



Examining shaping of two odor detection dogs

Stephanie Elizabeth Gabrielle Bye, Susan Hazel, Jade Fountain, Eduardo J. Fernandez *

School of Animal and Veterinary Sciences, University of Adelaide, Adelaide, South Australia, Australia

ARTICLE INFO

Article history:

Received 30 July 2023

Received in revised form 8 February 2024

Accepted 20 February 2024

Available online 27 February 2024

Keywords:

Animal
Training
Detection
Scent
Shaping
Dogs

ABSTRACT

The use of odor detection dogs provide many benefits to society. However, little has been done to empirically examine the learning procedure methodology used to train detection dogs. This study aimed to create a quantifiable shaping plan allowing the measurement of initial odor learning for detection dog training. The training progress of two dogs was measured with session-to-session data throughout the learning process, as well as before and after the addition of training rules, in which progression is based on quantified performance during the shaping plan. After the addition of training rules, successful completion of trials became more likely to occur. This study demonstrates that measurement of odor detection training can facilitate odor detection training plans, as well as improve the probability of training success.

© 2024 The Author(s). Published by Elsevier Inc. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

Examining Shaping of Two Odor Detection Dogs

Odor detection work has proven to be an important endeavor within the dog training industry. There currently exists no human technology with chemical detection capabilities equal to the olfactory acuity of the dog (Concha et al., 2019). Some examples include the training of detection dogs to detect cancers, to detect various kinds of explosives, and to locate wildlife for conservation purposes (McCulloch et al., 2006; Lazarowski and Dorman, 2014; Grimm-Seyfarth et al., 2021; Ehmann et al., 2012; Gazit et al., 2005; Hayes et al., 2018). Despite these benefits, there is little direct research documenting the training process of detection dogs. Instead, detection dog research is typically focused on end results such as successful detections, rather than the training process (Lazarowski et al., 2020; Hall et al., 2021). In addition, while there is no published data specific to the attrition rate of scent work dogs, other researchers have reported between 50% and 80% of working dogs not finishing their training (Bray et al., 2021; Cobb et al., 2021). Therefore, greater empirical evaluation of the training process for working dogs is clearly needed.

Shaping, originally termed by Skinner (1951), has been described as differential reinforcement of successive approximations to a target response (Cooper et al., 2020). Shaping is used to some degree in most animal training protocols and has been used to produce behaviors beneficial to the health and welfare of working animals (Fernandez

and Rosales-Ruiz, 2021). However, despite its importance, shaping is often seen as more an art rather than a science and difficult to quantitatively measure. Only a few studies have attempted to empirically evaluate shaping procedures (Osborne and Himadi, 1990; Galbicka, 1994; Ferguson and Rosales-Ruiz, 2001; Slater and Dymond, 2011; Ghaemmaghami et al., 2018; Fernandez, 2020; Fernandez and Dorey, 2020; Fernandez and Rosales-Ruiz, 2021; Midgley et al., 1989).

The following study examined the shaping process for training several dogs to engage in odor detection work. Specifically, we looked at changes in successful scent detection shaping step completions before and after the addition of training rules to quantify their training performance, and to allow progression based on meeting these criteria. Two dogs and their session-to-session data are shown, along with the success rate during parts of their training protocols.

Methods

Subjects

Four volunteers and their five dogs were recruited. Two dogs, Bronte and Zuri, are the focus of this manuscript. Bronte was a greyhound mixed breed and Zuri a Rhodesian Ridgeback, and at the time of recruitment they were aged 1 year and two and a half years old, respectively. Zuri had dog show training and both dogs had basic skills training (e.g., sit, stay, walk on leash) prior to their participation in this study. Each dog was under guardianship of a respective volunteer, who was responsible for their training between sessions.

* Address for reprint requests and correspondence: Eduardo J. Fernandez, School of Animal and Veterinary Sciences, University of Adelaide, Adelaide, SA 5005, Australia.
E-mail address: eduardo.fernandez@adelaide.edu.au (E.J. Fernandez).

