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Smelling more or less: Investigating the olfactory experience of the domestic dog

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ABSTRACT

The performance of tracking dogs and drug-, disease-, and explosives-detection dogs is a testament to trained dogs' olfactory acuity. The olfactory experience of an untrained dog, by contrast, has not been well documented. In the current research we begin to remedy that by testing untrained pet dogs' olfactory perception of quantity. While previous research found that dogs could discriminate visible quantities of more or less food (Prato-Previde, Marshall-Pescini, & Valsecchi, 2008), our results find that, by contrast, companion dogs do not reliably discriminate quantities when the food can be smelled but not seen. Sixty-one percent of dogs (39 of 64), given a choice between closed plates with one and five morsels of food, approached plates with the larger quantity: not significantly more than approached plates with the lesser quantity (binomial, $p = .169$). We did find that during dogs' initial investigation of both food amounts, subjects gave more attention to the plate containing the larger quantity (binomial, $p < 0.001$). In a second condition, we replicated, with closed plates, Prato-Previde et al.'s (2008) finding that owner interest in a plate holding a lesser quantity of food reliably leads dogs to approach that plate (binomial, $p < 0.001$). Though research has demonstrated dogs' preference for a larger amount of food (Ward & Smuts, 2007), in a third condition testing the effect of adding a strong odor to a visibly larger food quantity, we found that the addition of odor often *reversed* that preference (44/69 dogs; $p < .03$). Finally, we consider the methodological implications of this work on future dog cognition studies.

As humans see the world, dogs smell it. That is the impression left by an appreciation of the biological differences between humans and domestic dogs. Useful for their forebears (the ancestors of present-day wolves), a heightened sense of smell would have led to the detection of proximate prey and would also have been used for social communication. The anatomy of the domestic dog reflects this olfactory acuity: the dog nose has hundreds of millions more olfactory cells lining the epithelium than the human nose (Lindsay, 2000). The canid olfactory bulb and olfactory cortex are highly developed compared to these regions in the human brain. These features lead to a sense of smell that is some orders of magnitude more sensitive than humans'; able, in theory, to detect one milligram of butyric acid in a space the size of the city of Philadelphia (Lindsay, 2000). Moreover, the inhalation of odors in *Canis familiaris* is managed by an adaptive sniffing process. Respiratory and olfactory streams of inhaled air are separated into different flow paths within the nose (Craven, Paterson, & Settles, 2010), and odor habituation is prevented through side-nostril exhalation (Settles, Kester, & Dodson-Dreibelbis, 2003).

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That dogs have an excellent sense of smell is well known, and dogs are widely used as workers in roles that require they use their noses: in drug- and explosives-detection and in disease-detection, particularly cancers (e.g. McCulloch et al., 2006; Willis et al., 2004), for instance. Trained trackers can reliably determine an absent person's direction of departure in five footsteps, using the differential odor concentration from the first to fifth step (Hepper & Wells, 2005). Explosives-detection dogs use olfactory more than visual cues, allowing search in low- and no-light conditions (Gazit & Terkel, 2003). Dogs can distinguish identical twins by smell alone (Hepper, 1988), and trained dogs are skilled at matching a human odor sample to a cloth from the same individual (Settle, Sommerville, McCormick, & Broom, 1994). But exactly how acute the average dog's sense of smell is – and, especially, how much dogs use or rely on their noses in the anthropogenic environment which is now their natural environment (Miklósi, 2007) – is less well understood. The olfactory experience of an untrained dog, whose nose may be as keen as trained dogs but who has not been trained on smell tasks, has not been explicitly researched.

