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Can dogs (*Canis familiaris*) use a mirror to solve a problem?

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Abstract The ability of animals to use a mirror, either as a problem-solving tool or for the purposes of self-recognition, has been tested in several species. However, there are no empirical reports of studies using mirrors with companion dogs, which differ from most animals in that they are from infancy often kept in complex environments containing many reflective surfaces, including household mirrors. We used a simple repeated measures design, with no pre-training, to test whether pet dogs (n = 40) understand the concept of reflection. Each dog accompanied their owner into a room containing a large covered mirror. They were given 1 minute to explore the room, following which the mirror was uncovered. After another minute of exploration, the dog was motivated to attend to the mirror by the owner. A second owner then appeared in an adjoining room displaying the dog's favourite toy. The second owner stood behind the dog but could be seen in the reflective surface of the mirror. Dogs were more likely to attend to the mirror when the second owner was visible than when the owner was not visible in the mirror. Seven dogs turned away from the mirror to look toward the actual location of the owner. Of these, 2 then attended to the owner in the window more than the mirror. It is possible that these 2 dogs understood the real location of the owner and, therefore, the nature of reflection. However, none of these responses was completely unambiguous and most dogs tested showed no evidence of a capacity to spontaneously use the mirror to locate the second owner.

Introduction

The reaction of an animal to its own reflection has been of interest to animal cognition researchers for many years, since chimpanzees (*Pan troglodytes*) were reported to demonstrate mirror self-recognition or MSR (Gallup, 1970). In this initial study, 4 chimpanzees were exposed to a mirror for 10 days, after which a mark was secretly placed on each animal's forehead. The mark was not visible to the chimpanzee, except in the mirror; however, when each animal saw its reflection in the mirror, it began to touch the mark on the forehead, suggesting that it understood that it was looking at its own image. This is called the "mark test." Success is taken to imply that the animal has an idea or expectation of what it looks like from an outside perspective (Nielsen et al., 2006), but it could also mean that the animal is self-aware (Gallup, 1998). Most human children respond similarly to the mirror, when a

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mark is placed on their head, by the age of 24 months (Amsterdam, 1972).

Since this "first experimental demonstration of a self-concept in a subhuman form" (Gallup, 1970, p. 87), several other species have been claimed to have demonstrated an ability to recognize themselves in the mirror, by passing the mark test. For instance, after a period of exposure to a mirror under water, 2 dolphins (*Tursiops truncatus*) were marked with a visible marker and a sham marker, a visible marker only, or left untouched. The parts of the body that were marked were visible only in the mirror, and both dolphins spent more time looking at those particular parts of the body when marked with a real marker than when they had been sham-marked or not marked at all (Reiss and Marino, 2001). Furthermore, one Asian elephant (*Elephas maximus*) has also shown evidence of MSR after exposure to a mirror, by swinging its trunk and continually touching a mark made on the side of its forehead (Plotnik et al., 2006). The reaction of 5 European magpies (*Pica pica*) to a mirror was also studied, and 2 magpies showed clear mark-directed behaviors after being marked in highly visible yellow as compared with a black sham marker that was not visible on their black feathers (Prior et al., 2008). Rhesus monkeys (*Macaca mulatta*) that have been fitted with a head implant for electrophysiological research also show self-directed behaviors in the mirror, contrary to previous reports (Rajala et al., 2010). However, some caution is needed in interpreting results of self-directed behavior that is not clearly mark directed. A 1993 study with chimpanzees showed that there was no strong association between self-exploratory behaviors and passing the mark test (Povinelli et al., 1993).

MSR in the context of the mark test is clearly rare among animal species; furthermore, the results of experiments using this paradigm are difficult to interpret. It is argued that passing the mark test is not definitive evidence that an animal is self-aware because the required response could be based on previously learned behaviors (Epstein et al., 1981). Failing the mark test also does not definitively prove lack of self-awareness. It is possible that many animals are not motivated to attend to themselves in a mirror, in which case they may not successfully demonstrate mark-directed behaviors toward their bodies even if they are self-aware (Suddendorf and Collier-Baker, 2009). This possibility is supported by the fact that less than half of individual great apes tested display mark-directed behaviors in the mirror during this test; the remaining animals may be cognitively capable of displaying mark-directed behaviors but are not motivated to do so (Suddendorf and Collier-Baker, 2009). In an effort to answer these criticisms, one study showed that gibbons (genera: *Hylobates*, *Symphalangus,* and *Nomascus*) were unsuccessful in recognizing their self-image in a mirror, even when they were provided with strong motivation to do so (Suddendorf and Collier-Baker, 2009). Although these gibbons were marked on their faces with white paint that resembled sugar icing, which had been previously eaten by the gibbons when placed on their arms, they did not attempt to remove the paint from their faces after they had access to a mirror. In post-tests, in an attempt to encourage the gibbons to use the information in the mirror to remove the paint from their faces, the authors smeared icing on the surface of the mirror itself. Although the gibbons removed the icing from the mirror and ate it, they never showed any mark-directed behaviors toward their own bodies.

Despite the relative rarity of mark test success in the animal kingdom, an animal's reaction to a mirror can be interesting, even if it does not show MSR. Animals often go through a series of behaviors on exposure to a mirror, before, or instead of, demonstrating self-recognition. When initially exposed to a mirror, animals may react to their mirror image as if they are viewing a conspecific (another animal of that species) for the first time (Plotnik et al., 2006), and human children respond in this way before the age of 1 year (Amsterdam, 1972). In dogs, this behavior may manifest with play bows or staring with raised hackles. However, the "other animal" invariably responds in an unexpected way to the real animal's social cues (Zazzo, 1979), and the animal may then begin to physically inspect the mirror (Plotnik et al., 2006). A dog may therefore look behind it, jump onto it with the front paws, or paw at it. This corresponds to behavior that is observed in human infants at around 12-14 months of age (Amsterdam, 1972). A third response is considered the beginning of understanding the function of reflection, and is categorized by an animal showing self-directed behaviors in front of the mirror (Plotnik et al., 2006). This was noted by Gallup (1970) when the chimpanzees in his study picked their teeth and nose in front of the mirror, made faces at the mirror, and blew bubbles in the mirror. The final developmental step in human infants (Amsterdam, 1972), also demonstrated by certain animal species (Plotnik et al., 2006), is MSR, which is demonstrated by mark-directed behaviors in the mirror during the mark test.

In addition to MSR paradigms, there are studies exploring whether certain species can use a mirror as a tool. This could be evidence of an ability to understand the nature of reflection, and to subsequently use a mirror to locate an item of interest, such as food. For instance, pygmy marmosets (*Cebuella pygmaea*) are able to use a mirror to see hidden conspecifics in a neighboring compartment, separated by an opaque wall (Eglash and Snowdon, 1983). On seeing these conspecifics, the marmosets sometimes engaged in threat displays directed toward the actual location of the conspecific, as opposed to the mirror. This suggests that marmosets were aware of the location of the actual animal, and not just its image. In another study, Japanese monkeys (*Macaca fuscata fuscata*) learned to retrieve a piece of apple from various different compartments visible only in a mirror (Itakura, 1987). Other research showed that, after reinforcement training, pigeons (*Columba livia domestica*) were able to learn to peck a dot on the wall visible only in the mirror, and later they pecked dots on their