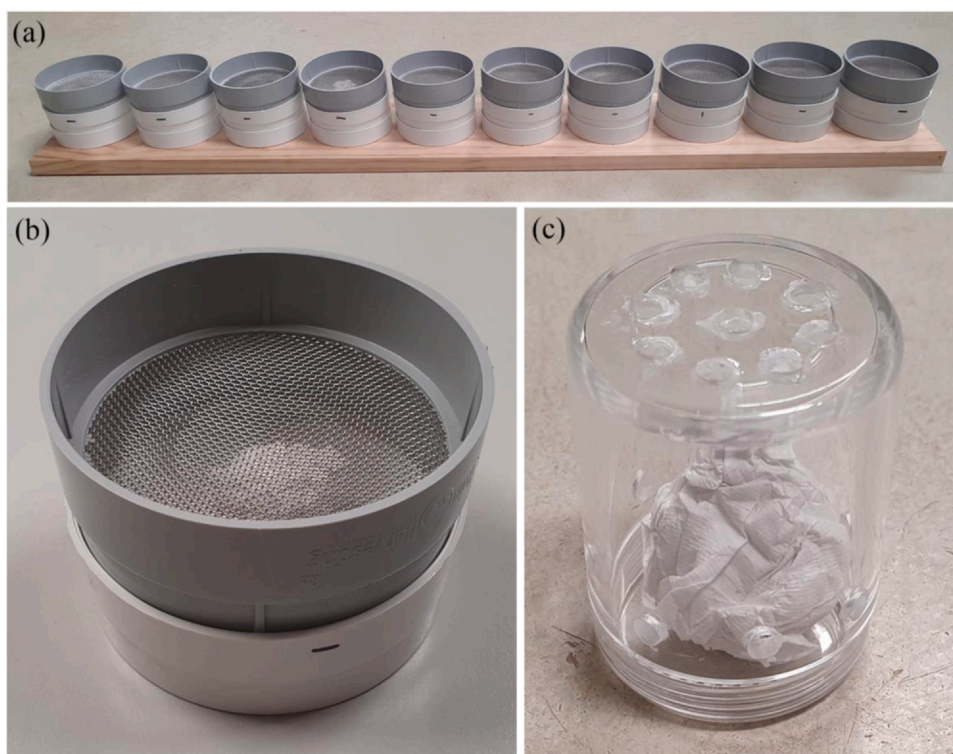


Figure 1. The scent training apparatuses. (a) The complete scent board with pots (minimum 1 cm spacing). Horizontal lines denote control pots and the vertical line denotes the target pot. (b) A scent pot (control). (c) A scent jar for free searching. Each jar was marked with an X or an O at the bottom (not visible) to denote target or controls, respectively.

Materials

The scent board and scent pots were made to the specifications of Rutter et al. (2021; see Figure 1). The scent board measured 100 cm × 14 cm, with scent pots on the board measuring 5 cm × 9 cm. The target odor was Kong™ cut into approximately 1 cm × 1 cm pieces and wrapped in paper towel to prevent visual discrimination. Wrapped paper towels without Kong were also used as controls. Scent jars, as opposed to scent pots, were used during room searching due to being inconspicuous and to prevent dogs having direct access to the Kong™ which was considered a choking hazard. Scent jars consisted of clear, screw top cylindrical jars measuring 5 cm × 3.8 cm. Jars were placed faced down (cylinder down; see Figure 1c) with holes drilled in the base and sides for airflow. Volunteers brought their own food rewards.

Procedure

Bronte and Zuri were brought onto the University of Adelaide, Roseworthy Campus by their respective volunteers once weekly for hour long training sessions. Training took place off lead in a well-lit 8 m × 8 m room and only one dog was ever present for training. During training sessions, the present dog was trained by both the first author and the respective volunteer. The first author also recorded data and used the same procedures to instruct volunteers on training methodology to continue the training with the dogs in the home setting. Dogs were prevented from watching the set-up of trials.

The odor detection method was similar to Rutter et al. (2021), and the shaping plan was developed based on the method of Rutter et al. (2021) (see Table). However, Kong™ was used as opposed to Myrrh oil due to greater ease of handling, storage and transport, and reduced concerns of odor contamination. The Kong™ was wrapped in paper towel and presented alongside controls that consisted of wrapped paper towel, or empty scent containers,

numbering four and five of each respective control when used with 10 scent containers.

