EFFECT OF LOOMING MOTION ON LEARNING IN CHILDREN WITH AUTISM

Lauren Moskowitz, Jennifer Juska, Jessica O'Grady, Vicky Smrcka, Barry Gordon

Department of Neurology, Division of Cognitive Neurology, Johns Hopkins Medical Institutions, Baltimore, MD

Introduction

Individuals with autism are typically slow to learn. Impairments of attention (ranging from lack of attention to overly focused attention) are also prominent in individuals with autism, and may be one of the major factors contributing to their learning difficulties. As a consequence, many teaching methods have attempted to attract and focus attention. In this pilot study, we explored movement as a method of improving attention and, hence, learning in individuals with autism.

Movement has been shown to be a potent inducer of attention in a number of situations and across a number of species. Even young infants will orient toward a moving object (Volkmann & Dobson, 1976; Dannemiller & Freedland, 1989; Aslin & Shea, 1990; Nagata & Dannemiller, 1996). Although motion in general is a powerful attractor of attention, motion *toward* an individual is particularly effective. Animals as diverse as pigeons and locusts have neurons that are tightly tuned for detecting and reacting to "looming stimuli" or rapidly approaching objects (Lee, 1976; Schlotterer, 1977; Rind & Simmons, 1999). Images that grow in size trigger avoidance reactions in many species (Schiff, 1965). Both human and primate infants exhibit startle responses, agitation, and fear in response to the rapid visual approach of a stimulus (Schiff, Caviness, & Gibson, 1962; Ball & Tronick, 1971; Rheingold & Eckerman, 1973). Loomingness captures attention independently of the fear or threat that it may invoke (Riskind and Maddux, 1993). Stimulus movement has been shown to improve discrimination learning in monkeys (Nealis, Harlow, & Suomi, 1977; Washburn, Hopkins, & Rumbaugh, 1989). There are reasons, therefore, for believing that presenting materials with looming motion will (a) capture attention and (b) therefore improve learning. We explored these linked hypotheses in two sets of experiments: one using stimuli that moved mechanically, and the other using stimuli presented on a video screen with simulated movement.

General Methods

Basic Design: Both experiments used a within-subjects, repeated-measures design. The first experiment used a matching-identical-pictures task; the second, an auditory-visual discrimination learning task. All possible response items in a given trial were either static or moving. Trials with static or moving response items were blocked in sets of up to 10 or 20 trials, depending upon the particular subject and session. Initial training involved manually prompting the subject toward the correct response, fading the prompts until the subject chose the correct target on his own. One target and two distracters were the response items. There were three measures of learning:
1) The number of training sessions to reach a mastery criterion of at least 80% correct for a given target.
2) The percent correct on a post-test at the end of each session, in which all targets trained that day in the moving and static conditions were displayed still, and the conditions were interspersed rather than blocked (i.e. one trial of an item that was trained moving, followed by one trial of an item that was trained still, etc.).
3) Percent correct on a post-test after a 1-week interval from mastery.

Subjects were four low-functioning males with autism: AI-14 yrs, HR-12 yrs, FN-12 yrs, RE-13 yrs. (falsified initials). All subjects scored at the preverbal level (approximately 20-22 months) on standard cognitive tests of expressive and receptive language. Informed consent was obtained in all cases, in accordance with procedures established by The Johns Hopkins Medical Institutions IRB.

Materials: For Experiment 1, visual response items were animal pictures from the Baby Dolittle flash card set (Baby Einstein, LLC.). Pictures from the Internet were used with AI, since he ceilinged with the flash card set. For Experiment 2, visual response items were selected from a set of 67 animal photographs from open sources on the Internet. Individual baselining identified a smaller set not known to the particular subject. From this set, pairs of items were pseudorandomly selected for testing in either the motion or static condition, subject to the requirement that the two items had to be from the same type of animal (e.g., feline). In both cases, pictures were selected to (a) represent specific species of animals, such as tigers or beetles or eagles, and (b) to be as clear photographic examples as possible.

