Investigation of Rudimentary Mathematics in Domestic Dogs: Can Dogs Add and Subtract?

Austin Roche, Christiana Fasola, Machael Mendoza, Steven M. Estrada, & Robert J. Polewan
Department of Psychology • Stephen F. Austin State University

Introduction

Numerical competency has been demonstrated in a variety of animals (e.g. Reznikova & Ryabko, 2011; Boysen, & Berntson, 1989). For example, West and Young (2002) demonstrated possible numerical competency in domestic dogs. Dogs' cognitive abilities (including computational ability) is of importance as humans continue to train dogs for more advanced cognitive tasks, such as rescue and therapy.

West and Young (2002) employed simple addition trials ("1+1=2," "1+1=1," and "1+1=3") to investigate dogs' numerical competency. Using the preferential looking technique first utilized by Wynn (1992), West and Young (2002) determined that dogs spent longer looking at the results of a trial with an unexpected result than a trial of an expected result, suggesting at the dogs have some level of numeracy.

However, West and Young (2002) employed only a between-groups analysis, the results of which may be skewed by individual differences between dogs. Also, the study did not investigate dogs' abililties to do subtraction computations. Thus, the current study presented each dog with six simple addition and subtraction trials ("1+1=2," "1+1=1," "1+1=3," "3-1=2," "3-1=1," and "3-1=3") to extend West and Young's (2002) findings.

Research Purposes

1. To extend West and Young's (2002) investigation of domestic dogs' numerical competency
2. To improve validity by using a within-groups design
3. To utilize both addition and subtraction trials to demonstrate enhanced numerical competency in dogs

Hypothesis

Dogs will spend more time looking at trials with unexpected results (i.e.: 3-1=1 and 1+1=3) than expected results (i.e.: 3-1=2 and 1+1=2).

Methods

Participants. A sample of 18 people volunteered their dogs for this study. Two dogs were excluded, one due to a technical error, and the other for inability to conform to the protocol. The final sample included 18 dogs from 8 months to 110 months in age (M=40, sd=29.19) with owner-reported temperaments (9 responsive, five nervous, and four independent).

Materials. A coroplast screen raised and lowered with pullies concealed the test area. The test area contained seven Styrofoam bowls placed 0.1m apart. Milkbone dog treats were placed on three bowls, and the remaining bowls concealed one bone each. A Panasonic video camera on a two-foot tripod recorded the dogs. Dogs received Pupperoni dog treats as reward.

Figure 1. View of test area with screen raised.

Procedure. For each trial a baseline time was recorded by raising the screen to reveal the test area that had either one (addition trials) or three (subtraction trials) bones present. The dog's gaze was measured until the dog looked away for more than two seconds. The screen was then lowered. The researcher then added or subtracted a bone to as the manipulation. Again the screen was raised and the dog's gaze was measured until it looked away for two seconds.

Trials. Each dog randomly received one of twelve orders of six trials:

- *3-1=1; less than expected.* The researcher removed one bone from behind the screen and hid a second in a pocket, showing only the first to the dog.
- *3-1=2; expected.* The researcher removed one bone and showed it to the dog.
- *3-1=3; more than expected.* The researcher pulled a bone from his or her pocket while behind the screen and showed it to the dog.
- *1+1=1; less than expected.* The researcher pretended to add a bone behind the screen, but hid it in a pocket.
- 3+1=2; expected. The researcher added one bone.
- *3-1=3; more than expected.* The researcher showed the dog adding one bone and also added a second hidden one.

Results

Inter-rater reliability. Three individual raters were instructed to view the videos (blind to the trial) and document the time each dog spent gazing at the test area. A gaze was defined as a look at the test area until the dog looked away for more than two seconds.

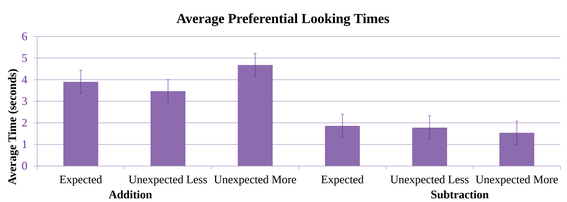
Figure 2. View of dog from camera.

