



A negative stimulus movement effect in pigeons

Thomas A. Daniel*, Jeffrey S. Katz

Auburn University, United States



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ABSTRACT

Rhesus monkeys and humans perform more accurately in matching-to-sample tasks when the sample stimulus moves through space (Washburn et al., 1989; Washburn, 1993). This Stimulus Movement Effect (SME) is believed to be due to movement increasing attention toward the sample stimulus, creating an easier discrimination between the sample and choice stimuli. To date, there is no evidence for this phenomenon in a non-mammalian species. In the current study, we investigate the possibility of an SME in an avian species. Across three experiments, pigeons were tested with moving and stationary sample stimuli in a non-matching-to-sample task. The area and velocity by which the sample stimulus traveled was manipulated but no advantage for moving over stationary sample trials was found within or across sessions. Even when a delay condition was implemented, there was no advantage for moving sample trials. Contrary to the results found in humans and monkeys, pigeons performed better when the sample was stationary, a negative SME, and no evidence was found that stimulus movement increases discrimination performance.

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1. Introduction

William James (1890) considered moving objects as “an instinctive stimulus, a perception which, by reason of its nature rather than its mere force appeals to some one of our normal congenital impulses and has a directly exciting quality” (p. 414). If something about movement is special, it is not specific to humans. A variety of species use movement along with social cues (e.g., eye gaze, pointing) to discover sources of food, including dogs (Bräuer et al., 2006; Udell et al., 2008), apes (Bräuer et al., 2006), and goats (Kaminski et al., 2005). In these cases, the inclusion of movement enhances the ability to discover hidden food more than just social cues alone. Rhesus monkeys have also been shown to perform better at discrimination tasks when one or more of the discriminanda are moving (Nealis et al., 1977). Later, Washburn et al. (1989) found that rhesus monkeys’ performance on a discrimination task was differentially affected by whether or not the sample stimulus (the item that was to be discriminated and remembered) was moving. In such cases, movement increased accuracy on both match-to-sample (MTS) and delayed match-to-sample (DMTS). The effect of sample stimulus movement increasing performance on these tasks is known as the Stimulus Movement Effect (SME) and has

been replicated in humans and monkeys with a variety of tasks including MTS, DMTS, positional-responding, and mirror-image MTS (Washburn, 1993; Washburn and Putney, 1998).

In a typical MTS or non-match-to-sample (NMTS) task, the subject is presented with a sample stimulus on a computer monitor and must then make an observing response to the sample stimulus (e.g., with a joystick-controlled cursor or with direct contact with the stimulus by touching or pecking it). Immediately following the completion of an observing response, two comparison stimuli appear on the display, with one stimulus being identical to the sample. In MTS, selecting the identical, matching stimulus is reinforced, whereas in NMTS, selecting the non-matching stimulus is reinforced. Washburn (1993) manipulated the presentation of the sample so that when the sample was presented, it either remained stationary or moved fluidly about the display screen. Subjects were more likely to choose the identical comparison stimulus in the choice display when the sample moved, thus creating the SME.

Washburn (1993) further found that while rhesus monkeys’ accuracy was higher on trials in which the sample stimulus moved, accuracy was highest when the sample stimulus moved at the fastest rate tested. Alternative explanations for the SME, accounting for position biases, exposure duration, and figure-ground grouping, did not successfully account for these findings. Regardless of where the stimulus moved or how long it was present, the biggest contributing factor to performance was whether the sample stimulus moved at all. Washburn and Putney (1998) came to the conclusion that the SME was a result of increased task difficulty. Because

* Corresponding author at: Department of Psychology, P.O. Box 8795, Williamsburg, VA 23187, United States.

E-mail address: tadaniel@wm.edu (T.A. Daniel).

the sample stimulus moved about, the discrimination tasks became more difficult and more attention must be paid to the stimulus. This explanation is paradoxical: why would increasing the difficulty of a task result in an increase in performance? Perhaps because the task became more difficult, humans and monkeys were required to expend more mental effort (i.e., selective attention) on the task, and this corresponded with an increase in accuracy on these discrimination tasks (Washburn and Tagliabue, 2012). An alternative explanation based on more recent research has dealt exclusively with humans. Franconeri and Simons (2003) demonstrated that moving objects captured attention, even when not directly relevant to task instructions. Abrams and Christ (2003, 2006) replicated a similar finding with the specification that the onset of movement captured attention rather than the movement itself. While these studies did not seek to replicate an SME, they do offer an explanation of an SME that is counter to Washburn and Putney's (1998) hypothesis that movement makes a task more difficult. According to Franconeri & Simons and Abrams & Christ, an SME is produced by the attentional capture that moving items created. Because the moving stimulus captured more attention than a static one, its visual properties were better encoded. If attentional capture is the process that produced an SME, then species that have shown attentional capture effects may also be susceptible to an SME. Regardless of the mechanism, the existence of the SME in species outside the realm of primates has yet to be investigated.

