International Journal of Humanities and Social Science Vol. 8 • No. 6 • June 2018 doi:10.30845/ijhss.v8n6p1

The Influence of Sex and Temperament on Spatial Learning in Domestic Dogs

Rebecca Showalter

Robert Polewan

Scott Drury

Department of Psychology
Stephen F. Austin State University
USA

Abstract

Past research indicates that dog temperament and sex may influence spatial learning and memory. The current study assessed how sex and temperament affect spatial learning in male and female dogs, using an appetitive spatial learning task. It was expected that male dogs would complete the task with more proficiency than female dogs and dogs with an obedient temperament would complete the task with more proficiency than dogs with an aggressive, fearful, or excitable temperament. Findings indicate that male and female dogs appear to learn the task to the same degree. Further, dogs with an obedient or an aggressive temperament appearmoreaccurate in learning the task than dogs with a fearful temperament. The current research may better explain the role that temperament and sex have on spatial learning and memory and can help create a more applicable animal model of spatial learning.

Keywords: spatial learning, dogs, temperament, sex differences, learning, memory

I. Introduction

People have used dogs for centuries in activities such as hunting, retrieving, and the protection of farm animals. At the present time, dogs are more commonly being used as service and comfort animals for individuals with physical and/or mental disabilities. Moreover, the military and police use K-9 units trained to navigate objects in order to detect illegal drugs or explosives (Ensminger, 2012). Prior to becoming a part of a K-9 unit, dogs must undergo extensive training; certain behaviors of these dogs, such asbeing able to pass obstacles with little hesitation, are associated with the certification of dogs for K-9 units (Svobodová, Vápeník, Pinc, & Bartoš, 2008). In addition to a number of behavioral tasks, dogs also need to be able to learn to navigate with in their spatial environment.

Spatial performance can be defined as the generally ability to encode, store, and retrieve mainly visual information specific to route navigation and object locations (Postma, Jager, Kessels, Koppeschaar, & van Honk, 2004), such as beacons, landmarks, and other various stimuli (Shettleworth & Sutton, 2005). Our environmental space plays a role in our spatial behavior. For instance, the ability to locate and navigate to places is necessary for efficient localization of resources and goals (Andersen, Dahmani, Konishi, & Bohbot, 2012; Tolman, 1948). Further, the ability to detect events in the environment is central to our ability to adapt, as the prediction of these events allows us to prepare for future events within the environment in which the learning of spatial information occurred in (Deroost & Soetens, 2006).

1.1 Spatial Learning

Spatial learning refers to the process through organisms encode information about objects in their environment in order to facilitate navigation and recall locations of significant stimuli (Floresco, 2010), in addition to recall of avoiding punishers. In non-human animal models, spatial learning can be assessed using a “maze” task (e.g., radial arm maze) that require the organism to navigate within the given environment. These spatial tasks differ from traditional mazes, which require memorization of a series of relative movements, in that they require the organism to navigate through the environment using information about its position relative to objects in the environment (egocentric information) and the relative position of objects to one another (all centric information).

In addition to relative information about objects in the environment, other mechanisms may also be necessary for spatial learning, including the use of landmark features, environmental geometry, and path integration (Timberlake, Sinning, & Leffel, 2007). Previous research has suggested that dogs are able to navigate the radial arm maze (RAM), but have a low spatial learning capacity when completing the radial arm maze task (e.g., MacPherson & Roberts, 2010). Specifically, six dogs made 83% mean correct arm choices, which is low when compared to other species (e.g., rats). However, according to Craig et al. (2012), dogs that completed the radial arm maze task had higher performance due to fewer trials per day, which suggests that spatial learning may vary due to trial length. Expanding on the finding that trial length may be important, researchers gave dogs training trials in which they varied the inter-trial interval (ITI) in a modified combination of the open-field and radial arm maze that assessed learning on a mass trial paradigm, intermediate trial paradigm, and long-delay trial paradigm (Showalter, Bashaw, Solomon, & Polewan, 2015). The study suggested that dogs might not need longer delays between trials to learn the specific task since dogs appeared to learn the learning task in mass trials.

1.2 Sex

In addition to trial length, other variables, such as the sex of the organism may have an effect on spatial learning. For instance, in spatial tasks, rats typically demonstrate more rapid acquisition than female rats and male rats have been shown to have a higher efficiency on spatial navigation tasks (e.g., Morris water maze)due to testosterone aiding in the increase in cell layer size within the hippocampus (Roof& Havens, 1992). Although the current study utilized dogs, the task utilized components from the radial arm maze.