General Procedures: Training and testing was done in one-on-one sessions. All training and testing was semi-self-paced, with breaks when the subject wanted them. All training sessions were videotaped, for double-checking.

Experiment 1

Manual Presentation – Matching Pict

Apparatus. The pictures were displayed using an upright wooden board, 30 inches long and 17 inches high (see Figure 1). The three response pictures were attached by Velcro to the wooden board. Above the three response items, the stimulus picture was attached by Velcro to a wooden dowel, which could be moved forward through a hole in the board.

Procedure

- **Initial baseline testing**: From a large set of static pictures, testing identified those which were matched at chance or lower rates. These unknown items were used for subsequent training.
- **Training**: In the moving condition, the experimenter, standing behind the wooden board, moved the stimulus picture towards the subject. The three response pictures below remained still. For the static condition, nothing was moved. Training was done in blocks of up to 10 trials, with mastery criteria being 80% correct. All sessions were videotaped.

Experiment 1 Results

- RE was better than chance on all animal stimuli during baseline testing; he was not trained on this task.
- FN consistently failed to respond to prompting; he was not tested beyond two sessions.
- AI (see Figure 2) also reached mastery criteria for all 10 animals, though he initially received higher scores for the 5 animals trained in the static condition than in the moving one.
- HR (see Figure 3) showed evidence of increased attention to moving stimuli in terms of his behavioral attitude (posture and directed gaze). He showed greater and faster learning for the 6 animals trained in the moving condition than for those trained in the static condition (Session 1 $z = 5.10$, $p < 0.001$)

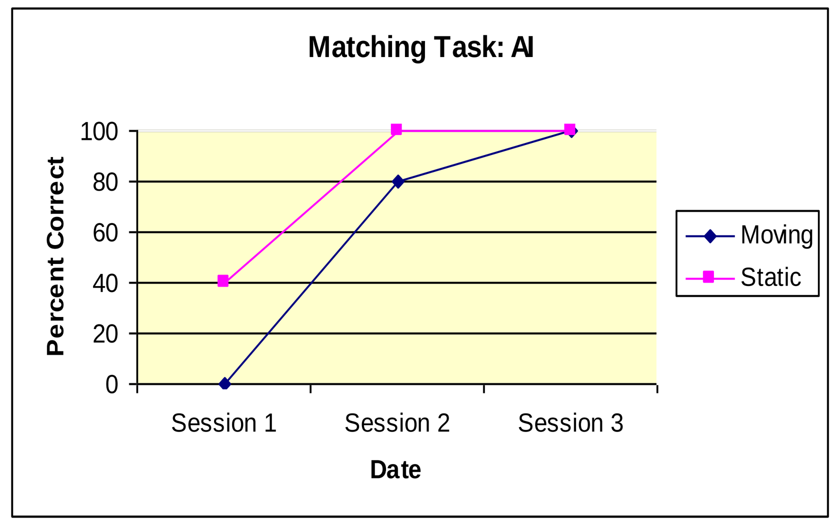

Figure 2. Note: Each data point represents 2-5 animals, with up to 10 trials per animal.

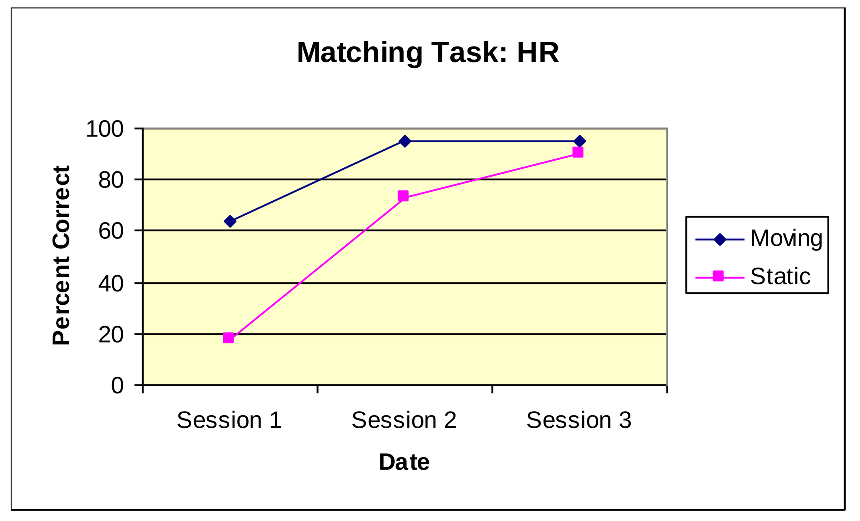

Figure 3. Note: Each data point represents 2-6 animals, with 10 trials conducted for each animal.

