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Temporal Bisection Task With Dogs: An Exploratory Study

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The temporal bisection task, one of the most widely used to study time perception, has helped to understand the psychophysics of time and the mechanisms of timing across different species. We extended the temporal bisection task to dogs. Five dogs were reinforced for choosing a yellow but not a blue stimulus after a 1-s tone, and for choosing a blue but not a yellow stimulus after a 4-s tone. After they learned this conditional discrimination, the dogs chose between the blue and yellow stimuli after tones with intermediate durations (1.4, 2.0, and 2.8 s). The results showed that the proportion of “Long” choices increased monotonically with stimulus duration. Moreover, the point of subjective equality was slightly below the geometric mean of the trained tone durations. These psychophysical results are consistent with those obtained with other nonhuman species, and suggest that common mechanisms underlie timing across different mammals and birds.

Keywords: point of subjective equality, psychometric function, temporal bisection task, timing, dogs

The canine ability to discriminate the time of day is well known. Dogs usually wait for their owners and seem to know the time when they typically come home. They also seem to anticipate the time to go for a walk or the time to eat. These examples probably depend on the dogs' circadian clock and their ability to associate the phase of the clock with a class of reinforcing events or activities. But dogs can learn also about arbitrary time intervals. Pavlov (1927/1960) reported an extraordinary ability in one of his dogs: Given a bit of food every 30 min, the dog learned to salivate about 30-s before the next food delivery. He also reported other instances in which interval timing was involved. However, no study has addressed the psychophysical properties of dogs' time perception, or how they learn to regulate their behavior according to stimulus durations.

Over the last decades, researchers have acquired a great deal of empirical knowledge about interval timing in animals—mostly rats and pigeons—and they have also built theories and mathematical models about the underlying processes. The experimental work relied on a variety of procedures of which the temporal

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bisection task is one of the most common. It has allowed researchers to explore the form of the function relating physical time to subjective time and its properties such as the point of subjective equality. In the present study, we used the bisection task to investigate the timing abilities of dogs.

In a temporal bisection task, the animal learns a conditional discrimination with different stimulus durations as samples and different (typically visual) stimuli as comparisons. To illustrate, a rat may learn to choose a left lever but not a right lever after a 1-s tone, and to choose the right lever but not the left lever after a 4-s tone. Similarly, a pigeon may learn to choose a red key over a green key after a 2-s light, and the green key over the red key after an 8-s light. After the animal learns the discrimination, the experimenter introduces test trials with intermediate sample durations and records the proportion of choices of one alternative, say, the one associated with the Long duration. The proportion of choices of the "Long" alternative after a t-s sample, abbreviated P ("Long" | t), is the psychometric function. Several studies (e.g., Church & Deluty, 1977; Gibbon, 1981; Meck, 1983; Raslear, 1983; Richelle & Lejeune, 1980; Siegel, 1986; Siegel & Church, 1984; Stubbs, 1968; see Castro, Andreia, & Machado, 2013 for a review) show that the psychometric function resembles an increasing ogive, with subjects rarely choosing "Long" after the shortest sample and often choosing "Long" after the longest sample. Moreover, the sample duration associated with indifference between the alternatives (i.e., the t for which P("Long" | t) = 0.5), known as the Point of Subjective Equality or PSE, tends to be close to the geometric mean of the two trained samples. If S and L represent the Short (S) and Long (L) training samples, the geometric mean equals $\sqrt{(S \times L)}$.

During the 1990s, Wearden (1992) and Wearden and Ferrara (1995) extended the temporal bisection task to humans. Their research showed that the human psychometric function also is ogival but its PSE seems to be closer to the arithmetic than the geometric mean of the trained samples, particularly when the ratio L/S is large.

In the present study we adjusted the temporal bisection task so that it could be used with dogs in a seminaturalistic setting outside the laboratory. We faced two main challenges, to design a task that would motivate the dogs to learn the temporal discrimination and to avoid any sort of Clever Hans effect (Hediger, 1981). To meet the first challenge the experiment was conducted by two people who provided not only food but also social reinforcers. The second challenge was met by preventing the person running the experiment from knowing the current sample duration, hence the correct comparison, until the dog responded. With the methodological challenges met, the theoretical aim of the study was to investigate the psychometric function of dogs in the temporal bisection task and compare it with the psychometric function of other animal species.