Table 1
Preferential looking times in seconds averaged across raters

Presented	3-1=2		3-1=1		3-1=3	
Participant	Baseline	Trial	Baseline	Trial	Baseline	Trial
Dog 01	0.25	0.50	1.50	1.25	0.50	1.00
Dog 02	2.25	2.50	2.75	5.50	5.75	3.00
Dog 03	1.75	1.25	1.00	0.50	1.00	1.25
Dog 04	1.00	0.50	1.75	1.25	4.25	0.25
Dog 05	1.75	2.75	0.75	0.50	0.50	1.25
Dog 06	9.25	6.25	4.00	3.25	9.25	2.75
Dog 07	0.75	0.50	2.25	2.00	3.25	0.25
Dog 08	3.25	1.25	4.00	1.50	2.25	1.25
Dog 09	4.25	2.25	4.00	2.75	1.25	3.00
Dog 10	2.00	1.50	1.50	1.75	1.25	0.50
Dog 11	1.75	0.75	1.00	2.25	2.50	1.75
Dog 12	2.25	1.50	5.25	2.50	5.25	1.25
Dog 13	2.25	2.75	2.50	1.25	1.00	0.50
Dog 14	1.00	2.25	1.25	0.50	5.00	0.50
Dog 15	5.25	2.25	10.00	1.75	10.50	4.25
Dog 16	1.00	2.25	3.25	1.25	4.50	1.50
Dog 17	1.25	1.50	2.00	1.50	1.50	2.25
Dog 18	0.50	1.00	1.75	0.75	0.25	1.00
Means	**2.32**	**1.86**	**2.81**	**1.78**	**3.32**	**1.54**

Presented	1+1=2		1+1=1		1+1=3	
Participant	Baseline	Trial	Baseline	Trial	Baseline	Trial
Dog 01	1.50	1.00	1.50	2.50	1.00	1.50
Dog 02	3.50	15.25	24.50	13.75	3.25	37.50
Dog 03	1.00	1.75	3.25	1.50	1.50	1.75
Dog 04	2.00	2.50	2.25	1.75	2.00	1.75
Dog 05	1.50	1.00	0.50	0.75	0.75	1.00
Dog 06	2.25	5.00	3.50	5.75	10.25	9.75
Dog 07	2.50	2.75	4.75	1.75	1.75	0.25
Dog 08	8.50	7.75	2.25	6.25	4.00	10.00
Dog 09	3.25	5.00	5.25	5.75	2.50	3.75
Dog 10	1.50	3.00	1.25	1.50	1.50	1.75
Dog 11	0.75	1.25	2.25	1.50	1.00	2.00
Dog 12	2.25	5.25	4.25	3.00	3.50	1.25
Dog 13	1.75	2.75	1.25	1.50	1.50	1.75
Dog 14	1.25	5.00	0.50	1.75	0.50	1.50
Dog 15	2.00	2.25	2.25	1.75	1.50	3.00
Dog 16	4.25	4.50	2.25	8.00	3.00	4.00
Dog 17	0.25	3.90	0.50	0.25	1.00	1.50
Dog 18	0.75	0.25	0.00	3.47	1.75	0.25
Means	**2.26**	**3.90**	**3.46**	**3.47**	**2.35**	**4.68**

Figure 3
Preferential looking times in seconds averaged across raters



Conclusions

Results of the current study do not support numerical competency in dogs for both addition and subtraction. The participants did not spend a significantly longer amount of time looking at unexpected trials compared to expected trials. However, the dogs showed more gaze time on addition trials compared to subtraction trials. One possible explanation for this finding is that dogs were more likely to look at the different amounts of bones presents, with more bone shown in addition trials than subtraction and baseline trials. Another explanation is that during subtraction trials, the dogs observed the researcher taking bones away and placing them out of view (in the research's pocket). This observation might have caused the dogs to shift their focus to the researcher instead of the test area.

Limitations. One limitation was the variability of inter-rater reliability, suggesting that our mean estimates were not reliable.
Another limitation was that some dogs did not seem very interested in the stimuli used.
The technique for recording the dogs' gaze made it difficult at time to discern where the dog was looking.

Future directions. In the future, we plan to broaden the depth of our research by rating other reaction behaviors other than gazing time (e.g. facial and body reactions such as head-tilt. Also, more colorful stimuli, such as tennis balls, will be used to try and illicit more interest from the dogs.

References

Reznikova, Z., & Ryabko, B. (2011). Numerical competence in animals, with an insight from ants. *Behaviour, 148*(4), 405-434.
Boysen, S. T., & Berntson, G. G. (1989). Numerical competence in a chimpanzee (Pantroglodytes). *Journal of Comparative Psychology, 103*(1), 23.
West, R. E., & Young, R. J. (2002). Do domestic dogs show any evidence of being able to count?. *Animal Cognition, 5*, 183-186.
Wynn, K. 1992. Addition and subtraction by human infants. *Nature, 358, 749-750.*

Contact Information

For more information, visit the Behavioral & Cognitive Neuroscience Lab at: http://bcnlab.weebly.com/