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Owner-implemented paired-stimulus food preference assessments for companion dogs

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Abstract

Behavioral interventions for animals typically require the inclusion of programmed reinforcers. Although pet owners and human caregivers can often identify items that the animal will consume, preference assessments can more accurately determine relative preference rankings between various stimuli, which is important given that higher preferred items tend to function as more effective reinforcers than lower preferred items. Preference assessments have been developed to identify rankings for a variety of stimuli across species, including the domesticated dog (*Canis lupus familiaris*). However, previous preference assessments for dogs were developed for laboratory use and could be challenging for dog owners to perform alone. The purpose of this study was to modify existing dog preference assessment methods to produce a valid and feasible preference assessment for dog owners. Results suggest that the preference assessment identified preference rankings for individual dogs. Owners were able to implement the protocol with high integrity and found the protocol acceptable.

KEYWORDS

canine, choice, training, treats, reinforcers

Over half of households in the United States have companion dogs (American Pet Products Association, 2020), many of which receive behavioral training to either increase desired behaviors (e.g., sit, down, stay) or decrease problem behaviors (e.g., mouthing, biting, jumping). Training may be important to ensure dogs stay in the home or perform critical behaviors. Specifically, the literature and animal behavior practitioner groups recommend using training that includes positive reinforcement as an effective, ethical option for companion dogs (China et al., 2020; Companion Animal Welfare Council, 2012; Cooper et al., 2014; Deldalle & Gaunet, 2014; International Association of Animal Behavior Consultants, n.d.).

For training with positive reinforcement, owners have access to a variety of reinforcers, including food (Feuerbacher & Wynne, 2012, 2014; Vicars et al., 2014; Winslow et al., 2018), toys (Dorey et al., 2012; Pfaller-Sadovsky et al., 2019), access to the owner (Feuerbacher & Wynne, 2016), and human attention (Feuerbacher & Wynne, 2012; Waite & Kodak, 2021). However, food is one of the most commonly used reinforcers for dogs (Hiby et al., 2004), and 83% of Italian owners surveyed said they give their dogs treats, mainly to reinforce desired behaviors (Morelli et al., 2020). Food is typically easily accessible, consumed quickly, and on average more effective than attention or praise for dogs (Feuerbacher & Wynne, 2012, 2014). Previous studies suggest dogs can engage in a discrimination of foods by scent and flavor and prefer foods that have meat, sugars, or fat (Hewson-Hughes et al., 2013; Houpt et al., 1978; Pételet al., 2018; Rao et al., 2018; Thompson et al., 2016; Tôrres et al., 2003). Nevertheless, individual dogs have unique food preferences (Cameron et al., 2013; Riemer et al., 2018; Vicars et al., 2014).

High-preference stimuli are more likely to function as reinforcers than low-preference stimuli (Francisco et al., 2008; Piazza et al., 1996), although lower ranked stimuli from a preference assessment can also function as reinforcers maintaining high response rates (Francisco et al., 2008). Historically, animal caregivers tend to inaccurately predict the preference rankings of animals (Gaalema et al., 2011; Mehrkam & Dorey, 2015). Thus, preference assessments can be used to empirically identify an individual's relative preferences. Preference assessments have been performed with a variety of animals, including nonhuman primates (Clay et al., 2009; Fernandez et al., 2004; Fernandez & Timberlake, 2019; Finestone et al., 2014; Hopper et al., 2019; Huskisson et al., 2020; Ogura & Matsuzawa, 2012), a California sea lion (Cox et al., 1996), big cats (Clayton & Shrock, 2020; Woods et al., 2020), captive wolves (Dorey et al., 2015; Isernia et al., 2022; Rao et al., 2018), domestic cats (Church et al., 1996; Vitale Shreve et al., 2017), and other species (Cameron et al., 2013, 2015; Gaalema et al., 2011; Mehrkam & Dorey, 2015; Slocum & Morris, 2020).

In addition, preference assessments have been performed in domestic dogs. These have functioned to identify individual dog preferences across stimulus classes (e.g., food versus attention; Feuerbacher & Wynne, 2012, 2014) and within stimulus classes such as toys (Protopopova et al., 2016), food delivery processes (Feuerbacher et al., 2022), food amounts (Feuerbacher et al., 2022; McGuire et al., 2018; Miletto Petrazzini & Wynne, 2016; Ward & Smuts, 2006), and food types (Bremhorst et al., 2018; Cameron et al., 2021; Hall et al., 2017; Li et al., 2018; Riemer et al., 2018; Thompson et al., 2016; Vicars et al., 2014). Food preference assessment methods for dogs vary widely and include nonconsummatory food preference assessments (Bremhorst et al., 2018; Pételet al., 2018; Riemer et al., 2018; Thompson et al., 2016), runway performance tests comparing response speed toward different items (Cameron et al., 2019, 2021; Riemer et al., 2018), restricted intake consummatory tests in which food is slowly released from an object (Li et al., 2018; Thompson et al., 2016), single-pan tests comparing the amount of each item consumed in a single sitting (Callon et al., 2017), free-operant assessments (Bhadra & Bhadra, 2014; Hall et al., 2017; Tôrres et al., 2003), multiple stimulus with/without replacement (Cameron et al., 2021), and paired-stimulus preference assessments (Cameron et al., 2021; McGuire et al., 2018; Miletto Petrazzini & Wynne, 2016; Prato-Previde et al., 2008; Vicars et al., 2014; Ward & Smuts, 2006).

Vicars et al. (2014) used a paired-stimulus preference assessment to determine food rankings by dogs. The six food items tested were selected by the owners, and the protocol was performed by the experimenters in the owners' homes. Each pair was presented only once, for a total of 15 trials, and the side of presentation for each food was randomized across trials. At the start of each trial, the dog was put in a sitting position and held in place by the collar. Two identical plates with the two foods were then placed on the ground, and the experimenter vocally prompted the dog to make eye contact, upon which the dog was released and vocally prompted to approach the plates. If the dog consumed one item, the plate with the unchosen food was lifted up and removed, and no selection within 5 s resulted in removal and brief re-presentation of the plates. Items were ranked based on the number of trials each was chosen. The reinforcer efficacy of the highest and lowest ranked items was then assessed in a progressive ratio reinforcer assessment that showed the highest ranked foods functioned as more effective reinforcers than the lowest ranked foods.

Although preference assessment results would be useful to all dog owners by identifying putative reinforcers to include in training, current published preference assessment methods are potentially problematic for the average owner. For example, most methods require one person to conduct the assessment and one person to hold the dog while the assessment is reset across trials (e.g., Vicars et al., 2014), whereas owners are often alone during assessments and training. Several methods require special equipment or supplies (e.g., nonconsummatory tests require the food to be secured under wire mesh). Additionally, most methods require that the experimenter remove or approach the unselected food item, which could be challenging to perform with a dog with a history of food-guarding behavior (Mehrkam et al., 2020). Given the importance of food preference assessments for dog training, the purpose of this study was to develop and test a paired-stimulus preference assessment method which was potentially more feasible for dog owners to perform alone.

