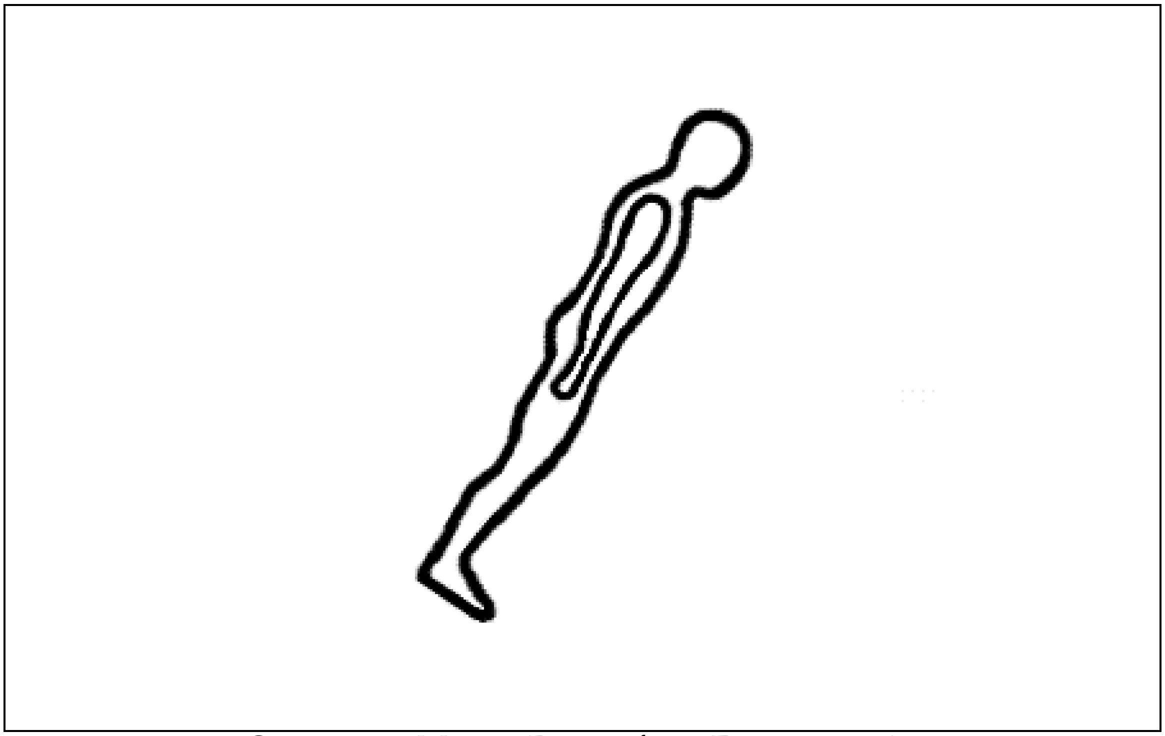
APPENDIX B THE

PICTURES USED IN EXPERIMENT 3

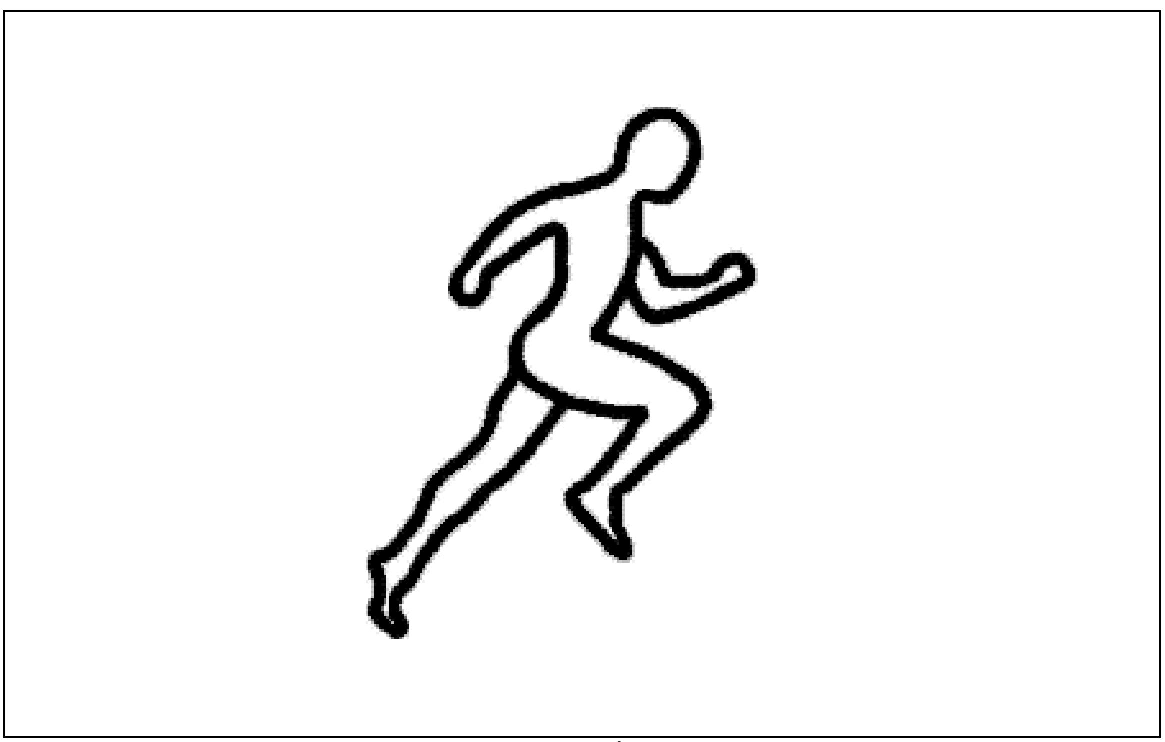
These are the pictures used in Experiment 3. These pictures are the actual size of the pictures used