Method

Animals

Five pet dogs (*Canis familiaris*) participated in the experiment, two females (Nina and Rockita) and three males (Zico, Dub and Bóris). Two were Labradors (Nina and Zico) and three had no defined breed. Their ages (in Rockita's case estimated) ranged from 1 to 4 years. They had been previously trained on basic obedience skills. Nina and Zico lived together with their owners. The other dogs lived in three different apartments in the same building as the first author. All dogs were acquainted with the experimenters; they had not participated in any other study.

Setting and Materials

The materials included a table, a notebook computer equipped with a wireless mouse and Microsoft Powerpoint software, a set of headphones, a video camera attached to a tripod, two colored boxes, a bag with dog biscuits, and a clicker. When the experimenter, wearing the headphones, clicked the wireless mouse, the notebook emitted a tone. The dog then approached and touched one of the colored boxes. The experimenter then clicked the mouse to display in the notebook the correct choice. If the dog made the correct choice, the experimenter pressed the clicker, petted the dog, and gave it a biscuit.

The samples were tones produced by the notebook using its internal speaker. They had the same frequency (1000 Hz) and intensity (60

db) but varied in duration. The two trained tones were 1-s and 4-s long; the three test tones were 1.4-, 2.0-, and 2.8-s long. The five durations form a geometric progression, and the 2.0-s duration equals the geometric mean of the trained durations.

The two colored boxes, one Yellow and the other Blue, served as comparison stimuli. The dogs' dichromatic color vision allows the discrimination between these colors (Neitz, Geist, & Jabobs, 1989; Range, Aust, Steurer, & Huber, 2008). The boxes were 40 cm long, 30 cm wide, and 12 cm high. Both were covered with plastic to protect them from wear and tear and to facilitate cleaning. The reinforcers were dog biscuits and petting.

Sessions took place separately for each dog, 5 days a week, at approximately the same time for each dog. For Nina and Zico the sessions initially occurred in a large, empty room, in their owner's apartment. For the other three dogs the sessions always occurred in a room at the first author's apartment. Figure 1 shows the room layout. Both were approximately 5 m long by 3 m wide. The two comparison stimuli were placed on the floor, at the back of the room, approximately 1 m apart. On the opposite end of the room, approximately 3 m from the comparisons, the table with the notebook on top was placed on the left side, and the 1-m high tripod with the video camera mounted on it was placed on the right side. The video camera was set at an angle that captured the Start location and the comparison boxes.

The two experimenters ran each dog's sessions on alternate days. Throughout the test sessions and approximately in 30% of the trained sessions, the experimenter wore headphones to prevent her from hearing the sample tone. The experimenter interacted with the notebook via wireless mouse. Each mouse click advanced a Powerpoint presentation, played the sample tone at trial onset, and informed the experimenter of the correct alternative after the dog had made its choice.

Procedures

The dogs learned the task by successive approximations. In the end, a training trial proceeded as follows. The experimenter and the dog stood side by side at the Start location, approximately 3 m away from the comparison stimuli and equidistant from them (see Figure 1). The experimenter then clicked the wireless mouse which instructed the notebook to turn on

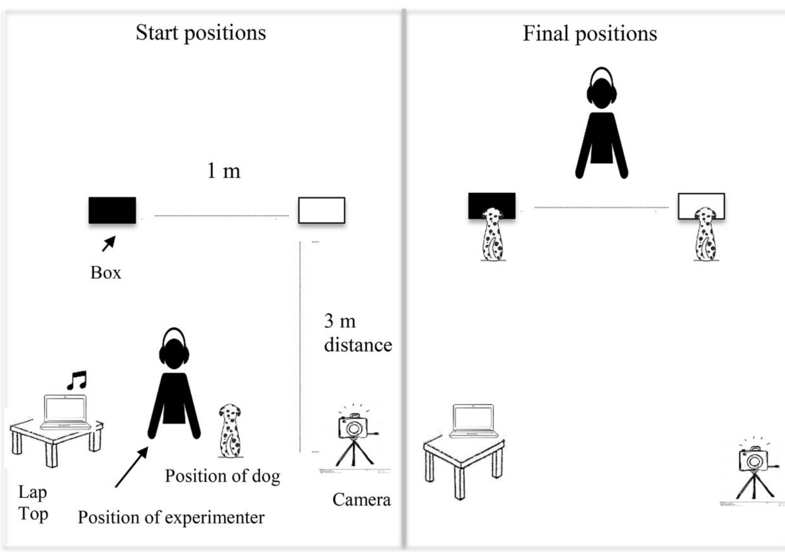

Figure 1. Setup of the experimental room. At the beginning of each trial, experimenter and dog stood side by side at the Start location. A click with the wireless mouse instructed the computer to present the sample tone. The experimenter counted silently from 1 to 5 and then walked toward the boxes. The dog had learned to approach and touch one of the boxes.