METHODS

Participants, setting, and materials

Dog owners were recruited via public, sharable postings on personal and dog-specific Facebook pages. Interested owners were screened for eligibility criteria, which required they were at least 18 years old and willing to follow a protocol while video-recording themselves and their dog. For safety purposes, the dog must have lived in the household for at least 3 months, and the owners further confirmed they had no concerns the dog would bite them during the protocol. All dogs had to be willing to consistently eat treats. All dogs were adults, ranging in age from 1.3 years to almost 16 years, and represented a variety of breeds (Table 1). They had lived in their homes for greater than 6 months (7 months to almost 16 years) at the time of enrollment. All dogs had at least some experience with training, whether in-home or with a professional trainer, and the majority continued to engage in some training with their owners. All study procedures were approved by the University of Wisconsin-Milwaukee Institutional Review Board and Institutional Animal Care and Use Committee.

Eleven owners of 15 dogs were interested in and verbally consented to participate in the study via Zoom video conferencing (Zoom Video Communications). Owners were provided with brief written protocols, video models of protocols, and prerandomized shared data sheets in Google Sheets. All protocols were performed in the owners' homes, and videos and data from each

TABLE 1 Dog demographics

Dog	Age	Breed	Sex	Duration in home	History of professional training	Training duration per week
Snapper Dan	6 years	Greyhound	M	2.5 years	Some (1–23 hr)	2 hr
Toaster	11 years	Greyhound	M	2 years	Some (1–23 hr)	1.5 hr
Pita Chip	3 years	Terrier Mix	M	2 years	Some (1–23 hr)	0 hr
Fang	6 years	Beagle	F	1.5 years	A lot (24+ hr)	0 hr
Mr. G	3 years	Australian Cattle Dog	M	5.5 years	Home training only	10 hr
Olive	2 years	Rottweiler/German Shepherd Mix	F	11 months	Some (1–23 hr)	2–3 hr
Max	1.25 years	Australian Cattle Dog Mix	M	7 months	Home training only	2–3 hr
Piglet	15 years	Mix	F	15 years	A lot (24+ hr)	0 hr
Murphy	8 years	Mix	M	7 years	Some (1–23 hr)	0.5–1 hr
Dobby	6 years	Mix	F	5 years	Some (1–23 hr)	1 hr
Murray	6 years	Labrador Mix	M	1 year	Some (1–23 hr)	< 1 hr

session were submitted by the owners into a private Google Drive folder. All owners were offered the opportunity to perform the sessions while overseen by the study team via Zoom or receive feedback on their sessions via video assessment; however, only two owners engaged in any Zoom calls with the study team during the protocol (Pita Chip and Fang). Pita Chip's owner requested consistent supervision, during which feedback was offered twice (0.2% of tasks performed). Fang's owner requested supervision during one session, during which no feedback was offered. Two owners requested feedback on one video session and received feedback on one task each. All other protocol sessions were performed independently by the owners.

Of the enrollees, nine owners and 11 dogs finished the paired-stimulus preference assessment, and seven finished the reinforcer assessments. One owner of three dogs did not submit any data, and one owner submitted only partial data and did not move beyond the training phase due to a lack of time. No dogs enrolled in the study were later excluded from participation for any reason other than owner nonparticipation; for example, dogs were not excluded if they exhibited evidence of side biases.

To test a variety of foods and ensure results were relevant for individual owners, owners were asked to choose four to five foods they wanted to evaluate with at least one item they thought would be highly preferred and one item they thought would be less preferred (see Supporting Information Tables S1 and S2). The foods had to be an edible item that each dog was known to or would be expected to consume (e.g., if a dog had previously been offered bananas but did not consume them, bananas were not selected). However, the items were not tested for consumption during owner selection. While choosing the food items, owners were asked to speculate on the putative highest ranked food and lowest ranked foods and the owners' predicted rankings were recorded as a categorical variable (highest and lowest ranked). Given the ability of dogs to engage in discriminated selections based on the magnitude of food and propensity to choose the larger magnitude (Prato-Previde et al., 2008; Riemer et al., 2018; Ward & Smuts, 2006), owners were asked to cut or break the various foods into similar sizes. Owners purchased their own treats for the study; however, those who finished the paired-stimulus preference assessment were compensated with a $20 gift card to Amazon or Petco.

Response measurement, interobserver agreement, and procedural integrity

The primary dependent variable of the paired-stimulus preference assessment was selection of a food item, defined as the dog removing the food from the owner's hand with their tongue or mouth. For the progressive ratio (PR) reinforcer assessment, a touch response was operationally defined as any part of the dog's nose/snout making contact with the owner's hand.

Interobserver agreement

Two trained observers independently collected data for 33% to 50% of paired-stimulus and reinforcer-assessment sessions for all dogs. Agreement for the paired-stimulus preference assessment was defined as scoring the selection of the same item in a trial. Trial-by-trial interobserver agreement (IOA) was calculated by dividing the number of trials with agreement by the number of trials per session and multiplying by 100. Agreement for the PR reinforcer assessment was defined as scoring the same break point for a session. Interobserver agreement was calculated by dividing the smaller of the two break points by the larger and multiplying by 100. Agreement for the FR1 reinforcer assessment was defined as scoring the same response count per session, and IOA was calculated by dividing the smaller count by the larger and multiplying by 100. Mean agreement for the paired-stimulus preference assessments, PR reinforcer assessment, and FR1 reinforcer assessment sessions was 100% across all dogs. All dogs had similar relative treat sizes except Piglet, for whom the kibble was approximately half the size of the other treats.

Procedural integrity

Data were also collected on owner procedural integrity for 37.2% of sessions for the paired-stimulus preference assessment (training and comparison) and 34.6% of the PR and FR1 reinforcer assessments. Supporting Information Table S3 lists the integrity criteria for each procedure, and Table 2 summarizes the integrity results. During the paired-stimulus preference assessment, integrity averaged 99.6% (range: 87.5% to 100%). The majority of errors in the paired-stimulus preference assessment occurred when owners presented and then removed the treats more quickly than recommended (<1 s) to their dog, resulting in less opportunity for the dog to attend to each item. During the PR and FR1 reinforcer assessments, integrity averaged 98.2% (range: 87.5% to 100%). One owner did not vocally count the responses during each session, and one owner skipped one of the response requirements (e.g., PR4).

Discrimination training

To teach the dog to differentiate and choose between two items, preassessment discrimination training sessions were initially performed for each dog. During training sessions, the putatively least preferred food was paired with each other food twice in a randomized, counterbalanced manner such that every potential combination was presented twice per session, once from each hand (left/right). For example, Toaster's putatively least preferred food (kibble) was presented opposite of hot dogs, cheese, seafood treats, and Zuke's during the discrimination training sessions. During each trial, the owner held one food item in each hand. The owners were asked to hold the treats between their fingers such that part of the food was exposed enough to allow the dog to sniff and lick the food but not take or consume it. At the start of each trial, both hands with food were held up by the owner's chest. Then one hand was lowered near the level of the dog's face, and the dog was allowed to engage with (e.g., sniff, lick), but not consume, the food. After at least 1 s, the hand was raised and the other hand lowered. After each item was presented twice to the dog, both hands were lowered and opened, and the dog was allowed to select one item. Once the dog selected one food item, the unchosen food was lifted up by the owner and returned to its container. If the dog did not select an item after 10 s, both food items were returned to their containers, and the trial was scored as no choice made. Each session consisted of two presentations of each pair of food items for a total of six to eight trials per session, depending on whether four or five treats were being tested. The protocol did not prespecify interval lengths between sessions for this or any other task, and each owner was able to engage in sessions at their own pace throughout the study.