1.3 Temperament

While there has been ample research on the effect sex on spatial learning, to the knowledge of the authors, there is little to no research that has looked at temperament and spatial learning. Overall, temperament (or reactivity) depicts general patterns of behavioral responding to novel stimuli (Jones & Gosling, 2005; Wright & Nesselrote, 1987) and is typically used in literature when describing non-human animal research (e.g., Jakuba et al., 2013; Jones & Gosling, 2005; McCrae et al., 2000). Moreover, it appears frequently in assessments of dog behaviors (e.g., Canine Behavioral Assessment and Research Questionnaire; Hsu & Serpell, 2003). Carere and Locurto (2011)suggest that temperament (reactivity) may influence non-social processes (e.g., spatial navigation). Further, the idea that temperament may influence non-social processes may be possible due to interaction between other factors, such as age, the brain (e.g., hippocampus), or the environment. If temperament can influence non-social processes, such as spatial learning, then temperament may be based on a dog's response to stimuli that induce stress. For instance, dogs with an obedient/trainable temperament may experience a non-stressed response in the event of negative stimuli, whereas dogs with an aggressive, fearful/anxious, or excitable temperament may have a stressed response in the event of negative stimuli.

Diamond, Fleshner, Ingersoll, and Rose (1996) found that rats placed into a novel, stress-provoking environment (enclosure that contained the scent of another rat) experienced impairments in working memory (short-term memory), but had an intact reference memory (long-term memory) on a 14-arm radial maze. However, after repeated daily exposure to the stressful environment, the memory impairment in the maze decreased. The findings show that once an animal begins to acclimate to stressors within an environment, impairments begin to disappear, as stress appears to be no longer impinging on short-term memory. Since temperament may be seen as how animals are responding to stressors within the environment, stressors may affect learning, motivation, and attention within the dog. Therefore, temperament may mediate the stress response and thus affect learning (especially in novel situations).

1.4 Hypotheses

As stated above, research indicates that the sex of subject can impact the proficiency on a spatial learning task (Bimontea, Hydea, Hoplighta, & Denenberga, 2000) and that temperament may be associated with emotional reactivity (Davidson, 1998) and moderate as a response to stimuli. The current study attempted to assess how sex and temperament may affect spatial learning in domestic dogs, as measured by a modified combination of a radial arm maze and open-field task in a diamond-shaped layout. It was hypothesized that male dogs would complete the task with more proficiency than female dogs. It was also hypothesized that dogs with an obedient/trainable temperament, as measured by the C-BARQ™, would complete the task with more proficiency than dogs with an aggressive, fearful, or excitable temperaments.

2. Method

2.1 Subjects

Subjects consisted of male (n = 16) and female (n = 21) domestic dogs (Canis familiaris) between the ages of 0.5 yearsand 9.08 years of age (M = 3.00, SD = 2.80). Dogs that did not meet learning criteria (did not approach containers three out of six trials) or did not meet the age restrictions cut off (0.5 years) were removed, leaving a total of 37subjects for the current study. Dogs of all temperaments were observed in the current study (obedient = 9, aggressive = 12, fearful = 10, excitable = 6).Dog owners were recruited through SONA and invited to bring their dogs into the lab. The Stephen F. Austin State University Institutional Animal Care and Use Committee (IACUC) and Institutional Review Board (IRB) approved all procedures prior to testing.

2.2 Materials and Apparatus

Online. Qualtrics was used for all self-report data collected online from the dog's primary owner. A short dog demographics questionnaire and a modified version of the Canine Behavioral Assessment and Research Questionnaire (C-BARQ™; Hsu & Serpell, 2003) was provided for dog owners to complete. In Lab.Testing took place in a designated research laboratory (16 ft 5 in x 11 ft 7.5 in). The room contained no windows, one door, and a counter (8 ft x 2 ft); the walls were painted white, with a neutral-colored carpet. One chair was placed in the corner of the room. Blue and yellow felt materials cut into various shapes (e.g., squares, triangles) were placed on the walls to serve as visual cues. A spatial task created by the researchers was utilized to measure spatial learning and memory within subjects and will be discussed in further detail in the procedure. The task utilizes six clear, square plastic 32 oz.Kroger Disposable Food Containers in a diamond-shape to serve as test stimuli. Purina Thick Cut Hickory Smoke Flavor Beggin' Strips broken into smaller pieces served as food reinforcement. An Apple iPad 2 recorded the spatial learning and memory trials; behaviors were also recorded by hand using a coding sheet created by the experimenter. A campus map with various walking paths was given to dog owners for walking the dog.

2.3 Procedure

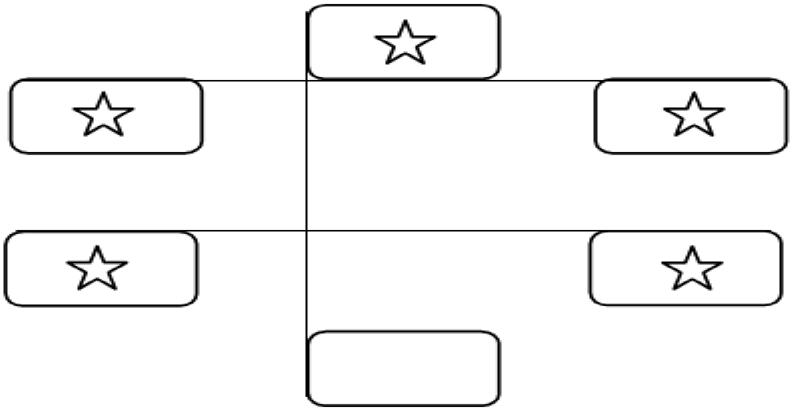


Figure 1. Stars indicate where food reinforcement can be placed in the Canine Appetitive Spatial Task (CAST). Only three containers had food reinforcement (dog treat) during a given trial. The location of food reinforcement was randomized across each subject to counterbalance scent trails.