the sample tone. Meanwhile, the experimenter counted covertly and slowly from 1 to 5, which lasted approximately 5 seconds and was always longer than the sample. Afterward the experimenter walked along a straight line toward the comparison stimuli and stopped when she was between them. Concurrently, the dog walked toward one of the two comparison boxes and touched it with its nose or paw, the operant response. After the dog responded, the experimenter clicked the mouse again to find out in the notebook screen which response was correct on the trial. If the dog had made the correct choice, the experimenter would then press the clicker, pet the dog, and give it a biscuit. Then, the experimenter placed the boxes for the next trial, walked toward the Start position, and began the next trial.

The experiment comprised four phases, pretraining, baseline training, partial reinforcement training, and stimulus generalization testing.

Phase 1. The main goal of this phase was to train the dogs to touch the comparison stimuli. The experimenter did not wear the headphones. During the first two sessions the experimenter did not change the location of the two comparisons. In the first session, only the Short tone was presented for 12 trials. After the tone, the experimenter walked toward the boxes, turned to the correct box, touched it, and pointed at it while encouraging the dog verbally to approach and touch the box. The top of the box was also occasionally baited with bits of biscuit to prompt the touch response. The second session was similar except that only the Long tone was presented and only responses to the other comparison box were reinforced.

During the next 2 sessions, response shaping continued, the number of trials increased to 24, but the prompts were used only during the first 6 trials. As before, only one tone duration was presented in each session.

In the fifth session, both samples were presented across trials. The Short tone was presented on the first 12 trials, the first 6 with prompts, and the Long tone was presented on the last 12 trials, the first 6 also with prompts. In the next two sessions, the Short and Long tones alternated every 6 trials, for a total of 24 trials, with the prompts used only on the first trial of each block of 6.

At this point in training, the dogs had learned the response and had started to learn the discrimination. Hence, all subsequent sessions comprised 24 trials, 12 with each sample, presented in random order, and without any prompts. Training continued until the dog showed at least 10 correct responses following each sample for three consecutive sessions (that is 83.3% of correct responses).

Phase 2. The next goal was to teach the temporal discrimination with the position of the comparison boxes randomized across trials. Sessions comprised 24 trials, 12 Short and 12 Long; in each set, 6 trials had the blue box on the left and the yellow on the right, and the other 6 trials had the alternate configuration. Trials were fully randomized and no prompt was used. Training continued until the dogs reached the same learning criterion adopted in Phase 1.

Phase 3. The main goal of this phase was to introduce extinction trials and thereby prepare the dog for the test phase. The experimenter started to use the headphones during some of the sessions. Each session comprised 30 trials, 12 reinforced trials plus 18 extinction trials. The learning criterion remained at 3 consecutive sessions with at least 80% of correct responses following each sample.

Phase 4. The goal was to conduct the temporal generalization tests. Throughout this phase and for all dogs, the experimenter always used the headphones. The test sessions comprised 30 trials in random order, 12 training trials (6 Short and 6 Long), and 18 test trials (6 with the 1.41-s tone, 6 with the 2.0-s tone, the geometric mean of 1 s and 4 s, and 6 with the 2.82-s tone). Responses following the Short and Long tones were reinforced if correct; responses on the test trials were never reinforced. In each set of 6 trials with the same tone, 3 trials had the blue box on the left and 3 had the yellow box on the left.

To maintain the basic discrimination, the test sessions alternated with training sessions. The latter were exactly equal to the sessions of Phase 3. A total of 4 test sessions were run.

After each session, the experimenter watched the video recording and categorized each response to each sample as correct or incorrect. The response consisted of touching one of the boxes with nose or paw. A second observer watched 30% of the test sessions and the agreement rate reached 90%. The 10% disagreement occurred in the training samples and they concerned whether a dog's touch of the box was intentional or accidental (i.e., a part of its motion). Hence, on these trials

a dog may have received a reward when no reward should have been given or vice versa. However, the relatively small number of such disagreements did not seem to question the method of data analysis or its interpretation.

