Training Dogs for Awake, Unrestrained Functional Magnetic Resonance Imaging

by

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Abstract

Awake, unrestrained canine functional Magnetic Resonance Imaging (fMRI) is of great interest in working dog sectors for its potential to elucidate mechanisms of scent processing and odor detection, as well as biobehavioral markers of successful career performance. The method is also of interest to anthropologists, evolutionary psychologists, and the general public. Awake canine fMRI is a new procedure that lacks well established training methods. The potential of a new training method was investigated on the quality of awake, unrestrained canine fMRI data. The aim was to design a procedure that produces high-quality functional and structural data at first exposure to the MRI environment in a cost-effective manner. The method segments operant conditioning of the in-bore stationing behavior, a 5-minute prone down stay aligned in a chin rest, from appetitive classical conditioning of a positive response to the assorted 90+ decibel scan sequences. Using minimal and easily accessible training aids and trained to completion in a location away from the MRI suite, the new method utilized a transfer phase of mock MRI sessions conducted in five different locations before the final transfer test in the MRI environment. Maximum duration performance was stable and over five minutes at the end of training and across transfer sessions. Two dogs were able to station to the 5-minute criterion in all transfer locations, and two dogs were able to station to the above criterion in 4/5 transfer locations (T2-T5). Three of the dogs transferred to the MRI scanner and demonstrated repeated bouts of the max possible duration (206 s). Motion, a proxy of data quality, during echoplanar imaging (EPI) scans, was compared between dogs trained with the new method (n=4) and four ideally-performing dogs scanned in previous fMRI experiments at Auburn University. Although

one dog failed MRI transfer, dogs trained with the new method were able to produce comparably high-quality data to the previously tested dogs.

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List of Abbreviations

MRI	Magnetic Resonance Imaging
MR	Magnetic Resonance
fMRI	Functional Magnetic Resonance Imaging
T	Tesla
ROI	Region of Interest
AU	Auburn University
CPS	Canine Performance Sciences
C/T	Click and Treat
AE	Auditory Exposure
CS	Conditioned Stimulus
CR	Conditioned Response
CER	Conditioned Emotional Response

Training Dogs for Awake, Unrestrained Functional Magnetic Resonance Imaging

In vivo functional magnetic resonance imaging (fMRI) is a primary tool of modern cognitive science as it allows brain imaging while subjects are awake and responsive to stimuli. At the moment there are five laboratories around the world that are scanning dogs (Atlanta, USA; Auburn, USA; Budapest, Hungary; Queretaro, Mexico; Vienna, Austria). There are several advantages of fMRI for studying brain function in unrestrained awake dogs. First, the, data collection is similar to that of humans, and therefore more readily generalizable across species (Bunford, Andics, Kis, Miklosi, & Gacsi, 2017). Second, there is no need for anesthesia eliminating any undesirable after effects. Third, brain activity is altered by anesthesia and hence cognitive function can be better assessed without anesthesia. Fourth, while fluid/food deprivation and physical restraint allow researchers to probe nonsedated animals, (e.g., rodent, avian, and primate models), those animals can be in very different cognitive states than their non-deprived and unrestrained counterparts (Bunford et al., 2017). Awake, unrestrained fMRI is a new but expanding technique that has led to new insights in canine facial recognition (Cuaya, Hernandez-Perez, & Concha, 2016; Dilks et al., 2015; Hernández-Pérez, Concha, & Cuaya, 2018); Thompkins et al. (2018), language processing (Andics et al., 2016; Andics, Gácsi, Faragó, Kis, & Miklósi, 2014; Prichard, Cook, Spivak, Chhibber, & Berns, 2018), scent processing (Berns, Brooks, & Spivak, 2015; Jia et al., 2014; Jia et al., 2016), reward expectancy (Berns, Brooks, & Spivak, 2013; Berns, Brooks, & Spivak, 2012; Cook, Prichard, Spivak, & Berns, 2018; P. F. Cook, Prichard, Spivak, & Berns, 2016; Prichard, Chhibber, Athanassiades, Spivak, & Berns, 2018), temperament (Cook, Prichard, et al., 2016; Cook, Spivak, & Berns, 2014), resting state connectivity (Kyathanahally et al., 2015; Szabo et al., 2018), and predictability of performance outcomes in service dogs (Berns, Brooks, Spivak, & Levy, 2017). Taken together these publications represent the five research groups that have used canine fMRI without restraint or sedation: the Berns group at Emory University in the United States, the Jia group at Auburn University in the United States, the Andics group at Loránd University in Hungary, the Cuaya group at Universidad Nacional Autónoma de México in Mexico, and the Huber group at the University of Vienna in Austria.

Training dogs to cooperatively participate in functional MRI scans is inherently difficult; the goal state requires dogs to remain in a down-stay with less than 3mm of head movement for durations ranging from 30 seconds to six minutes in the elevated, confined, and noisy (up to 100dB) environment of the scanner bore. This long duration stationing behavior has been trained using a variety of techniques (e.g., positive reinforcement behavior shaping and social learning paradigms), the comparative efficacy of which have not been systematically explored (Berns & Cook, 2016; Huber & Lamm, 2017; Thompkins, Deshpande, Waggoner, & Katz, 2016).

In the following sections I will describe previously used procedures for acclimating dogs to the magnetic resonance (MR) scanner environment, address the central challenges in acquiring and interpreting canine functional neuroimaging data, speak to the applied value of functional neuroimaging in working dog populations, report on the current state of animal training literature, develop a rationale for using a new scanner acclimation training protocol, and describe a creative measurement construct to index and compare behavior quality between training programs.

Existing Scanner Acclimation Methods

Tóth, Gásci, Miklósi, Bogner, and Repa (2009) published the first account of structural MRI in two awake dogs as a proof of concept; the authors describe their training method, "during the training subjects learn to ignore the noise and vibration of the magnetic resonance (MR) machine and remain immobile during the scan." This ambiguity of the training procedures used to acclimate dogs to the MR environment is pervasive in the literature, however, from procedure sections, supplemental materials, and secondary sources, a picture of training for each research group does emerge. Defining and refining these procedures is important in light of overcoming the challenges of imaging awake dogs, namely time to train, cost to train, regular access to the MR environment for training, motion artifacting/data attrition, small n designs, and selection bias against dogs with anxious pathologies or less tractable (trainable) dispositions (Berns & Cook, 2016; Cook et al., 2014; Huber & Lamm, 2017; Thompkins et al., 2016)

The Berns Group in the US (at Emory). Berns et al., (2012) conducted the first functional scans of two awake dogs. The reward processing paradigm explored in that study required the dogs to learn associations between the presentation of two distinct hand signals and the subsequent receipt or non-receipt of a food reward. A follow up study in 2013 replicated their findings of ventral striatum activity increase to the reward condition in 11 additional dogs (Berns et al., 2013). Between the two studies, dogs were required to station for up to 30 seconds. On average, 43% of volumes were retained (ranging from 30% to 59%) for data analysis. Three dogs became sensitized (exhibited an exaggerated fear response, dishabituation (Ramirez, 1999)) to the scanner noise in the MR environment, preventing data collection at first exposure.

Cook and colleagues (2014) in the Berns group replicated the reward processing paradigm with familiarity manipulations of stimulus presentation and owner-reported temperament covariates using the Canine Behavioral Assessment and Research Questionnaire (C-BARQ); dogs with low aggressivity scores displayed higher differential caudate activation between reward and no-reward conditions when the signals were presented by a familiar individual, compared to dogs with high aggressivity scores whose differential activation was greater when the conditioned signals were presented by an unfamiliar individual or computer. The thirteen dogs used were required to station for up to 30 seconds. On average 51% of scan volumes were retained for each subject (ranging from 38% to 60%), and one dog's data was excluded entirely due to excessive motion. Next, Berns and colleagues (2015) investigated olfactory processing and social context in 12 dogs, concluding that while the olfactory bulb and peduncle were similarly activated in all scent conditions (self, familiar human, strange human, familiar dog, strange dog), the caudate was maximally activated to the scent of a familiar human. The dogs were required to station for repeated bouts of 30 seconds for runs lasting between 7-14 minutes. In addition to the initial scanner acclimation training time (2-4 months), it took this cohort of dogs on average 67 (range from 26-113) additional days of training to prepare for this experiment. 61% of the original EPI volumes were retained for analysis (ranging from 43% to 85%). That same year, Dilks et al. (Dilks et al., 2015) reported findings of selective activation to human and dog faces over objects in the canine temporal lobe – a selectivity that was absent in the primary visual cortex. The 8 dogs were previously trained to station for up to one minute prior to data collection. Two dogs were excluded from analysis due to excessive motion, and for the remaining six dogs, between

47%-76% of EPI volumes were retained. A study of canine self-control was conducted in 2016 (Cook, Spivak, & Berns, 2016) converging cognitive testing and awake neuroimaging with active task data; a brain region in the frontal cortex (ventrolateral pre-sylvian cortex) was localized for inhibition of response during an in-scanner go-no-go task, the magnitude of activity for which correlated with fewer false alarms, and better performance on the out-of scanner A not B task. Dogs were required to station for durations of up to 30 seconds and achieve 80% correct performance on a go-no-go out-of-scanner practice session; additional training time to achieve these data collection criteria ranged from 2-4 months. Two dogs were excluded from data analysis due to excessive motion and on average 42% of EPI volumes were retained for analysis (ranging from 16.5% to 59%). That same year (2016) Cook and colleagues investigated neural correlates of reward preference for either praise or food. The two experiments conducted involved conditioned signals for praise, food, or nothing, and a Y-maze of reward choice (owner or food). The researchers found that relative activation to food vs. praise in the caudate was a stable indicator of reinforcer choice in the Y-maze. The majority of dogs (13/15) preferred praise over food, implicating the importance of social interaction in dog training and individual variability in reward preference. One dog was excluded from analysis due to excessive motion and two additional dogs only completed ¾ of the runs. On average, 54% of volumes were retained for analysis for each dog (ranging from 30% to 70%). The following year (2017), the Berns group assessed neurobiological correlates of performance in 49 service dogs using their established conditioned signal reward paradigm with stimulus presentation familiarity manipulations. Their model implicated the caudate and amygdala as predictive regions of interest (ROIs). Mean differential caudate activation (between reward and no-reward, regardless of familiarity of stimulus presenter) positively correlated with successful career performance, and mean differential amygdala activation (between familiar and unfamiliar presenter, regardless of signal) correlated negatively with program outcomes. Dogs were required to station for repeated bouts of 30 seconds prior to data collection, which took approximately two months to train. The authors did not report functional volume retention or subject attrition rates in this publication.

Berns et al., 2012 (n=2), Berns et al., 2013 (n=13), Cook et al., 2014 (n=13), Dilks et al., 2015 (n=8), Berns et al., 2015 (n=12), Cook, Spivak, & Berns, 2016 (n=13), and Cook, Prichard, Spivak, and Berns, 2016 (n=15) used dogs from the same original cohort of 15 pet scanner dogs trained between 2012 and 2013. The researchers utilized a birdcage head coil for their first proof of concept study (Berns et al., 2012), and a neck coil for all subsequent studies. The researchers also created custom chin rests out of stiff foam boards cut into semicircles based on the unique cranial anatomy (nose to ramus of mandible) of each scanner dog. The dogs' station duration criteria ranged from 30 seconds to one minute, depending on the experiment. In their initial training, although 12 dogs were able to station for viable data collection at first exposure to the MR environment, three became sensitized to the noise and had to undergo further training (Berns et al., 2013; Berns et al., 2012) Moreover, several of these initially successful dogs were excluded from subsequent studies due to excessive motion. Across studies, the Berns group retained on average a range of 42% to 57% of scan volumes, and typically excluded data from 1-2 dogs entirely per study due to excessive motion. It is worth noting that the rates of subject and data attrition are significant, given this group's short duration criterion for stationing (30 seconds) compared to other groups (several minutes).

The Berns group scanner acclimation training broadly consisted of behavior shaping, desensitization, and habituation with an end goal of repeated bouts of up to 30 seconds of motionless down-stay in a chin rest. Custom chin rests were built for each scanner dog to facilitate training and reduce head movement during scanning. First, dogs were trained to place their heads in the radiofrequency (RF) coil. This initial training utilized clicker training (conditioned signal pairing of an audible "tic-toc" stimulus with immediate delivery of a food reinforcer) and behavior shaping (contingent reinforcement of successive approximations towards a goal behavior). The dogs were then trained to place their heads on a chin rest located horizontally across the RF coil until a release signal was given, for increasing durations up to 30 seconds. Concurrent to all stages of training, recordings of localizer, structural, and functional scan sequences were played over speakers to passively desensitize (habituate) the dogs to those stimuli. The authors note that once the animal became conditioned (showed calm behavior towards) to the noise while stationing, the volume was gradually increased. When the dogs were able to station calmly for 30 seconds with the noise playing, the trainers introduced the MuttMuffs hearing protection. Once acclimated to the hearing protection and able to station for 30 seconds with scanner playback at a volume of 90 decibels (dB), the animals were shaped to station with the hearing protection and noise in a head coil in a mock scanner bore placed on the ground. Upon consistent performance at this approximation, the entire apparatus was elevated to the height of the scanner patient table (aprox. 3 feet), and the stationing behavior (with hearing protection and 90dB scanner playback) was shaped to criterion once more. Prior to data collection, dogs performed full practice scan sessions of each experiment's unique protocol. Upon completion of a single practice session in the mock environment, the dogs were transitioned to the MR environment for data collection. To minimize the startle responses of scan onset, recording of the pertinent scans were played over the MRI console's intercom system, gradually increased to match the volume of the scan sequence (aprox. 95 dB) and terminated when the actual scan begun.

The Jia Group in the US (at Auburn). Jia, Pustovyy, Waggoner, Beyers, Schumacher, Wildey, Barrett, Morrison, Salibi, Denney, Vodyanoy, and Deshpande (2014) compared olfactory processing of awake and anesthetized dogs. Using an olfactometer, the researchers delivered high (0.16 mM) and low (0.016mM) concentrations of an ethyl butyrate solution to a cohort of six trained detection canines (Labradors) while awake and anesthetized. The parametric increases in magnitude of activation to low and high concentrations of odorant in olfactory regions (olfactory bulb, bilateral piriform lobes, cerebellum) was in accordance with Weber's Law (threefold perceived increase for a tenfold concentration increase). They further found that while the olfactory bulb, periamygdala, anterior olfactory cortex, entorhinal cortex, and piriform lobes were active in both awake and anesthetized dogs during odorant delivery, regions implicating higher-order cognitive processing (superior, medial and orbital portions of frontal cortex) were activated mainly in awake dogs. Researchers were not able to collect functional data on one dog and discarded 25% of awake functional volumes from the other five subjects due to excessive motion. Kyathanahally et al., (2015) conducted a seed-based correlation analysis and an independent component analysis on the resting state data of that cohort of dogs (Jia et al., 2014) to characterize the Default Mode

Network (DMN) in dogs. The analyses revealed that, unlike primates, the anterior (anterior cingulate and medial frontal lobe) and posterior (posterior cingulate) regions of the DMN were dissociated in both awake and anesthetized dogs. The DMN is a resting state network implicated in self-referential processing (theory of mind, future metallization, autobiographical remembering), the lack of connectivity for which in dogs suggests lower-level cognitive processing compared to primates. In this study, researchers were not able to use any functional data from two out of six dogs in their analyses due to excessive motion. In a follow-up study of olfactory processing, Jia and colleagues (2016) investigated the enhancement of olfactory processing by zinc nanoparticles (ZNP) in two cohorts of trained detection dogs, six and eight dogs, respectively. They found that administration of an odorant with ZNPs increases magnitude of activation in olfactory ROIs, namely the olfactory bulb and hippocampus, compared to administration with gold nanoparticles or administration of the odorant alone. For the first cohort of six dogs, the final dataset used for post-processing consisted of 122 runs from 25 independent scan sessions. For the second cohort of eight dogs, 46 runs were collected over eight scan sessions.

