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Supplemental Information

Visual Short-Term Memory

Compared in Rhesus Monkeys and Humans

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Inventory of Supplemental Information

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SUPPLEMENTAL EXPERIMENTAL PROCEDURES

Rhesus Monkeys

Animals

The subjects were two adult male rhesus monkeys (*Macaca mulatta*) that were 9 and 13 years old at the beginning of this experiment. The monkeys were individually housed in a colony room. After daily test sessions, the monkeys were fed a standard diet of primate chow and water with supplemental fruits and vegetables on weekends. All animal procedures conformed to National Institutes of Health guidelines and were approved by the Institutional Animal Care and Use Committee at the University of Texas Health Science Center at Houston.

Apparatus

The monkeys were trained and tested unrestrained within a custom-made (47.5 cm wide × 53.13 cm deep × 66.25 cm high) aluminum test chamber. A white-noise sound generator located outside of the chamber masked extraneous noise. Reinforcement dispensers delivered banana pellets (Bio-Serv, 300-mg, Frenchtown, NJ) and Cherry Koolaid pseudorandomly on correct trials. An infrared touch-screen (17-inch Unitouch; ELO, Round Rock, TX) detected responses to the 17-inch EIZO computer monitor. The same make and model of touchscreen and monitor were used with the human subjects. A Plexiglas template with 16 cutouts matching the size and possible locations of the stimuli was used to direct touch responses. Experimental sessions were created, controlled, and recorded using custom software written in Microsoft Visual Basic 6.0. A video card (ATI graphics adaptor) controlled the monitor. A computer-controlled relay interface (Model PI0-12; Metrabyte, Taunton, MA) was used to operate the pellet dispenser and the juice system. The chamber was illuminated with green (25 watt) light bulbs located outside of the chamber during the intertrial interval. Green light illuminated the chamber through a small (0.5 cm) gap between the touchscreen and the monitor. The offset of the green light cued the start of the next trial. Video cameras were used to monitor the monkeys' attention and the task, and the monkeys were found to rapidly and reliably turn to the

sample display following the offset of the green light, indicating that the green light served as an effective warning stimulus.

Objects

The objects consisted of eight, 4-cm diameter colored circles (red, yellow, blue, aqua, green, purple, magenta, and orange) and 976 color clip art images presented on a black background. Example clip art objects are shown in Figure 1. The clip art images were not perfectly square but each clip art fit within a 4 x 4 cm square. Objects were presented in random locations on an invisible 4 by 4 matrix (26 × 22 cm) which was aligned with the response template. Based on the average distance of the monkey from the screen, stimuli subtended a visual angle of approximately 5.75 degrees.

Training

Monkeys were initially trained to touch a single object following a change in color. After they were reliably responding they were trained (and tested) with 2 objects in the display for 346 96-trial daily sessions (M1), and 450 96-trial daily sessions (M2) before beginning the tests presented in this manuscript.

Test Procedures

In the colored circle condition, the monkeys were tested for a total of 4, 96-trial sessions with 19 trials per display size (total of 76 trials per display size). The intertrial interval (ITI) in all sessions was 15 s because such a separation in time between trials was found to facilitate acquisition and potentially maintain high performance in the task. The monkeys were tested with randomly intermixed display sizes of 2, 4, and 6 for the clip art objects over 18, 96-trial sessions. The clip art objects were selected without replacement and were unique for 2 sessions. A total of 144 trials per display size were tested with each monkey across 18 sessions. Other clip art trials with viewing times ranging from 1000-4500 ms and delays ranging from 200-1000 ms were tested but are not included in the analyses of this report in order to make the two tests comparable. The monkeys performed similarly at all viewing times, including the 1000 ms

viewing time used with humans, thereby validating comparisons between human performance at 1000 ms and monkey performance at 5000 ms. Prior work in our laboratory has also demonstrated that these monkeys performed well with delays (800 and 1600ms), which bracketed the 1000 ms delay used to test human subjects (Elmore et al., Accepted Pending Revision, *Journal of Comparative Psychology*). However, since both the colored objects and the clip art were tested with 50-ms delays, these are the results presented here.

Human Subjects

Subjects

Six human subjects (5 females) aged 22-32 (mean age 26.3) participated in the study. The subjects visited the lab for 11, 1-hour sessions as part of a larger study and were compensated \$10 per session. Five of those sessions included the test trials presented here. Study procedures were approved by the University of Texas Health Science Center at Houston Institutional Review Board.

Apparatus

Testing sessions took place in a small room equipped with a PC computer. The computer had a 17" EIZO monitor fitted with a touch-screen (17-inch Unitouch; ELO, Round Rock, TX). Twenty-five watt light bulbs mounted on the wall behind the subjects provided feedback by illuminating the room. The green light was illuminated for 1 s following correct responses and the red light was illuminated for 1 s following incorrect responses. Sessions were created, controlled and recorded using custom software written in Microsoft Visual Basic 6.0.

Objects

The objects consisted of 6 colored squares (red, green, yellow, blue, aqua, magenta), and the same 976 clip art images that were used with the monkeys. The objects were randomly presented in 16 possible locations (colored squares) and 20 possible locations (clip art). Both object types subtended a visual angle of 1.3 degrees.

Test Procedures

Subjects were tested with a total of 150 trials composed of colored squares, 30 trials per display sizes of 2, 4, 6, 8, and 10 items. The viewing time for each sample display was 1000 ms and the delay was 900 ms. In the clip art condition, subjects were tested with a total of 189 trials, 43 trials per display size of 6, 8, and 10 items and 30 trials per display size of 2 and 4. In this condition, the viewing time and delay were both 1000 ms. The ITI was 2000 ms in both cases. This short ITI was used to prevent boredom and facilitate rapid data acquisition.

SUPPLEMENTAL DATA ANALYSIS

Multidimensional Scaling: The algorithm works by attempting to transform the 8-dimensional accuracy matrix into a 2-dimensional “perceptual” space that maintains as best as possible the distance structure in the original matrix. This analysis was performed on all 56 combinations of color changes. Colors with small distances of separation on the plot were frequently confused by the monkey when one changed to the other.

SUPPLEMENTAL REFERENCE

Elmore, L.C., Katz, J.S., Magnotti, J.F., & Wright, A.A. (in press) Change Detection by Rhesus Monkeys (*Macaca mulatta*) and Pigeons (*Columba livia*). *Journal of Comparative Psychology*.