in the experiment. However, the frame around the pictures was one inch wider and one-half inch taller on the screen during the experiment.



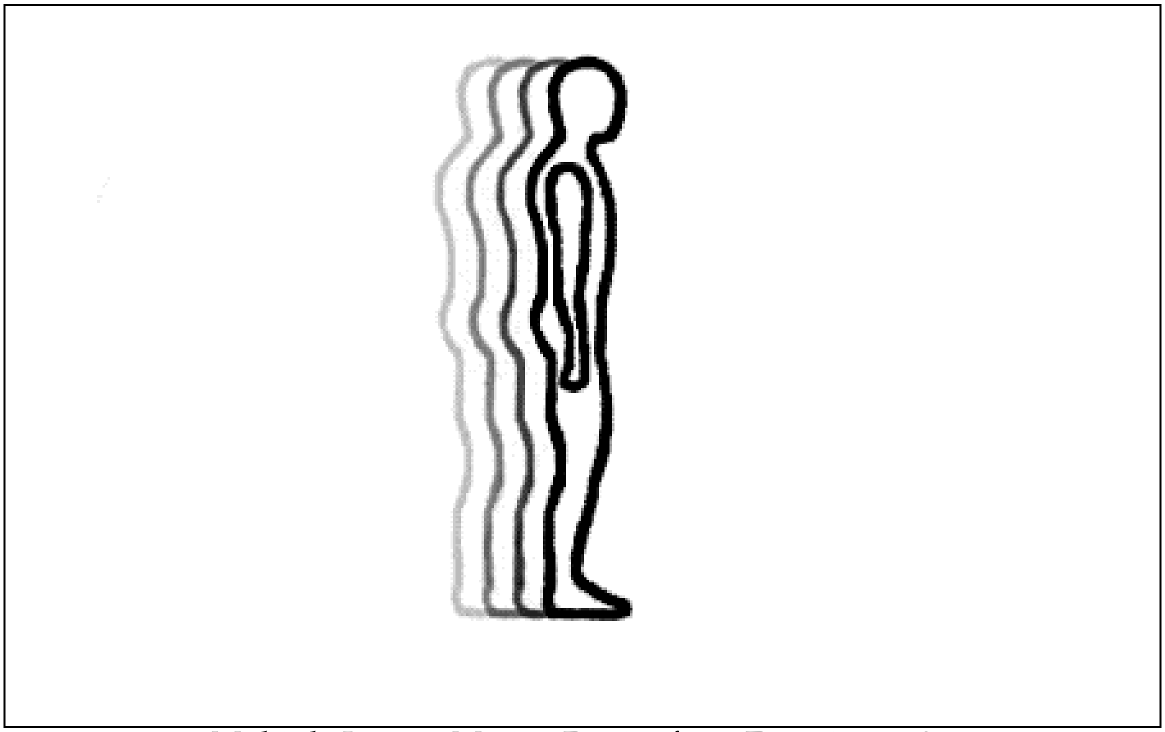
Control Motion Device from Experiment 3.