To move on to the preference assessment sessions, each dog was required to show a clear and consistent discrimination between the putatively low- and high-preferred foods. This was defined as at least four consecutive sessions in which the selection percentages of the high/low items did not overlap and had either a stable or opposing trend (i.e., selections of the putatively high-preferred item had an increasing trend, whereas selections of the putatively low-preferred had a decreasing trend). However, data for Snapper Dan and Toaster were collected during initial protocol testing (i.e., pilot participants),

TABLE 2 Participant paired-stimulus preference assessment and reinforcer assessments integrity

	Paired-stimulus preference assessment			Reinforcer assessments		
Participant	% w/PI	PI	Range	% w/PI	PI	Range
Snapper Dan	57	100	100–100	33	100	100–100
Toaster	38	100	100–100	33	100	100–100
Pita Chip	38	99.6	98.1–100	-	-	-
Fang	38	99.5	98.6–100	33	100	100–100
Mr. G	33	99.5	98.6–100	38	100	100–100
Olive	33	99.5	98.1–100	33	91.7	87.5–100
Max	33	100	100–100	-	-	-
Piglet	38	100	100–100	-	-	-
Murphy	33	100	100–100	33	99.1	98.2–100
Dobby	33	100	100–100	36	96.3	87.5–100
Murray	33	97.9	87.5–100	-	-	-

Note. Paired-stimulus preference assessment integrity includes both training and comparison phases. PI = procedural integrity.

resulting in longer training phases than other dogs. Additionally, because owners sometimes submitted two sessions of data at once, participants occasionally performed one more session than was necessary to switch phases.

If a dog's initial training results suggested a continued lack of discrimination and position bias, two additional reinforcer-quality training phases were incorporated. In the first reinforcer-quality training phase (RQ), a putatively low-quality and historically not consumed food item (lettuce) was paired against a putatively high-quality item (Dentastix) across one session of eight trials. The trial procedures were identical to discrimination training. Discriminated responding in the reinforcer-quality training phase was followed by a phase in which lettuce was consistently paired against all five other items (reinforcer quality training with all items; RQA phase), similar to the discrimination training trials procedure. Once discriminated responding occurred in this phase, then the initial discrimination training with the original putatively low-preferred item (liver bites) versus all other foods was reinstated. This additional training was only required for one dog (Murray).

Paired-stimulus preference assessment

Sessions included trials presented in a randomized order. Each item was paired against the other item twice per session. The number of trials per session was dependent on the number of food items being compared. Comparisons of four items required 12 trials per session, and comparisons of five items required 20 trials per session. Owners performed between one and two sessions per day, up to 7 days per week.

The procedures were identical to discrimination training trials. Because owner attention toward one of the food options can influence the dog's choice (Prato-Previde et al., 2008), owners were asked to avoid looking at either treat/hand, keep both hands at the same level, and avoid praising the dog for choosing an item. To increase the likelihood that food functioned as a reinforcer during the assessment, owners were also asked to avoid performing sessions soon after a meal and avoid performing more than two sessions in a row. In addition, because dogs use scent to engage in discriminations between some foods (Houpt et al., 1978), owners were asked to start with scent-free hands (e.g., no scented soaps or lotions right before a session) and to wipe down their hands with a towel occasionally throughout the session, as needed.

Reinforcer assessment

After completing the paired-stimulus preference assessment, owners were invited to perform a reinforcer assessment to validate the results of the preference assessment. The reinforcer assessment included an evaluation of responding under a PR schedule to identify the maximum number of touch responses the dog would perform for a particular food item. The most and least preferred food items identified from the preference assessment were tested in the reinforcer assessment. A touch response was selected for the reinforcer assessment because it is simple for owners to train, and many enrolled dogs either already had a trained touch response or were quickly trained by their owners prior to the first session (details of this training can be obtained from the first author upon request). The PR schedule progression was altered slightly from Vicars et al. (2014). Vicars et al. (2014) used a "basis 2 progressive ratio 1" schedule, wherein each criterion had to be met twice in a row before increasing the requirement by one response (1, 1, 2, 2, 3, 3, etc.), whereas the current study used an arithmetic progression (i.e., the criterion increased by one response after meeting the criterion [1, 2, 3, 4, 5, etc.]). For example, the starting criterion required one response; if the dog met this criterion, they were presented with the food reinforcer and the criterion was increased to two, thus requiring two additional responses before presentation of the next reinforcer. Sessions of both food items were presented within the same day, and owners were asked to avoid conducting the sessions after meals or directly in succession of each other to avoid satiation. The order of session presentation on the first day was randomized; each day thereafter, the order was reversed (e.g., AB, BA, AB).

At the beginning of each session, an empty bowl or plate was placed in front of the dog, and all food during the session was given to the dog by dropping it into the bowl. At the start of each session, the owner placed one piece of the food being tested into the bowl to assist with early discrimination. The owner then held one hand out flat near the dog's face, which functioned as a discriminative stimulus for the touch response, and vocalized the current response count (e.g., "One," then "Two," etc.) for the purpose of adherence to the protocol by Vicars et al., (2014) and also for procedural integrity data collection. If the dog engaged in the touch, then the hand was retracted, the other hand was held out flat, and the next response count was vocalized. Once the dog met the current PR response criterion, the owner remained silent and dropped the food into the bowl. Then, the schedule requirement increased by one response. If the dog did not engage in the response within 10 s of the discriminative stimulus, then the session ended and the most recently completed ratio requirement was identified as the break point.

Alternative reinforcer assessment (Fang only)

During the PR reinforcer assessment, Fang's food items included cheese and popcorn. During sessions with cheese, she rapidly and completely consumed the cheese;

however, instead of touching her nose to the next presentation of an outstretched hand, she often sniffed/licked the plate where the cheese had been, moved the plate around to sniff under it, or stared for long periods at the owner's other hand, which was at their side. In contrast, Fang slowly consumed some of the popcorn, often spitting bits out or leaving some on the ground. During sessions with popcorn, Fang looked at the owner's other hand or looked around the room. Thus, the rate of responding and likelihood of consumption varied across food items. These behaviors suggested that the contingencies for the PR schedule may not have been discriminable to Fang, who was only recently taught the touch behavior. As a result, an FR1 reinforcer assessment was implemented to compare rates of responding across food items.

During each session, the owner put one hand behind their back and used the same hand consistently throughout the session as the discriminative stimulus for the touch behavior. Each session began with the owner dropping the food item into the bowl. After Fang consumed the item, the owner held out a flat hand as a discriminative stimulus for the touch behavior. If Fang engaged in a touch, then the owner dropped a piece of food into the bowl. Thus, the owner implemented an FR1 schedule for touch behavior. Each session lasted 2 min, and the total responses per session was converted to a response rate (touches per minute).

Social validity

To assess the social validity of the paired-stimulus preference assessment, owners were asked to submit anonymous responses to a modified version of the Treatment Evaluation Inventory—Short Form (TEI-SF; Kelley et al., 1989). The modified TEI-SF is a seven-item questionnaire, with each item rated on a scale of 1–5. Responses were collected by Qualtrics survey software (*Qualtrics*, version 2021; https://www.qualtrics.com) after completion of participation in the study.

RESULTS

Except for the two pilot dogs (Snapper Dan and Toaster) and Murray, who required additional discrimination training, the dogs were able to finish the discrimination training within a mean of 4.8 sessions. Across all enrolled dogs, an average of 6.3 paired-stimulus preference assessment sessions were conducted.