The owner brought the dog into the testing room, and was the only person to handle the dog during the entire process. The researcher explained the procedures, benefits, and risks that involved in the current study and provided an informed consent and liability waiver. Following consent, the owner was given the iPad, where the C-BARQ and a short dog demographics questionnaire (e.g., age, sex, etc.) were completed. The time the owner spent filling out all needed documents (approximately 15-20 minutes) allowed the dog to acclimate to the experimental room. The owner was given a dog treat that was used as the food reinforcer and asked to step out of the room and into the hallway to give the dog the treat. While the owner and dog were out of the room, the researcher placed the food reinforcement into the test stimuli. By having the owner give the treat to the dog, the dog was able to acclimate to the treat and learned they were permitted to consume the treat. The size of the treat was also varied based on the size of the dog, in order to account for the possibility of satiation.

Containers in the spatial memory task were placed on the floor (14 ft 5 in x 11ft 7.5 in) in a diamond shape (Figure 1); only three out of the six containers were baited with the food reinforcement. Felt materials in various shapes (e.g., squares, triangles) were placed within the room to serve as visual cues. The materials were in blue and yellow colors, as canine color range is limited. To counterbalance odor cues, each plastic container contained a dog treat with another plastic container with holes of top of it to allow for the odor cue of the dog treat to remain consistent across each container. In addition, the location of food reinforcement was pseudo-randomized across each subject to counterbalance scent trails; the pseudo randomization was put in place so that the same containers would not be used each time. Once the dog was brought back into the testing room, it was walked to the center of the room, let off the leash, and allowed to roam freely for 10 minutes; dogs were able to navigate the room in order to find the containers with food reinforcement. During this time, the owner would sit in a chair placed in the corner of the room and was told to disengage with the dog, whereas the experimenter stood in a corner of the room recording the trial. If the treat was not found within 10 minutes, the trial ended. If the dog consumed all three treats before the 10 minutes, then the trial ended. There were a total of 6 (six) trials.

Once a trial was complete, the owner would walk the dog along an outdoor path indicated by a map; different paths were used so the dog did not establish cues for the task. The walk took between five and seven minutes. The procedure was then repeated, until all trials were finished. Initial approaches, correct container choices, working memory errors, reference memory errors, and latency were recorded by both a video camera and by hand to ensure reliability. Once all trials were completed, the dog owner was given a certificate of completion and written feedback concerning the study, thanked, dismissed. If a student's dog participated, the student was given SONA Systems credit.

2.4 Dependent Variables

Learning. Percent correct container choices and a mean composite score for correct container choices served as the main dependent measures for learning. Dividing the trial's total correct container choices by the total container choices and multiplying that number by 100 yielded percent for correct container choices. The mean composite score for correct container choices was calculated by dividing the overall total correct container choices by the overall total container-choices made and multiplying that number by 100. Dogs that had a higher correct choices percentage and a higher mean composite score for correct container choices were defined as having more proficiency on the task.

Working Memory. Working memory error scores and a mean composite score for working memory errors served as the main dependent measures for working memory. Working memory errors were defined as repeated approaches to a container that previously had a food reinforce, as well as the repeated approaches to a container that never contained a food reinforcer (e.g., Jarrard, 1986; Tarragon et al., 2012). Working memory error scores were calculated by dividing the trial's total working memory errors by the total container choices for that specific trial; the mean composite score for working memory errors was calculated by dividing the overall total working memory errors by the overall total container choices made. Dogs that had lower working memory error scores and lower mean composite scores for working memory errors were defined as having more proficiency on the task.

Reference Memory. Reference memory error scores and a mean composite score for reference memory errors served as the main dependent measures for reference memory. Reference memory errors were defined as the initial approaches to a container that never contained a food reinforcer (e.g., Jarrard, 1986; Tarragon et al., 2012). Reference memory error scores were calculated by dividing the trial's total wrong errors by the total container choices for that specific trial. The mean composite score for reference memory errors was calculated by dividing the overall total wrong errors by the overall total container choices made. Dogs that had a lower reference memory error score and a lower mean composite score for reference memory were defined as having more proficiency on the task.

2.5 Data Analysis

Data from percent correct container choices, working-memory error scores, and reference memory error scores were analyzed using a series of multivariate repeated measures (RM) ANOVAs with sex and temperament as between-subject factors and trial as the within-subject factor. Temperament was partitioned into four groups: obedient, aggressive, fearful-anxiety, excitable using the C-BARQ^{TM}. However, we generally hypothesize that dogs falling under the "obedient" temperament will outperform those of other temperaments. Were an effect of temperament to be observed, a binary comparison will be compelled to rule out differences among non-hypothesized temperaments. Trial consisted of trials one through six.