Discussion

Behavioral observations of HR (i.e. gaze and posture) and his results suggested that presenting moving items might help improve both attention and learning. AI also seemed to pay more attention to the moving materials, though this was often negative attention (i.e. swiping at the moving picture). AI, however, did not show better learning for the moving items.

Experiment 2

Computer Presentation – Picture Selection Task

Rationale: Given the prior literature and HR's results on Experiment 1, the method looked promising enough to investigate further. It was clear from Experiment 1 that the mechanical apparatus was problematic to use. Therefore, for Experiment 2, stimulus presentation was done on a computer monitor. We added a post-test following each training session to test the subjects' learning when the pictures were still and interspersed, as in the initial baseline. In addition, to better test whether there might be differences in learning even when items had reached criterion, for Experiment 2, we administered a post-test one week after the subject had reached mastery.

Stimuli: Photos taken from Internet sources, as previously described, were presented either statically or with pseudo-motion. To create the appearance of motion, the images were presented over 3-second intervals, growing and shrinking in size and zigzagging across the area on the screen. (See demonstration on the laptop.) The pictures were given motion that was as realistic as possible (e.g., fish were presented as if they were swimming forward, birds as if they were flying).

Apparatus: Stimuli and responses were presented on a 15" Princeton EO750 touchscreen monitor and were controlled through a separate monitor and keyboard. All aspects of stimulus presentation and response recording were managed by the Foundations System (Infostructure, Yardley, PA www.infostweb.com)

Procedure

Baseline: All 67 animal photos were baselined, with static presentation, with each subject.
Training: For each new stimulus to be learned, the experimenter gave the instruction, "Touch (<u>target</u>)" when the stimulus appeared on the touchscreen. The subject was manually prompted to touch the target until he chose the correct target independently. If the subject chose an incorrect response, then the correct animal was displayed and the same trial was repeated, with the subject being prompted to touch the correct response. Mastery criterion for a target was reached when the subject chose the correct target independently 90% of the time. Each animal was trained in blocks, with 10-20 trials per animal in a session. The number of trials differed between subjects and sessions, based upon their tolerance and experience, but the number was consistent for each animal within subjects and within sessions.
Post-training testing: Testing was done with static images only. Materials that had been presented with motion were randomly mixed with those presented statically for testing. Testing was done without feedback or reinforcements. One testing session was done immediately after each training session. Another was done one week after the subject reached mastery criterion.

Experiment 2 Results

- **RE** was able to choose all items with 90% accuracy in the first session, only needing to be prompted once in order to know which animal to choose thereafter.
- **AI** mastered all animals – the 12 items trained in the moving and still conditions – scoring 90% or higher within three days. He received at least 90% on each target in the end-of-the-session post-test. (Figure 4). A retention post-test was conducted one week after AI mastered the first set of animals, and he received 97% on the animals trained in the static condition (3 animals, 30 trials total) and 100% on the animals trained in the moving condition (3 animals, 30 trials total). This 1-week post-test is not displayed on the post-test graph.
- **HR** and **FN** both had more correct responses in the still condition than in the moving condition. (Figures 5 & 6.) Both subjects started to choose the moving items correctly during the training, but when all items were presented statically in the post-test, they rarely selected the correct response for items that were trained moving (i.e. 29% correct on the post-test for HR on Day 2). Both HR and FN are still currently being trained.