The Jia group scanner acclimation training broadly consisted of positive reinforcement behavior shaping, clicker training, and desensitization with an end goal of a 3-4 minute motionless prone down-stay in the scanner bore and head coil. Acclimation to the scanner noise occurred concurrent to all training phases. A nose-to-target stick behavior (touch and remain touching) was conditioned to position the dogs' heads in the radiofrequency coil, a human knee coil, in this case. This phase of training took between 30 minutes and three hours per dog, divided into approximately 30-minute individual training sessions. The next phase of their station training took place in a mock scanner environment, requiring the dogs to perform a down-stay on a scanner-height table with their heads in a mock coil for several minutes. This phase of training took between 12 and 30 hours per dog, divided into 1-hour individual training sessions. The final phase consisted of retraining in the MRI suite during several mock scan sessions. Frequent scanning at the MRI facility was an integral part of their training system; dogs were scanned once per week with data (potentially) collected only every other week. The interim weeks of scanner operation were for training purposes only. In each experiment, at least one dog experienced extreme performance decrement (became sensitized) to the scanner environment such that functional data were not able to be collected at all. For the remaining dogs, scanner acclimation training took approximately four months for viable data collection. The Jia group implemented a secondary motion control using an optical head motion tracking camera mounted externally in the magnet suite. These motion parameters, as well as motion parameters obtained from FSL registration, were used as nuisance regressors in their General Linear Models (GLMs).

<u>The Andics Group in Hungary</u>. Andics, Gácsi, Faragó, Kis, & Miklósi (2014) conducted a comparative neuroimaging study of language processing in 22 humans and 11 pet dogs. They assessed differential patterns of cortical activation to conspecificity (human or dog vocalization) and emotional valence (highly negative to highly positive); the researchers included silent baseline and non-vocal environmental noise condition controls. Unlike humans, dogs displayed selective regions of maximal activation to dog v. human v. environmental noises. Similar to humans, dogs displayed differential activation for positively v. negatively valanced stimuli regardless of conspecificity. A follow-up study

(Andics et al., 2016) with thirteen pet dogs examined neurofunctional correlates of lexical processing. Their findings hold evolutionary significance; the dogs exhibited left-hemisphere biased activation of familiar praise words v. unfamiliar neutral words, regardless of intonation, right-hemisphere biased activation of intonation differences, and dominant reward center activation (mesolimbic dopamine system) in conditions that matched praise words with praise intonation. Taken together these findings suggest an ability to differentiate word meaning from intonation – an ability that evolved in the absence of spoken language.

The Andics' group scanner acclimation training broadly consisted of positive reinforcement behavior shaping and social learning. Training occurred in two phases: down-stay training (5-20 sessions) and training at the MRI facility (5-9 sessions). Dogs were initially reinforced (food-rewarded, praised, stroked) for assuming a still down-stay position. Subsequent training was conducted in the MR environment; the model-rival social learning paradigm was implemented at the beginning of this stage. Novice dogs (rivals) were allowed to walk about the MRI suite off-leash and were ignored. Meanwhile, a training session would be underway with more experienced dog (model), receiving food, petting, and praise for stationing in the scanner. Researchers used a SENSE Medium coil secured above and below the dogs' muzzles with Velcro. One run was collected per imaging session, with no more than two imaging sessions per day. On average, 3.4 scanning sessions were needed per dog for data acquisition. Researchers reported 80% success on data collection for a given run on the first attempt, 16% on the second attempt, and 4% on the third attempt – suggesting dogs became detrimentally sensitized to the scanner environment.

The Cuaya Group in Mexico. Cuaya, Hernández-Pérez, and Concha (2016) investigated the functional and neuroanatomical correlates of human face perception in seven pet dogs. They observed bilateral differential activation in the ventral-posterior temporal cortex between face and object projection conditions and presumed the ROI to be analogous to the fusiform face area in primates. With motion censoring exclusion criteria of greater than 3mm of movement or 1 degree of rotation between volumes, on average, approximately 80% of their functional volumes were retained for analysis. In a follow-up study with eight dogs, Cuaya et al. (2018) explored the functional and neuroanatomical correlates of human facial affect. They observed the highest differential activation between happy and neural face stimulus presentations in the right superior and ventral temporal cortex, as well as in anterior regions of the caudate. Data attrition was not reported in this publication.

The Cuaya group scanner acclimation training broadly consisted of positive reinforcement behavior shaping and chaining. Their end goal was a dog that would station in the actual MRI for durations of up to 5-minutes while attending to projected visual stimuli. The training occurred in three phases: down-stay at the owner's home, down-stay and chin rest in the mock scanner with concurrent noise desensitization, and down-stay and chin rest at the MRI facility. First, dogs were trained to remain in a down-stay for a duration of five minutes at the owners' homes. Next, dogs were trained to perform the same behavior while wearing ear protection in a mock scanner and head coil, with scan recordings playing. The last stage of training consisted of several training sessions at the MRI facility, habituating the dogs to stationing in the actual MR environment and visual projections. Training took approximately four months and consisted of several up to fifteen-minute sessions one day per week. The group built custom chin rests like those described by Berns et al., 2013, that were adjustable to various canine cranial anatomies. They used a SENSE Flex Small coil secured above and below the dogs' muzzles with Velcro. Data collection was spread out over several imaging sessions for each dog: 1-3 runs per session until 5 runs were acquired.

Summary of Methods and Existing Challenges

Basic scanner acclimation training takes on average two to four months per dog (Cook et al., 2014; Huber & Lamm, 2017). Research groups train the initial stationing behavior away from the actual MR environment, in superficially constructed head coils and scanners. Desensitization (habituation) to the scanner noise is conducted during training of the stationing behavior in the mock scanner environments via playback of scan recordings. Playback volume and reinforcement contingencies of duration for the down-stay behavior are co-manipulated during these training sessions. Due to challenges transferring the stationing behavior to the MR environment at first exposure, sessions of retraining at the actual MRI facilities are conducted prior to data collection (Andics et al., 2014; Berns et al., 2013; Cuaya et al., 2016; Jia et al., 2014). With MRI facilities charging upwards of $500 per operating hour, if a dog needs several hour-long sessions of retraining at an MRI facility, the expense can be significant. Moreover, the time and associated expense is prohibitive of large subject designs, jeopardizing the power of canine fMRI studies across the board (Huber & Lamm, 2017; Thompkins et al., 2016). The present training strategies require selection of tractable, highly food-motivated, social, and environmentally sound dogs; consequently, this selection bias excludes subject populations with pathologies that could be of interest to cognitive researchers (Cook et al., 2014; Huber & Lamm, 2017). Motion artifacting (ghosting of tissue/fluid in the direction of phase encoding due to movement during scans) is another major issue with the method (Berns & Cook, 2016; Huber & Lamm, 2017; Thompkins et al., 2016). With in-vivo functional imaging, the stillness quality of the in-scanner stationing behavior directly impacts the quality of the data, and the types of questions researchers can ask about those data. Aggressive censoring based on conservative motion exclusion criteria (>1 or 3mm displacement in x, y, z direction, >1º rotation) is one approach, but risks data attrition to the extent that the researcher no longer has enough volumes for valid analysis across groups or conditions. Unanimously, researchers use motion correction algorithms within the statistical analysis packages (e.g., MCFLIRT motion correction in FSL), to obtain cardinal and rotational realignment parameters, to be regressed out as nuisance variables in the GLM. Researchers have also used external, out-of-scanner camera systems to obtain additional motion time series data to be regressed out in the experimental model (Jia et al., 2014; Jia et al., 2016; Thompkins et al., 2018). The threat of motion on image quality has severe repercussions in the analysis of structural and functional data. More broadly, it limits the validity and generalizability of findings across studies.

Using Working Dogs for Canine fMRI

Increasing our understanding of the cognitive processing of information by dogs will contribute to the effectiveness and efficiency of training dogs for the roles in which they serve people. Military, homeland security, and law enforcement working dogs are used in a variety of operations, including bomb detection, search and rescue, drug interdiction, and combatant/suspect suppression/apprehension. Service dogs assist individuals with physical limitations (e.g., blind, hearing impaired), and work as emotional support dogs, mitigating symptoms of Post-Traumatic Stress Disorder (PTSD) and Traumatic Brain Injury (TBI) in returning military service members. Certain dog breeds, ideally bred for this work, are rare (a limiting resource) and variability in dog training and performance limits their effectiveness in operational environments. Better selection and screening of detection and service dogs would ensure that the best dogs, with optimal temperament (motivation and trainability), are selected for service.

Variations of canine temperament with respect to general intelligence, impulse control, neophobia, motivation, and exploration are optimal for different working roles (Bray, Sammel, Seyfarth, Serpell, & Cheney, 2017). Behavioral assessments conducted at or after six months of age have been able to capture temperament characteristics associated with success in various working programs. For military, homeland security, and law enforcement, canines scoring high on levels of search focus, sharpness, prey drive, and aggression are more likely to succeed (Bray et al., 2017). According to Slabbert and Odendaal (1999) police dog training agencies like the South African Police Service Dog Breeding Centre experience significant attrition; up to 70% of the purpose-bred dogs at their facility were not suitable for use in the field. For service dogs, guide dogs for the blind specifically, high scores of obedience, tractability (trainability), and low scores of reactivity, hyperactivity, aggression, distraction, and anxiety are characteristic of program success. Service dog agencies reportedly experience between 30-70% attrition, driving up estimated costs of training a single service dog to between $20,000 and $50,000 (Berns et al., 2017; Bray et al., 2017). For detection canines, high scores on obedience, activity, and concentration tests are associated with program success (Bray et al., 2017).

Detection training agencies, both private and government-subsidized, are reported to have approximately 50% attrition between initial procurement (or breeding) to sale as a detection dog at a certifiable quality of performance (Thompkins et al., 2016). A partially trained detection canine can sell for upwards of $8,000, and a fully trained “finished” canine team can sell for upwards of $50,000. At AU it costs CPS approximately $3500 per year to keep a dog on the premises, whether or not it is in training. The development and training of each detector dog takes approximately two years, one year at CPS and at least one year of additional training on client-specified odorants at an intermediate sale location. The expense and loss of revenue associated with these high attrition statistics cannot be overstated.

The challenge of attrition provides a multidisciplinary motivation to study convergent aspects of the dogs’ innate temperament, development, and training, and to create predictive procurement and performance models with whatever tools are available – be they functional neuroimaging techniques (Berns et al., 2017; Lazarowski, Waggoner, & Katz, 2019), cognitive-behavioral psychometric test batteries (Bray et al., 2017; MacLean & Hare, 2018), behavioral phenotyping and genetic assays (Overall, Dunham, & Juarbe-Diaz, 2016) and/or training facility development and performance records (Lazarowski et al., 2018). A multidisciplinary approach to this applied research will inform purchase and breeding decisions, as well as program operations regarding the development and maintenance training of these valuable dogs.

Awake, unrestrained fMRI can be a powerful way to quantify working dogs’ cognitive processing of olfactory, visual, and auditory stimuli. With a robust method of scanner acclimation, the limitations of its utility are bound only by the creativity of the researchers' questions and experimental designs. fMRI of the brains of awake, unrestrained working dogs while they are engaged in stimulus processing will allow for the identification of brain activity characteristics that may be associated with those dogs' level of working performance (odor processing efficiency, memory, impulse control, reward processing, g factor). This project is aimed at increasing the efficiency and reducing the stress of preparing these dogs to engage in awake, unrestrained fMRI.

By using working dog populations for these functional experiments, you tap into a set of experimental controls that are beneficial for the study of learning and training method. When using pet dogs, the study of learning in the context of dog training can be extremely variable with difficult-to-isolate training parameters and hard-to-match conditions across subjects. Pet dog studies are confounded by breed differences and unknown subject histories. Working dogs, on the other hand, tend to have controlled genetic and training histories, optimal for studies with this motivation. Not only are the genetics better controlled for when using working dog program populations, the training and socialization histories are also more consistent. These seemingly innocuous details make a huge impact in the variability of a canine cognition or training study. With these controls in place, the true consequence of an experimental manipulation can be better supported.

Why Study Training Method?

A variety of training methods exist, ranging from friendly and innocuous to aversive and suppressive. Modern dog trainers are moving away from traditional means of training through coercion and punishment, (e.g., shock collars, physical correction) due to performance decrements in the form of global behavioral suppression, handler avoidance, fear/pain-induced aggression, and welfare concerns (Haverbeke, Laporte, Depiereux, Giffroy, & Diederich, 2008; Schilder & Van Der Borg, 2004). Walker et al. (2006) reported findings in support of positive reinforcement for training odor discrimination tasks; their dogs could detect n-amyl acetate in concentration thresholds 30 to 20,000-fold lower than dogs trained on the discrimination using electroshock and water deprivation.

One particular method of positive reinforcement training, called clicker training, is being adopted by pet and working dog trainers alike (Alexander, Friend, & Haug, 2011; Johnen, Heuwieser, & Fischer-Tenhagen, 2013). All but one of the research groups utilized clicker training in their scanner acclimation protocol. The method works by associating a stimulus (the ‘tic-toc’ sound of a clicker) with the immediate delivery of a primary reinforcer, something the animal innately desires (e.g., food, play, tactile, praise, etc.) (Pryor, 1999) Once associated in this way, the ‘click’ becomes a conditioned stimulus with a three-fold function: conditioned reinforcer, behavioral event marker, and temporal bridge. Feng, Howell, & Bennett (2016) published a comprehensive review of the efficacy and three-fold function of the clicker within the existing literature. According to the reinforcing hypothesis (Skinner, 1938), by association, the clicker becomes a secondary reinforcer by taking on the properties of the primary reinforcer with which it is paired. According to the marking hypothesis (Williams, Friend, Nevill, & Archer, 2004), the clicker emphasizes a moment of behavioral occurrence, and that added attention to the action facilitates learning. According to the bridging hypothesis, the clicker fills a temporal gap in time between occurrence of the behavior and receipt of the primary reinforcer.