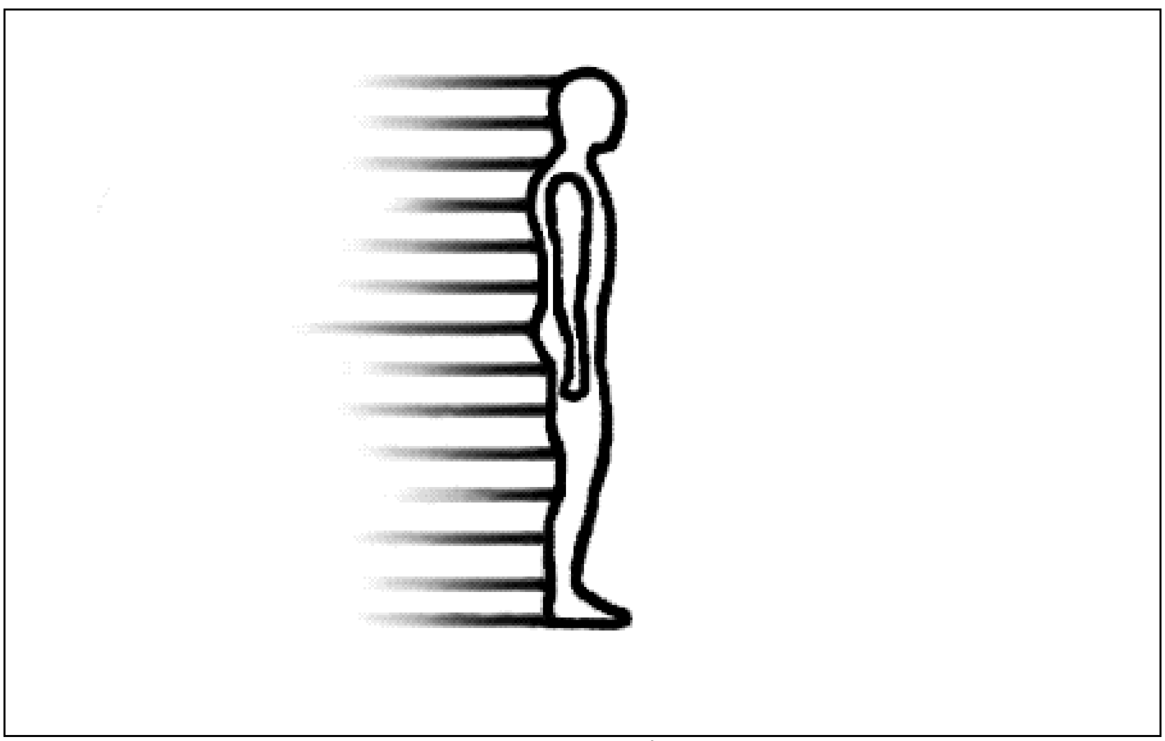
Orientation Motion Device from Experiment 3.