Mean composite scores for correct container choices, mean composite scores for working memory errors, and mean composite scores for reference memory errors were analyzed. A series of three mixed ANOVAs were run testing the effect of trials on the three dependent variables of correct container choices, mean composite scores for working memory errors, and mean composite scores for reference memory errors. Between-subject factors were sex and temperament. Alpha was set to 0.05 for all statistical tests. Measures of effect size were omitted for null findings.

3. Results

3.1Percentage of correct container choices

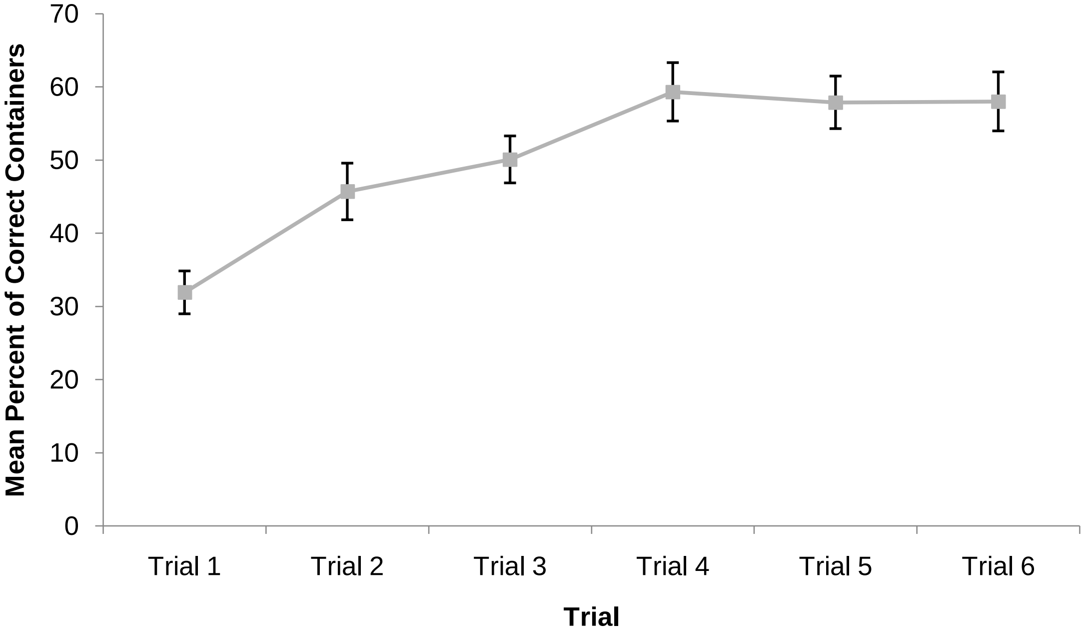


Figure 2. Mean percent of correct container choices across all 6 trials. Trial 1 is significantly different from trial 2-6 (* denotes significance). Mean percent (standard errors) for trial 1-6 are respectively 31.91 (±2.93), 45.70 (±3.87), 50.08 (±3.21), 59.32 (±3.99), 57.88 (±3.59), and 58.01 (±4.03).

Subjects demonstrated learning in the form of percentage of correct container choices, wherein the first trial featured a lower mean that the subsequent trials as depicted in Figure 2, $F(5, 160) = 11.04$, $p< .001$, partial $\eta2 = .26$. There were no main effects for sex, with each sex showing similar levels of learning as depicted in Table 1(females, M = 51.29, SD = 12.63; males, M= 49.43, SD = 17.65), $F(1, 32) = .05$, $p = .82$. However, there was a main effect for temperament, with obedient and aggressive temperaments having a higher percentage of correct container choices than the fearful/anxious temperament, whereas the fearful temperament did not differ from the others (see Table 1), $F(3, 32) = 3.99$, $p< .05$, partial $\eta2 = .27$. The interaction of trial and sex was not significant, $F(5, 160) = .64$, $p = .67$, nor was the interaction of trial and temperament $F(15, 160) = .64$, $p = .84$. Considering both sex and the binary version of temperament as between-subjects variables, subjects demonstrated learning in the form of correct container choices, $F(5, 170) = 9.76$, $p< .001$, partial $\eta2 = .223$.There were no main effects for sex, $F(1, 34) = .19$, $p = .67$, however the effect for temperament as a binary variable held, as expected, $F(1, 34) = 5.53$, $p< .05$, partial $\eta2 = .140$, wherein non-obedient dogs scored a mean of M = 47.40 (SD = 13.67) collectively. Severely unequal sample sizes compel an address of presumed heterogeneity of variance, given that nine of the 37 dogs were classified as obedient. Box’s Test was not significant ($p = .42$) and Levene’s test was not significant for five of the six trials. The interaction of trial and sex was not significant, $F(5, 170) = .47$,$p = .80$, as was the interaction of trial and temperament $F(5, 170) = .90$, $p = .48$.