Shaping—changing criterion design

For the shaping plan, two periods of time were compared. Prior to the implementation of a systematic training rule (pre-TR) and following the implementation of the training rule (post-TR). The training rule specified that shaping steps must occur in numerical succession. In addition, for progression to the next shaping step, two consecutive sessions with at least four out of five (80%) trials successfully completed had to occur. Finally, the training would return to the previous shaping step if either one session had no or only one trial (0% or 20%) successfully completed, or two consecutive sessions had only two or three trials (40% or 60%) successfully completed. Training occurred in sessions of five single and consecutive trials, that is, attempts to perform the behavior required to meet the criteria for the current step of training, with approximately 2 minutes rest between sessions. A trial terminated when the dog had given a successful or unsuccessful attempt, after the amount of time specified for a given step had elapsed (specified in Table), or if the dog performed a trial terminating behavior.

Prior to the implementation of the training rules, progression of the dogs was based on anecdotal assessment of training progress for any given day (i.e., shaping as an “art”), rather than adherence to the systematic training rule. Sessions varied with between one and seven trials per session prior to implementation of the training rule.

Only positive reinforcement (i.e., no aversive stimuli, physical corrections, or force) was used during training. Dogs were marked immediately upon giving correct responses via a verbal bridging stimulus “good” given by a handler who then reinforced the response with a food reward. Reinforcement was contingent on completing the current criteria and was given for every successful

Table

The odor detection shaping plan based on the method of Rutter et al. (2021), showing the step number, the name of the behavior approximation, and a description of the success criteria for the desired behavior for that step.

Steps	Approximation	Description
Steps 1–4	Introduction of scent containers (scent identification pairing)	Introduction of the scent containers (pots) and the target odor, occurring at first in the hand (step 1) and then on the ground (step 2) and with two controls added (steps 3–4). No scent board is present.
Steps 5–8	Scent board introduction and alert shaping	The scent board is introduced, and the scent containers (pots) are moved onto the scent board (step 5). Following this step, an additional control is added (step 6). The dog is then trained to display an alert behavior upon sniffing the target odor, on cue (step 7) and off cue (step 8).
Steps 9–14	Training on the scent board	Controls are added singly to the scent board until the dog is working on a complete scent board; from four to nine controls (steps 9–14). Pots were spaced at least 1 cm from each other. Time limit: 60 s
Steps 15–18	Conditioning to free search	The dog is conditioned to search for scent jars rather than scent pots (see Methods for a description of both). The target container is now a scent jar on the board, rather than a scent pot (step 15), four control pots are substituted with control jars (step 16), then followed by the remaining five control pots replaced with scent jars (step 17). All the scent jars are then placed immediately beside the scent board rather than on it (step 18). Time limit: 60 s
Steps 19–24	Developing free search skills	The dog is conditioned to searching away from, and then without the presence of the scent board. The scent jars are placed within 30 cm of the scent board (step 19), then within 1 m of the scent board (step 20). The scent board is removed, and the scent jars are placed randomly to fill a search area of 2 m × 2 m (step 21), then increased to a search area of 4 m × 4 m (step 22), then a search area of 6 m × 6 m (step 23) and finally a search area of 8 m × 8 m (step 24). Time limit: 120 s

attempt. No response or feedback was given for unsuccessful attempts and trial terminating or undesirable behaviors.

A changing-criterion design (Osborne and Himadi, 1990; Fernandez, 2020) was used to measure shaping progress during the study. Ethics approval was given by the University of Adelaide (Human research ethics H-2022-094; animal research ethics S-2022-038).