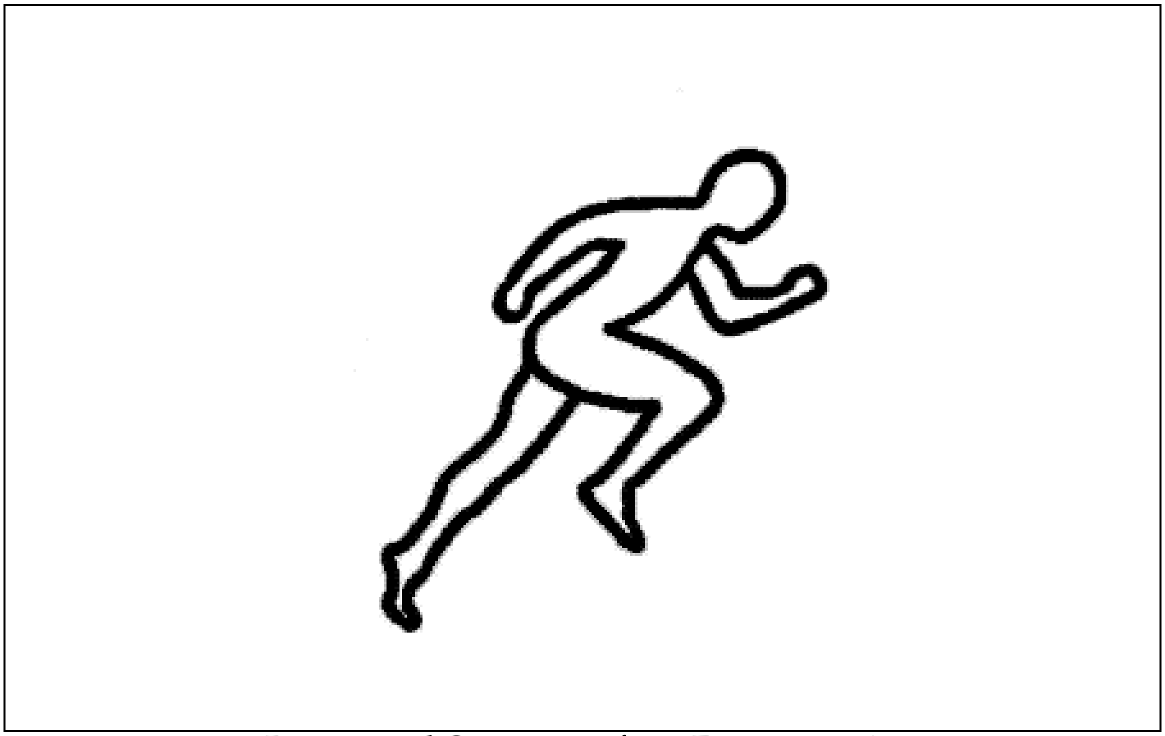
Posture Motion Device from Experiment 3



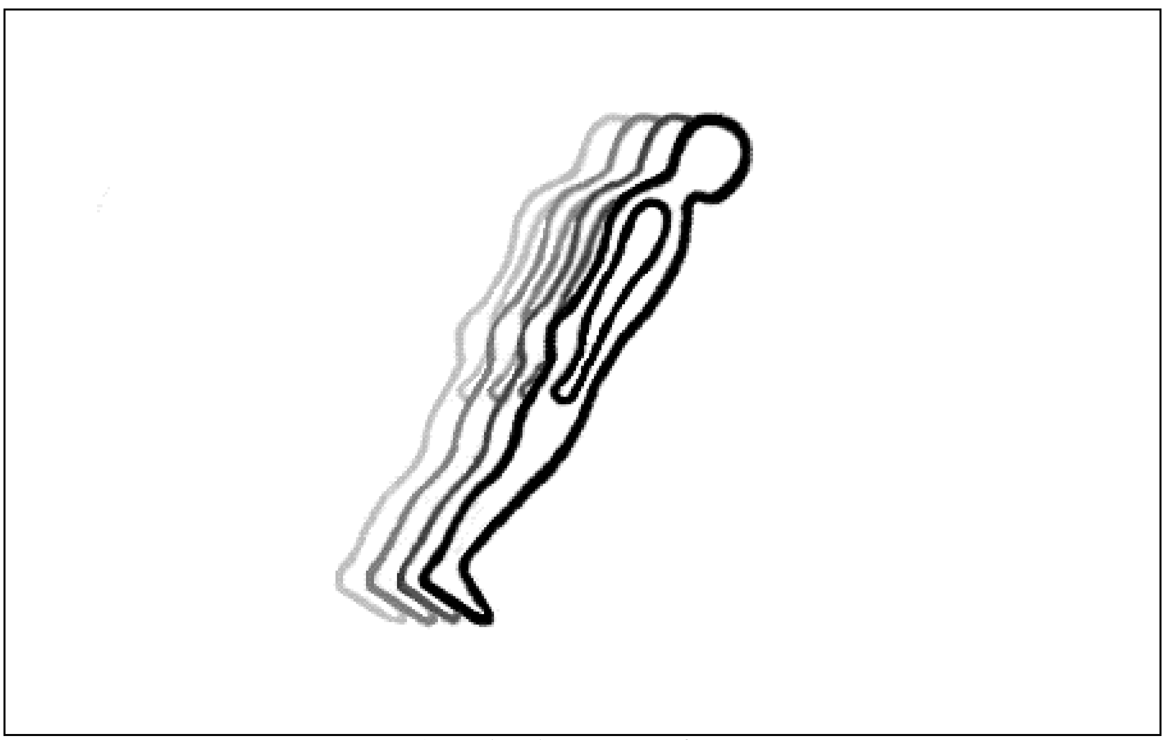
Multiple Images Motion Device from Experiment 3.