Figure 1 shows the results of discrimination training and the paired-stimulus preference assessments for Snapper Dan, Toaster, and Pita Chip. The preference assessment was performed twice with Snapper Dan, where one food item was substituted across assessment phases; specifically, hot dogs were substituted for bison meal treats in the second preference assessment phase starting on Session 10. In other words, hot dogs were only tested in Sessions 10–14, whereas bison treats were tested in Sessions 6–9. During both preference assessments for Snapper Dan, cheese was the highest ranked food and kibble ranked lowest (Figure 1, top panel). For Toaster, hot dogs were the highest ranked food and seafood treats ranked lowest (Figure 1, middle panel). For Pita Chip, kibble was the highest ranked food and cheese ranked lowest (Figure 1, bottom panel).

Figure 2 shows the results of discrimination training and the paired-stimulus preference assessments for Fang, Mr. G, Olive, and Max. For Fang, cheese was the highest ranked food and popcorn was ranked lowest (Figure 2, top panel). For Mr. G, cheese was the highest ranked food and kibble was ranked lowest (Figure 2, top middle panel). For Olive, Nutro was the highest ranked food and marshmallows ranked lowest (Figure 2, bottom middle panel). For Max, peanut butter was the highest ranked food and kibble ranked lowest (Figure 2, bottom panel).

Figure 3 shows the results of discrimination training and the paired-stimulus preference assessments for Piglet, Murphy, Dobby, and Murray. For Piglet, Happy Howie's turkey, Happy Howie's beef, and jerky were tied as the highest ranked foods and kibble ranked lowest (Figure 3, top panel). For Murphy, tuna was the highest ranked food and kale ranked lowest (Figure 3, top middle panel). For Dobby, cheese was the highest ranked food and kibble ranked lowest (Figure 3, bottom middle panel). Murray's results were unique in that he required addition training sessions (Figure 3, bottom panel). Specifically, during the first discrimination training phase, Murray had a right-side bias and made 87.5% of selections from his owner's right hand (Figure 4). During the reinforcer quality discrimination training phase (RQ), biased responding was successfully treated when Murray almost exclusively selected Dentastix over lettuce regardless of side. During the three sessions of reinforcer quality discrimination training with all items (RQA), Murray continued to select all other items over lettuce, regardless of side. After returning to the original discrimination training, Murray typically selected all other items over the putatively low-preferred item, liver bites, which showed he no longer engaged in biased responding. During his paired-stimulus preference assessment, cheese was the highest ranked food and liver bites ranked lowest. Murray was the only dog with a persistent position bias; nevertheless, most dogs displayed position biases at the beginning of their discrimination training (Figure 4). Specifically, six out of 11 dogs had at least one discrimination training session in which at least 75% of selections were made from a single side, defined here as a side bias. Three dogs had at least one paired-stimulus preference assessment session meeting this side-bias criterion. Of the six dogs who exhibited side biases, the average percentage of sessions with side biases was higher during

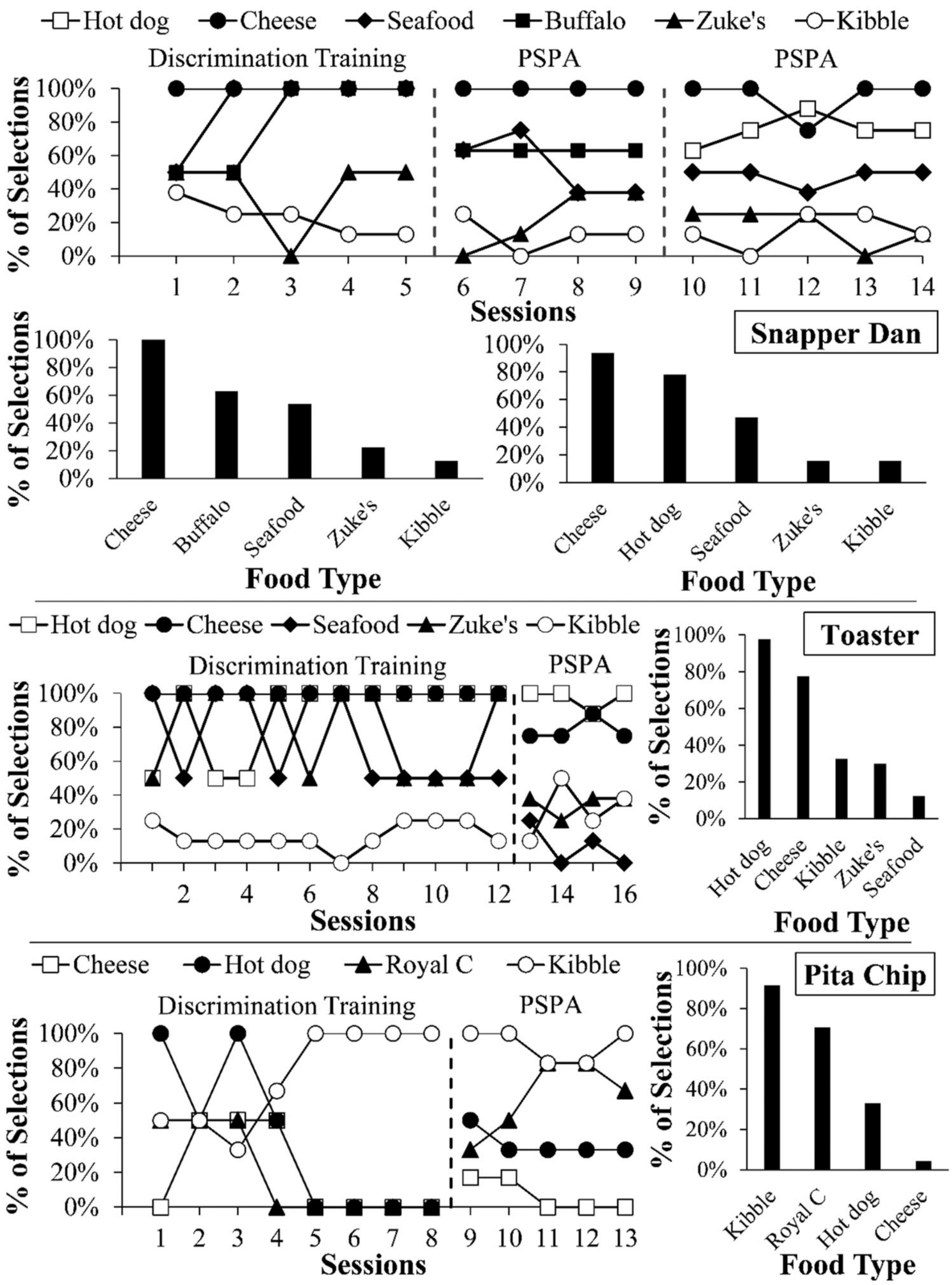

FIGURE 1 Paired-stimulus preference assessment results for Snapper Dan, Toaster, and Pita Chip. Bar graphs represent the selections during the final four sessions. White squares and white circles indicate foods the owner hypothesized would be highest and lowest preferred, respectively. PSPA = paired-stimulus preference assessment. Bar graphs average the results from the last four sessions of the PSPA.

discrimination training (35.5% of sessions) than during the paired-stimulus preference assessment (7.5% of sessions).

Results of the PR and FR1 reinforcer assessments are shown in Figure 5. During the PR reinforcer assessment, all dogs except Dobby had higher break points for their high-preference foods than for their low-preference foods, which verified the results of the paired-stimulus preference assessment. Dobby's initial PR assessment sessions resulted in considerable overlap in break points for kibble and cheese; however, his last three sessions produced higher break points for cheese than kibble. Fang's FR1 reinforcer assessment showed high rates of responding for cheese. In contrast, no responses were emitted during sessions with popcorn, as Fang did not eat the popcorn provided at the start of each session.