Results

Shown below in Figures 2 and 3 are periods of training which display the discrepancy in progress and performance before and after the addition of systematic training rules (pre- and post-TR, respectively). Both figures are split into two sections, with the left side (Figures 2a and 3a) showing performance prior to the

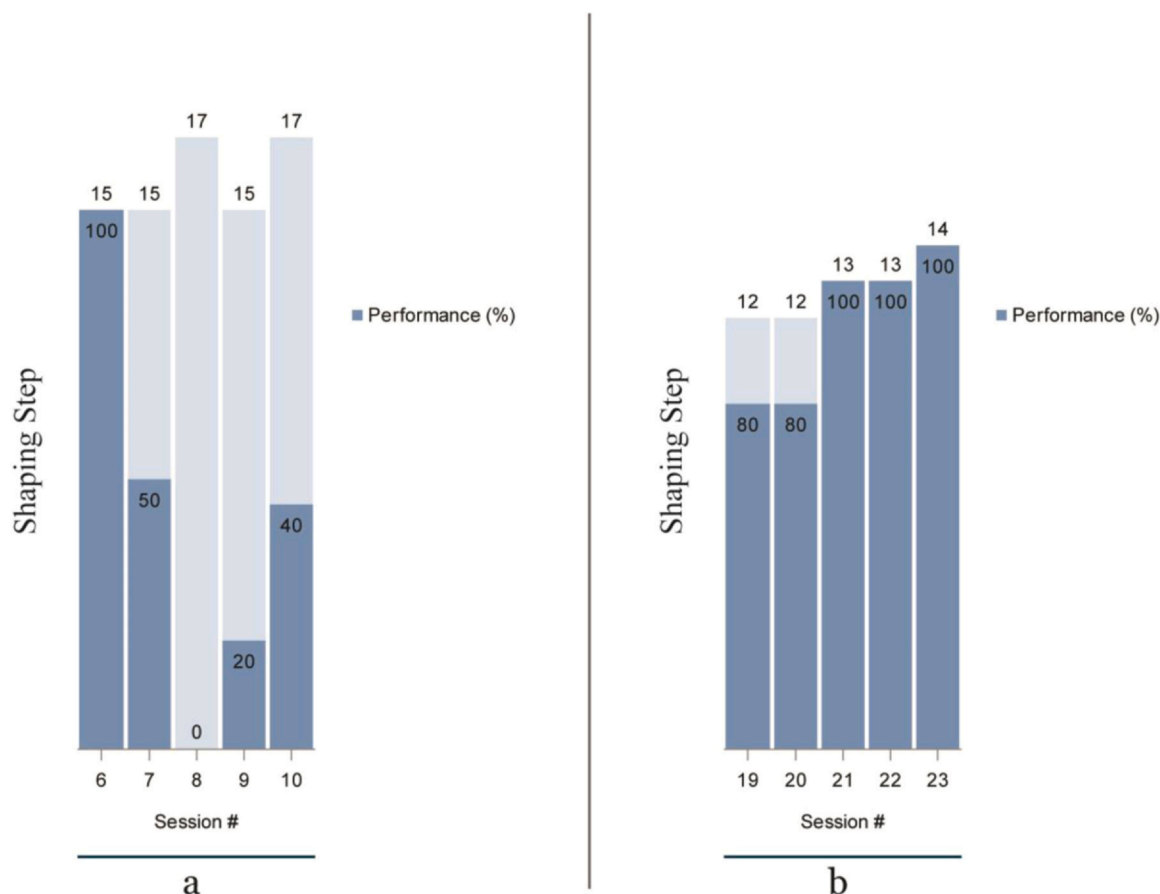


Figure 2. Training progress for Bronte over sessions 6–10 (a) and 19–23 (b). Each graph shows the session along the x-axis, with the step (bar height) and percentage of correct trial completions for that session (amount of each bar filled) for each session. The left graph (a) shows Bronte's performance prior to the implementation of the training rule (pre-TR), while the right graph (b) shows Bronte's performance after the training rule was implemented (post-TR).