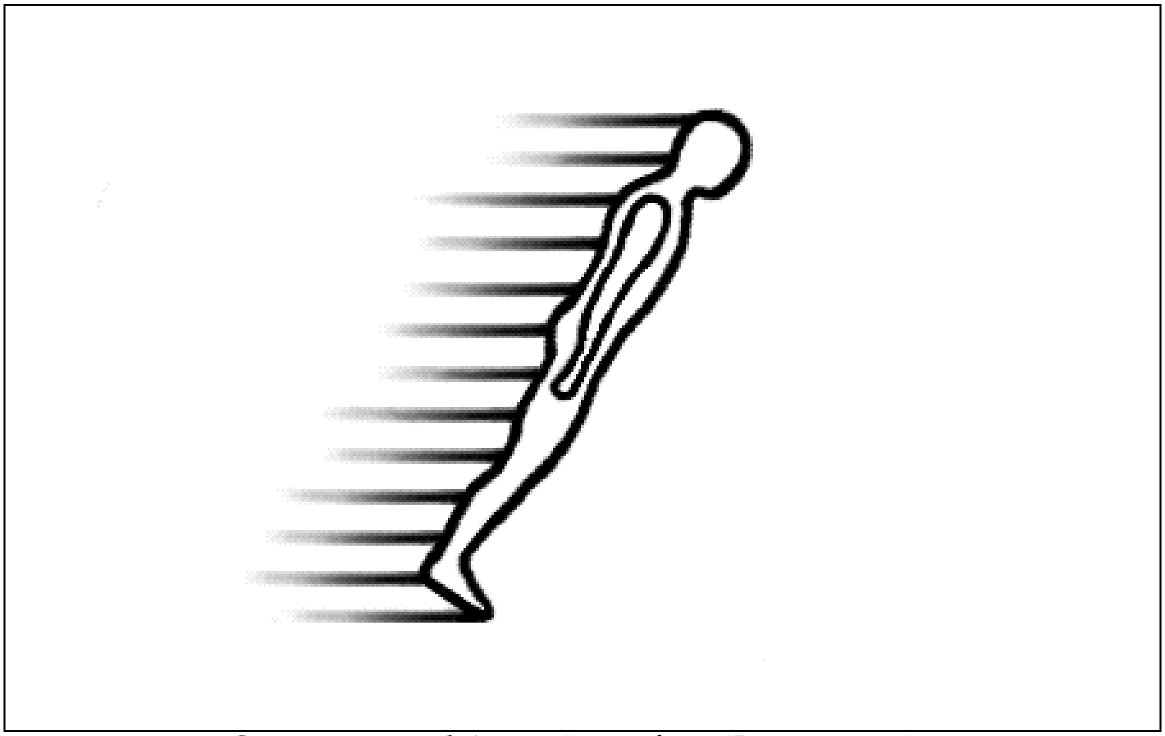
Action Lines Motion Device from Experiment 3.



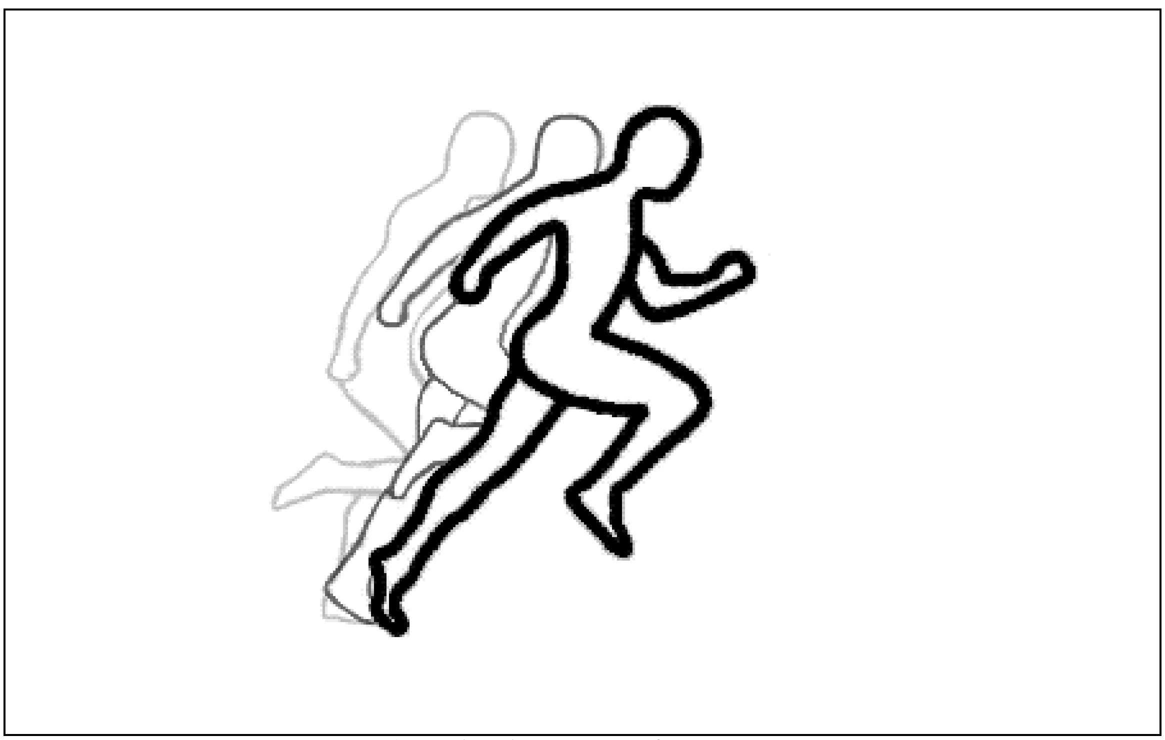
Posture and Orientation from Experiment 3.



