A note on visual, olfactory and spatial cue use in foraging behavior of pigs: indirectly assessing cognitive abilities

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Abstract

The micro pig’s (Sus scrofa) ability to use visual, olfactory and spatial cues to locate a food resource in a novel environment was investigated. In Experiment 1, four castrated male pigs were trained to identify a food resource—one of two plastic flower-pots placed within a 12.8 m × 6.7 m arena. Correct pots differed only in color from incorrect pots. During the first 10 trials, the location of the correct pot was constant, and pigs were allowed to search until the correct pot was displaced. Pigs were then presented 10 single-choice trials with constant location, repeated until each pig made 8 of 10 correct choices. Next, pigs were given 10 single-choice trials with location of correct pot randomized, to determine whether they would follow visual cues (color) or return to previously correct locations (i.e. rely on learned spatial cues). Trials were then conducted with 4, 6, 8 and 10 pots. In random location trials, pigs performed above chance (P < 0.005). Experiment 2 was designed to assess performance with olfactory cues. Discriminative stimuli were food extract odors. Pigs were required to select pots containing a specific odor. Trials used 2, 4, 6, 8 or 10 pots. In all, except two-pot trials, pigs performed above chance on random location trials (P < 0.005). We propose that when multiple cues are available, pigs can use vision and olfaction to navigate, rather than relying solely on spatial memory.

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1. Introduction

Understanding an animal’s foraging behavior and navigational strategies requires knowledge of its perceptual, sensory, and cognitive abilities. Experiments with farm animals indicate some of the perceptual and cognitive processes involved in foraging. Hosoi et al. (1995a,b) reported that sheep, goats, and cattle all adopt “win-stay” strategies when negotiating radial arm mazes (i.e. when these species found a location with food, they tended to resample that same location on the following trial). However, the extent to which visual and olfactory cues may also be used during navigation by livestock species is unknown. Klopfer (1966) suggested that pigs do not acquire and maintain the use of visual cues while foraging. Other studies have suggested that swine can learn multiple choice spatial tasks, but that the first problem that they encounter influences their ability to learn subsequent tasks (Kilgour, 1987). Further investigations have revealed that pigs’ spatial memory abilities may be impaired by stressful situations, such as restraint and time delays (Mendl et al., 1997; Laughlin et al., 1999).

Because cues that are salient during navigation and foraging can affect a pig’s cognitive state, it is important to identify these so that they may be taken into account during handling and management to optimize swine welfare. Thus, the objective of the current investigation was to examine whether micro pigs could learn to use visual and olfactory cues to locate food in a novel environment. It was hypothesized that pigs that had learned to associate both a spatial cue and a visual/olfactory cue with a reward could then learn to disregard the spatial cue, and rely instead on visual or olfactory cues to locate a food resource.

2. Methods

2.1. Animals and materials

Four male micro pig barrows (43–48 kg) ages 2.5–3 years were used. All had been previously trained for cognitive tests. Pigs were given food rewards, (Milk-Bone brand small dog biscuits, Nabisco Co., East Hanover, NJ) in addition to their daily rations of Purina Lab Minipig diet (Lab mini-pig HF grower diet 5L80, PMI Feeds, St. Louis, MO). They also received alfalfa cubes ad libitum.

The testing arena (12.8 m x 6.7 m) contained 12 metal poles (0.6 m height) located (0.9 m) apart from each other. Plastic flower-pots (orange or green colored) were hung upside-down from the poles with white cotton string.

Tests were conducted once daily 5 days per week. Voice commands were used to move the pigs from their pens to the test arena and back, and a clicker was used to signal when a correct choice was made during testing. Tests were designed to avoid unintentionally assisting the pigs in making correct choices. The experimenter recording the pigs’ responses stood in the center of the testing aisle, facing the pigs as they entered. This experimenter wore mirrored sunglasses to avoid cueing the pigs to the correct flower-pot with her eye movements. The experimenter who allowed the pigs to enter the test arena from the opposite end of the room had no eye contact with pigs during testing. This experimenter notified
the recording experimenter and sounded the clicker immediately after a correct choice was made. The pigs returned to this experimenter to receive food rewards after making a correct choice.

2.2. Experiment 1—visual stimuli

Each pig was randomly assigned a target pot based on color (orange or green). This pot was “correct” throughout the experiment and distinguishable from other pots only by its color. Each pig was presented with five test problems consisting of 2, 4, 6, 8, and 10 choices, each with only one correct pot. Each test problem consisted of a multi-choice, fixed-position (“search”) trial, a single-choice, fixed-position trial, and a single-choice, random-position trial. Pigs completed all phases before proceeding to subsequent problems. During search trials, the pigs explored as many pots as necessary until displacing the correct pot. Upon doing so, they were rewarded with the sound of a clicker and a food reward. During the single-choice, fixed-position trial the pigs were allowed to displace only one pot, and had to reach a criterion of 8 correct choices out of 10. Failure to attain this criterion resulted in a repeat session of 10 trials. For both the search and fixed-position trials, the correct pot remained in the same location relative to the incorrect pots, thus confounding correct spatial location with correct color. Correct pots were randomly moved throughout the arena during the random-position 10-trial session. The aim of this phase of the test was to determine whether pigs would attend to the visual cue, independent of spatial position, despite previously having both cues rewarded.