Social validity

Responses to the modified TEI-SF social validity survey indicated that owners found the protocol to be acceptable, effective, and comfortable for their dog (Table 3).

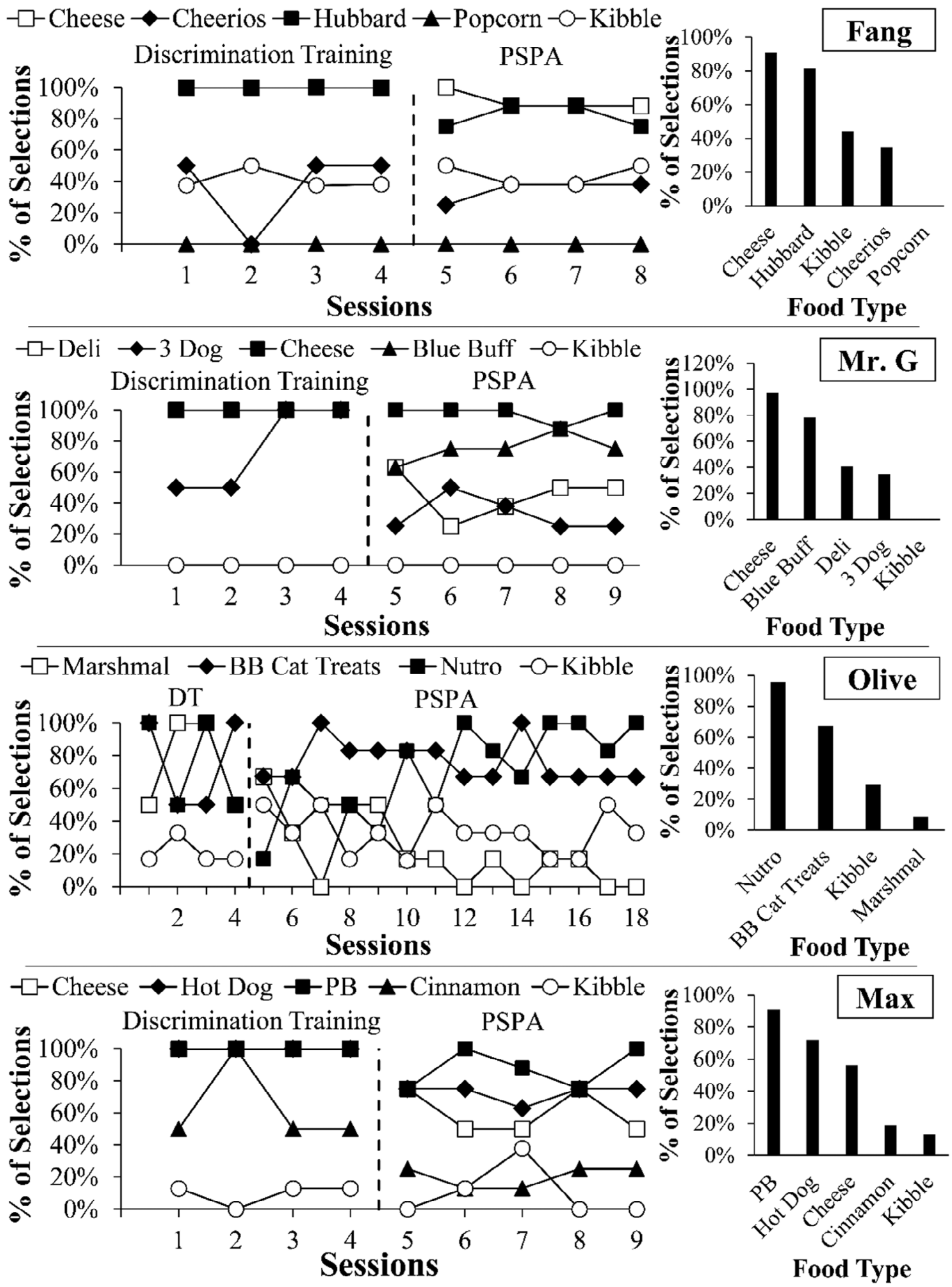

FIGURE 2 Paired-stimulus preference assessment results for Fang, Mr. G, Olive, and Max. Bar graphs represent the selections during the final four sessions. White squares and white circles indicate foods the owner hypothesized would be highest and lowest preferred, respectively. DT = discrimination training; PSPA = paired-stimulus preference assessment. Bar graphs average the results from the last four sessions of the PSPA.

DISCUSSION

The results suggest the paired-stimulus preference assessment was effective at identifying the relative food preferences for dogs enrolled in the study. This was validated by the PR reinforcer assessment, which showed overall higher break points for high-preference foods relative to low-preference foods. These outcomes are consistent with previous studies conducted with dogs and humans that showed higher response rates and reduced latencies to approach higher preferred items compared with lower preferred items (Cameron et al., 2019, 2021; Penrod et al., 2008; Vicars et al., 2014).

Procedural integrity analyses indicated that all owners were able to implement the procedures with high integrity, suggesting that the general owner population may be able to implement the protocol with minimal support. This is important, as animal behavior practitioners may be able to identify client dogs' food preferences with relatively minimal effort by providing procedural models, data collection sheets, and data oversight/graphing to their clients. To further reduce practitioner effort, future