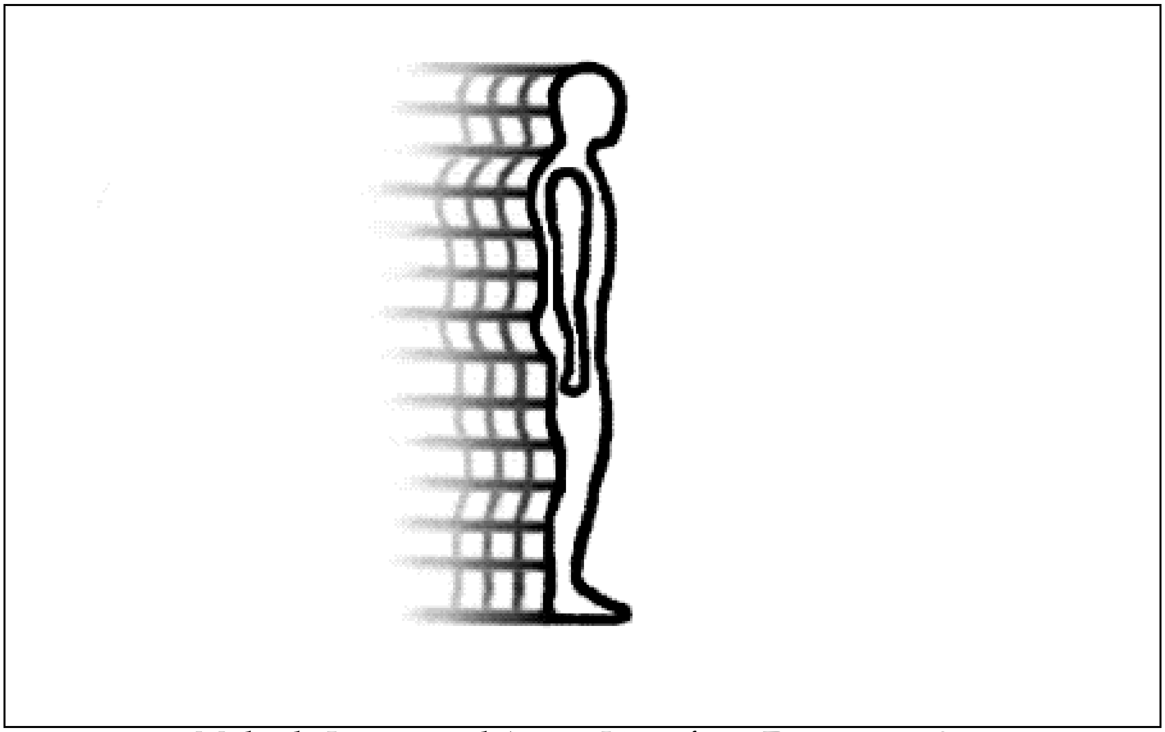
Orientation and Multiple Images from Experiment 3.



Orientation and Action Lines from Experiment 3.



Posture and Multiple Images from Experiment 3.



Multiple Images and Action Lines from Experiment 3.

Posture and Action Lines from Experiment 3.

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