Results

The dogs needed 34 sessions on average to learn the basic discrimination. During the last 5 sessions of the baseline and partial reinforcement phases that preceded the tests, the average proportion of correct responses was consistently above 0.8.

Generalization Tests

Figure 2 shows the individual psychometric functions obtained during the test sessions. The bottom right panel shows the average. The vertical bars on the individual functions represent the exact 95% confidence intervals for the binomial proportion[1]; the vertical bars on the average function represent the 95% confidence intervals based on the *t*-distribution.

The individual panels show that, in most cases, the proportion of Long choices increased monotonically with the sample duration. For Rockita the function changed abruptly, in step-like manner, but for the other dogs the function changed more gradually.

To determine whether the individual functions reveal significant biases for one comparison (visually, whether the functions shifted up or down), we contrasted the proportions of Long and Short responses averaged across samples. Three dogs, Zico, Dub, and Bóris, were biased toward the Long comparison (for all three, $p < .05$ based on normal approximation to binomial distribution); Nina was biased toward Short ($p < .05$), and Rockita showed no significant bias. Visually, the function shifted up for three dogs, down for one, and it did not shift for another dog. The two end points revealed no consistent tendency for the dogs to perform better at the Short or Long samples (proportion correct averaged 0.86 for the Short and 0.85 for the Long samples).

Because the psychometric functions were smooth, we obtained the PSE by linear interpolation using the two data points that straddled 0.5. The obtained PSEs were below the geometric mean of 2.0 s for four dogs, but above it for one, Nina. The 95% confidence interval for the PSE based on the *t*-distribution ranged from 1.41 to 2.23 s, an interval that includes both the harmonic and geometric means of the trained durations (1.6 and 2.0 s, respectively), but excludes the arithmetic mean (2.5s).

The average curve revealed the characteristic ogival shape. The curve was symmetric at the end points revealing equal accuracy following Short and Long samples. Its PSE (1.7 s) was slightly below the average of the individual PSEs (1.8 s) and the geometric mean of the training stimuli; its height denoted a slight bias for the Long comparison.

Discussion

In the last 15 years, students of animal cognition have become more interested in dogs, perhaps because dogs have lived in close contact with humans for a long domestication period (e.g., Budyansky, 2000), and evolved sophisticated abilities to respond to human cues (Udell & Wynne, 2008). Several studies have assessed the abilities of dogs to use arbitrary signals in communication (Rossi & Ades, 2008) or to learn by imitation (cf., Heberlein & Turner, 2009; Topál, Byrne, Miklósi, & Csányi, 2006), and whether they have object permanence (Fiset & LeBlanc, 2007; Miller, Rayburn-Reeves, & Zentall, 2009), show responding by exclusion (Aust, Range, Steurer, & Huber, 2008, Kaminski, Call, & Fischer, 2004), or have some form of metacognition (McMahon, Macpherson, & Roberts, 2010). In the present study, we investigated the performance of dogs in a temporal bisection task.

[1] An exact 95% confidence interval for a binomial proportion is found as follows. Suppose that on the $N = 24$ trials with a given duration, the subject chose "Long" on 10 of them. Our point estimate of the probability of choosing "Long," π, would be 10/24 or approximately 0.417. To find the upper limit of the interval, we search for the highest value of π that predicts (according to the Binomial distribution) 10 or fewer choices of "Long" with probability 0.025. That value is approximately 0.634. Similarly, to find the lower limit of the interval, we search for the lowest value of π that predicts 10 or more choices of "Long" with probability 0.025. The result is approximately 0.221. Hence, the 95% confidence interval for π is [0.221, 0.634]. This interval is not symmetric around the observed value of 0.417, and it is not based on the normal approximation to the binomial distribution (see, e.g., Smithson, 2003).