Although it is used extensively in applied settings (Feng, Howell, & Bennett, 2018), the method has yet to achieve the empirical support that matches its purported anecdotal utility; that said, the literature base is small. Only one out of five studies supported faster acquisition of behavior with the clicker and food compared to food alone. Langbein et al. (2007) trained a shape discrimination behavior in dwarf goats and found this to be the case. Conversely, McCall and Burgin (2002) and Williams et al. (2004) trained nose-target tasks in horses using food, or clicker and food training paradigms, both reporting a non-significant difference in the speed of behavior acquisition. Smith and Davis (2008) also found a nonsignificant difference in rate of behavior acquisition between training paradigms in the training of a nose-target task in pet dogs. They did report, however, that the clicker and food group experienced greater resistance to extinction of their nose-target behavior, compared to food-only controls. Chiandetti et al. (2016) implemented training under three conditioning paradigms: clicker and food, spoken word and food, and food alone. They compared behavior acquisition rates and generalization ability across the three groups and found no significant between-groups differences in either measure. More research in this area is warranted to disentangle if, and when, training with conditioned signals such as the clicker is appropriate. It is important to expand this literature base of applied training in dogs to studies that assess methods as they relate to specific working objectives, as well as how the different training paradigms interact with underling temperament characteristics.

Training for Canine fMRI

The goal behavior for awake and unrestrained scanning is for the dog to mount the gantry (scanner table) via a ramp, enter the scanner bore (tube or tunnel-like opening of

MRI), and position his head/muzzle in the radiofrequency coil (e.g., knee, SENSE Flex, neck). The dog must do this in a prone down position and remain relatively motionless for the duration of a scan; anatomical scans last from several seconds to several minutes, and functional scans last from three to six minutes. The dog must be capable of repeating this performance with short (approximately 1-minute breaks) for up to 8 scans. An ideal training protocol would produce a dog that is fully acclimated for data collection at first exposure to the magnetic resonance environment. I posit that the observed difficulty of transferring the stationing behavior from the mock to actual MRI environment stems from how the existing protocols address desensitization (habituation) to the scanner noise and generalization of the final stationing behavior prior to scanning. Refining the method of scanner acclimation in the proposed ways could heighten the quality and quantity of data collected.

Desensitization. Broadly, desensitization is getting an animal used to a new stimulus by gradual exposure to it (Ramirez, 1999). Desensitization can be sub-classified as a passive or active process, referred to as habituation (or extinction) and counterconditioning, respectively. Desensitization as habituation refers to the passive exposure to a stimulus, which over time, results in decreased response to that stimulus (Clay, Bloomsmith, Marr, & Maple, 2009) or, decreased response to repeated presentation of a stimulus unaccompanied by reinforcement (Pavlov, 1957). Desensitization as counterconditioning refers to the "active pairing of a positive stimulus [reinforcement] with a negative event, causing the negative event to lose its ability to adversely influence behavior" (Clay et al., 2009). Said another way, counterconditioning is the addition of an unconditioned stimulus that elicits a response antagonistic to the existing response (Goldstein, 1969). In both cases of passive and active desensitization, fear-inducing stimuli may be presented in a progressive approach paradigm, wherefore the animal is exposed to presentations of the stimuli in ranked order of fear aroused, with the least fear-evoking stimulus level being presented first (Goldstein, 1969). Sensitization is the direct opposite of desensitization, wherefore an enhanced response to an otherwise neutral stimulus is observed after repeated exposure (Ramirez, 1999), and by making the context aversive.

The approximately 95 dB scanner noise and vibration inside of the scanner bore can be extremely jarring. In all of the existing protocols, desensitization to the scanner noise occurs in conjunction with the shaping sessions of the stationing behavior, passively, as ambient noise (Andics et al., 2014; Berns et al., 2013; Cuaya et al., 2016; Jia et al., 2014). Trainers must place great emphasis on desensitizing the dogs to the scanner environment and its operations, but they all currently do so under the extinction and habituation paradigms of desensitization. Jia et al. (2014) produced a training manual recommending dogs be acclimated to the MRI scanner noise during initial stages of stationing and mock MRI training; the following is an excerpt from the supplemental materials, describing how to gradually increase the volume over the course of a shaping session. “1. Increase level with success in training events 2. Decrease level with failures in training events 3. Decrease level at the start of progression to a new training step 4. Decrease level slightly if needed at beginning of new session 5. Decrease level slightly if dog appears stressed or performance is disturbed by sound (but, again increase gradually with every successful training event).” Without explicit statement, it is assumed that other research groups conduct habituation to the scanner noise in a similar passive exposure paradigm.

Goldstein (1969) compared passive (extinction) and active (counterconditioning) strategies with and without progressive approach on the runway traversal behavior in 10 Cebus monkeys. The neophobic primates were exposed to a teddy bear in different desensitization training paradigms post-acquisition of the runway traversal behavior. He found that above all other treatments, counterconditioning and progressive approach produced significant reductions in time to traverse the runway with bear present, as well as significant reductions in avoidance distance to the bear within the apparatus. Clay and colleagues (2009) examined fear behavior to daily husbandry tasks in 18 rhesus macaques, pre- and post-treatment of habituation (control), husbandry training (habituation and operant conditioning), and active desensitization (counter-conditioning). They found significant reductions in fear behavior, characterized as cringing towards humans, in response to the active desensitization treatment, but not in response to husbandry training or simple habituation procedures. In both studies, control subjects in the simple habituation exposure paradigms became sensitized to the test stimuli (increased minimum avoidance distance and incidence of human-directed cringe behaviors) at test. As the scanner playback is a naturally aversive stimulus, these findings suggest a need to conduct active desensitization to the scan noises outside of the operant conditioning sessions in order to improve animal welfare (stress levels) during training as well as behavioral outcomes.

Aversive context aside, ambient noise is also simply that, noise in the training process which can retard learning. Ramirez (1999) and Heidenreich (2012) echo that sentiment, that during the shaping of a new behavior, minimization of distractions and focus on the task facilitates rapid skill acquisition. This is experimentally supported by Maes and Groot (2003), who examined the effects of noise on the acquisition of an operant discrimination task. They reported significant decrements in acquisition of steady-state behavior of rats trained under a white noise condition as compared to rats trained in silence; rats in both conditions learned to lever press in the presence, but not absence, of a visual stimulus Specifically, they observed limitations of learning the actual discrimination task (S^- , the absence of a visual stimulus, never occasioned a response-inhibiting effect), as well as non-specific suppression of behavior due to the presence of noise during testing and training. They attributed these performance decrements in the white noise conditions to over-arousal and misdirection of attention, resulting in the elicitation of behavior incompatible with the task being trained.

The first potentially beneficial difference of this scanner acclimation training protocol is the desensitization and counterconditioning of the scan noise stimuli. This training will take place during weekly Auditory Exposure (AE) sessions, outside of operant conditioning sessions of the stationing behavior. In these dedicated sessions a positive conditioned emotional response (CER) to the scanner noise will be installed using a short-delay classical conditioning paradigm, pairing reinforcing unconditioned stimuli (e.g., feeding, play) with progressive approximations of the various scanner noises, up to their full 95 dB volume. These AE sessions should effectively transform the naturally aversive scan noise stimuli into a conditioned reinforcer, a predictor of salient activities like feeding or play. Upon reintroduction of the scan noise stimuli in the last stages of the shaping protocol, the aversive characteristics of the stimuli should be null or significantly dampened. By this logic, the proposed separation of operant conditioning and desensitization should facilitate faster stationing behavior acquisition (by removing naturally aversive and distracting stimuli during shaping sessions) and reduce the likelihood of sensitization to MR operations during data collection (by using an active counterconditioning paradigm). Globally, this manipulation could enhance the quantity and fidelity of the data collected.

Generalization. Generalization, as defined by Rilling (1977) in the Handbook of Operant Behavior, is "the continuum along which a particular property of stimulus is varied during a test for stimulus control." As it is understood by animal trainers, generalization is the identification of a characteristic or set of characteristics across events, consequences, or objects, such that the common characteristic(s) may guide an animal's response in a new context without explicit retraining of that response in the new context (Ramirez, 1999). It applies to conditioned behavior as well as abstract concept learning (sameness, difference), and suggests that experience with more unique exemplars during training translates to better performance in test settings with novel stimuli (Daniel, Wright, & Katz, 2015). In both applied training and experimental settings, there is a known performance decrement of operant behavior when it is trained in one context and tested in another, referred to in the scientific literature as a "generalization decrement" or "context-shift effect" (Pearce & Pearce, 1997; Ramirez, 1999)

As an illustration of this phenomenon, Perkins and Weyant (1958) trained rats to traverse a runway for a food reward. One day after training, rats were tested on the same runway either in its original state, or color-altered (e.g., black instead of white). Runway traversal performance depreciated (slow running speed) for the rats tested in the new color context, but not in the original color context (fast running speed). There is a large literature on how a shift of context enhances variability in behavior, and the contexts for which that may be detrimental or beneficial (see (Neuringer, 2002) for review).

All existing scanner acclimation protocols transition dogs directly from the mock scanners, or wherever the stationing behavior was initially conditioned, to the real MR scanner, with little regard for retraining the desired behavior in different environments. Consequently, generalization decrements are observed in the stationing behavior at data collection; these performance decrements are realized by the high levels of data attrition (and subject attrition) due to excessive motion (Huber & Lamm, 2017). Use of the MR facility as a training space burdens researchers with mounting scanner operation costs and logistical scheduling issues for time with the magnet for each scanner dog; it would therefore be ideal to condition the finished stationing behavior without the need of the MR-environment for training sessions.

In zoological settings, long-duration husbandry behaviors are trained to prepare the animal for cooperative, low-stress medical procedures (i.e., x-rays, ultrasounds, injections, etc.). To generalize these behaviors, they are retrained in different contexts: in different locations, with different props, by different trainers (Heidenreich, 2012; Ramirez, 1999). When the auditory, visual, or tactile sensations of a medical procedure cannot be exactly replicated in a training context (e.g., an injection), the trainer will teach the animal a history of novelty in performance of the behavior (e.g., variety of dissimilar tactile sensations - brush, pinch, tickle, poke, etc. - on presented limb). When an animal acquires a history of having the same contingency presented in multiple stimulus rearrangements and settings (i.e., is taught to accept variability)—that the procedure does not sound, look or feel the same way every time, the conditioned behavior becomes more durable, as the animal does not startle when exposed to different settings and stimuli (personal communication, Ramirez, 2015). Characteristics of the environment that may exist outside of our perceptual experience may be highly perceptible and relevant to the dogs. For the sake of simplifying the training protocol and cutting expense associated with training at the MR facility, the tradeoff is not being able to exactly replicate the MR environment (magnetic field, ambient frequency, etc.). When trainers are not able to exactly replicate a procedure, as will be the case with our MR scanner dogs, the concept of variability can theoretically be emphasized.

The second gross manipulation of scanner acclimation training I would like to assess is the effect of generalization of the stationing behavior across multiple dissimilar settings prior to data collection in the MR environment. As few as five transfer sessions of the finished stationing behavior in different locations (academic building, outdoors, industrial warehouse, etc.), could significantly improve the fidelity of data collected at first exposure to the MR environment.

The goal of this project is to enhance capabilities to perform fMRI in awake and unrestrained dogs. With refined scanner acclimation training technique, the transferability of the stationing behavior to the MR environment for data collection at first exposure, the length of the stationing time, as well as the stillness quality of the behavior, can be improved. The proposed study will measure the impact of two gross manipulations of existing scanner acclimation protocols on MR transfer performance and behavior stillness quality: (1) separation of desensitization (habituation to the scanner noise) from operant conditioning (shaping the stationing behavior), and (2) training with generalization across dissimilar locations. Four Auburn University (AU) Canine Performance Science (CPS) detection canines with controlled genetic and training histories will be used. The dogs will experience separate desensitization (desensitization to noise separate from shaping of stationing), and transfer testing (five distinct location transfers of final stationing behavior prior to data collection at the MRI facility). All shaping, desensitization, and transfer sessions will be video recorded and analyzed. Quantification of absolute and relative (x, y, z), rotational, and translational motion correction time series parameters will be computed using FMRIB Software Library (FSL) MCFLIRT pre-processing. These time series parameters will serve as the dependent measure of behavior stillness quality, and will be compared against those of four ideally-performing, previously trained AU scanner dogs who have undergone concurrent desensitization (desensitization to noise during shaping of stationing) and no transfer testing.

Methods

Subjects

The dogs used in this study were four odor detection canines from the Canine Performance Sciences (CPS) program at Auburn University in Auburn, Alabama, USA. The dogs were of varying age, gender, and program disposition (3-6 years, 3 females). CPS dogs are socialized by puppy developers until six months of age, at which point they are transported to training centers at Florida and Georgia prisons for their first experience with odor detection training. At ten months of age the dogs are transported back to the CPS training facility for purpose-specific detection training. All dogs are evaluated by CPS at three, six, and ten months of age on their hunt (odor detection) and environmental (emotional reactivity) performance. Program disposition decisions are made at the eleven-month time point, and include: sale dog, breeder, research/prison teaching assistant (TA), adopted out. Dogs may be placed in the research or adopt out categories on behalf of medical or behavioral (environmental soundness) issues. Ethical approval for the study was obtained from the Auburn University Institutional Animal Care and Use Committee.

The comparison group consisted of four ideally-performing dogs scanned in a previous fMRI experiment at the AU MRI Research Center: functional MRI of the olfactory system in conscious dogs (Jia et al., 2014). These four dogs were Labrador Retrievers (1-5 years, 4 males) procured and trained by CPS with similar training histories to the above-stated participating dogs. The first data collection session was analyzed for each dog; each session was comprised of 5 to 15 structural (T1-weighted MPRAGE) and functional (EPI stimulus and Resting State) scans, brain extracted, and pre-processed to derive mean absolute and relative displacement values for each functional run.

Apparatus

Over the course of the protocol multiple stimuli and apparatuses were introduced at specific stages and for specific intervals. These materials were easily and inexpensively procured.

MR-compatible chin rest apparatus. The chin rest provides head placement information to the dog, as well as stabilizes the muzzle. The behavior was started on a stack of towels and was generalized to a foam chin rest made out of rolled exercise mat material. The rolled foam chin rest apparatus is designed to fit each individual dog's muzzle; my foam chin rest measured 6” wide with a 4” wide by 2.5” deep notch cut out of the center. The chin rest was secured with a strip of heavy-duty velcro to either a 2”x4” plank of wood for open environment training, or the plywood platform for mock MRI training.

Scan audio. The entire MRI transfer test protocol was run on a phantom in the 3T magnet at the AU MRI Research Center. Recordings were obtained of scanner baseline, shimming, localizer, GRE Field, MPRAGE, EPI, Multiband EPI, and DTI sequences via the microphone and audio recording application of an iPhone 6S Plus through the open door of the scanner suite. Volume level of audio playback during training sessions was determined via a decibel meter phone application (i.e., Decibel 10th).