3.2Working memory errors

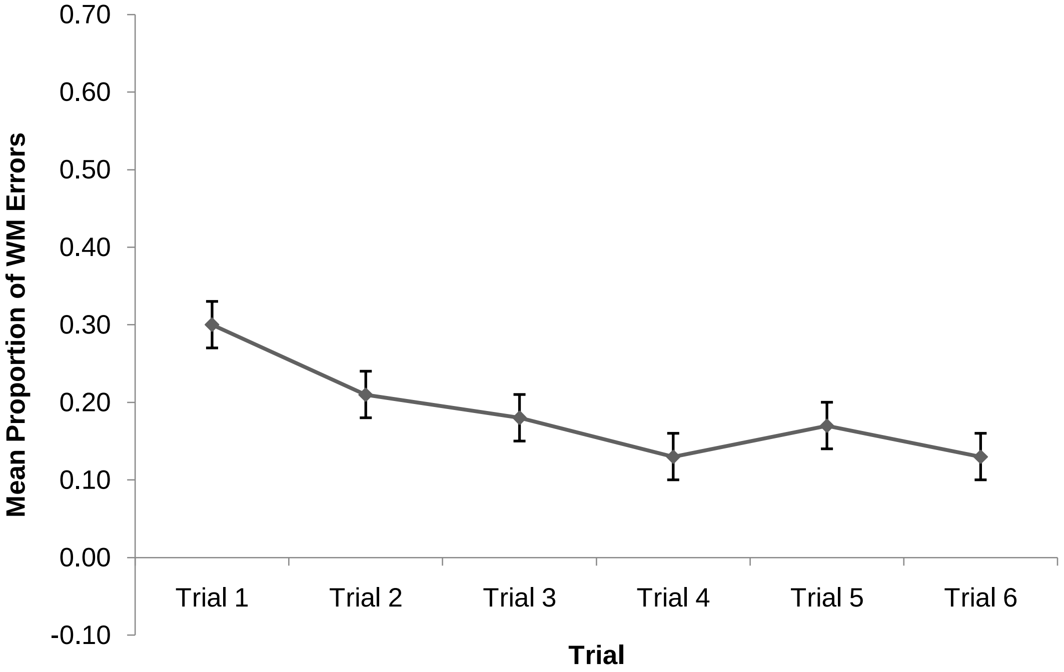


Figure 3. Mean proportion of errors in working memory across all 6 trials. Trial 1 was significantly different from trial 2-6 (* denotes significance). Mean proportion (standard errors) for trial 1-6 are respectively .30 (±.03), .21 (±.03), .18 (±.03), .13 (±.03), .17 (±.03), and .13 (±.03)

As shown in Figure 3, subjects demonstrated fewer working memory errors by trial,wherein the first trial featured higher mean working memory errors than subsequent trials, F(5, 160) = 4.93, p< .001, partial η2 = .134, as depicted in Figure 3. There were no main effects for sex, with each sex showing the same level of working memory errors (females, M = 0.21, SD = 0.11; males, M= 0.17, SD = 0.09), F(1, 32) = .90, p = .35, as depicted in Table 1. There was no main effect for temperament, although the obedient temperament (M = 0.16, SD = .09)again outpaced the other three in terms of showing low working memory errors, the nearest competitor being Excitable (M = 0.18, SD = 0.08), F(3, 32) = 0.45, p = 0.72, , as depicted in Table 1.The interaction of trial and sex was not significant, F(5, 160) = .59,p = .71, nor was the interaction of trial and temperament F(15, 160) = .25, p = .99.

3.3 Reference memory errors

While not statistically significant, subjects tended to show fewer reference memory errors as trials continued, wherein the first trial featured a higher mean, F(5, 160) = 0.53, p = .75. There were no main effects for sex, with each females showing only a slight advantage (females, M = 0.25, SD = 0.08; males, M= 0.28, SD = 0.10), F(1, 32) = .31, p = .58. There was no main effect for temperament, F(3, 32) = 1.91, p = 0.15. The interaction of trial and sex was not significant, F(5, 160) = 0.44,p = .82, as was the interaction of trial and temperament F(15, 160) = 1.18, p = .30.

4. Discussion

The purpose of the current study was to assess if sex or temperament would have an effect on a dog's proficiency to complete a spatial learning and memory task. The current study findings showed there were significant differences in trials for percentage of correct container choices and working memory errors. More specifically, dogs made more percent-correct container choices in trial 6 than in trial 1. The findings suggest that dogs tended to learn the task over repeated trials, which has been indicated to be possible based on previous literature assessing spatial learning in dogs (e.g., Craig et al., 2012).

4.1 Sex of Dogs

The current study expected that male dogs would complete the task with more proficiency than female dogs. However, no sex differences were seen; specifically, the current study showed that male and female dogs made the same amount of percent correct container choices, working memory errors, and reference memory errors.

The findings may be in part due to the cues that dogs establish for finding hidden food reinforcement, which appear to differ from rodent spatial strategies. Ashton and De Lillo (2011) found that dogs displayed an associative learning strategy regardless of whether or not cues were available. It is possible then that associative learning can produce long-lasting effects than can be counterproductive towards the task requirement. In the current study, dogs tended to display a more associative learning strategy by visiting every container in a circular fashion until each treat was consumed. Of the 37 dogs tested, 56.8% of dogs (n = 21) employed this circular strategy. The circular search strategy could be due the lack of spatial continuity between the sight of the reinforcer and a particular location that was established as a cue, which was powerful enough to induce a bias towards searching in that pattern.