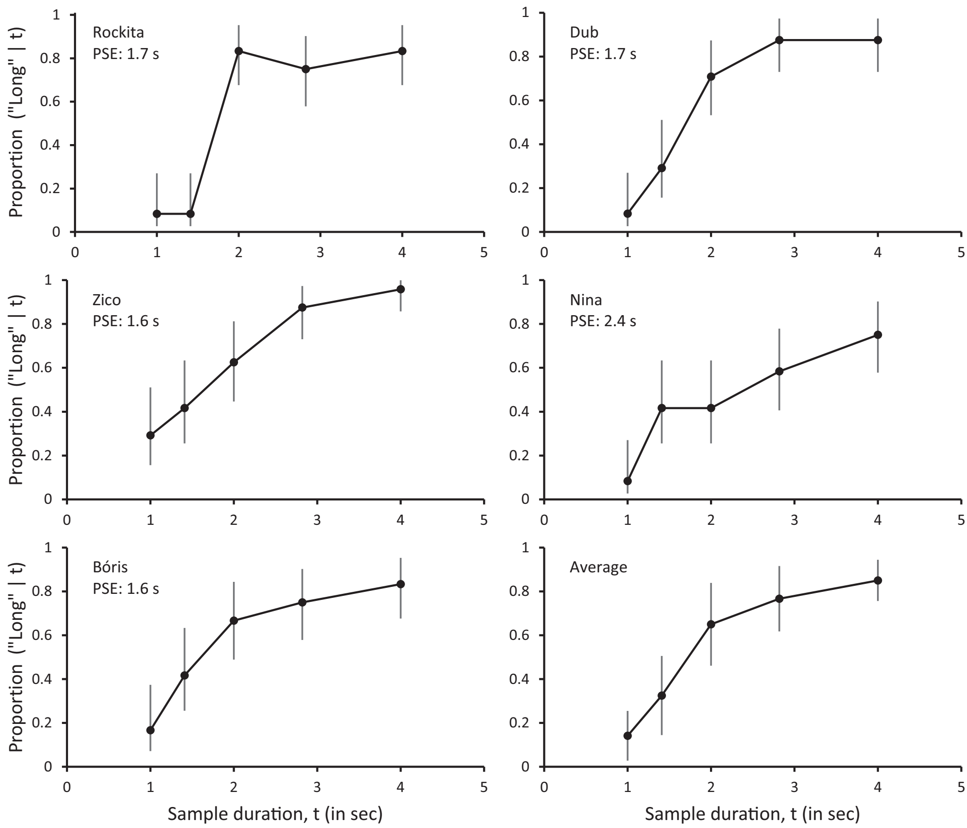

Figure 2. Individual and average psychometric functions. The individual functions plot the proportion of "Long" choices against sample duration. The bars show the (exact) 95% confidence intervals for the probability of choosing "Long." The bottom right panel shows the average psychometric function with 95% confidence intervals based on the *t*-distribution.

The study implemented a matching-to-sample procedure in a seminaturalistic environment, and, through a variety of techniques of shaping, prompting, and fading, trained the dogs to touch one of two separated colored boxes according to the duration of a previous tone. Although the general procedure was similar to other studies with dogs (e.g., McMahon et al., 2010; Zaine, Domeniconi, & Costa, 2014), we stress three features that seem important to successful training and valid data interpretation. First, the choice response was simple, close to the natural repertoire of dogs, and easy to detect by the experimenter. The nose touch response allowed the experimenter to concentrate her efforts mostly on stimulus control issues after the first few sessions. Second, taking into account the dog's sensitivity to human cues, intentional or otherwise, "blinding" the experimenter to the sample duration—and therefore to the correct response—during the test trials is critical to avoid a "Clever Hans" effect. And third, videotaping the trials frees the experimenter from having to record the dog's choices during the trials and permits her to reinforce correct behavior promptly. Variations of this procedure may prove useful to study other issues related to canine behavior and cognition.

The study's ultimate goal was to obtain reliable psychometric functions from dogs and compare them with the functions obtained from other species. All dogs learned the task and showed relatively accurate discrimination (slightly above 80%) at the end of training. The psychometric functions obtained during testing showed that proportion Long increased with

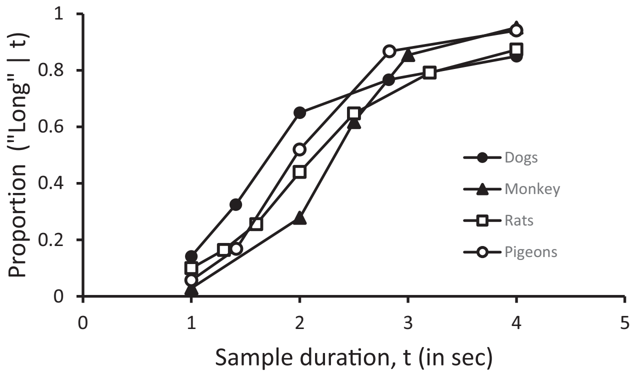

Figure 3. The curves show the psychometric functions obtained in four studies with different species: monkeys (Catania, 1970), rats (Church & Deluty, 1977), pigeons (Machado & Keen, 1999), and dogs (present study).

stimulus duration, followed the typical ogival shape with a slight bias toward the Long comparison, and crossed indifference (PSE) on average close to but slightly below the geometric mean of the trained stimuli.