Mock MRI. The mock MRI was comprised of a tunnel (proxy MRI bore), a plywood platform, an acrylic mock radio frequency (RF) receiver coil, a foam chin rest apparatus and a speaker system (see below for stationary vs. portable materials). Buffer pads affixed to the interior of the mock RF coil provided padding against the dogs’ ears and additional cranial stabilization/placement feedback.

Stationary Mock MRI. The stationary mock MRI scanner was constructed out of a 70 cm diameter cardboard concrete form Sonotube cut to a length of six feet and elevated on a three-foot high folding table. The mock bore was stabilized on the table with two plywood braces. The stationary mock MRI speaker system was a Philips surround sound home theatre system, capable of over 150 dB audio playback.

Portable Mock MRI. The portable mock MRI scanner was a regulation agility tunnel, stabilized with sand bags. The portable mock MRI speaker system was a Shark Bluetooth speaker, capable of up to 85 dB audio playback.

Additional materials. Additional materials included basic handling materials (e.g., leash, collar, crates and vehicle for transport), rewards (e.g., ¼" soft training treats, chuck-it ball), and data collection equipment (e.g., stopwatch, video camera, tripod). Training session worksheets were used for analog coding of the progression of each training session at each session level (Appendix B).

Procedure

Timeline. Data collection for two cohorts of two dogs each spanned from December 2017 to May 2019, December 2017 to August 2018 for the first cohort (Ice and Beaufort), and September 2018 to May 2019 for the second cohort (Amanda and Annie). All dogs received the same training regimen of separate Auditory Exposure and Stationing training sessions and five transfer locations (Figure 1). Auditory Exposure and Stationing training sessions occurred concurrently, in the same week. Depending on the session level, training and testing took 25 to 75 minutes per week, per dog: one 10-minute Auditory Exposure session and two or more 5 to 30-minute Stationing sessions. During transfer testing dogs executed several bouts of a 5-minute motionless down/stay and chin rest in a portable mock MRI (bore, radiofrequency coil, 90+ dB audio, ear padding) in five dissimilar locations. Transfer sessions occurred approximately once per week for 30 minutes, over five weeks. During MRI testing dogs executed several bouts of the final stationing behavior during a 60-minute session of structural and functional data acquisition in a real MRI scanner.

Stationing Behaviors. Throughout training and testing a chin rest was the behavior of focus. A chin rest is the dog touching his chin to an object's surface following some cue to target (i.e., rest his chin) to that surface. That cue to target can be physical (e.g., gesture, lure), verbal (e.g., spoken word “rest”), or an object (e.g., access to the chin rest itself). Fluent performance of the chin targeting behavior was critical to limiting head motion. In this protocol, the chin rest behavior was conditioned, maintained, and generalized to occur in multiple contexts (different rest apparatuses, in multiple locations) with increasing target duration (up to five minutes). Additionally, strong performance of behaviors down and stay were conditioned and maintained, as well as good stimulus control over the release cue “Okay”, the conditioned reinforcer and behavioral event marker ‘click’, and the Keep Going Signal (KGS) “good”(Ramirez, 1999). For auditory exposure, progression through the sessions was based on week number. For stationing sessions, a level-specific performance criterion (e.g., at least eleven-second duration of chin targeting), had to be met before I advanced the dog to the next session level in that training phase (Appendix A). Otherwise, that level was repeated.

Reinforcement. A note on reinforcement – Some dogs are inherently more motivated by food, whereas others are more motivated by play or praise (Gerencser, Bunford, Moesta, & Miklosi, 2018). In “click-then-treat” (C/T), the T does not necessarily mean food treats, rather it refers to the reward procedure, whatever that was for each dog at that particular point in its training (i.e., mark and reinforce). Although food rewards lended themselves to higher rates and stiller repetitions of behavior, whatever the dog preferred was used initially; in many cases that was high-motion play (e.g., ball, tug). In those cases, as the chin target behavior became more resilient against distraction and duration (i.e., accumulated behavioral mass (Craig, Nevin, & Odum, 2014)), I transitioned to using non-preferred food rewards and reserved toy play for long-duration or chained bouts of chin rest performance. Dogs received their morning ration at the regularly scheduled feeding time. Their afternoon ration was often suspended until after the training sessions to increase motivation for food reinforcers.

Auditory Exposure. These sessions constituted passive exposure and active classical counter-conditioning of a positive Conditioned Emotional Response (CER) to MRI scanner noise; the scanner noise was established as a stimulus predicting the access to toy play or food rewards. Exposure sessions occurred once per week for approximately ten minutes. Passive Exposure (PE) sessions were ambient, 40-70 decibel (dB) exposures to MRI scanner noises. The dogs were transported to a familiar exercise area and allowed to walk around while audio playback was quietly audible at the session-specified volume through a portable Bluetooth speaker. Three PE sessions of ten-minute playback of scanner noise were conducted, once per week for three weeks (PE_1 40-60 dB, PE_2 65 dB, PE_3 70 dB). Active Exposure (AE) sessions utilized a standard classical conditioning paradigm. AE sessions were conducted after three PE sessions. Each dog was brought to a familiar indoor training room and run through ten trials of a short-delay classical conditioning procedure (Figure 2). Scan audio was played at the session-specified volume for ten seconds. After ten seconds elapsed, the dog was engaged in 20 seconds of toy-play (or continuous food reward) while the scanner noise was still audible. After 20 seconds of play, the toy was retrieved from the dog and the noise was paused. I then waited with the dog (in silence, dog without toy/food) for ten seconds. After this delay, the next trial was started. Ten trials were conducted per session. Volume was incrementally increased over sessions. AE sessions were conducted once per week for twelve weeks (AE1 45 dB, AE2 50 dB, AE3 55 db, AE4 60 db, AE5 65 db, AE6 70 db, AE7 75 db, AE8 80 db, AE9 85 db, AE10 90 db, AE11 100 db, AE12 > 100 db).

Stationing. Stationing sessions were divided into two phases: Open environment and Mock MRI. After the chin-to-object target was learned, durations were increased on a percentile schedule of 10% increases. As new elements and pieces of equipment were added into the training context, certain criteria of the behavior (e.g., duration) were temporarily relaxed. In the stationing sessions, a nose-touch behavior was first trained to a folded towel, and then a chin rest on a folded towel. That chin rest behavior was generalized to occur in a foam chin rest and gradually built to a five-minute bout duration. Simultaneously, robust down and stay behaviors were conditioned and maintained. Those behaviors were then conditioned to occur in an enclosed space (i.e., tunnel) and at a 3' elevation. The dogs were then acclimated to the head enclosure (mock human extremity RF coil). Ear padding was introduced, and scan audio was (re)introduced in the context of the stationing behavior. Each dog was ultimately able to perform a robust chin rest with head and body enclosed at a 3' elevation, with ear padding and scan audio playing at 90 + dB, for at least five minutes bouts (Table 2). The steps of the stationing session levels are described below and summarized in Table 2.

1. Charge the clicker. This session installed an association between the 'tic-toc' of the clicker and the dog's primary reward (e.g., food) while capturing attention. Rapid repetitions of C/T events for attention (body orientation towards and/or eye contact) were conducted. This session occurred once for approximately three minutes, by the end of which each dog was showing signs of the clicker being established as a conditioned reinforcer—orientation towards the trainer and emission of reward-seeking behaviors upon hearing the click.

2. Capture chin target to towel. With the dog standing, sitting, or in a down, the trainer C/T the dog for looking at, then investigating (i.e., sniffing) the towel. Once the beahvior was occurring reliably, the trainer C/T for any nose-to-towel, and then chin-to-towel contact. Towel contact duration was built to two seconds. This session was repeated until the dog would chin target for two seconds; each session lasted approximately five minutes. If a dog was struggling with this step, the trainer (a) rubbed a treat on the towel to get the behavior started via a food odor lure and/or (b) taught the dog a nose target (nose-to-palm), then a chin target (chin-to-palm), and then cued for a chin target over the towel.
3. Chin-to-towel target with short duration and addition of cue. With the dog standing, sitting, or in a down, the trainer C/T for one to two seconds of chin contact to the towel. "Rest" was said while the dog was touching or about to touch the towel. After many repetitions of one to two second bouts, the trainer C/T after three, then four, then five, then seven seconds. This session was repeated until the dog would chin target for seven seconds; each session lasted approximately five minutes. The bout lengths of each chin rest were varied so that the next repetition was not always longer than the previous repetition (i.e., 1", 1", 3", 1", 5", 2", 6", 4", 1", 2", 7", instead of, 1", 1", 1", 1", 2", 2", 3", 4", 5", 6", 7").
4. Chin rest on towel in a down and addition of distraction. With the dog in a down, the trainer cued "rest" and C/T for one to five seconds of chin-to-towel contact. Gradually the trainer added visual and acoustic distractions in the form of

moving her hands and feet (e.g., knock on ground, wiggle fingers, shuffle foot, etc.). Chin-to-towel contact duration was built to eleven seconds. Increments were 1”-5”, 6”-7”, 8”, 9-10”, 11” +. This session was repeated until the dog would chin target for eleven seconds; each session lasted approximately five minutes.

5. Chin rest on towel with distance. With the dog in a down beside a folded towel or stack of folded towels, the trainer cued “rest” and C/T for one to three seconds of chin-to-towel contact. The trainer then cued the behavior from progressively farther away (i.e., sitting on ground, kneeling, standing). Chin-to-towel contact duration was built to sixteen seconds. Increments were 1”-3”, 4”-8”, 9”-11”, 12”-14”, and then 16” +. This session was repeated until the dog would chin target for at least sixteen seconds; each session lasted between five and ten minutes.
6. Chin rest on towel with increasing duration and distance. With the dog in a down beside a folded towel or stack of folded towels, the trainer cued “rest” and C/T for one to eleven seconds of chin contact. Chin-to-towel contact duration was built to 26 seconds. Increments were 1”-11”, 12”-16”, 17”-19”, 21”-23”, 26” +. This session was repeated until the dog would chin target for at least 26 seconds; each session lasted between five and ten minutes.
7. Introduce foam chin rest. The trainer C/T for any investigation (i.e., sniffing, close proximity, orientation towards) of the foam chin rest apparatus. After several reinforced investigations of the apparatus, the trainer cued “rest” and C/T for one to ten seconds of chin contact. Duration was built to 40 seconds. Increments were chin rest for 1”-10”, 11”-21”, 23”-31”, 40” +. This session was

repeated until the dog would chin target for at least 40 seconds; each session lasted between five and fifteen minutes.

8. Chin rest in foam chin rest with increasing distraction and duration. With the dog in a down beside the foam chin rest, the trainer cued "rest" and C/T for 1"-23" of chin contact. Gradually the trainer added visual and acoustic distractions. Duration was built to 73 seconds, with and without distraction. Increments were 1"-23", 26"-31", 34"-45", 50"-60", and 73" +. This session was repeated until the dog would chin target for at least 73 seconds; each session lasted between five and fifteen minutes.
9. Introduce bore and elevation with reduced duration. The entire first session was conducted with the mock bore on the ground. The trainer cued the dog to enter the tunnel and lie down on the platform, C/T. The trainer then cued the dog to "rest" and C/T for any duration of chin targeting to the foam chin rest inside the bore on the ground. Subsequent sessions were conducted with the mock bore elevated 3'. The trainer invited the dog to jump or lifted the dog into the elevated bore, C/T. The trainer then cued the dog to lie down, C/T. The trainer then cued the dog to "rest" and C/T for one to twelve seconds of chin contact to the foam chin rest in the elevated bore. This session was repeated until the dog would chin target for at least sixteen seconds; each session lasted between five and fifteen minutes.
10. Elevated chin rest with increasing duration. The trainer invited the dog to jump or lifted the dog into the mock bore and cued the dog to lie down, C/T. The trainer then cued the dog to "rest" and C/T for one to twelve seconds of chin

targeting to the foam chin rest in the elevated bore. Duration was built to 60 seconds. Increments were 1”-12”, 16”-23”, 26”-45”, 60”+. This session was repeated until the dog would chin target for at least 60 seconds; each session lasted between five and fifteen minutes.

11. Introduce mock radiofrequency (RF) coil with no elevation and reduced duration. While seated on the ground beside the mock RF coil and foam chin rest, the trainer C/T the dog for any investigation (i.e., sniffing, close proximity, orientation towards) of the apparatus. The trainer then cued the dog to “rest” and used a nose touch or food lure to guide the dog’s head into and through the mock RF coil onto the foam chin rest and C/T for one to five seconds of chin contact. Duration was built to 30 seconds. Increments were chin rest for 1”-5”, 6”-12”, 16”-26”, 30”+. This session was repeated until the dog would chin target through the mock RF coil for 30 seconds; each session lasted between five and fifteen minutes.
12. Elevated chin rest in mock RF coil. With the mock RF coil and foam chin rest inside the mock bore, the trainer invited the dog to jump or lifted the dog into the bore. The trainer cued the dog to lie down and “rest”, and C/T for one to five seconds of chin contact. Duration was built to 50 seconds. Increments were 1”-5”, 6”-12”, 16”-26”, 28”-37”, 50” +. This session was repeated until the dog would chin target to the foam chin rest through the mock RF coil in the elevated bore for 50 seconds; each session lasted between five and fifteen minutes.
13. Elevated chin rest in mock RF coil with increasing distraction and duration. With the mock RF coil and foam chin rest inside the mock bore, the trainer invited

the dog to jump or lifted the dog into the bore. The trainer cued the dog to lie down and “rest”, and C/T for one to twelve seconds of chin contact. Gradually the trainer added visual and acoustic distractions. Duration was built to 100 seconds (1’40”) with and without distraction. Increments were 1”-12”, 16”-37”, 41”-60”, 66”-88” (1’6”-1’28”), 100” + (1’40” <). This session was repeated until the dog would chin target for 100 seconds; each session lasted between five and fifteen minutes.

14. Introduce ear padding, duration initially reduced. The trainer lifted or invited the dog to jump into the bore, cued “down,” outfit the dog with ear padding, and C/T for any duration of tolerating the ear padding without excessive movement. The trainer cued “rest,” and C/T for one to five seconds of chin contact. Duration was built to 60 seconds. Increments were 1”-5”, 6”-26”, 28”-45”, 60” +. This session was repeated until the dog would chin target in the mock bore with ear padding for 60 seconds; each session lasted between five to fifteen minutes.
15. Elevated chin rest in mock RF coil with ear padding and increasing duration and distraction. The trainer lifted or invited the dog to jump into the bore, cued “down” and “rest,” outfitted the dog with ear padding, and C/T for one to twelve seconds of chin contact. Gradually the trainer added visual and acoustic distractions. Duration was built to 107 seconds. Increments were 1”-12”, 16”-37”, 41”-60”, 66”-88”, 107” +. This session was repeated until the dog would chin target in the mock bore with ear padding for 107 seconds; each session lasted between five to fifteen minutes.