2.3. Experiment 2—olfactory stimuli

The olfactory test problems followed the same paradigm as for visual stimuli. However, flower-pots were the same color for all pigs and each was randomly assigned to a target “correct” scent (coconut or almond). Identical, opaque, plastic bottles (227 ml Fisher Scientific Sample Bottle NM HDPE, Pittsburgh, PA) were set on top of all flower-pots, with only the correct bottle being scented. A choice was scored when a pig knocked a bottle off a flower-pot. As was done for visual testing, the pigs were given five test problems consisting of 2, 4, 6, 8, and 10 choices.

2.4. Statistical analysis

The analysis focused on the number of correct choices out of 10 test runs during random-position trials. Trials were run in sequential order and were not randomized so the treatment design was a two (stimulus) by five (trial) factorial. The data were analyzed using a repeated measures analysis of variance (ANOVA) (SAS, 1996). Pigs were blocked with respect to stimulus type and problem.

The pigs’ performance was compared to chance level of success on each problem. Chi-square analyses were used to compare mean percentage of correct responses on each phase of the single-choice, random-position trials. A variable called ‘score’ was created for each trial for each pig (score = percent correct chance) and was compared to the chance values for all trials of each stimuli.
3. Results

The number of choices (2, 4, 6, 8, 10) significantly influenced percent correct responses ($P < 0.001$). There was no significant trial by stimulus interaction ($P < 0.10$) and stimulus (visual or olfactory) was not a significant effect ($P < 0.10$). A regression analysis of percent correct responses by number of choices yielded a significant effect ($R^2 = 0.1928$, $P < 0.001$). Learning occurred during both visual and olfactory stimuli experiments as evident in the graphic representation of average score value for each trial when plotted against chance, represented by the zero line (Fig. 1). The score value indicates how much the average percent correct value deviated from chance. Visual and olfactory stimuli results are plotted separately. On visual tests, mean percent correct responses on 2, 4, 6, 8, 10 choices (chance = 50, 25, 16, 12.5, 10%, respectively) was 45, 47.5, 50, 47.5, 70%, respectively; ($\chi^2 = 1, 27, 86, 112, 400$; all $P < 0.005$, except for the two-choice problem; $P > 0.05$). On olfactory tests, mean percent correct responses on 2, 4, 6, 8, 10 choices was 60, 55, 70, 75, 88, respectively ($\chi^2 = 4, 48, 217, 357, 676$; all $P < 0.005$, except for the two-choice problem; $P < 0.05$).

4. Discussion

The result of the current investigation, namely that pigs could successfully locate a “food source” when provided with either visual or olfactory cues, suggests that pigs can use either or both types of stimuli during foraging. These findings refute Klopfer’s (1966) suggestion that pigs cannot learn to use visual cues while foraging. Performance using olfactory cues was generally better (although not significantly different) than performance with visual cues, suggesting that olfactory cues are at least as salient as visual cues for pigs during learning and foraging situations. These results resemble those of Croney (1999) who found that pigs performed better on discrimination learning tasks when olfactory rather than visual stimuli were used. The observation that the pigs performed well when given odor cues is not surprising given the well-known olfactory capabilities of the species (Ewbank et al., 1974; McGlone et al., 1987; Encyclopaedia Brittanica, 1995; Jensen, 2002).
The current investigation also shows that pigs are capable of discrimination learning when multiple choices (i.e. more than two choices) are presented. The pigs consistently performed well above chance in trials with a greater number of choices. This slightly unexpected finding may be understood given the assumption that learning was ongoing throughout each phase of both the visual and olfactory testing. Evidently, some aspect of what was learned in the trials with fewer choices was transferred to trials with a greater number of choices. Since the study was run sequentially, and the pigs were assigned the same color and smell for the entire trial, they did not need to relearn the task at each phase. Rather, it would seem they may have formed a general learning set related to the task demands, which may have been transferred across tests.

Alternatively, it is possible that as the number of choices (pots) increased, it became easier for the pigs to choose correctly based on the relative frequency (or rather, infrequency) of the physical properties of the correct pot. This, however, would still support the hypothesis that instead of relying solely on spatial cues during the task, the pigs attended to the available visual or olfactory cues, particularly during the random-location trials, in which the position of the correct pot varied.

There are several implications of the finding that pigs can learn to use both visual and olfactory cues to forage and navigate through the environment. First, it is possible that pigs could learn to associate negative and positive events with environmental stimuli such as odors and visual cues. Consequently, this could have detrimental or desirable implications for the behavior, ease of handling and movement of pigs kept in confinement. For instance, the distress a pig might experience upon encountering an odor or visual cue it had learned to associate with an unpleasant stimulus or occurrence might be lessened by removing such cues from general areas. Likewise, undesirable behavior that might be partly due to such associative learning might also be reduced. Also, olfactory or visual stimuli could possibly be used to facilitate movement of pigs from one location to another, thereby increasing handling efficiency. Further research is needed to explore these possibilities.

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References