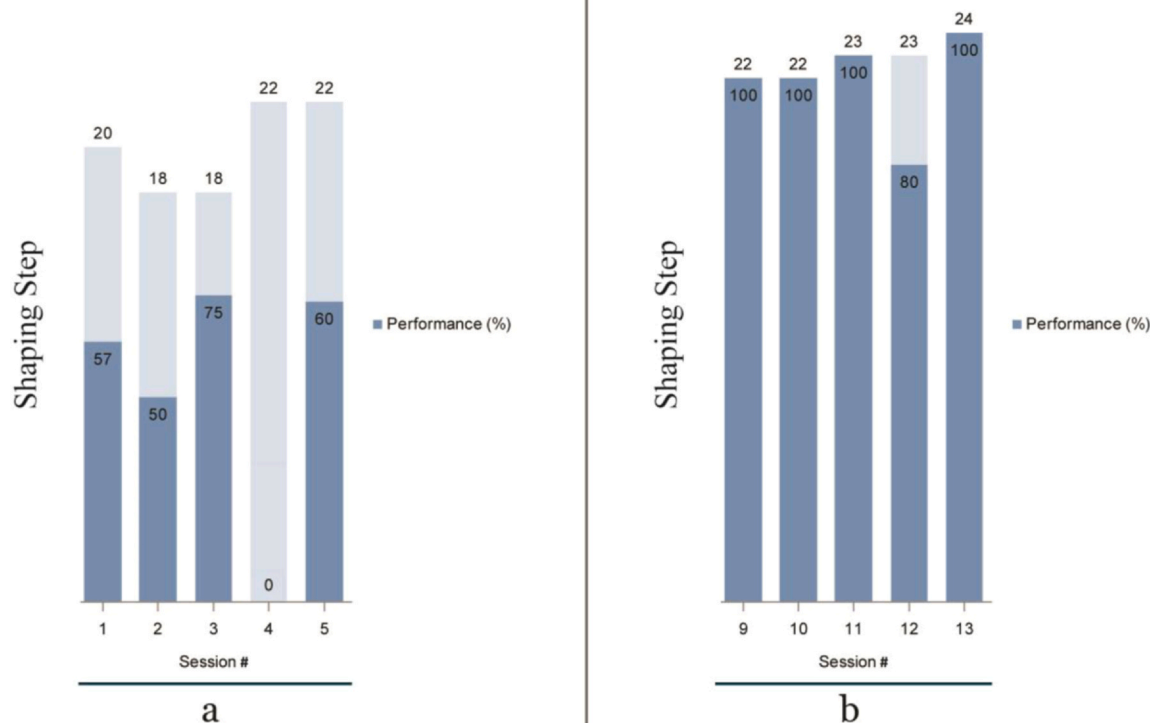


Figure 3. Training progress for Zuri over sessions 1–5 (a) and sessions 9–13 (b). Each graph shows the session along the x-axis, with the step (bar height) and percentage of correct trial completions for that session (amount of each bar filled) for each session. The left graph (a) shows Zuri's performance prior to the implementation of the training rule (pre-TR), while the right graph (b) shows Zuri's performance after the training rule was implemented (post-TR).

implementation of the training rule (pre-TR), and the right side (Figures 2b and 3b) showing performance after the implementation of the training rule (post-TR). Only five session segments of the pre-TR and post-TR conditions are presented below, to help clearly illustrate the difference between the two conditions.

As seen with Bronte in Figure 2a, prior to the implementation of the training rule (pre-TR), performance was variable from sessions 6–10, ranging from 0% to 100% of trials of steps 15 or 17 successfully completed (as noted in the Methods, prior to the implementation of systematic training rules, some sessions varied from four to seven trials). After the implementation of the training rule (post-TR; Figure 2b), steps were dropped to a lower criteria (step 12) where performance was more reliable, and then gradually increased. Successful step completions remained consistent, ranging from 80% to 100% of trials completed in sessions 19–23.

Similarly for Zuri, performance pre-TR (sessions 1–5), as shown in Figure 3a, was variable, ranging from 0% to 75% of trials successfully completed for steps 18–22 (as noted for Figure 1 and in the Methods, prior to the implementation of systematic training rules, some sessions varied from four to seven trials). Performance post-TR (sessions 9–13), as shown in Figure 3b, was reliably consistent, ranging from 80% to 100%.