16. Introduce scanner noise. The trainer lifted or invited the dog to jump into the bore, cued “down” and “rest,” and outfitted the dog with ear padding. Scan audio was played at a barely audible volume between 0-40 dB and the trainer C/T for one to twelve seconds of chin contact. Duration was built to 107 seconds. Increments were 1”-12”, 16”-37”, 41”-60”, 66”-88”, 107” +. This session was repeated until the dog would chin target in the mock bore with ear padding and up to 40 dB scan audio for 107 seconds; each session lasted between fifteen to thirty minutes.
17. Build duration to 2 minutes 30 seconds with increasing distance. The trainer lifted or invited the dog to jump into the bore, cued “down” and “rest,” and outfitted the dog with ear padding. Scan audio was played between 41-70 dB and the trainer C/T for 1 to 37 seconds of chin contact. Gradually the trainer added distance, moving around the mock bore, out of sight then back into sight of the dog. Duration was built to 142 seconds. Increments were 1”-37”, 41”-88”, 97”-107”, 117”-129”, 142” +. This session was repeated until the dog would chin target in the mock bore with ear padding and 41-70dB scan audio for 142 seconds, with and without distraction and distance; each session lasted between fifteen to thirty minutes.
18. Build duration to 4 minutes. The trainer lifted or invited the dog to jump into the bore, cued “down” and “rest,” and outfitted the dog with ear padding. Scan audio was played between 60-90 dB and the trainer C/T for 1 to 107 seconds of chin contact. Duration was built to 240 seconds. Increments were 1”-107”, 117”-142”, 156”-189”, 208”-229”, 240” +. This session was repeated until the

dog could chin target in the mock bore with ear padding and 60-90 dB scan audio for 240 seconds, with and without distraction and distance; each session lasted between fifteen to thirty minutes.

19. Build duration to 5 minutes. The trainer lifted or invited the dog to jump into the bore, cued “down” and “rest,” and outfitted the dog with ear padding. Scan audio was played between 80-110 dB and the trainer C/T for 1 to 120 seconds of chin contact. Duration was built to 300 seconds. Increments were 1”-120”, 129”-189”, 208”-229”, 252”-277”, 300” +. This session was repeated until the dog would chin target in the mock bore with ear padding and 80-110 dB scan audio for 300 seconds, with and without distraction and distance; each session lasted between fifteen to thirty minutes.

Transfer. Upon reaching final criterion of the stationing behavior in the mock MRI training location (five-minute down-stay and chin rest in mock bore and mock RF coil while wearing ear padding, with scanner noise playing at 80-110 dB), the dogs underwent five distinct location transfer (generalization) sessions. During these transfer sessions the dogs stationed to the above criteria in several indoor and outdoor locations that were as unique as possible, with different sights, sounds, and degrees of social distraction across settings (e.g., secluded grass field, quiet academic building hallway, busy academic building lobby, crowded bus stop, loud water treatment plant) (Ramirez, 1999). During these sessions the trainer sat on the ground beside the portable mock bore (an agility tunnel stabilized with sandbags, with the platform, mock RF coil, and chin rest inside), gestured the dog to enter the bore, cued “down” and “rest,” and outfitted the dog with ear padding. Scan audio was played at 80-85 dB. The dog was C/T for 1-30 seconds of stationing in the new location. Next, criterion duration was probed (C/T the dog at five minutes or when the dog broke). The latency between the time it took the dog to finish the 30 second set bout and reset itself in the chin rest for the longer probe bout was recorded. After the probe, the dog were cued to repeat bouts of one to five-minute chin rest repetitions for approximately 30 minutes. One 30-35-minute session was conducted in each the following locations, in the following order: Golden House Field, Thach Hallway, Student Center Bus Stop, Student Center Hallway, Water Treatment Plant. Once the dogs generalized the stationing behavior to criterion in the five distinct transfer locations, the dog was ready for data collection in the real MRI environment.

Test (MRI). Once the dogs accomplished the final stationing behavior in five distinct locations (five-minute motionless down-stay in portable mock bore with ear padding and scanner noise playing at 80-85 dB) they were scanned in the Siemens Verio open-bore 3T MRI scanner at the AU MRI Research Center. Each MRI data collection session took between 30 to 60-minutes. The dog was not physically restrained and was allowed to leave the bore at any time. For two of the dogs it was helpful to play audio of each over the console intercom prior to its initiation. The data collection session began with a localizer, followed by acquisition of high-resolution anatomical images to serve as a prescription reference using the 3D magnetization-prepared rapid gradient echo (MPRAGE) sequence with the following parameters: TR/TE of 35/5ms, matrix of 256x208x192 mm, for a 1-mm isotropic resolution. Following the anatomical scan, the fMRI scans (i.e., stimulus presentation and resting state) were conducted. Each functional image set scan acquired 200 temporal T2*-weighted image sets of the entire brain using a single-shot gradient recalled echo-planar imaging (EPI) sequence. An optimal TE = 29 ms was used for maximum sensitivity to blood oxygen level-dependent (BOLD) contrast, and other parameters included: TR = 1,000 ms, FA = 90 deg, in-plane matrix = 64 9 64, number of 3 mm thick slices = 14, voxel size = 3.0 9 3.0 9 3.0 mm3, for overall volume of view = 192 9 192 9 90 mm3. The localizer scan was approximately 10 seconds long and the MPRAGE and EPI scans were approximately 3 minutes and 30 seconds long. The dogs were given short breaks with their reward outside of the scanner between scans.

Data Analysis

Stationing Sessions. These sessions were video recorded and live scored. Each session was characterized by session level and session repetition (within the level). Several undergraduate research assistants and I coded the videos for session duration, step repetitions, rates of reinforcement, and bout durations. Bout duration averages, medians, and means were calculated for each session. Kappa reliability statistics were calculated for interrater agreement on session total step repetitions ($k=.848$, $p<.001$), maximum bout duration ($k=.854$, $p<.001$), and on whether or not the final step level was met in a given session ($k=.96$, $p<.001$).

Auditory Exposure Sessions. These sessions were video recorded and coded for time spent engaged in the conditioned response (freeze) during the conditioned stimulus (CS) period of a trial compared to the delay period of a trial. The durations were summed across trials and divided by 100 (ten trials of ten-second CS or Delay periods) to calculate CS Percent CR and Delay Percent CR for each session for each dog.

Transfer Sessions. These sessions were video recorded and coded for bout durations. Latencies between the first and second bouts in each location were also calculated and compared.

fMRI Motion Analysis. Manual brain extraction of functional EPI and structural MPRAGE scans was accomplished in Mango. Functional data processing was carried out using FEAT 6.0 FSL. Each brain-extracted run was registered to the dog's own structural image, then to a standard space canine brain atlas using FLIRT (Paxinos et al., 2012). Mean absolute and relative displacement were then derived using MCFLIRT (Jenkinson, Bannister, Brady, & Smith, 2002). Absolute displacement compares displacement between the current volume, n, and volume N/2 (i.e., volume 100). Relative displacement compares between the current volume, n, and volume n-1. A functional brain volume is comprised of a series of 2D images, collected at each TR. 200 volumes were collected during these EPI scans.

Results

The mean number of repetitions of each session level is listed in Table 2. The complete training and testing protocol required about 14 hours (*M* = 13.55 hours, range 12-16 hours) and consisted on average of 90 sessions (range 87-93 sessions). Open environment training lasted an average of 4.38 hours (range 3-5 hours) and consisted on average of 38 sessions (range 25-50 sessions). Mock MRI training lasted an average of 5.4 hours (range 4.2-6.5 hours) and consisted of 35 sessions (range 30-37 sessions). Transfer was divided into five 30-minute sessions totaling 2.5 hours. Maintenance sessions at level 19 were conducted during transfer and are reflected in the complete training times above.

Auditory Exposure. Percentage of time engaged in the conditioned response (CR: freeze) was compared between the conditioned stimulus (CS: scan audio) and delay portions of all trials of the first nine sessions of training, collapsed across all dogs (top panel, Figure 3. Error bars are SEM. The bottom panel of Figure 3 compares percent CR during CS and delay for each dog, collapsed across all sessions. Annie failed to establish comparable levels of conditioned responding due to excessive panting during the sessions. In a two-way repeated measures ANOVA on percent CR with Session (1-9) and Component (CS, Delay) as factors, the main effect of component, $F(1, 3) = 9.12$, $p = .057$, session, $F(8, 24) = 1.4$, $p = .258$, and the interaction, $F(8, 24) < 1$, were not significant. When Annie is removed from the analysis, there is a main effect of component, $F(1, 2) = 23.38$, $p = .04$, but no main effect of sessions, $F(8,16) = 1.58$, $p = .209$ or the interaction, $F(8,16) < 1$.

Training and Transfer Sessions. The maximum durations of the four dogs trained in the protocol for the last three training sessions and the five different transfer locations is shown in Figure 4. All dogs met the max duration performance criterion and transferred at an equivalent max duration to the five locations, as supported by the following analyses. To test for stability, a one-way repeated measures ANOVA of the last three training sessions on max duration indicated performance was stable at the end of stationing training, $F(2, 6) < 1$, and over five minutes ($M = 311.9$ seconds, $SE = 2.4$). A one-way repeated measures ANOVA on max duration for the five transfer locations confirmed performance was also stable across these transfer sessions, $F(4,12) = 2.38$, $p = .11$, and over five minutes ($M = 325.1$ seconds, $SE = 13.6$). A one-way repeated measures ANOVA comparing max duration for training and transfer revealed no difference, $F(1,3) < 1$, and was over five minutes (M = 318.5 seconds, SE = 6.59). Two dogs (Ice and Beaufort) were able to station to the 5 min criterion in all transfer locations, and two dogs (Amanda and Annie) were able to station to the above criterion in 4/5 transfer locations (T2-T5). Three of the dogs transferred to the MRI scanner and demonstrated repeated bouts of the max possible duration (206 s). The one dog that did not transfer to the MRI scanner had a larger head than the other dogs and could not comfortably fit within the coil. This discomfort likely led to the dog not willing to participate in the scans.

fMRI Motion Analysis. Average *absolute* displacement by scan volume of the best scans of the new method dogs (Ice, Amanda, and Annie) was compared to the old method dogs (Eli, Tabby, Yancey, Yardley) (top panel, Figure 5). On average, new method dogs appear to move less at the onset of the scans, and about as much as the old method dogs towards the middle and end of the scans. In a two-way repeated measures ANOVA with Method (Old, New) and Volume (1-99) as factors on absolute displacement, there was no difference between methods, F(1, 5 <1. There was a significant main effect of volume, $F(98,490) = 1.5$, $p = .003$, due to the decrease in absolute displacement across volume, indicating that the dogs became stiller over the progression of their scans, regardless of method. There was no significant interaction, $F(98, 490) < 1$.

Average *relative* displacement by scan volume of the best scans of the new (M =.44, SE = .024) and old (M = .28, SE = .013) dogs was also compared (middle panel, Figure 5). In a two-way repeated measures ANOVA with Method (Old, New) and Volume (1-99) as factors on relative displacement, there was no difference between methods $F(1, 5) < 1$, across volume, $F(98, 490) = 1.2$, $p = .22$, or an interaction, $F(98, 490) = 1.1$, p = .32Excluding Annie (bottom panel, Figure 5), there is a main effect of volume, $F(98, 392) = 1.358$, $p = .02$, due to the fact that the dogs became stiller over the progression of their scans, regardless of method, $F(1, 4) < 1$. There was no significant interaction, F(98, 392)

= 1.23, *p* > .08. The new method dogs are able to perform as well as the old method dogs in the most meaningful measure of run motion, relative displacement scan to scan.

Figure 6 compares average absolute and relative displacement of all acquired scans, weighted by dog. New method dogs performed comparably well to old method dogs. In a one-way ANOVA, average absolute motion was consistent between dogs trained with the old (*M* = 2.15 mm, *SE* = .46) and new (*M* = 2.02 mm, *SE* = .52) methods, $F(1, 5) < 1$. Average relative motion was also consistent between dogs trained with the old (*M* = .53 mm, *SE* = .12) and new (*M* = .92 mm, *SE* = .4) methods, $F(1, 5) = 1.15$, $p = .33$; one dog's constant panting inflated the group's relative displacement values, (new method without Annie M =.55 mm, SE=.31).

Discussion

The new training method separated the training of the stationing (chin rest) behavior from desensitization to the MRI environment. Further, the method utilized a generalization procedure of stationing in several dissimilar locations, to assist in the transfer of the stationing behavior to the real MRI scan environment; the method did so without the need for extensive training time in the MRI scan environment, which can be expensive. Although it is difficult to compare methods across laboratories in a meaningful way at this time, a canine fMRI training protocol was successfully designed that can be completed in a cost-effective manner, with high-energy dogs, for acquisition of functional and structural data.

Overall Findings

1. Length of protocol. The complete training protocol consisted of 19 levels and a transfer phase requiring approximately 90 sessions, totaling 14 hours of

training. Levels 1-8 comprised Open Environment stationing, and required approximately 40 sessions, totaling 4 hours. Levels 9-19 comprised Mock MRI stationing, and required approximately 35 sessions, totaling 5 hours. Transfer was divided into five 30-minute sessions totaling 2.5 hours. Maintenance sessions at level 19 were conducted during transfer and are accounted for in the complete training time. The old training method, by comparison, took between 12 and 30 hours per dog (Jia et al., 2014).

2. Training and transfer performance. All dogs acquired the performance criterion and transferred to five locations. Two dogs (Ice and Beaufort) were able to station to the 5 min criterion in all transfer locations, and two dogs (Amanda and Annie) were able to station to the above criterion in 4/5 transfer locations (T2-T5). Three of the dogs transferred to the MRI scanner and demonstrated repeated bouts of the max possible duration (206 s).
3. Conditioned responding to scan audio. There was a significant difference in the proportion of time spent in a freeze response (i.e., the CR) during the scan audio (i.e., the CS) and the delay. Although one dog failed to establish comparable levels of conditioned responding due to excessive panting, in general, the dogs were able to discriminate the scan(s) as a stimulus predictive of their reward. These AE sessions effectively transformed the naturally aversive scan stimulus into a conditioned reinforcer. Upon reintroduction of the scan noise stimuli in the last stages of the shaping protocol, the aversive characteristics of the stimuli were significantly dampened, which likely facilitated transfer to the actual MR environment.