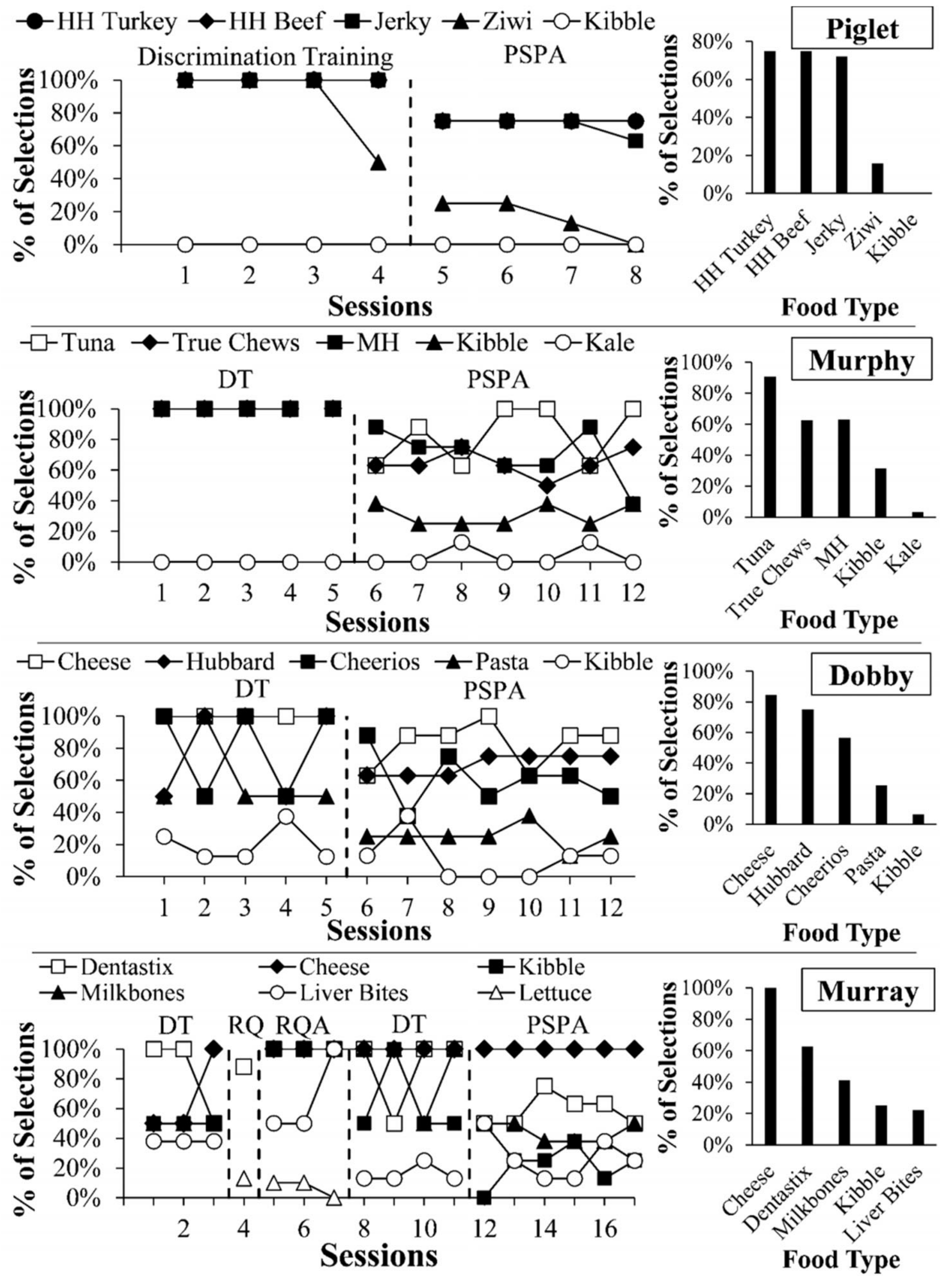

FIGURE 3 Paired-stimulus preference assessment results for Piglet, Murphy, Dobby, and Murray. Bar graphs represent the selections during the final four sessions. White squares and white circles indicate foods the owner hypothesized would be highest and lowest preferred, respectively. DT = discrimination training, PSPA = paired-stimulus preference assessment, RQ = reinforcer quality training, and RQA = reinforcer quality training with all items. Bar graphs average the results from the last four sessions of the PSPA.

studies could identify opportunities to automate these tasks, whereby owners could input their list of foods and trial result data into a computer program capable of randomizing trials, flagging phase changes, and graphing results.

In addition to performing the procedures with high integrity, owners also reported the procedures had high social validity. Results from the modified social validity questionnaire showed that respondents consistently gave very positive scores for protocol acceptability and effectiveness and owners perceived little or no possible negative effects. These high-integrity and social-validity results are critical, as this is the first preference assessment empirically validated for in-home use by dog owners. However, owner procedural integrity was not tested in previous dog preference assessment studies; therefore, the relative feasibility of the current protocol compared with others is unknown. Future studies could compare procedural integrity across preference assessment methods.

One important modification from previous preference assessment protocols is the programmed opportunity for

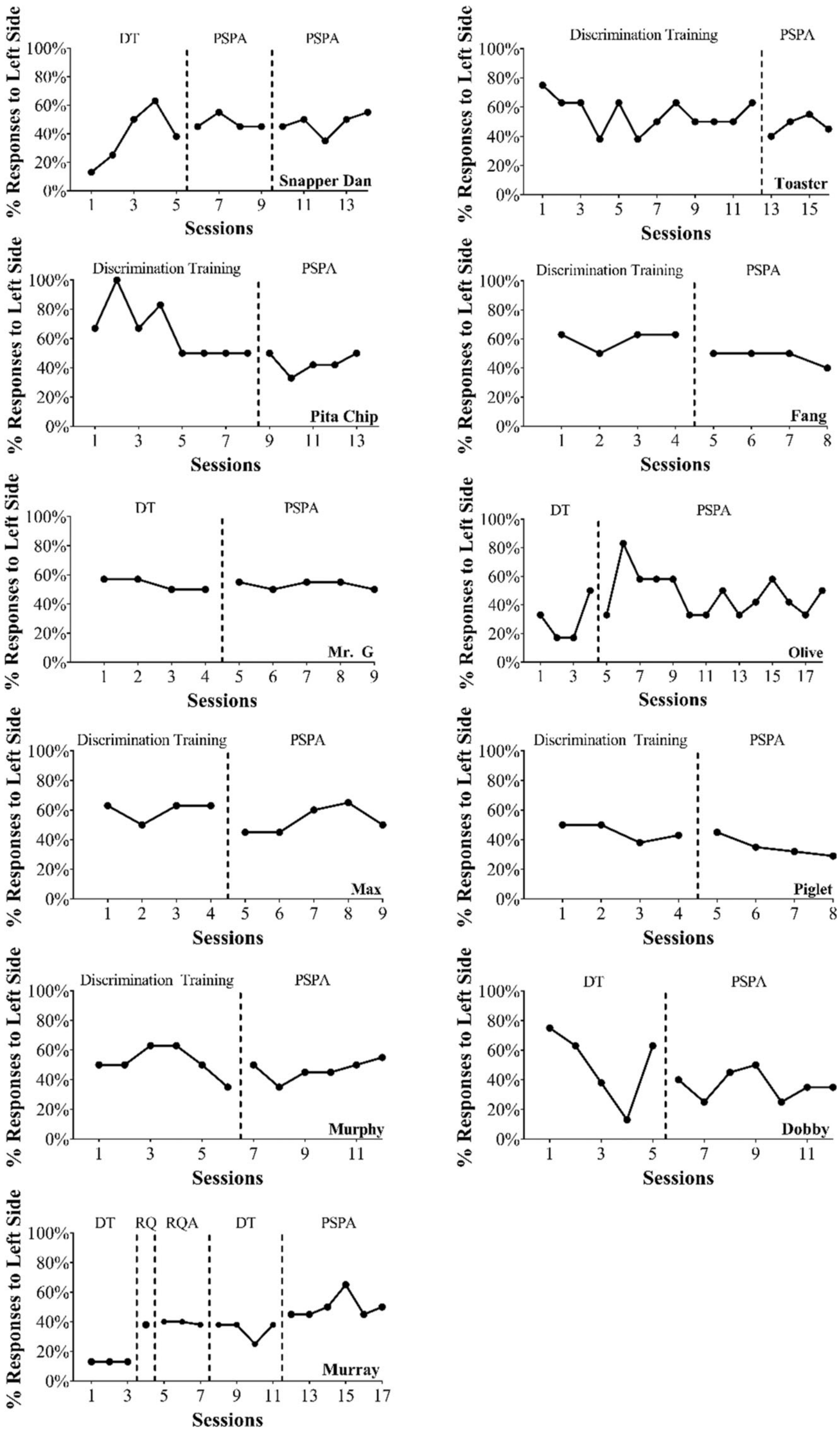

FIGURE 4 Selections by side during the paired-stimulus preference assessment. DT = discrimination training, PSPA = paired-stimulus preference assessment, RQ = reinforcer quality training, RQA = reinforcer quality training with all items.

the dog to both smell and taste the food choices. This is critical because either scent or taste is sufficient for differentiating between meat presence/absence and types (Hall et al., 2017; Houpt et al., 1978; Pétel et al., 2018), whereas taste is necessary and sufficient for differentiating the presence and concentration of sucrose (Houpt et al., 1978). The ability to taste the food may be paramount, as dogs previously failed to choose the correct location of food hidden under one of two cups (Byrne et al., 2020), calling into question whether the food odor had stimulus control over the selection behavior.