Discussion

This study documented the odor detection training process for two dogs prior to the implementation of a training rule (pre-TR) and following the implementation of a training rule (post-TR). As previously noted, little is typically done to document training progress or implement systematic training rules. Figures are not available specifically for odor detection dogs, but failure rates in working dog training programs are high, resulting in 50%–80% of dogs not

completing training (Bray et al., 2021; Cobb et al., 2021). Therefore, there is a strong need to better assess both training progress and overall success of all working dogs, including odor detection dogs. Quantitative measurement of shaping procedures is one feasible way of achieving this outcome, with past research showing such a systematic approach to produce faster and consistent results (Galbicka, 1994; Fernandez and Rosales-Ruiz, 2021).

Problem behaviors and poor motivation are commonly cited causes for the withdrawal of a dog from training (Bray et al., 2021; Cobb et al., 2021). Other shaping studies have found reductions in problem behaviors during intervention procedures compared to baseline (Ferguson and Rosales-Ruiz, 2001; Slater and Dymond, 2011; Jezierski et al., 2014; Troisi et al., 2019). These studies indicate that aside from a systematic, measurement-focused approach improving performance, it may also help reduce problem behaviors that might deter or interrupt successful training programs, such as attending to external events or stimuli (i.e., distractibility).

Shaping and training techniques are important in the production of behaviors necessary for working dogs, as well as their health and welfare. While there is increasing interest in the scientific investigation of the use of detection dogs, most studies look at the end results rather than the training process (Lazarowski et al., 2020; Hall et al., 2021). There is a lack of systematic, empirical evaluations of shaping in the scientific literature (Fernandez, 2020). The documentation and quantification of detection training used by dog trainers should help to evaluate and improve the detection training requirements.

In other words, approaching training methodology as a science, including quantifying all variable manipulations, can help increase the repeatability and reliability of training procedures (Minhinnick et al., 2016). One key element is the use of single-case designs, which allow us to evaluate individual learning over time (Kazdin, 2021;

Fernandez, 2022; Fernandez and Martin, 2023). The combination of individual learning-focused data and systematic training manipulations should help advance the science of odor detection training.

Acknowledgments

The authors would like to thank the volunteers who offered their dogs and time in their participation of this study.

Conflict of Interest

We have no conflicts of interest to disclose.