To compare the dog's average function with the function obtained with other species, Figure 3 shows the data from four studies. They all used the same matching-to-sample task with 1-s and 4-s samples and two comparisons. The filled circles are from the present study. The filled triangles are from theCatania (1970) study with one squirrel monkey, using tones as samples and two levers as comparisons. The open squares are from Church and Deluty's (1977) seminal study with rats ($N = 8$), using dark periods as samples, and two levers as comparisons. The open circles are from the Machado and Keen (1999) study with pigeons ($N = 8$) using a white keylight as samples and red and green keys as comparisons.

The two sets of functions (dog vs. other animals) are similar in their roughly ogival shape. The PSE's vary considerably across species, but they remain consistent with the geometric mean of the training samples. The functions differ in overall accuracy at the trained samples and overall bias. The dogs showed lower accuracy following the two trained samples than the other animals. This difference is not surprising because the laboratory settings of the other three studies provide greater control over the subject's motivation and the training and testing environment than the seminatural setting of the present study. The amount of training was also significantly shorter in the present study. In addition, the dogs showed a somewhat stronger bias for the Long comparison, which is most noticeable at the 2-s sample. This result suggests that the threshold to respond "Long" (the PSE) may have been shorter for most dogs than the other animals (cf., the shift of some psychometric functions in Figure 2). Future studies with larger samples, other duration ranges, and more training trials should investigate the nature of these apparent differences.

In the meantime we conclude that dogs are suitable subjects to study time perception, and that their psychometric function in the bisection task is similar to the function produced by other species. This similarity is clearly consistent with common mechanisms of interval timing (e.g., SET, LeT), but it remains to be seen whether different tasks (e.g., waiting for different periods of time) unravel differences among dog breeds or differences between dogs and other species.

References

Aust, U., Range, F., Steurer, M., & Huber, L. (2008). Inferential reasoning by exclusion in pigeons, dogs, and humans. *Animal Cognition, 11,* 587–597. http://dx.doi.org/10.1007/s10071-008-0149-0

Budyansky, S. (2000). *The covenant of the wild: Why animals chose domestication*. New Haven, CT: Yale University Press.

Castro, A. C. V., Andreia, M. P. D., & Machado, K.-C. A. (2013). A percepção do tempo: Contributos do procedimento de bissecção [Time perception: Contributions of the bisection procedure].

Temas em Psicologia, 21, 49–70. http://dx.doi.org/10.9788/TP2013.1-04

Catania, A. C. (1970). Reinforcement schedules and the psychophysical judgments: A study of some temporal properties of behavior. In W. N. Schoenfeld (Ed.), *The theory of reinforcement schedules* (pp. 1–42). New York, NY: Appleton-Century–Crofts.

Church, R. M., & Deluty, M. Z. (1977). Bisection of temporal intervals. *Journal of Experimental Psychology: Animal Behavior Processes, 3,* 216–228. http://dx.doi.org/10.1037/0097-7403.3.3.216

Fiset, S., & Leblanc, V. (2007). Invisible displacement understanding in domestic dogs (*Canis familiaris*): The role of visual cues in search behavior. *Animal Cognition, 10,* 211–224. http://dx.doi.org/10.1007/s10071-006-0060-5

Gibbon, J. (1981). On the form and location of the psychometric bisection function for time. *Journal of Mathematical Psychology, 24,* 58–87. http://dx.doi.org/10.1016/0022-2496(81)90035-3

Heberlein, M., & Turner, D. C. (2009). Dogs, canis familiaris, find hidden food by observing and interacting with a conspecific. *Animal Behaviour, 78,* 385–391. http://dx.doi.org/10.1016/j.anbehav.2009.05.012

Hediger, H. K. P. (1981). The Clever Hans phenomenon from an animal psychologist's point of view. *Annals of the New York Academy of Sciences, 364,* 1–17. http://dx.doi.org/10.1111/j.1749-6632.1981.tb34459.x