Owners of 10 dogs made predictions for food preference rankings (high and low), and results for eight dogs

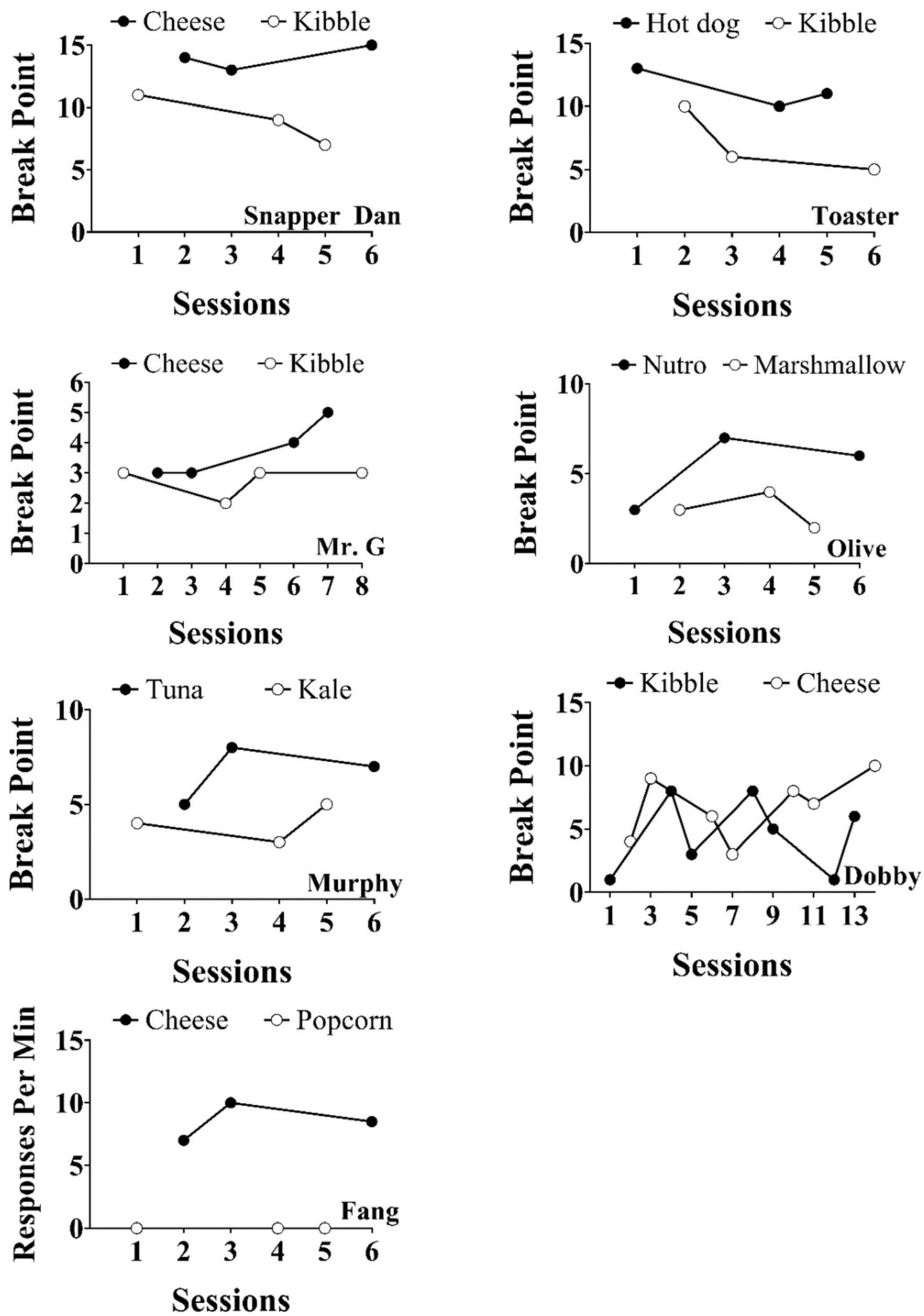

FIGURE 5 Progressive ratio and fixed ratio reinforcer assessments. All data are for progressive-ratio reinforcer assessments except for Fang's data, which are for a fixed-ratio reinforcer assessment. Closed circles mark the highest ranked item from the paired-stimulus preference assessment and open circles mark the lowest ranked item.

diverged from their owners' predictions. Results for Pita Chip and Olive were notably different from their owners' predictions in that the food items predicted to be highest preferred were shown to be least preferred in the preference assessment. This is consistent with previous studies in which preference assessment results were more accurate than predictions by dog owners (Vicars et al., 2014), exotic animal caretakers (Gaalema et al., 2011; Mehrkam & Dorey, 2015), and human caregivers (Green et al., 1988). Further, individual dogs' preference results often diverged from dog food preferences identified in the literature. For example, studies suggest that dogs tend to choose foods with higher meat content (Callon et al., 2017; Houpt et al., 1978; Pételet al., 2018; Riemer et al., 2018; Thompson et al., 2016), sucrose over bland foods (Houpt et al., 1978; Tôrres et al., 2003), moist over dry foods (de Brito et al., 2010; Rao et al., 2018), and fat over protein or carbohydrates (Hewson-Hughes et al., 2013). Although several dogs' preferences in the current investigation matched these general guidelines

TABLE 3 Owner social validity results

Question	Mean	Range
I find this assessment to be an acceptable way of identifying my dog's treat preferences	5	N/A
I like the procedures used in this assessment	5	N/A
I believe the dog will experience discomfort during this assessment	1	N/A
I believe it would be acceptable to use this assessment with dogs	4.9	4–5
Overall, I have a positive reaction to this assessment	4.8	4–5
I would suggest this assessment to someone else	4.9	4–5
I believe this assessment is likely to be effective at finding my dog's relative treat preferences	4.8	4–5

Note. 1 = *Strongly Disagree*, 2 = *Disagree*, 3 = *Neutral*, 4 = *Agree*, and 5 = *Strongly Agree*.

(e.g., Toaster), some results diverged. For example, Pita Chip preferred dry kibble to either moist meat (hot dogs) or high-fat (cheese) items, and Snapper Dan, Max, and Murray chose high-fat, nonmeat foods over meat options. Therefore, although general data on dog food preferences may provide a useful guideline for predicting species preference rankings, use of preference assessments may produce more accurate rankings for individual dogs. This is consistent with studies showing preference differences between breeds (Kahraman & Inal, 2021), litters within the same breed (Ferrell, 1984), and individuals (Vicars et al., 2014).

Of the 11 owners, nine completed the paired-stimulus preference assessment, resulting an in 81.1% completion rate. Of the two owners who did not complete the study, one did not start the procedures and one dropped out after several sessions because of major life stressors and resulting time constraints. The paired-stimulus preference assessment procedure averaged 28 sessions with 224 trials, with 32 trials per food pairing. This average does not include reinforcer assessment sessions, as the reinforcer assessment was used for research validation purposes and would generally not be necessary or practical to complete in a home setting. Nevertheless, owners may be more likely to complete the paired-stimulus assessment protocol if it were shorter. Previous paired-stimulus preference assessment studies in dogs did not include discrimination training sessions and, therefore, the training sessions could potentially be removed, which would substantially reduce the assessment duration. Further, all other studies preprogrammed a limited number of trials (between 1 and 6 pairings of each comparison) as opposed to running sessions until a criterion was met, which further reduced assessment duration. However, these modifications could also reduce the validity of the assessment procedure. For example, results differed for several dogs in their early discrimination training or paired-stimulus preference assessment sessions compared with their later sessions (e.g., Snapper Dan), suggesting that some dogs may require extended exposure, either to the protocol or to new items being tested, to show consistent preferences for items. For example, Olive was least likely to select kibble during discrimination training but selected marshmallow the least during the preference assessment. It is unknown whether Olive had previous experience with marshmallows, but this change in preference across trials could be due to a temporary novelty effect (see review by Stasiak, 2002). Nevertheless, most dogs' results during their early paired-stimulus preference assessment sessions were relatively similar to their final rankings. To reduce the assessment duration, future studies should assess the requirement for discrimination training sessions and determine whether and how early and later session results correlate.

