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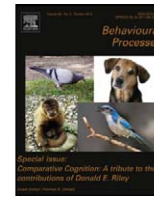

Dogs choose a human informant: Metacognition in canines

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ABSTRACT

The presence of metacognition in animals has been suggested by the observation that non-human primates will seek out information about the location of a hidden reward before responding. In experiment 1, dogs failed to make an information-seeking response that involved re-positioning themselves in space so that they could view a cue that indicated the location of food. In experiments 2 and 3, dogs were allowed to choose between two people, an informant that pointed to the location of food and a non-informant that provided no information. Dogs showed a clear preference for the informant, even when choice of the informant led to no greater chance of reward than choice of the non-informant. In a procedure that involves human communication, dogs show information-seeking behavior.

1. Introduction

Metacognition is an important property of human consciousness that allows people to probe the contents of their own memories (Metcalfe, 2009; Nelson, 1996; Shimamura and Squire, 1986). When asked a question, a person may immediately provide the answer, indicate that he can retrieve the answer with some effort, or admit that he does not know the answer but will look it up. Further, people can judge the degree to which they know or understand a particular topic and choose to spend their study time on less well known material (Son and Metcalfe, 2000).

Could an animal also monitor the contents of its own memory and take advantage of this knowledge? Research carried out with rhesus monkeys over the last 10 years has led to that conclusion. When monkeys were required to make a perceptual judgment or to match a previously seen stimulus from memory, tests included correct and incorrect choices presented on a video monitor, with a large reward for a correct response and no reward for an incorrect response. In addition, monkeys could make a third choice called an uncertainty response. Choice of the uncertainty response led to a modest reward and advancement to the next trial. A number of experiments have shown that monkeys tend to choose the uncertainty response as judgments become more difficult and that monkeys respond more accurately on trials when they choose to take the test than on control trials when they are forced to take the test (Hampton, 2001; Smith et al., 1997, 1998, 2003). Evidence for similar effects has also been found with dolphins (Smith et al., 1995) and rats (Foote and Crystal, 2007). The implication of these findings is that animals judge the degree to which they know the correct answer and choose the uncertainty response when it is low.

The conclusion that animals show metacognition, based on uncertainty responses, has been challenged recently. Based on Carruthers' (2008) ideas, Crystal and Foote (2009) suggest that these experiments can be explained by the use of first-order rather than second-order explanations. First-order explanation is based on an animal's immediate perception of a stimulus; if an animal's behavior is a product of a learned response to that perception, then there is no need to invoke a process of metacognition. Second-order explanation arises when an organism compares its immediate perception with its knowledge base (beliefs about the world) in order to make a judgmental response. First-order explanation involves lower level associative processes, and second-order explanation involves higher level cognitive processes. Based on an associative model developed by Smith et al. (2008), Crystal and Foote (2009) concluded that all of the findings from experiments using an uncertainty response could be explained by animals making the reinforced uncertainty response when the correct and incorrect responses based on the stimulus or memory were weak.

Another finding which suggests the possibility of metacognition in animals may be less easily explained by associative mechanisms. In studies with apes and children (Call and Carpenter, 2001) and with monkeys (Basile et al., 2009; Hampton et al., 2004), participants responded to a set of horizontal tubes, one of which contained a reward. If the correct tube was grasped and pulled into a vertical position, its reward dropped out of the tube and was obtained by the participant. On some trials, the participant was allowed to see which tube was baited before making its choice. On other trials, a screen prevented the participant from seeing which tube was baited. Children, apes, and monkeys all made an observing response before choosing a tube on screened trials but not on trials when

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they could see the baiting process. On screened trials, participants bent down and peered through the tubes before making a choice, and thus their level of accurate choice was nearly perfect on both screened and non-screened trials. These interesting findings suggest that both human and non-human primates were aware of the state of their working memory, whether knowledge about the location of the reward was there or not. If that knowledge was not there, they took appropriate action to inform themselves about the location of the reward.

Only mixed evidence is found that suggests non-primate animals would seek out information necessary to obtain a reward. A series of experiments with pigeons asked what they would do on delayed matching-to-sample trials if they could choose initially to either view the sample stimulus (thus insuring a high level of accurate choice and reward) or go directly to the choice between test cues without seeing the sample (thus insuring only a chance level of accurate choice and reward) (Roberts et al., 2009). Pigeons strongly preferred to go directly to a test between comparison stimuli instead of viewing the sample stimulus before taking the test (experiments 1 and 2). A confounding factor in these experiments was a differential length of delay to reinforcement. If pigeons chose to see the sample, the extra time taken to view the sample added a delay to opportunity for reinforcement. Thus, preference for the test key might have arisen from a preference for more immediate opportunity to earn a reinforcer. Subsequent experiments (experiments 3 and 4) minimized the difference in delay to reinforcement and still found no evidence that pigeons preferred sample information. Birds showed no preference for sample information and thus no evidence of metacognition.