4.2 Temperament of Dogs

Dogs with an obedient/trainable temperament were expected to complete the task with more proficiency than dogs with other temperaments, as measured by the C-BARQ™, based on the emotional reactivity. The current results showed a significant difference in temperament. Specifically, dogs with obedient and aggressive temperaments performed better in percent correct container choices than dogs with a fearful/anxious temperament. It is possible that obedient dogs are handling stressors from the environment more effectively than fearful-anxious dogs, as trainable/obedient dogs may be more composed and calm in their behaviors. It is also possible that aggressive dogs are handling stress more efficiently than fearful/anxious dogs, as aggressive dogs may be more assertive in their behaviors.

Emotional reactivity may have resulted in dogs with an obedient temperament responding to stimuli through non-stressed behaviors, whereas dogs with other temperaments mayhave responded to stimuli through stressed behaviors. The current study findings for temperament indicate that dogs' responses may be due to stress. For instance, research has shown chronic stress can impair spatial memory and motivation for reward in rats (e.g., Kleen, Sitomer, Killeen, & Conrad, 2006). Although not chronically stressed, most dogs in the current study were not familiar with the testing room and reacted in a stressed manner by frequently approaching the door and/or whining. The current study findings may reflect the dog's tendency to utilize response routines with well-learned habits, which would lead to stereotyped behavior patterns that are often quite difficult to alter (Maier, 1949).

4.3 Study Limitations and Future Research

The current study is not without limitations. For instance, the researcher was unable to control for rearing conditions.Rearing has been shown to promote excellent retention, which can lead to ceiling effects on tasks like these (Nippak, Mendelson, Muggenburg, & Milgram, 2007). Therefore, it may be possible that dogs that are raised alongside other dogs or given sensory enrichment (toys) will end up having better performance on our task than dogs that may have been reared alone with a limited amount of interaction from owners. Additionally, dogs were not observed in their natural environment; specifically, the owner and researcher in the room could have an effect on the dog. Head et al. (1997) found that dogs engage in exploratory behavior when given appropriate stimulation (through engaging with a person in the room). Therefore,it is possible that the researcher and the owner being in the room will have increased exploratory behavior for the spatial memory task. In order to account for the possible increase in exploratory behaviors, the researchers informed the owner not to engage with the dog, as both adult dogs and puppies use human head pointing, head turning, and gaze as cues to find hidden locations of food (e.g., Hare & Tomasello, 2005). Future research should look into implementing a true experimental design when assessing sex and temperament, by utilizing a probe trial. For example, in one probe trial, the cues would be taken away in trial 6 to assess if dogs were actually utilizing spatial orientation to find the food reinforcement. By contrast, after the six trials are completed, the dogs can be given a probe trial in which the food reinforcement could be taken away to see if dogs would orient themselves to the correct container still.

4.4 Conclusion

The findings of the current study may better explain the role that temperament, regardless of sex, can have on spatial learning and memory. The dog animal model of spatial learning and memory is important because dogs are typically used as service animals, in the form of guide dogs, K-9 units, etc. Guide dogs need to be able to readily navigate for their owner and K-9s need to be able to navigate to possible drug locations. Those responsible for training dogs may be able to assess which dogs are going to learn tasks with lowest amount of errors made based on the dog's temperament.

Furthermore, since the lifespan of dogs is longer than rats (two years for a rat versus 13 years for a dog), allowing for the utilization of the dog as an animal model for aging, learning, and memory, and may be more appropriate for the mimicking longevity and cognitive decline that is seen in humans, compared to rodent models.

5. Disclosure

The authors declare no conflict of interest.

References

Andersen, N. E., Dahmani, L., Konishi, K., & Bohbot, V. D. (2012). Eye tracking, strategies, and sex differences in virtual navigation. Neurobiol. Learn. Mem., 97(1), 81-89.doi:10.1016/j.nlm.2011.09.007

Ashton, R. L., & De Lillo, C. (2011). Association, inhibition, and object permanence in dogs' (Canis familiaris) spatial search. J. Comp. Psychol., 125(2), 194.doi:10.1037/a0022584

Bimontea, H., Hydea, L., Hoplighta, B., & Denenberga, V. (2000). In two species, females exhibit superior working memory and inferior reference memory on the water radial-arm maze. Physiology & Behavior, 70(3-4), 311-317. doi:10.1016/S0031-9384(00)00259-6

Carere, C., & Locurto, C. (2011). Interaction between animal personality and animal cognition. Current Zoology, 57, 491-498. doi:10.1093/czoolo/57.4.491

Craig, M., Rand, J., Mesch, R., Shyan-Norwalt, M., Morton, J., & Flickinger, E. (2012). Domestic dogs (Canis familiaris) and the radial arm maze: spatial memory and serial position effects. J. Comp. Psychol., 126(3), 233.doi:10.1037/a0025929