Importantly, this study included all dogs, regardless of whether they exhibited position biases in early sessions. To avoid position-based stimulus control, discrimination training sessions were programmed. Although this study did not test whether the training sessions were necessary to avoid later position biases, at least a subpopulation of dogs engage in biased responding across studies (Bremhorst et al., 2018; Byrne et al., 2020; Miletto Petrazzini & Wynne, 2016; Vicars et al., 2014). For example, 17% of dogs had a complete position bias (i.e., no shifting between choices) when choosing between two opaque cups in which only one cup was baited with food (Byrne et al., 2020). After excluding dogs with consistent biases (stay only, shift only, or always choosing the cup with food), the rest of the dogs showed a win–stay, lose–shift strategy. In addition, other studies identified position biases in a subset of dogs during different choice procedures, including choosing between different food amounts (Miletto Petrazzini & Wynne, 2016), selecting a potentially food-baited string (Riemer et al., 2014), and engaging in paired-stimulus food preference assessments (Vicars et al., 2014). Some dogs even made position-based selections despite owners' gestures toward the "correct" choice (Gácsi et al., 2009; Gerencsér et al., 2019; Hare & Tomasello, 1999).

Humans and animals are also prone to position bias during two-stimulus array discrimination procedures due to the inherent intermittent (VR2) reinforcement schedule (Grow et al., 2011; Kangas & Branch, 2008). Given the propensity for multiple species to engage in biased selections and given that even lower preferred items have the potential to function as reinforcers (Francisco et al., 2008; Piazza et al., 1996), it is reasonable to expect that some biases will occur during preference assessments.

Designing methods to prevent biases from developing or correcting them early may be ideal. For example, Kangas and Branch (2008) found 100% of pigeons displayed some bias (position bias or sample bias) during a match-to-sample task. Although biases in 5/6 pigeons resolved in the absence of a correction procedure, the number of sessions required to resolve the bias varied and only four pigeons had greater than 90% accuracy after 30 sessions. In contrast, when the matching-to-sample protocol included a bias-correction procedure from the onset, all pigeons' biases were corrected in fewer than 30 sessions (Kangas & Branch, 2008). This suggests that, although biases tended to self-correct over time, it may be more efficient to program a bias-correction procedure at protocol onset, such as the discrimination training phase used here.

Six dogs displayed some position biases in initial discrimination training session(s), and only one dog out of 11 displayed a consistent position bias during early training sessions. Murray selected items from the left side in 7/8 trials across three sessions. This bias was addressed by implementing reinforcer-quality training sessions (Bourret et al., 2012), in which a nonpreferred food item (e.g., lettuce) was paired with the owner-predicted highest preferred item. The purpose of this protocol was to produce discriminated responding by reducing or even eliminating reinforcement for choosing one item by including historically nonconsumed items. This training resolved the position bias. Alternative training procedures could be implemented to correct position bias, such as repetition of error trials (Bourret et al., 2012; Kangas & Branch, 2008) or forced-choice procedures (Dalal & Hall, 2019). To address these potential biases while also reducing the number of sessions required, future studies could assess ways to further improve the efficiency of the discrimination training. For example, pairing the putatively high-quality food item against a food the dog historically did not consume (e.g., lettuce) instead of a putatively low-quality item (e.g., kibble) may reduce the number of sessions required for discrimination training. Including a historically nonconsumed item in the training may also avoid potential issues resulting from pairing putatively high- versus low-quality items. For example, Piglet did not consistently select turkey or beef over each other; thus, pairing turkey versus beef in the discrimination training would likely have produced inconsistent results. Reducing the effort required to address position biases will be critical for increasing protocol adherence and integrity in the general population.

Although the paired-stimulus preference assessment was successful at identifying the relative rankings of foods for all dogs, there were some limitations to the method. For Piglet, three of the five foods were selected at similar frequencies. Piglet's undifferentiated selection may have been the result of failure to differentiate between stimuli, given that all three foods had a high meat content and similar textures, or similar preference rankings between items.

Although results suggest the preference assessment outperformed owner speculation, future studies could more directly assess the relative efficacy of the preference assessment versus owner selection by comparing PR assessment results of the highest ranked item from the preference assessment versus the owner-identified highest ranked item. Future studies should also assess how frequently the preference assessment needs to be performed once trained and whether any maintenance is required. For example, human preferences are known to change across time, resulting in a general recommendation to perform additional preference assessments every 30 days (MacNaul et al., 2021), whereas no such data exist to inform recommendations for dogs. This may be especially important if novel foods are being used, given that novelty can affect preferences in animals (Callon et al., 2017; Stasiak, 2002).

A potential limitation is that the enrolled owners were provided with brief training, a video model, a written protocol, and an opportunity to ask questions throughout the study. Consistent opportunities to ask questions or get feedback likely provided the enrolled owners with access to more training support than a typical dog owner may have in the absence of working with a behavior professional. However, only a few owners requested feedback during the protocol, and the only feedback provided to owners was to ensure that food presentations were each at least 1-s long, as some presentations were too short for the dog to engage with the item. Finally, the owners or caregivers may require assistance with analyzing data.

A further study limitation is a potential lack of generalizability of study results to the general population, thus necessitating future study replications and modifications. Specifically, all dogs enrolled in the study, and presumably their owners, had some experience with training, and seven of the owners (78% of enrollees) reported their dog had some professional training. In contrast, previous reports suggest that 88% of the general owner population has ever engaged in training with their dog and only 20%–64% engaged in training outside the home (Blackwell et al., 2008; Kobelt et al., 2003; Rohlf et al., 2010). Therefore, although 81% of owners finished the protocol and found the average of 28 sessions to be socially valid, owners and dogs naïve to training may respond differently or even be unwilling to perform the protocol. Future studies could assess the rate of protocol uptake, procedural integrity, and number of sessions required for owners and dogs naïve to training. It is also critical for future studies to describe and compare owner motivation levels for training versus engagement in and adherence to training protocols, as these data could potentially assist with predicting the likelihood of protocol uptake within the general population.

Overall, the results suggest that dog owners were able to accurately conduct the paired-stimulus preference assessment procedure and collect data. Once the owner and dog are trained to perform the assessment procedures, the preference assessment could be implemented multiple times throughout the dog's life to identify preference rankings between new foods and across the lifespan. This is important, as the incorporation of higher preferred food items during behavioral intervention increases the likelihood that the stimulus will function as a more effective reinforcer and thereby increases the effectiveness of behavior interventions. In this sense, preference assessments like this may be important preparatory components of behavior intervention protocols, which can improve the welfare of both dogs and their families.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

ETHICS STATEMENT

All study procedures were approved by the University of Wisconsin-Milwaukee Institutional Review Board and Institutional Animal Care and Use Committee.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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