4. Motion analysis. The new method dogs were able to perform as well as the old method dogs in the most meaningful measure of run motion, relative displacement scan to scan. There was no difference in absolute or relative displacement in the best scans of the dogs between methods. Regardless of method, all dogs became stiller over the progression of their scans with regard to total movement, and (excluding Annie, the panter) scan-to-scan displacement. On average, all dogs performed within the parameters for data retention (i.e., < 10 mm absolute (total) displacement, < 1 mm relative displacement (Berns et al., 2013; Jia et al., 2014). Therefore, this training method produced dogs capable of high-fidelity data collection at their first exposure to the MRI environment

Clicker training, successive approximation, and classical-counter conditioning are methods used to condition behavior in a diverse range of species, from laboratory mice to wild animals in captivity (Ramirez, 1999). The methods are forgiving with respect to small mistakes made throughout the training process (e.g., marking and reinforcing the wrong behavior, lack of interest in the reward) (Leidinger, Herrmann, Thone-Reineke, Baumgart, & Baumgart, 2017). The same dimensions that make the methods more forgiving for novice teachers also make them more universal to the animal learners; by potentially increasing the success of more dogs in the subject pool and more types of dogs (e.g., special population detection dogs), one can begin to combat an inherent selection bias due to subject and data attrition. This bias afflicts experimental samples and stems from an inability of the method to adapt to individual variability in temperament and tractability for an apparatus-oriented task that necessitates high levels of patience and impulse control, as is required for stationing for MRI. The training materials are easily and inexpensively procured. The classical counter conditioning and generalization elements of this method reduce stress and novelty of the scanner environment, without the need for several expensive training hours in a rented scanner environment.

Limitations

Without training in the MRI environment, the trainer is unable to replicate the static magnetic field within the scanner bore or the unusually high/low frequency audio emissions of the scan sequences. Ideally, the audio and speaker system used in training would be of a quality that could reproduce the high frequencies that dogs can hear well; the highest quality digitization using the highest sampling rate possible, using a high-quality microphone, and a high-quality speaker that is connected by wire to the playback. This investment still neglects replication of the magnetic field sensation, and is possibly unnecessary; this limitation is potentially addressed because theoretically, these dimensions are lumped into a 'variability' component from performing the behavior in diverse settings during training. That said, it is a small investment in hardware as compared with the large investment in time that goes into training.

Another limitation is that this protocol is not optimized for speed. The stationing behavior can be conditioned in fourteen hours of training, which over six months equates to approximately 90 five to fifteen-minute training sessions. The methodological approach is "slow and correct," instead of "fast and fix it later". A mentality of "rushed and fix it later" leads to potential sensitization of the scanning environment, and subsequent attrition of data or entire subjects. In a study of lexical processing in dogs, researchers were able to collect data at a success rate of 80% on a given dog's first attempt. For the 20% of dogs that needed a second attempt, success dropped to 16%, and just 4% if the dog needed a third attempt, suggesting that those dogs became detrimentally sensitized to the scanning environment with repeated exposure (Andics et al., 2016). The protocol described above will likely not work on all dogs, and methodological alternatives include using a nose-to-target stick behavior instead of a chin rest behavior, increasing the frequency of the training sessions, and/or implementing longer training sessions. In hind sight, the three *passive* Auditory Exposure sessions may have been unnecessary, or worse, counter-productive, by triggering latent inhibition to the scan audio CS during *active* Audio Exposure; latent inhibition is a decrement in learning performance resulting from nonreinforced pre-exposure of the to-be-conditioned stimulus (Lubow, 1973). One could pre-screen for more suitable subjects (e.g., tractability, temperament), although the trade-off with selection bias persists, and further, the more difficult-to-train dogs might be model pathologies of interest: disordered anxiety, aggression, special population working dogs (e.g., those selected for high-drive/energy). Nevertheless, effective training protocols mey be able to overcome temperament issues.

To better compare methods of acclimating and training for stationing in the MRI, we would need more dogs and more trainers. At this time, it is not possible to say that any one method is better or more efficient/effective than another. There are no data available to support this claim and it would be difficult to justify collection of these data due to the time and cost of such a study (i.e., direct comparison of training with and without generalization, while keeping everything else constant). Although these data represent only four dogs, the nature of the training, its progression, and its potential final outcomes have been characterized. Overall, these data may also underrepresent the potential of the new method, and overrepresent the quality of the old method. In the new dogs, motion characteristics were reported from scans acquired at first MR exposure, while for the comparison dogs, motion data were reported from the first useable data, but not the first scans in the MR environment. Those data were considered training scans and were not retained for storage or analysis.

Independent of training method, certain technological improvements could enhance the fidelity of canine MRI data, including improved radiofrequency coil design to facilitate imaging of canine cranial anatomy, as well as improved hardware and sequences to quiet the scanner during data acquisition (Huber & Lamm, 2017).

A strength of the work done at AU is the researcher's access to the "Auburn Dog" population through CPS. The detection dogs used in these studies have similar genetics and near-identical rearing and training histories. Canine fMRI can and has been used to probe information processing in special working populations (e.g., signal processing in service dogs and parametric odor processing in detection dogs) (Berns et al., 2017; Jia et al., 2014). The neuroimaging technique therefore has translational utility when it comes to determining operational potential and suitability to a working role. As a convergent technique alongside genetic and behavioral analyses, information gained from MR stimulus-presentation paradigms can inform selection of suitable working dog phenotypes for breeding purposes.

Regarding the generalization of this training protocol to other trainers, while we used kenneled purpose-bred detection dogs, this protocol should bode well for other dog populations. Detection dogs are typically repurposed American Field Trial, Hunt Test, and Upland Game dogs with intrinsically high-energy, and "high-drive" (Lazarowski et al., 2018). The term “drive,” referring to the dog’s intrinsic motivation to work, is both difficult to operationalize and measure, and widespread in its use to characterize dogs that are most suitable for detection work; the industry favors and selects for bold, excitable, high-energy dogs, with higher baseline levels of arousal (i.e., excitement, anxiety) than other types of working dogs and pets (Lazarowski et al., 2019). If such dogs can be trained to station, other populations should be successful too. Further, all four dogs were able to station in a variety of locations, which supports this work as a method for immediate transfer to the real MRI scanner.

Conclusions and Future Directions

Motion was compared between dogs trained with the new method and four ideally-performing dogs scanned in previous fMRI experiments at Auburn University. Although one dog failed transfer, the others trained with the new method produced comparably high-quality data to the previously tested dogs.

Many training strategies come from marine mammal and zoo animal training practices, adapted from Skinner, to approximate husbandry procedures via reinforcement-based enrichment and training (Heidenreich, 2012; Ramirez, 1999). Routine veterinary procedures (weight-taking, nail clipping, blood draws), or anything uncomfortable or anxiety-provoking, can be facilitated with reinforcement by successive approximation following a dedicated training plan, modeled after the one suggested here for canine fMRI. Awake, unrestrained MRI has even been discussed as having clinical utility in its own right for epileptic dogs (Berns, Spivak, Nemanic, & Northrup, 2018).

In summary, canine fMRI is in its nascent stages. I have presented a humane training program that can be successfully implemented in a cost-effective manner. The future is promising for the continued use of “man’s best friend” in understanding, brain-behavior relationships as the field of cognitive neuroscience continues to evolve.

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Paper	N	Drop Out Rate	Data Loss	Exclusion Criteria
Tóth, Gásci, Miklósi, Bogner, & Repa (2009)	2	n.d.	n.d.	n.d.
Berns, Brooks, & Spivak (2012)	2	0/2	144/380 (38%) and 158/380 (42%)	>1% scan-to-scan signal change
Berns, Brooks, & Spivak (2013)	15	2/15	57% [70% - 41%]	>0.1 fraction of outlier voxels in each volume >1mm scan-to-scan displacement
Cook, Spivak, & Berns (2014)	13	1/13	49% [62% - 40%]	>1% scan-to-scan signal change >1mm scan-to-scan displacement
Andics, Gacsi, Farago, Kis, & Miklosi (2014)	11	n.d.	9%	>3mm head translation >1º rotation
Jia et al. (2014)	6	1/6	12.5%	>10mm total displacement
Berns, Brooks, & Spivak (2015)	12	1/12	39% [57% - 15%]	>0.01 fraction of outlier voxels in each volume >1mm scan-to-scan displacement
Dilks, Cook, Weiller, Berns, Spivak, & Berns (2015)	8	2/8	38.5% [53% - 24%]	>1% scan-to-scan signal change >1mm scan-to-scan displacement
Kyathanahally et al. (2015)	6	2/6	n.d.	n.d.
Jia et al. (2016)	14	n.d.	4/168 (2%)	>10mm total displacement
Cuaya et al. (2016)	7	n.d.	<20%	>3mm head translation >1º rotation
Cook, Spivak, & Berns (2016)	13	2/13	58% [83.5% - 41%]	>1% scan-to-scan signal change >1mm scan-to-scan displacement
Cook, Prichard, Spivak, & Berns (2016)	15	1/15 2/15 only completed ¾ of trials	46% [70% - 30%]	>1% scan-to-scan signal change >1mm scan-to-scan displacement
Andics et al. (2016)	13	1/13	n.d.	>3mm head translation >1º rotation
Berns et al. (2017)	50	1/50	n.d.	>0.01 fraction of outlier voxels in each volume >1º rotation

Table 1. Data Attrition in Previously Published Canine fMRI Studies. Table 1 describes data attrition as Drop Out Rate (subject attrition), Data Loss (number, percentage, average, or range of runs or volumes discarded from analysis) due to excessive motion, and Exclusion Criteria (censorship criteria for analysis exclusion). N.d. = not disclosed.

	Session Level	Criteria	Duration	Session Repetitions (M, SE)
Open Environment	1. Charge the clicker	Build an association between the 'tic-toc' of the clicker and the dog's primary reward (e.g., food) while capturing attention.	3 mins	1, 0
	2. Capture chin target to towel	Build chin-to-towel contact to 2+ seconds. *	5 mins	3.75, .75
	3. Chin-to-towel target with short duration and addition and a cue	Chin contact for 7+ seconds. *	5 mins	8.25, 2.8
	4. Chin rest on towel in a down and addition of distraction	Chin contact for 11+ seconds, with and without distraction.	5-10 mins	2.75, .25
	5. Chin rest on towel with distance	Chin contact for 16+ seconds, cued from progressively farther away (i.e., sitting on ground, kneeling, standing).	5-10 mins	3.5, .87
	6. Chin rest on towel with increasing duration and distance	Chin contact for 26+ seconds.	5-10 mins	5.5, 1.5
	7. Introduce foam chin rest, duration initially reduced	Chin contact to foam chin rest for 40+ seconds.	5-15 mins	4.75, .75
	8. Chin rest in foam chin rest with increasing duration and distraction	Chin contact for 73+ seconds.	5-15 mins	6, 1.2
Mock MRI	9. Introduce bore and elevation with reduced duration	Chin contact in bore on table for 16+ seconds. **	5-15 mins	2.5, .5
	10. Elevated chin rest with increasing duration	Chin contact in bore on table for 60+ seconds.	5-15 mins	3, 0
	11. Introduce mock radiofrequency (RF) coil with no elevation and reduced duration	Chin contact in RF coil on ground for 30+ seconds.	5-15 mins	2.75, .25
	12. Elevated chin rest in mock RF coil	Chin contact to foam chin rest through the mock RF coil in the elevated bore for 50+ seconds.	5-15 mins	2, 0
	13. Elevated chin rest in mock RF coil with increasing distraction and duration	Chin contact for 100+ seconds, with and without distraction.	5-15 mins	2.5, .29
	14. Introduce ear padding, duration initially reduced	Chin contact in mock bore and RF coil (mock MRI) with ear padding for 60+ seconds.	5-15 mins	3, .41
	15. Elevated chin rest in mock RF coil with ear padding and increasing duration and distraction	Chin contact for 107 seconds, with and without distractions.	5-15 mins	2.5, .29
	16. Introduce scanner noise	Chin contact in mock MRI with ear padding and up to 40 dB scan audio for 107+ seconds.	10-30 mins	2.5, .5
	17. Build duration to 2 minutes 30 seconds with increasing distance	Chin contact in mock MRI with ear padding and 41-70 dB scan audio for 142+ seconds, with and without distraction and distance.	10-30 mins	2.5, .5
	18. Build duration to 4 minutes	Chin contact in mock MRI with ear padding and 60-90 dB scan audio for 240+ seconds, with and without distraction and distance.	10-30 mins	2.75, .75
	19. Build duration to 5 minutes	Chin contact in mock MRI with ear padding and 80-110 dB scan audio for 300+ seconds, with and without distraction and distance.	10-30 mins	10, 1.8
Transfer	20. Five distinct location transfer (generalization) sessions	During these transfer sessions the dog stations to the above criteria in several indoor and outdoor locations that are as unique as possible, with different sights, sounds, and degrees of social distraction across settings.	30 mins	5, 0
All	Final behavior(s)	The dog performs a chin rest with head and body enclosed at a 3' elevation, with ear padding and scan audio playing at 90 + dB, for at least five minutes.	12-16 hours (M=13.55, SE=0.94)	87-93 sessions (M=90, SE=1.5)

Table 2. Stationing Training Outline. Table 2 describes the different training and testing phases, and provides a brief description of content, completion criteria, and duration and number of sessions.

<table>
<tr><th colspan="2">Training</th><th colspan="6">Testing</th></tr>
<tr><td colspan="2">Auditory Exposure (PE then AE)
(~20 weeks)</td><td colspan="5">Transfer
(5 weeks)</td><td rowspan="2">MRI</td></tr>
<tr><td>Phase 1
Stationing in Open Environment
(~ 10 weeks)</td><td>Phase 2
Stationing in
Mock MRI
(~10 weeks)</td><td>T1</td><td>T2</td><td>T3</td><td>T4</td><td>T5</td></tr>
</table>

Figure 1. Training Timeline. The protocol timeline was divided into two components, Training and Testing. Training is further divided into two phases, Open Environment and Mock MRI. Separate Auditory Exposure sessions occurred during training as well. Testing consisted of stationing in a portable mock MRI, in five different transfer locations (T1-T5). Once the dog had generalized the stationing behavior to criterion in five distinct transfer locations, the dog underwent data collection in the real MRI environment.

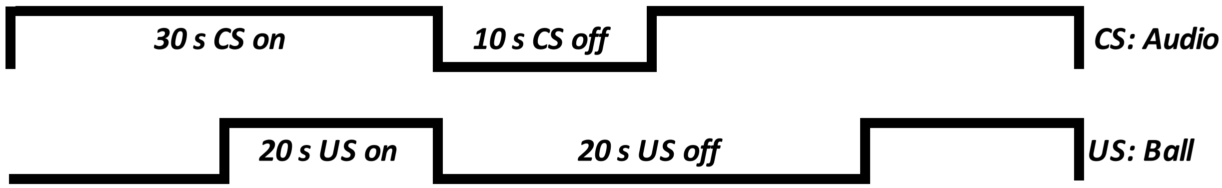


Figure 2. Active Audio Exposure Paradigm. Active Exposure (AE) is a short-delay classical conditioning procedure. 10 s CS (i.e., scan audio presented by itself), 20 s CS + US (i.e., ball and scan audio presented together), 10 s delay (no ball, no scan audio). After this delay, the trial starts over. There are ten trials per session, with incremental volume increases over sessions.