Davidson, R. J. (1998). Affective style and affective disorders: Perspectives from affective neuroscience. Cogn. Emot., 12(3), 307-330.doi:10.1080/026999398379628

Deroost, N., & Soetens, E. (2006). Spatial processing and perceptual sequence learning in SRT tasks. Exp. Psychol., 53(1), 16-30.doi:10.1027/1618-3169.53.1.16

Diamond, D. M., Fleshner, M., Ingersoll, N., & Rose, G. (1996). Psychological stress impairs spatial working memory: relevance to electrophysiological studies of hippocampal function. Behav. Neurosci.,110(4), 661.doi:10.1037/0735-7044.110.4.661

Ensminger, J. J. (2012). Development of police and military dog functions. Police and military dogs: criminal detection, forensic evidence, and judicial admissibility / John J. Ensminger. Boca Raton: CRC Press, c2012.

Floresco, S. (2010). Spatial learning in animals. In Encyclopedia of Psychopharmacology (pp. 1259-1262). Springer Berlin Heidelberg.

Hare, B., & Tomasello, M. (2005). Human-like social skills in dogs? Trends Cogn.Sci., 9(9), 439-444.doi:10.1016/j.tics.2005.07.003

Head, E., Callahan, H., Cummings, B. J., Cotman, C. W., Ruehl, W. W., …&Milgram, N. W. (1997). Open field activity and human interaction as a function of age and breed in dogs. Physiol. Behav., 62(5), 963-971. doi:10.1016/S0031-9384(97)00198-4

Hsu, Y., & Serpell, J. A. (2003). Development and validation of a questionnaire for measuring behavior and temperament traits in pet dogs. Journal of the American Veterinary Medical Association, 223(9), 1293-1300. doi:10.2460/javma.2003.223.1293

Jakuba, T., Polcová, Z., Fedáková, D., Kottferová, J., Mareková, J., … &Ondrašovič, M.(2013). Differences in evaluation of a dog's temperament by individual members of the same household. Society & Animals, 21(6), 582-589.doi:10.1163/15685306-12341314

Jarrard, L. E. (1986). Selective hippocampal lesions and behavior. In The hippocampus (pp. 93-126). Springer US. doi:10.1007/978-1-4615-8024-9_4

Jones, A. C., & Gosling, S. D. (2005). Temperament and personality in dogs (Canis familiaris): A review and evaluation of past research. Appl. Anim. Behav. Sci., 95(1), 1-53.doi:10.1016/j.applanim.2005.04.008

Kleen, J. K., Sitomer, M. T., Killeen, P. R., & Conrad, C. D. (2006). Chronic stress impairs spatial memory and motivation for reward without disrupting motor ability and motivation to explore. Behav. Neurosci., 120(4), 842.doi:10.1037/0735-7044.120.4.842

MacPherson, K., & Roberts, W. A. (2010). Spatial memory in dogs (Canis familiaris) on a radial maze.J. Comp. Psychol.,124(1), 47.doi:10.1037/a0018084

Maier, N. R. (1949). Frustration, the study of behavior without a goal. Ann Arbor, MI: University of Michigan Press.

McCrae, R. R., Costa Jr, P. T., Ostendorf, F., Angleitner, A., Hřebíčková, M., ... &Saunders, P. R. (2000). Nature over nurture: temperament, personality, and life span development.J. Pers. Soc. Psychol., 78(1), 173-186. doi:10.1037//0022-3514.78.1.173

Nippak, P. M. D., Mendelson, J., Muggenburg, B., & Milgram, N. W. (2007). Enhanced spatial ability in aged dogs following dietary and behavioural enrichment. Neurobiol. Learn. Mem., 87(4), 610-623.doi:10.1016/j.nlm.2007.01.001

Postma, A., Jager, G., Kessels, R. P., Koppeschaar, H. P., & van Honk, J. (2004). Sex differences for selective forms of spatial memory. Brain Cogn., 54(1), 24-34. doi:10.1016/S0278-2626(03)00238-0

Roof, R. L., & Havens, M. D. (1992). Testosterone improves maze performance and induces development of a male hippocampus in females. Brain Res., 572(1), 310-313. doi:10.1016/0006-8993(92)90491-Q

Shettleworth, S.,& Sutton, J. (2005). Multiple systems for spatial learning: dead reckoning and beacon homing in rats. J. Exp. Psychol. Anim. Behav. Process,31(2), 125-141. doi:10.1037/0097-7403.31.2.125

Showalter, R., Bashaw, R., Solomon, R.,& Polewan, R. J. (2015, April). Spatial learning in domestic dogs: A pilot study on diverse testing trials. Poster presented at the meeting of Southwest Psychological Association, Wichita, KS.