Kaminski, J., Call, J., & Fischer, J. (2004). Word learning in a domestic dog: Evidence for "fast mapping." *Science, 304,* 1682–1683. http://dx.doi.org/10.1126/science.1097859

Machado, A., & Keen, R. (1999). Learning to Time (LET) or Scalar Expectancy Theory (SET)? A critical test of two models of timing. *Psychological Science, 10,* 285–290. http://dx.doi.org/10.1111/1467-9280.00152

McMahon, S., Macpherson, K., & Roberts, W. A. (2010). Dogs choose a human informant: Metacognition in canines. *Behavioural Processes, 85,* 293–298. http://dx.doi.org/10.1016/j.beproc.2010.07.014

Meck, W. H. (1983). Selective adjustment of the speed of internal clock and memory processes. *Journal of Experimental Psychology: Animal Behavior Processes, 9,* 171–201. http://dx.doi.org/10.1037/0097-7403.9.2.171

Miller, H. C., Rayburn-Reeves, R., & Zentall, T. R. (2009). What do dogs know about hidden objects? *Behavioural Processes, 81,* 439–446. http://dx.doi.org/10.1016/j.beproc.2009.03.018

Neitz, J., Geist, T., & Jacobs, G. H. (1989). Color vision in the dog. *Visual Neuroscience, 3,* 119–125. http://dx.doi.org/10.1017/S0952523800004430

Pavlov, I. P. (1960). *Conditioned reflexes: An investigation of the physiological activity of the cerebral cortex* (N. York, Trans.). New York, NY: Dover. (Original work published 1927)

Richelle, M., & Lejeune, H. (1980). *Time in Animal Behavior*. Oxford, UK: Pergamon Press.

Range, F., Aust, U., Steurer, M., & Huber, L. (2008). Visual categorization of natural stimuli by domestic dogs. *Animal Cognition, 11,* 339–347.

Raslear, T. G. (1983). A test of the Pfanzagl bisection model in rats. *Journal of Experimental Psychology: Animal Behavior Processes, 9,* 49–62. http://dx.doi.org/10.1037/0097-7403.9.1.49

Rossi, A. P., & Ades, C. (2008). A dog at the keyboard: Using arbitrary signs to communicate requests. *Animal Cognition, 11,* 329–338. http://dx.doi.org/10.1007/s10071-007-0122-3

Siegel, S. F. (1986). A test of the similarity rule model of temporal bisection. *Learning and Motivation, 17,* 59–75. http://dx.doi.org/10.1016/0023-9690(86)90020-2

Siegel, S. F., & Church, R. M. (1984). The decision rule in temporal bisection. *Annals of the New York Academy of Sciences, 423,* 643–645.

Smithson, M. (2003). *Confidence intervals*. London, England: Sage. http://dx.doi.org/10.4135/9781412983761

Stubbs, A. (1968). The discrimination of stimulus duration by pigeons. *Journal of the Experimental Analysis of Behavior, 11,* 223–238. http://dx.doi.org/10.1901/jeab.1968.11-223

Topál, J., Byrne, R. W., Miklósi, A., & Csányi, V. (2006). Reproducing human actions and action sequences: "Do as I Do!" in a dog. *Animal Cognition, 9,* 355–367. http://dx.doi.org/10.1007/s10071-006-0051-6

Udell, M. A. R., & Wynne, C. D. L. (2008). A review of domestic dogs' (*Canis familiaris*) human-like behaviors: Or why behavior analysts should stop worrying and love their dogs. *Journal of the Experimental Analysis of Behavior, 89,* 247–261. http://dx.doi.org/10.1901/jeab.2008.89-247

Wearden, J. H. (1992). Temporal generalization in humans. *Journal of Experimental Psychology: Animal Behavior Processes, 18,* 134–144. http://dx.doi.org/10.1037/0097-7403.18.2.134

Wearden, J. H., & Ferrara, A. (1995). Stimulus spacing effects in temporal bisection by humans. *The Quarterly Journal of Experimental Psychology Section B: Comparative and Physiological Psychology, 48,* 289–310.

Zaine, I., Domeniconi, C., & Costa, A. R. A. (2014). Exclusion performance in visual simple discrimination in dogs (*Canis familiaris*). *Psychology & Neuroscience, 7,* 199–206. http://dx.doi.org/10.3922/j.psns.2014.014

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