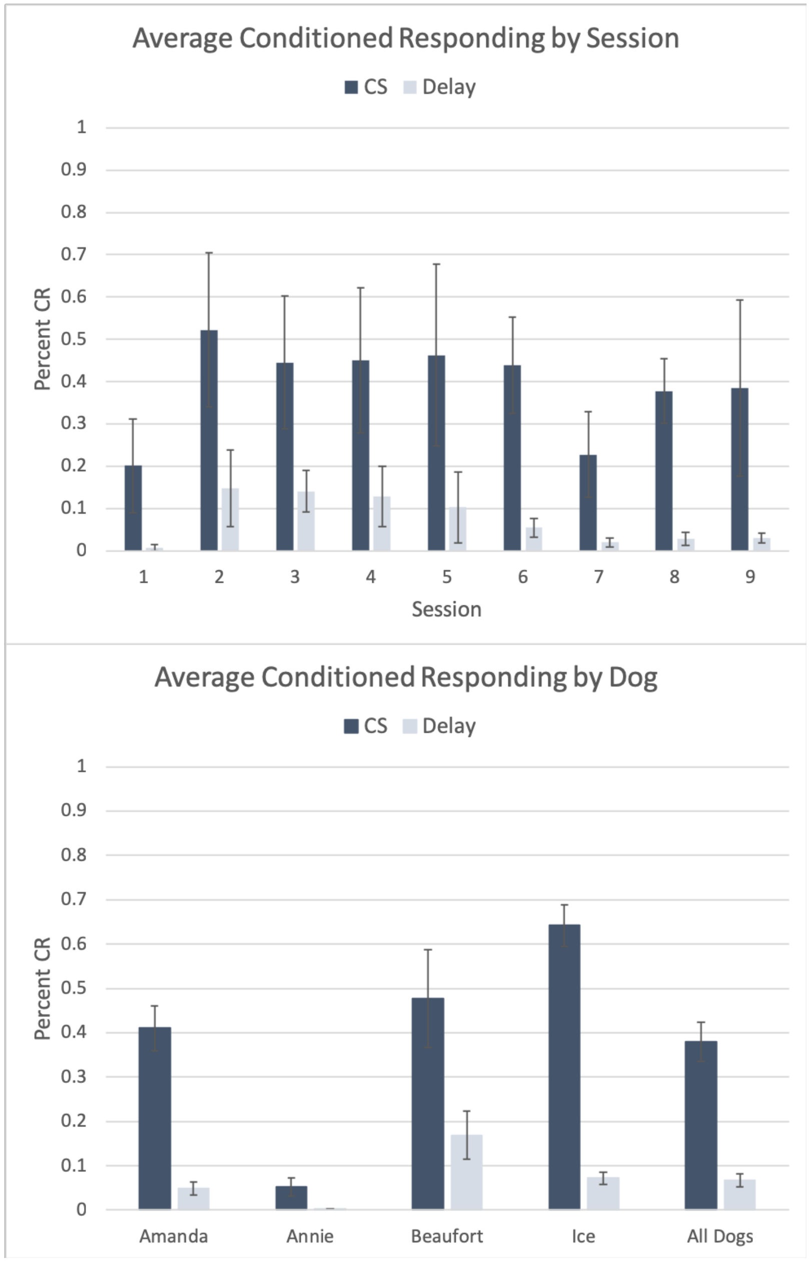


Figure 3. Conditioned Responding. Figure 4 shows percentage of time engaged in the conditioned response (freeze) during conditioned stimulus compared to delay trials. The top panel compares percent CR during CS and Delay across sessions, collapsed across dogs. The bottom panel compares percent CR during CS and Delay for each dog, and averages for all dogs, collapsed across sessions.

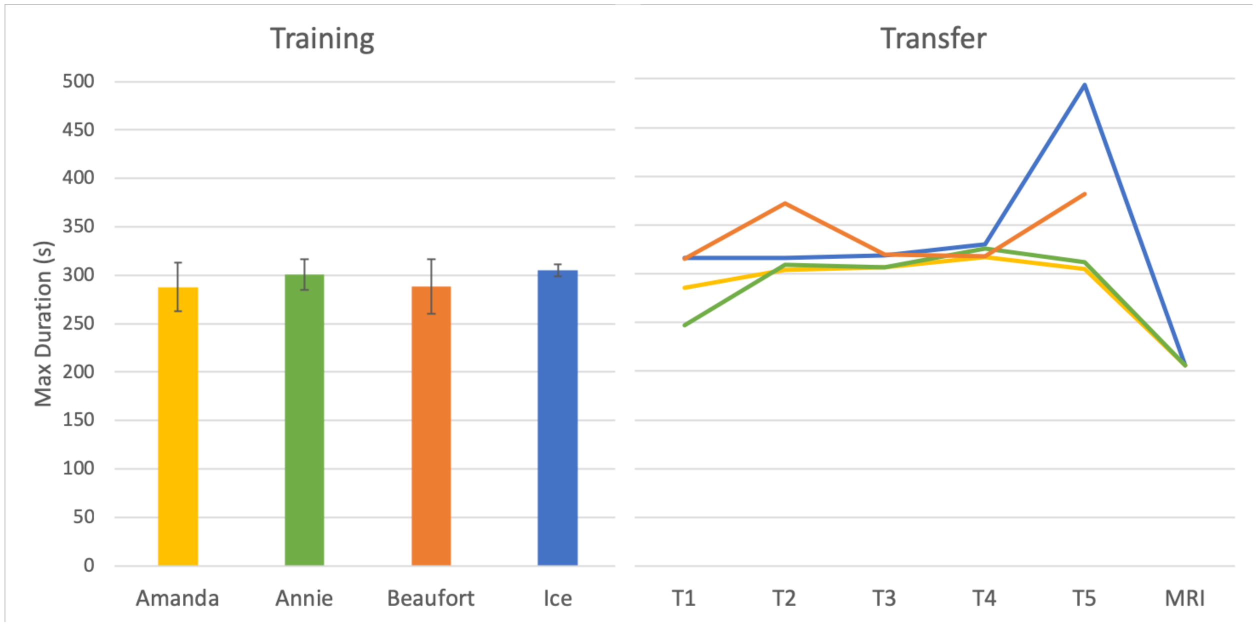
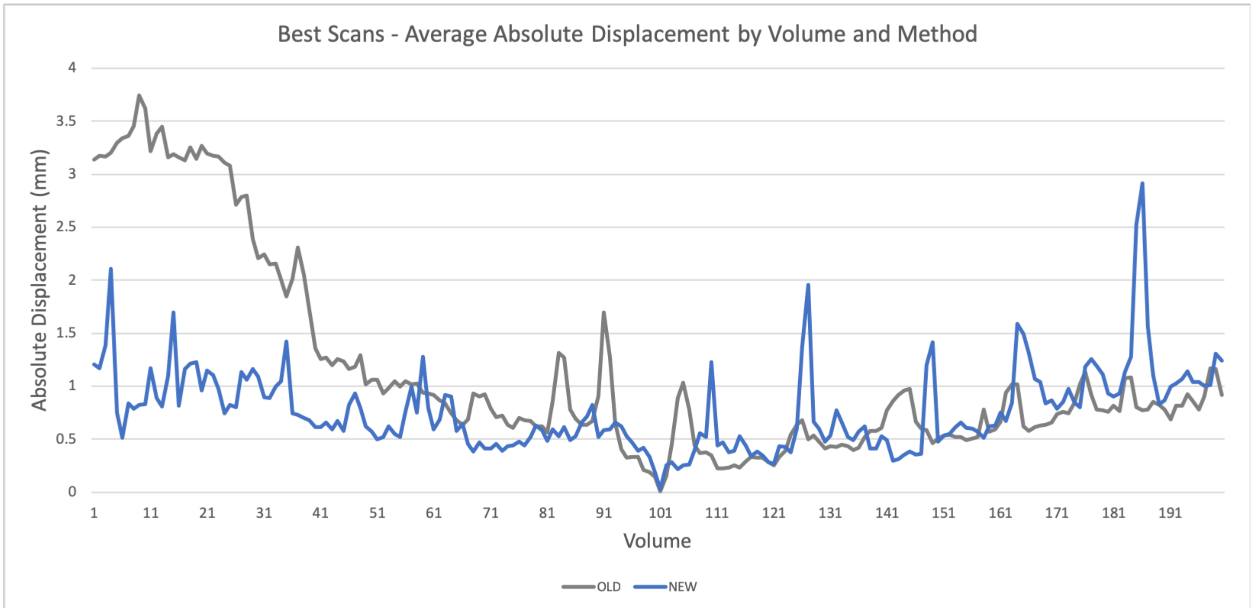
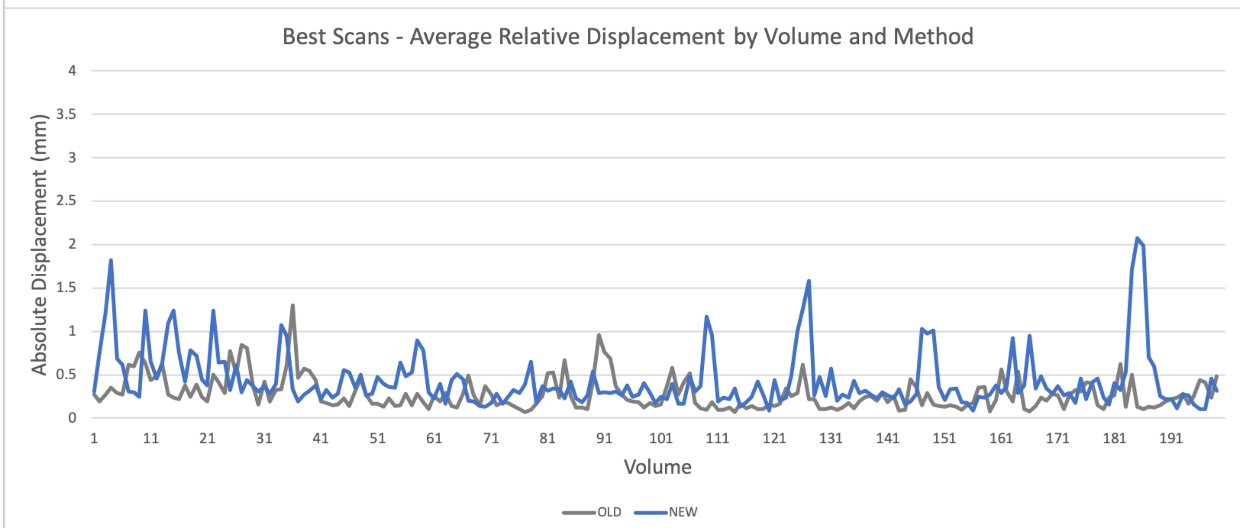


Figure 4. Stationing Training and Testing. Figure 3 shows the maximum duration of four dogs trained in the protocol for the last three sessions at the end of training and the different training locations. All dogs transferred to the mock training locations and three of the dogs transferred to the MRI scanner demonstrating the max possible duration (206 s).


Best Scans - Average Absolute Displacement by Volume and Method
Absolute Displacement (mm)
Volume
OLD
NEW


Best Scans - Average Relative Displacement by Volume and Method
Absolute Displacement (mm)
Volume
OLD
NEW

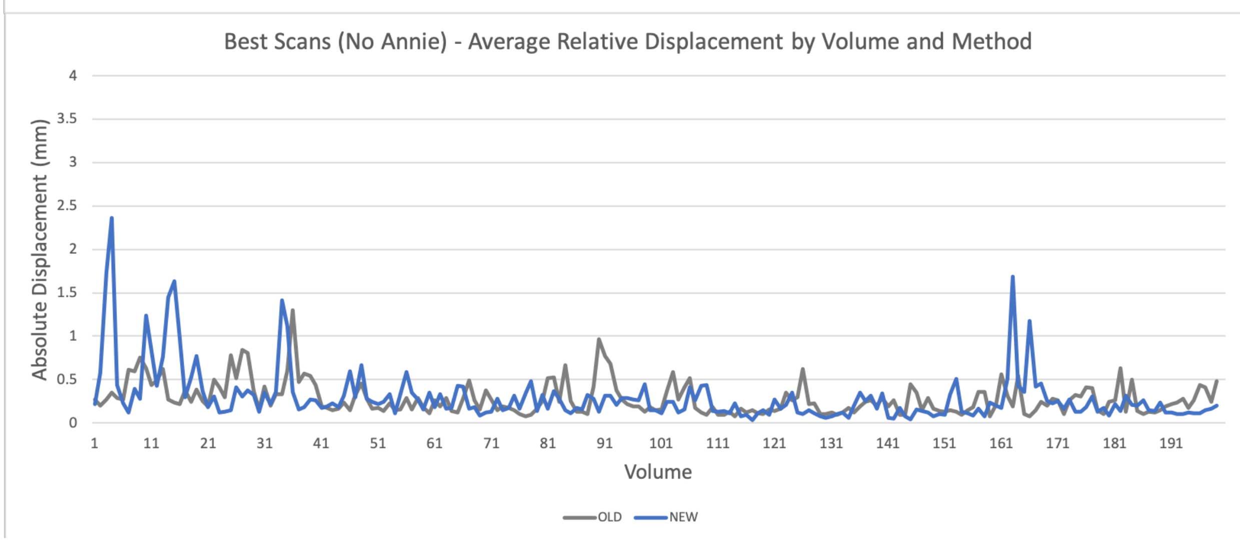

Best Scans (No Annie) - Average Relative Displacement by Volume and Method
Absolute Displacement (mm)
Volume
OLD
NEW

Figure 5. Average Motion of Best Scans by Method. The top panel shows average absolute displacement by scan volume of the best scans of the new method dogs (Ice, Amanda, and Annie, M=.77, SE=.023) compared to the old method dogs (Eli, Tabby, Yancey, Yardley, M=1.14, SE=.066). The middle panel shows average relative displacement by scan volume of the best scans of the new dogs (M=.44, SE=.024) and old dogs (M=.28, SE=.013). Excluding Annie who never stopped panting, the new method dogs are able to perform as well as the old method dogs in the most meaningful measure of run motion, relative displacement scan to scan.