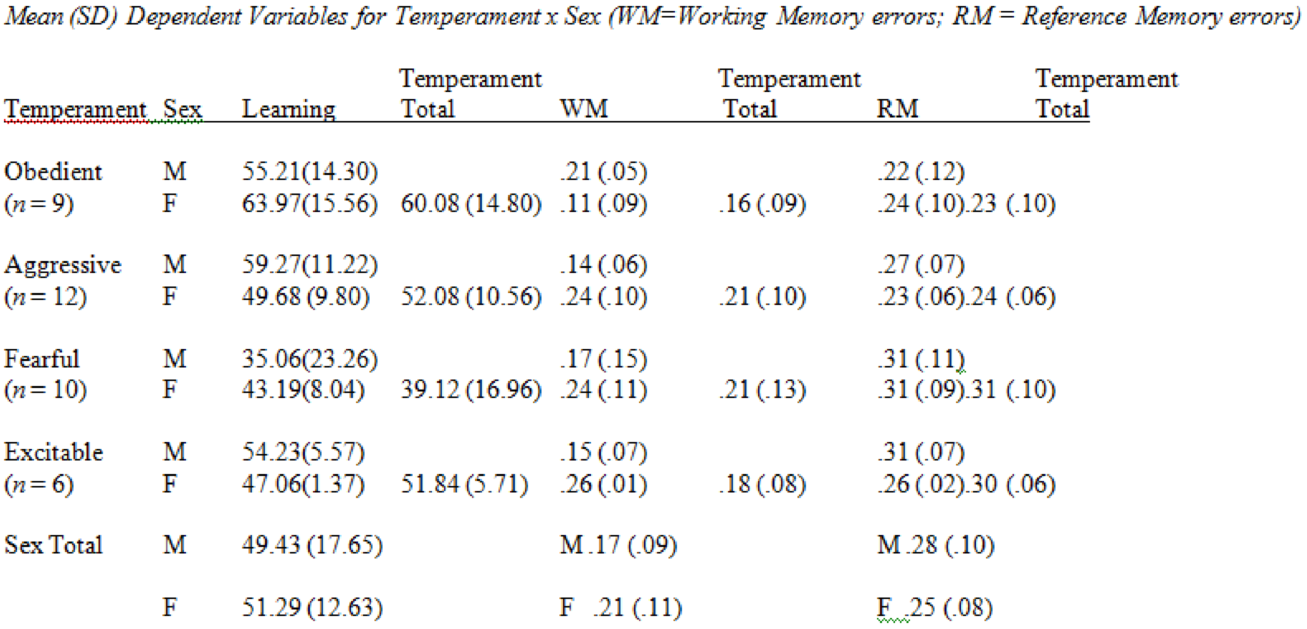
Svobodová, I., Vápeník, P., Pinc, L., & Bartoš, L. (2008). Testing German shepherd puppies to assess their chances of certification. Appl. Anim. Behav. Sci., 113139-149.doi:10.1016/j.applanim.2007.09.010

Tarragon, E., Lopez, L., Ros-Bernal, F., Yuste, J. E., Ortiz-Cullera, V.,... &Herrero, M. T. (2012). The Radial arm maze (RAM) for the evaluation of working and reference memory deficits in the diurnal rodent Octodon degus. Proceedings of Measuring Behavior(pp. 98-100). Utrecht, The Netherlands: International Conference on Methods and Techniques in Behavioral Research.

Timberlake, W., Sinning, S., & Leffel, J. (2007). Beacon training in a water maze can facilitate and compete with subsequent room cue learning in rats. J. Exp. Psychol., 33(3), 225-243.doi:10. 37/0017-7403.33.3.225

Tolman, E. C. (1948). Cognitive maps in rats and men. Psychol. Rev., 55(4), 189.

Wright, J. C., & Nesselrote, M. S. (1987). Classification of behavior problems in dogs: distributions of age, breed, sex and reproductive status. Appl. Anim. Behav. Sci., 19(1-2), 1-117. doi:10.1016/0168-1591(87)90213-9



Mean (SD) Dependent Variables for Temperament x Sex (WM=Working Memory errors; RM = Reference Memory errors)

Temperament	Sex	Learning	Temperament Total	WM	Temperament Total	RM	Temperament Total
Obedient	M	55.21(14.30)		.21 (.05)		.22 (.12)	
(*n* = 9)	F	63.97(15.56)	60.08 (14.80)	.11 (.09)	.16 (.09)	.24 (.10)	.23 (.10)
Aggressive	M	59.27(11.22)		.14 (.06)		.27 (.07)	
(*n* = 12)	F	49.68 (9.80)	52.08 (10.56)	.24 (.10)	.21 (.10)	.23 (.06)	.24 (.06)
Fearful	M	35.06(23.26)		.17 (.15)		.31 (.11)	
(*n* = 10)	F	43.19(8.04)	39.12 (16.96)	.24 (.11)	.21 (.13)	.31 (.09)	.31 (.10)
Excitable	M	54.23(5.57)		.15 (.07)		.31 (.07)	
(*n* = 6)	F	47.06(1.37)	51.84 (5.71)	.26 (.01)	.18 (.08)	.26 (.02)	.30 (.06)
Sex Total	M	49.43 (17.65)		M .17 (.09)		M .28 (.10)	
	F	51.29 (12.63)		F .21 (.11)		F .25 (.08)	