Is the SME a general process shared widely across species or perhaps more specific to mammalian species? The current study's aim was to test if pigeons might demonstrate an SME. Pigeons were used because they can easily learn discriminations involving motion (e.g., Kennedy, 1936; Hodos et al., 1976; Koban and Cook, 2009; Cook et al., 2011), and have shown characteristics of attentional capture (Cook et al., 1997). Others have shown that pigeons are adept at categorizing stimuli on the presence of movement (Dittrich and Lea, 1993), direction in two-dimensional space (Herbranson et al., 2002), and rotational direction (Koban and Cook, 2009). Pigeons are also better at discriminating rotating 3-D objects, such as cube or pyramids, compared to stationary objects (Cook and Katz, 1999). Known as the dynamic superiority effect, this contrasts with the SME because the process of rotation allows for better extraction of an object's structural features. In other words, discrimination is easier for rotating objects because more features are present compared to stationary objects. The SME, however, does not reveal more of an object's features because it is simply translating across flat 2-D space, rather than rotating in 3-D.

If the SME is a general process of behavior, pigeons should show better performance in a discrimination task when the stimuli are moving. However, if the SME is specific to mammalian species, stimulus movement should provide no benefit to pigeons' ability to discriminate. Three experiments were conducted to test whether pigeons were sensitive to motion cues in NMTS. In Experiment 1, the area and velocity in which a sample stimulus could move were manipulated. In Experiment 2, a within session design was implemented in contrast to the between session design of Experiment 1. In Experiment 3, the memory for sample motion over a retention interval was tested in Delayed-NMTS.

2. Experiment 1

The aim of Experiment 1 was to test for any differential effects of motion in NMTS performance. The procedures were modeled after Washburn et al. (1989). To measure for the sensitivity of the SME in pigeons, two parameters were manipulated across multiple conditions: (1) the spatial area in which the sample moved about the display, and (2) the velocity with which the sample moved about the display. We hypothesized that if pigeons were sensitive to

the SME, one or more of these manipulations would demonstrate increased accuracy on NMTS. The apparatus, stimuli, and general procedure used in the current study have been adopted from tasks that show pigeons can learn MTS (Bodily et al., 2008) and NMTS (Daniel et al., 2015).

2.1. Methods

2.1.1. Subjects

Three male pigeons (*Columba livia*) from the Palmetto Pigeon Plant served as subjects. All subjects had extensive training in NMTS ($M = 113$ days) and demonstrated abstract-concept learning for difference (Daniel et al., 2015). Two subjects (B21545 and Z1590) also had previously performed in a *Same/Different* task (Schmidtke et al., 2010). Subjects were kept within 80–85% of their free-feeding body weight throughout the study; in the event that a subject's weight fell above or below this range for the day, it did not participate in that day's session. Subjects resided in a colony room governed by a 12 h light/dark cycle and were housed individually with free water and grit access.

2.1.2. Apparatus

Pigeons were tested using custom wood (35.9-cm wide \times 45.7-cm deep \times 51.4-cm high) operant chambers. A fan (Dayton 5C115A, Niles, IL) located in the back wall of each chamber provided ventilation and white noise. The computer detected pecks via an infrared touch screen (17" Unitouch, Carroll Touch, Round Rock, TX). This pressure-fit touch screen sat within a 40.6 \times 32.1-cm cutout in the front panel that was centered 7.7 cm from the top of an operant chamber. A 28-V (No. 1829, Chicago Miniature, Hackensack, NJ) houselight, located in the center of the ceiling, illuminated the chamber during intertrial intervals (ITI) and a light located above the hopper illuminated the presentation of grain. A custom hopper containing mixed grain was accessed through an opening (5.1 \times 5.7 cm) centered in the front panel 3.8-cm above the chamber floor.

Custom software written with Visual Basic 6.0 on a Dell Optiplex GX110 recorded and controlled all events in the operant chamber. A video card (ATI Xpert 98) controlled graphics generated by the computer, displayed on a 17" CRT monitor (Eizo Flexscan T566) set to a resolution of 800 \times 600 pixels with a refresh rate of 75 Hz. A computer-controlled relay interface (Model no. PI0-12, Metrabyte, Taunton, MA) maintained operation of the grain-hopper and the lights to both the hopper and the chamber.

2.1.3. Stimuli

Visual stimuli were 768 computer-created, color cartoon JPEG images that were 2.5-cm high \times 3-cm wide at 28 pixel/cm (cf. Katz et al., 2008; Fig. 2). Stimuli were arranged in the display such that the sample and comparisons formed a triangle (8-cm high \times 9.19-cm wide) with the comparison stimuli symmetrically placed around the sample. Each sample stimulus appeared centered horizontally at approximately 8-cm above the bottom of the display. Left- and right-comparison stimuli appeared 4-cm above the bottom of the monitor, with the center of the left and right comparison stimuli 8.5 cm from the center of the sample.

2.1.4. Procedure

Sessions were carried out 5–7 days a week, with each session comprised of 96 trials (48 left responses and 48 right responses). All trials began with a sample stimulus displayed on the monitor. Pigeons pecked the sample stimulus 4 times (FR 4). The observing response was less than that used in the pigeons' previous training (i.e., 10). The FR 4 was used because the pigeons were performing very well before the onset of this experiment and we wanted to decrease the likelihood of ceiling effects (e.g., Grant, 1976) to

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