References

- Bray, E., Otto, C., Udell, M., Hall, N., Johnston, A., MacLean, E., 2021. Enhancing the selection and performance of working dogs. *Front. Vet. Sci.* 8, 430.
- Cobb, M., Otto, C., Fine, A., 2021. The Animal Welfare Science of working dogs: Current perspectives on recent advances and future directions. *Front. Vet. Sci.* 8, 1116.
- Concha, A., Guest, C., Harris, R., Pike, T., Feugier, A., Zulch, H., Mills, D., 2019. Canine olfactory thresholds to amyl acetate in a biomedical detection scenario. *Front. Vet. Sci.* 5, 345.
- Cooper, J.O., Heron, T.E., Heward, W.L., 2020. *Applied Behavior Analysis*. Pearson, UK.
- Ehmann, R., Boedeker, E., Friedrich, U., Sagert, J., Dippon, J., Friedel, G., Walles, T., 2012. Canine scent detection in the diagnosis of lung cancer: Revisiting a puzzling phenomenon. *Eur. Respir. J.* 39 (3), 669–676.
- Ferguson, D.L., Rosales-Ruiz, J., 2001. Loading the problem loader: The effects of target training and shaping on trailer-loading behavior of horses. *J. Appl. Behav. Anal.* 34, 409–423.
- Fernandez, E.J., 2020. Training petting zoo sheep to act like petting zoo sheep: An empirical evaluation of response-independent schedules and shaping with negative reinforcement. *Animals* 10, 1122.
- Fernandez, E.J., 2022. Training as enrichment: A critical review. *Anim. Welf.* 31 (1), 1–12.
- Fernandez, E.J., Dorey, N., 2020. An examination of shaping with an African crested porcupine (*Hystrix cristata*). *J. Appl. Anim. Welf. Sci.* 24, 372–378.
- Fernandez, E.J., Martin, A.L., 2023. Applied behavior analysis and the zoo: Forthman and Ogden (1992) thirty years later. *J. Appl. Behav. Anal.* 56 (1), 29–54.
- Fernandez, E.J., Rosales-Ruiz, J., 2021. A comparison of fixed-time food schedules and shaping involving a clicker for halter behavior in a petting zoo goat. *Psychol. Rec.* 71, 487–491.
- Galbicka, G., 1994. Shaping in the 21st century: Moving percentile schedules into applied settings. *J. Appl. Behav. Anal.* 27, 739–760.
- Gazit, I., Goldblatt, A., Terkel, J., 2005. The role of context specificity in learning: the effects of training context on explosives detection in dogs. *Anim. Cogn.* 8, 143–150.
- Ghaemmaghami, M., Hanley, G., Jessel, J., Landa, R., 2018. Shaping complex functional communication responses. *J. Appl. Behav. Anal.* 51, 502–520.
- Grimm-Seyfarth, A., Harms, W., Berger, A., 2021. Detection dogs in nature conservation: A database on their world-wide deployment with a review on breeds used and their performance compared to other methods. *Methods. Ecol. Evol.* 13 (4), 568–579.
- Hall, N., Johnston, A., Bray, E., Otto, C., MacLean, E., Udell, M., 2021. Working dog training for the twenty-first century. *Front. Vet. Sci.* 8, 646022.
- Hayes, J., McGreevy, P., Forbes, S., Laing, G., Stuetz, R., 2018. Critical review of dog detection and the influences of physiology, training, and analytical methodologies. *Talanta* 185, 499–512.
- Jezierski, T., Adamkiewicz, E., Walczak, M., Sobczyńska, M., Górecka-Bruzda, A., Ensminger, J., Papet, E., 2014. Efficacy of drug detection by fully-trained police dogs varies by breed, training level, type of drug and search environment. *Forensic. Sci. Int.* 237, 112–118.
- Kazdin, A.E., 2021. Single-case experimental designs: Characteristics, changes, and challenges. *J. Exp. Anal. Behav.* 115 (1), 56–85.
- Lazarowski, L., Dorman, D., 2014. Explosives detection by military working dogs: Olfactory generalization from components to mixtures. *Appl. Anim. Behav. Sci.* 151, 84–93.
- Lazarowski, L., Krichbaum, S., DeGreef, L., Simon, A., Singletry, M., Angle, C., Waggoner, L.P., 2020. Methodological considerations in canine olfactory detection research. *Front. Vet. Sci.* 7, 408.
- McCulloch, M., Jezierski, T., Broffman, M., Hubbard, A., Turner, K., Janecki, T., 2006. Diagnostic accuracy of canine scent detection in early- and late-stage lung and breast cancers. *Integr. Cancer. Ther.* 5, 30–39.
- Midgley, M., Lea, S., Kirby, R., 1989. Algorithmic shaping and misbehavior in the acquisition of token deposits by rats. *J. Exp. Anal. Behav.* 52, 27–40.
- Minhinnick, S., Papet, L.E., Stephenson, C.M., Stephenson, M.R., 2016. Training fundamentals and the selection of dogs and personnel for detection work. In: Ensminger, J., Jezierski, T., Papet, L.E. (Eds.), *Canine Olfaction Science and Law*. CRC Press, London, pp. 155–171.
- Osborne, M.L., Himadi, B., 1990. Evaluation of a shaping procedure with the changing-criterion design. *Behav. Interv.* 5 (2), 75–81.
- Rutter, N., Howell, T., Stukas, A., Pascoe, J., Bennett, P., 2021. Can volunteers train their pet dogs to detect a novel odor in a controlled environment in under 12 weeks? *J. Vet. Behav.* 43, 54–65.
- Skinner, B.F., 1951. How to teach animals. *Sci. Am.* 185, 26–29.
- Slater, C., Dymond, S., 2011. Using differential reinforcement to improve equine welfare: Shaping appropriate truck loading and feet handling. *Behav. Processes.* 86, 329–339.
- Troisi, C., Mills, D., Wilkinson, A., Zulch, H., 2019. Behavioral and cognitive factors that affect the success of scent detection dogs. *Comp. Cogn. Behav. Rev.* 14, 51–76.