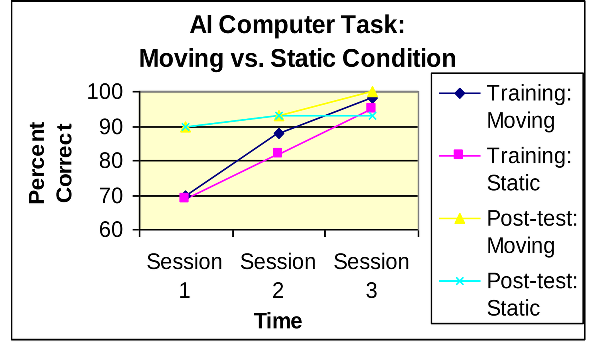

Figure 4. Note: The daily post-tests represent the 2nd set of animals trained. Each data point represents 6 animals trained and 3 animals post-tested.

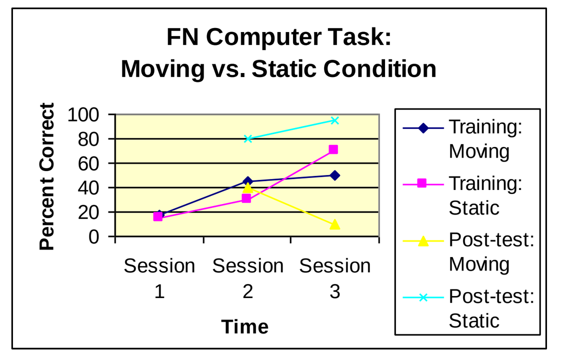

Figure 5. Note: Each data point represents 2-3 animals, 10-20 trials per animal.

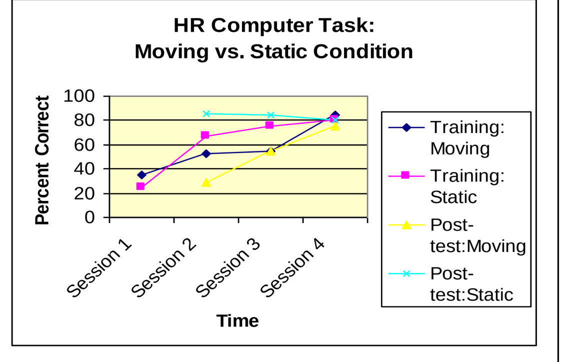

Figure 6. Note: Each data point represents 2 animals, with 10-20 trials per animal (except 7 trials per each animal on Day 2 post-test)

General Discussion

Informal observations during the testing confirmed our expectations that motion would improve attentiveness to the materials. AI, RE, and HR straightened up in their chair, turned their bodies, head, and eyes to the materials that were moving. They scanned the field for a much longer time when the pictures were moving than when they were still, as seen in the videotapes of the testing.

The data also suggest that movement might improve learning, in line with our expectations. However, at best, these results show individual variation; there was no clear pattern across the entire set of subjects tried. The general lack of clear results, and HR and FN's particular difficulties with learning the moving animals, may be the result of a number of factors apart from an effect of motion on attention and learning. For example, the way the animated pictures looped (getting larger and then smaller) could have been confusing and made them difficult to identify; three animals moving on a screen at once could have been overstimulating; the subjects might have learned to respond to moving animals, and not static ones as given on the post-tests.

Whether we have truly found individual differences, or simply a null result, will require more testing. However, the results so far suggest that attention is not really the rate-limiting barrier for learning, in this task, with these individuals, and with these particular materials.

For the future, therefore, we will be adding independent measures of attentiveness. We will also be trying materials that may be less intrinsically appealing (such as pictures of cars or people) and which therefore may benefit more from presentation using motion. We will also be exploring lateral motion, in addition to looming motions.

Acknowledgments

These studies were supported in part by an anonymous donor, by the Therapeutic Cognitive Neuroscience professorship, and by The Benjamin A. Miller Family Endowment for Aging, Alzheimer's Disease, and Autism. We thank Robert Glatzer for developing the Foundations System and the test materials, and Shauna Stark and Dr. Katharina Boser for their input and support. And most of all, we thank our subjects and their parents and caregivers for their patience and perseverance with the experiments.