A recent study by Zentall and Stagner (in press) does suggest that pigeons might seek relevant sample information in a delayed matching-to-sample task. At the beginning of a trial, pigeons could peck either a plus or a circle on different side keys. A peck on the plus key led to a 5 s presentation of a red or green sample on the center key, followed by choice between matching and non-matching red and green side keys. Thus, a pigeon could be correct on all trials by choosing the matching key. If a pigeon pecked the circle, however, a yellow or blue sample appeared for 5 s, followed by red and green comparison stimuli. Because choice of the red or green comparison stimulus was not correlated with the yellow or blue sample, the sample was non-informative and pigeons could only earn 50% of the reinforcers. On probe trials that offered pigeons a choice between the plus and circle, pigeons learned to prefer the plus stimulus that led to an informative sample stimulus. When the outcomes of pecking the circle and plus were reversed, pigeons continued to track the informative sample alternative. Although these findings may suggest that pigeons chose information, one concern is that they received more reinforcement for choosing the stimulus that led to an informative sample than for choosing the key that led to a non-informative sample. Thus, the preference shown could reflect choice of a higher probability of reinforcement and not of information.

In the experiments reported here, we used procedures based on the Call and Carpenter (2001) and Hampton et al. (2004) studies to look for evidence of metacognition in dogs (*Canis familiaris*). Dogs may be an excellent choice of species in which to look for evidence of memory awareness among non-primate animals. Dogs have evolved from ancestral wolves over the last 10,000–20,000 years under human domestication pressure (Csányi, 2000; Miklósi, 2007; Vila et al., 1997). As a consequence, they have developed traits highly adapted to life among humans, including communicative, cooperative, and attachment behaviors (Hare and Tomasello, 2005; Miklósi, 2007; Miklósi et al., 2004). In the three studies presented here, we ask if dogs will perform behaviors that seek out information necessary in order to make an informed choice among several stimulus alternatives for food reward.

2. Experiment 1

In one previous study of cue-seeking behavior in dogs, Bräuer et al. (2004; experiment 3) had dogs choose one of two boxes by pressing a lever, with food reward in only one of the boxes. On seen trials, the dog viewed the experimenter baiting one of the boxes and chose this box on about 90% of the trials. On unseen trials, however, a barrier prevented the dog from seeing which box was baited. The dog could find the location of the food, however, by approaching each box and looking through a transparent Plexiglas window before making its choice. Dogs almost never checked the window before pressing a lever and thus were rewarded on unseen trials at only a chance level.

We carried out a further test of information-seeking behavior in dogs. Dogs were trained to choose among 4 different boxes, each with a food tray under it. The boxes were all black, with the exception of one box that had a white side, and food was always placed only under this box. After dogs had learned the visual discrimination of choosing the white box, the boxes were rotated around their vertical axes through 45°, 90°, and 135° on successive sessions. The question of interest was whether dogs would seek out information about the location of the white box by walking around the boxes to a position where they could see the white cue.

2.1. Method

2.1.1. Animals

Six pet dogs and their owners participated in the experiment. The dogs were 1 rough collie, 2 golden retrievers, 2 labrador retriever crosses, and 1 Australian shepherd.

2.1.2. Apparatus

Four cardboard boxes that each measured 28.3 cm × 22.0 cm (base dimensions) × 28.5 cm (height) were spray-painted black on all sides, except for one box that was painted white on one side. Each box was placed on a white plastic tray that measured 23 cm × 15.5 cm × 5.5 cm and contained a metal mesh insert. Food was placed in the bottom of each tray and covered with the mesh insert and a layer of aluminum foil. A reward piece of food was placed on top of the foil. In this way, odor cues were controlled but dogs could only gain access to food under the baited box. The rewards used varied between dogs, depending on their preference, and included chicken wiener, cookies, and dried liver bits.

2.1.3. Procedure

Testing was carried out at a dog training facility, in a room that measured 12 m × 6.5 m (see Fig. 1). Each dog was introduced to the facility and allowed to explore it and then was trained to eat from the trays and to push over the boxes in order to get to the trays. Once a dog retrieved food by pushing boxes off trays, the dog's owner became involved. The single box with a white side was baited with food and placed on the floor facing the dog and its owner, who stood on a mat 3 m from the box. The owner walked the dog to the box and allowed it to obtain the reward. Gradually, the dog learned to approach the box and retrieve the reward while its owner stayed at the mat. On subsequent training sessions, additional boxes were added. First, a dog chose between 1 white box and 1 black box for 10 trials, with each box on the left and right on 5 trials in random order. Once a dog chose the white box on 7/10 trials (chance = 5/10), a third black box was added, and dogs were trained for 12 trials in a session with each position containing the white box on 4 trials. When a score of 8/12 correct (chance = 4/12) or better was reached, a fourth black box was added. The boxes were placed in a row, with a 75 cm separation between adjacent boxes. The dogs were now given 16-trials per session, with the white box placed in each of the four spatial locations for 4 trials, in random order. The owner