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The case of the magic bones: Dogs' memory of the physical properties of objects

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ABSTRACT

Dogs' memory for properties of occluded objects was assessed using a looking-time procedure. The looking-time procedure has been used to indicate that a change in expectation has been observed, with longer looking times associated with change as compared with no change. In our experiments, a bone-shaped dog biscuit (bone) was placed behind a horizontal screen that then rotated up to occlude the object before the screen returned to its horizontal position. Dogs were shown one of two test events. In one (congruent) event, the screen rotated up to obscure the bone and then rotated back down to reveal the unchanged bone. In the other (incongruent) event, the screen rotated up to obscure the bone and then rotated back down to reveal a bone that had changed in size (Experiment 1) or color (Experiment 2). Looking times were measured to assess which events represented the detection of a change. Increased looking time on incongruent trials indicated that the dogs remembered the size and color of the occluded object.

When searching for a missing item, it is good to begin by evaluating what is known about the missing object before starting one's search. Piaget (1954) asserted that human infants begin to remember the physical properties of objects at approximately 9 months of age. He used the term *object permanence* to describe this understanding. Piaget relied on the infants' attempt to actively, physically search for a hidden object to indicate their knowledge about the object, and similar procedures have been used with dogs, requiring them to be trained in the search paradigm (Miller, Gipson, Vaughan, Rayburn-Reeves, & Zentall, 2009; Miller, Rayburn-Reeves, & Zentall, 2009). However, later research by Baillargeon (1987) and others has used looking time as a novel means of investigating infants' knowledge about objects without requiring the infants to coordinate and plan intricate motor movements. This methodology, called the *violation of expectation* (VOE), relies on comparing the infant's looking time at a congruent or *expected* event to its looking time at a similar but incongruent or *unexpected* event. Longer looking times indicate what Baillargeon termed *surprise* though she pointed out that the term is a shorthand descriptor of the state of heightened attention or interest. Whatever the interpretation of the effect, it has been shown to produce reliable differences in very young children (Dejonckheere, Smitsman, & Verhofstadt, 2005).

Recent research has demonstrated object permanence similar to that of infants in a number of non-human animals, including our own work with dogs (Pattison, Miller, Rayburn-Reeves, & Zentall, 2010), cotton top tamarins (Neiworth, Steinmark, Basile, Wonders, Steely, & DeHart, 2003), orangutans and chimpanzees (Call, 2001), rhesus monkeys (de Bois & Novak, 1994), cats (Doré, 1986), dolphins (Jaakkola, Guarino, Rodriguez, Erb, & Trone, 2010), an African Grey parrot (Pepperberg & Kozak, 1986), New Zealand parakeets (Funk, 1996), magpies (Pollok, Prior, & Güntürkün, 2000), and scrub jays (Salwiczek, Emery, Schlinger, & Clayton, 2009). Others researchers have found that dogs fail to demonstrate object

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permanence in invisible displacement tasks but are successful in visible displacement tasks (Fiset & Leblanc, 2007; Fiset & Plourde, in press).

In their recent research, Muller, Mayer, Dorrenberg, Huber, and Range (2011) reported that female dogs, but not male dogs, encode size information about a moving ball as measured by looking time. Female dogs that saw a ball move behind a fixed barrier looked longer at the ball exiting the other side of the barrier when the ball's size was not consistent with the initial presentation. Our experiment differs from that procedure in that the target object (bone) was static, not in motion, to control for expectations of momentum and differences in the visual processing of motion versus static form.

What aspects of static occluded objects might animals encode to form their memory for the object? For example, when its favorite bone disappears behind the couch cushions, does a dog probe under the cushions because the last time it did so it was rewarded by finding a bone or does it represent a multidimensional representation of the missing bone?

To investigate what, if any, dimensions of an object dogs remember, we used a looking time procedure similar to that used by Baillargeon and other infant researchers, as well as by West and Young (2002) to investigate numerical competence in dogs. We have also used this procedure to investigate object permanence in dogs (Pattison et al., 2010). There has been some controversy in the past about the violation of expectation procedures used with infants. Some researchers have suggested that the infants look longer at impossible events not because they have expectations about the objects in question but because the habituation trials typically used in such procedures involve repeated exposure to the expected event. Thus, the unexpected events tend to confound impossible events with their novelty (Schilling, 2000). In response to this criticism, some infant researchers have eliminated habituation trials and have continued to find a significant increase in the looking times of infants when viewing unexpected events (Wang, Baillargeon, & Brueckner, 2004). To control for this novelty of the manipulated trials, we used very few familiarization trials and we never paired the bone with the screen rotation during familiarization. Thus the dogs were never habituated to either type of experimental trial before the start of such trials.

In the present experiments, dogs were shown a bone-shaped dog biscuit (bone) that was subsequently occluded for a brief period and unobtrusively replaced by a bone that was different in size or color. The time dogs spent looking at the changed bones was compared to the time spent looking at control presentations of a replaced bone that had the same characteristics as the original bone (to control for replacing the original bone rather than changing its appearance). When looking times at the manipulated target are longer than looking times at the control (unmanipulated) target, it suggests that the dogs encoded information about the property of the bone that had changed. In this way, we could determine whether the dogs remembered the size and color of the bone they had seen earlier.

Although dogs might be expected to remember the size of an object, we were not sure if they would remember its color. Dogs are dichromats, having only two (as compared to our three) kinds of retinal cones. They are able to perceive color similarly to humans who are red-green color blind (deuteranopia), having trouble distinguishing between red and green hues but being able to detect blue and yellow hues (Alderton, 1984). However, their visual system evolved to aid hunting, and while their ability to discriminate movement is excellent, their visual acuity is generally not as keen, with Snellen ratings estimated at 20/75, although this varies by breed (Coren, 2004). For a more thorough explanation of the canine visual system, see Miklosi (2007). With these visual limitations in mind, in two experiments, we tested dogs' memory for the size (Experiment 1) and the color (Experiment 2) of an object.

Experiment 1

Methods

Subjects

Thirteen dogs were recruited (*Canis familiaris*), 6 females and 7 males, ranging in age from 6 to 72 months ($M = 47$ months), belonging to private owners. All dogs matched several selection criteria: they were friendly, were motivated by the opportunity to interact with the experimenters, and were motivated by food reinforcers. Two dogs were dropped due to fear of the apparatus, and one dog was dropped because she did not look at any of the presentations of the objects. Of the dogs that participated in the experiment (6 males, 4 females), two were Golden Retrievers, one was a Siberian Husky, one was a Boxer, and six were of mixed breed. All of the dogs had been trained to sit on command.

Apparatus

The apparatus consisted of three plywood panels attached by hinges. The center panel was 94 cm high × 124 cm wide × 1.27 cm thick. The side panels were 94 cm high × 63.5 cm wide × 1.27 cm thick. The side panels could be set at an angle so that the apparatus was supported in an upright position (see Fig. 1). All three panels were painted flat black. The panels were placed such that a small table could fit in front of the middle panel and the side panels could extend to the sides of the table to create a stage. A hole (35.5 cm high × 30.5 cm wide) was cut out of the center of the middle panel to allow access to the stage from behind the panel. The hole was covered by black cloth that was attached to the panel above the hole. The table was occluded from the dog between trials by an opaque curtain that was placed between the dog and the apparatus. This curtain was attached to a metal frame (1.40 m wide × 1.22 m tall) by means of shower hooks. A length of fishing line was attached to the hooks so that an experimenter could open the curtain. Opaque fabric was also hung both from the left and right side of the middle panel to the metal frame behind which Experimenter 2 was hidden (see Fig. 1).

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