By contrast, the *cognition* of companion dogs has recently received much attention, mostly through studies of the physical cognition and (especially) the social cognitive abilities of the dog (Cooper et al., 2003), such as their use of human gaze for information (Agnetta, Hare, & Tomasello, 2000), their attention to others' attention (Call, Brauer, Kaminski, & Tomasello, 2003; Horowitz, 2009; Schwab & Huber, 2006), and their following of communicative pointing (Pettersson, Kaminski, Herrmann, & Tomasello, 2011; Soproni, Miklósi, Topál, & Csányi, 2002). It is surprising, on reflection, that nearly all recent studies of dogs have been of their ability to navigate a *seen* scenario, or communicate or interpret communication *visually*, given that dogs are primarily olfactory. Dogs are quite skilled at what could be called visual social problem-solving tasks, but given their ancestry one might expect their *olfactory* problem-solving to be preeminent. Olfaction has been considered in the dog-cognition literature, although largely in its role not as primary motivator of behavior, but as a possible conflicting cue in otherwise visually oriented studies (Szetei, Miklósi, Topál, & Csányi, 2003).

Our question is: Given the olfactory acuity of dogs, to what extent do they use this ability in daily life? In the current research we aimed to begin to unpack the untrained pet dog's olfactory experience by determining empirically if untrained pet dogs discriminate quantities by smell. Previous research has found that dogs could discriminate visible quantities of more or less food (Prato-Previde, Marshall-Pescini, & Valsecchi, 2008). In that study, subjects chose to approach a plate which held eight pieces of food instead of one. In a further trial, when the dogs' owners made enthusiastic noises about the plate with the smaller quantity, though, dogs more often chose the small plate. These results were taken as demonstration of the dog's ability to (a) discriminate quantity, and (b) follow human guidance instead of their own sensory abilities.

In the current study, subjects were also presented with quantity-discrimination tasks; however, in the first condition, the quantities to be compared were covered, instead of being visible. The question explored was whether subjects could distinguish quantity when smelled but not seen. Because dogs show a robust interest in more food (Araujo & Milgram, 2004; Prato-Previde et al., 2008; Ward & Smuts, 2007), the experiment was designed to provide subjects with an opportunity to select a larger quantity of food over a smaller quantity, should they discern the difference.

In the first condition, dogs were presented with two plates, one of which held a single piece of food (hot dog wedge); the other held five pieces of food. The plates were then placed equidistant from the dog, the experimenter moved away, and the dog could, after being released by the owner, make a choice between the plates. If dogs discriminate quantity by smell, they should, given their choice in Prato-Previde et al. (2008), approach the plate with the larger amount. If dogs are not discriminating quantity by smell, they should choose at random.

In a second condition, the further (above-described) trial of Prato-Previde et al. (2008) was replicated with a variant: presenting the subjects with covered instead of open plates, holding differing quantities of food. Here, the owner was asked to make enthusiastic noises about the plate with the smaller quantity. Again, the dog's subsequent behavior in selecting between the plates is the dependent variable.

A further dimension of the domestic dog's olfactory experience is the effect on dogs of odors that human owners add to their environments as fragrance or for cleaning, medicinal, or other purpose. Anecdotally, owners sometimes report dogs' apparent disgust or distaste for specific odors applied to the dog or home (McConnell, 2006). Some scents have been studied in the context of a shelter environment and shown to effect a change in rate of vocalizations or movement (Graham, Wells, & Hepper, 2005). Thus, in a third condition, we explored whether three familiar odors were sufficiently noxious to dogs that they would prompt the dogs to reverse their preference for *more food* and avoid a visible, larger quantity of the same foodstuff in favor of a small quantity with no added scent. The odors we tested were vinegar, a common household cleaner; and two scents not considered to be repellent to dogs (Graham et al., 2005) – lavender, the fragrance in a dog shampoo, and mint, the flavor in a spray billed as a dog breath freshener. Should dogs have an aversion to these odors, they may select the non-odorous, smaller-quantity plate.

Finally, in this study we were also interested in exploring some of the effects of chosen methodology on the dogs' plate selection. Our interest in the dog's experience of the world extends to an interest in the dog's experience of an experimental setting. The effects not just of the independent quantity but also of the experimental design, experimental measure, and human participants are discussed.

Methods

Our protocol was designed to investigate dogs' choice behavior between two differing food amounts. The experimental design involved presenting the dog with two plates and asking the dog to "select" one by approaching it. The specific design is as follows.

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