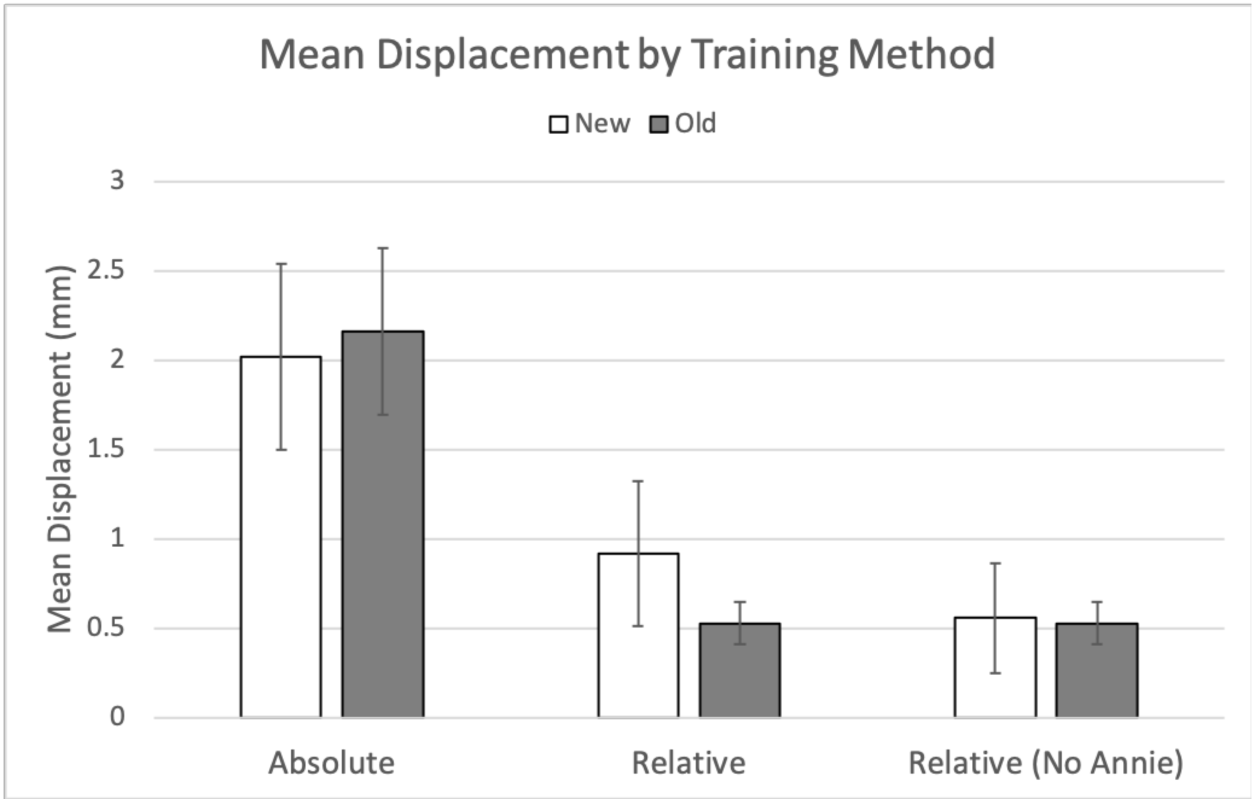


Figure 6. Average Absolute and Relative Displacement. There was no significant difference between dogs' mean absolute displacement for those trained with the old method (M=2.15 mm, SE=.46) and that for dogs trained with the new method (M=2.02 mm, SE=.52), nor was there a significant difference between dogs' mean relative displacement for those trained with the old method (M=.525 mm, SE=.11) and that for dogs trained with the new method (M=.92 mm, SE=.4). Without Annie, (M=.55 mm, SE=.31).

Appendix A: Detailed Training Plan

Summary

Training Schedule (25 to 75 min per week, per dog)

- One 10-minute Auditory Exposure (AE) session / week / dog, and
- Two or more 5 to 30-minute Stationing sessions / week / dog, and
- Two or more non-training days of exercise in break pen or on obstacle course

Materials & Stimuli to Introduce

- Towel for chin rest
- MR-safe chin rest
- Mock scanner bore (agility tunnel, concrete form tube)
- Elevation (3’ height)
- Mock RF coil (size-appropriated acrylic cylinder)
- Ear padding (buffer pads)
- Scan audio recordings
    - Baseline
    - Shim
    - Localizer
    - MPRAGE
    - Resting State
    - EPI
    - Multiband
    - RESOLVE DTI

Behaviors to Install

- Chin rest (cues: chin rest (object), “rest” (verbal))
- Down (cues: “down” (verbal), platform in bore (object))
- Stay (cues: “stay” (verbal), platform in bore (object))
- Release (cues: “Ok” (verbal), ‘click’ (auditory))
- Keep Going Signal (KGS) (“good” (verbal), movement distraction (gestural))

Auditory Exposure Training Plan:
Passive & Active Classical Conditioning of CER to Scanner Noise

Aims:
- Passive habituation and active classical counter-conditioning (H/CC) to scanner noises via development of a positive conditioned emotional response (CER)

Training Frequency and Session Duration:
- Once per week for approximately 10 minutes
- On non-training days dog is exercised in CDRI pen, on GH lawn, or on GH obstacle course; when playing fetch, ball-throwing is contingent on dog performing an auto-down

Procedure:

Passive (habituation): Quiet (<40 dB) passive exposure to scanner noises. Transport dog from home kennel to GH sprint run. Break dog while playback is audible at session-specified volume.

Active (counter-conditioning): Transport dog from home kennel to Behavior Lab at the AUMRI RC. Conduct ten trials of the short-delay classical counter conditioning procedure:
- Play scan audio for 10 seconds
- Engage in play with ball reward for 20 seconds while scan is still audible
- Out the ball and turn off audio – CS and US absent for 10 seconds
- Repeat

Materials:
- Portable Bluetooth speaker
- Ball reward
- Scan audio files — actual protocol, randomize order

Measures:
- Duration/percent CR during CS alone (10”)
- Duration/percent CR during CS/US absence (10”)

Passive (habituation):
Three sessions of ten-minute playback of scanner noise at <40 dB during breaking. Once per week for three weeks.

<u>Session ID: H#</u>

Active (counter conditioning):
Classical counter-conditioning to scanner noise using a short-delay procedure. Ten trials per session with incremental volume increase session-over-session. Once per week for ten weeks.

<u>Session ID: CC#</u>

Stationing Training Plan:
Open Environment, Mock MRI

Aims:

- Installation of a nose-touch behavior to a folded towel
- Installation of a chin rest behavior on a folded towel, with minimal head movement
- Transfer of chin rest behavior to foam chin rest
- Robust chin rest performance for a duration of up to five minutes
- Installation of a down/stay behavior for a duration of up to five minutes
- Acclimation to and ability to down/stay in an enclosed space (tunnel)
- Acclimation to and ability to down/stay at a 3' elevation
- Robust chin rest performance in an enclosed space at a 3' elevation
- Acclimation to head enclosure (mock RF human extremity coil)
- Robust chin rest performance with head and body enclosed (in mock RF coil and mock bore) at a 3' elevation
- Robust chin rest performance with head and body enclosed at a 3' elevation with ear protection
- Robust chin rest performance with head and body enclosed at a 3' elevation, with ear padding, with scans audio playing at 90+ dB

Training Frequency and Session Duration:

- 2-4 times per week for 5-30 minutes
- On non-training days dog is exercised in at GH or on GH obstacle course (down-stay in tunnel); when playing fetch, ball-throwing is contingent on dog performing an auto-down.

Procedure: Break dog (in GH sprint runs) then transport to appropriate training location:
Phase 1 — OPEN ENVIRONMENT
Phase 2 — MOCK MRI

Follow steps of each session according to listed increment progressions; the last increment (approximation) is the final criterion for that session. The training will be video recorded and transcribed to analog data (session increment repetitions and durations) before the next operant session is conducted. Advance to next session when final criterion is met. Preferably, final criterion step is executed to completion twice in one session OR is executed once to completion in two consecutive training sessions.

Materials:

- Cotton blanket/towel
- Foam chin rest
- Mock RF (human extremity) coil
- Mock MRI bore (3' table, cardboard concrete form Sonotube, and flat platform)
- Ear buffer pads
- Audio playback file — clips of a 3-4 scan sequence (actual protocol, randomize order)
- Portable Bluetooth speaker
- Surround sound speaker system

Measures:

- Session duration
- Session level

- Session repetition
- Step level
- Step repetitions
- Bout duration
- Rate of Reinforcement

STAGE 1 – OPEN ENVIRONMENT

1. "Charging the Clicker/Capturing Attention," association of clicker with primary reward

Session Duration: 3 min

Cue: n/a

1. Rapid repetitions of click-then-treat (C/T) events for attention (body orientation towards trainer and/or eye contact; treats are tossed to reset dog's position).

2. Capture chin target to towel

Props and setup: Trainer is seated in chair or on ground with towel in lap or is beside a platform with towel folded atop. Dog is standing, sitting, or in a down.

Session Duration: 5 min

Cue(s): presentation of towel (object)

1. Look at towel
2. Investigate towel (sniff, no touching)
3. Nose-to-towel contact
4. Brief chin-to-towel contact
5. [Final] Build towel contact duration to 2+ seconds

3. Chin-to-towel target with duration (short), add cue

Props and setup: Trainer is seated in chair or on ground with towel in lap or is beside a platform with towel folded on top. Dog can be standing, sitting, or in a down.

Session Duration: 5 min

Cue(s): presentation of towel (object), "rest" (verbal)

1. Chin contact for 1-2 seconds
2. Chin contact for 3 seconds
3. Chin contact for 4 seconds
4. Chin contact for 5 seconds
5. [Final] Chin contact for 7+ seconds, with and without distraction

4. Chin rest on towel in a down (add distraction)

Props and setup: Trainer is seated on ground with towel in lap or kneeling beside a low platform with folded towel on top. Dog is in a down.

Session Duration: 5 min

Cue(s): presentation of towel (object), "rest" (verbal)

1. Chin contact for 1-5 seconds, with and without distraction
2. Chin contact for 6-7 seconds, with and without distraction
3. Chin contact for 8 seconds, with and without distraction
4. Chin contact for 9-10 seconds, with and without distraction
5. [Final] Chin contact for 11+ seconds, with and without distraction

5. Chin rest on towel with distance

Props and setup: Trainer is seated or standing beside a folded towel on ground or on a low platform. Dog is in a down.

Session Duration: 10 min
Cue(s): presentation of towel (object), “rest” (verbal)

1. Chin contact for 1-3 seconds
2. Chin contact for 4-8 seconds
3. Chin contact for 9-11 seconds
4. Chin contact for 12-14 seconds
5. [Final] Chin contact for 16+ seconds

<u>6. Chin rest on towel with duration (long), and distance</u>
Props and setup: Trainer is seated in chair or standing beside folded towel on ground. Dog is in a down.
Session Duration: 10 min
Cue(s): presentation of towel (object), “rest” (verbal)

1. Chin contact for 1-11 seconds
2. Chin contact for 12-16 seconds
3. Chin contact for 17-19 seconds
4. Chin contact for 21-23 seconds
5. [Final] Chin contact for 26+ seconds

<u>7. Chin rest in foam chin rest (duration initially reduced)</u>
Props and setup: Trainer is standing, seated in chair, or seated on ground beside foam chin rest. Dog is in a down. Conduct at least one session rep in mock bore on ground.
Session Duration: 15 min
Cue(s): presentation of towel (object), presentation of chin rest (object) “rest” (verbal)

1. Investigate apparatus
2. Chin contact for 1-10 seconds
3. Chin contact for 11-21 seconds
4. Chin contact for 23-31 seconds
5. [Final] Chin contact for 41+ seconds

<u>8. Chin rest in foam chin rest with distraction (increase duration)</u>
Props and setup: Trainer is standing or seated beside foam chin rest. Dog is in a down. Conduct at least one session rep in mock bore on ground.
Session Duration: 15 min
Cue(s): presentation of chin rest (object), “rest” (verbal)

1. Chin contact 1-23 seconds, with and without distraction
2. Chin contact for 26-31 seconds, with and without distraction
3. Chin contact for 34-45 seconds, with and without distraction
4. Chin contact for 50-60 seconds, with and without distraction
5. [Final] Chin contact for 73+ seconds, with and without distraction

STAGE 2 – MOCK MRI

<u>9. Introduce elevation and bore (duration reduced)</u>
Props and setup: Trainer is standing beside dog on table. Dog is in a down.
Session Duration: 15 min
Cue(s): presentation of chin rest (object), “rest” (verbal)

1. Lie down in bore *
2. Chin contact in bore on ground (any duration)
3. Hup into bore on table and lie down

4. Chin contact for 1-12 seconds
5. [Final] Chin contact for 16+ seconds

* May have dog lie down in the bore on the ground prior to elevating it to ease transition

<u>10. Elevated chin rest with duration</u>
Props and setup: Trainer is standing beside mock bore on table. Have dog walk up ramp or hup and lay down.
Session Duration: 15 min
Cue(s): presentation of chin rest (object), "rest" (verbal), entering bore (behavioral)
1. Hup (jump) on to table and lay down
2. Chin contact for 1-12 seconds while in down in bore on table
3. Chin contact for 16-23 seconds
4. Chin contact for 26-45 seconds
5. [Final] Chin-to-blanket contact for 60+ seconds

<u>11. Introduce mock RF coil (no elevation, duration reduced)</u>
Props and setup: Trainer is sitting on ground beside mock head coil and foam chin rest. Use nose touch/food lure to guide dog's head into coil and onto the chin rest.
Session Duration: 15 min
Cue(s): presentation of chin rest (object), "rest" (verbal), hand presentation (gestural)
1. Investigate apparatus
2. Chin contact for 1-5 seconds
3. Chin contact for 6-12 seconds
4. Chin contact for 16-26 seconds
5. [Final] Chin contact for 30+ seconds

<u>12. Elevated chin rest in mock RF coil (duration reduced)</u>
Props and setup: Trainer is standing beside mock bore on platform with mock RF coil inside. Chin rest is affixed to mock RF coil. Have dog walk up ramp or hup and lay down.
Session Duration: 15 min
Cue(s): presentation of chin rest (object), "rest" (verbal), entering bore (behavioral)
1. Chin contact for 1-5 seconds
2. Chin contact for 6-12 seconds`
3. Chin contact for 16-26 seconds
4. Chin contact for 28-37 seconds
5. [Final] Chin contact for 50+ seconds

<u>13. Elevated chin rest in mock RF coil with duration</u>
Props and setup: Trainer is standing beside mock bore on platform with mock RF coil inside. Chin rest is affixed to mock RF coil. Have dog walk up ramp or hup and lay down.
Session Duration: 15 min
Cue(s): presentation of chin rest (object), "rest" (verbal), entering bore (behavioral)
1. Chin contact for 1-12 seconds, with and without distraction
2. Chin contact for 16-37 seconds, with and without distraction
3. Chin contact for 41-60 seconds, with and without distraction
4. Chin contact for 66-88 seconds, with and without distraction (1'6"-1'28")
5. [Final] Chin contact for 100+ seconds, with and without distraction (1'40"$\leq$)

14. Introduce ear protection (duration reduced)
Props and setup: Trainer is standing/seated beside mock bore on table with mock RF coil inside. Chin rest is affixed to mock RF coil. Have dog walk up ramp or hup and lay down. Outfit dog with ear protection.
Session Duration: 15 min
Cue(s): presentation of chin rest (object), "rest" (verbal), entering bore (behavioral)
1. Tolerate ear protection without movement
2. Chin contact for 1-5 seconds
3. Chin contact for 6-26 seconds
4. Chin contact for 28-45 seconds
5. [Final] Chin contact for 60+ seconds

15. Elevated chin rest in mock RF coil with ear protection (increase duration, add distraction)
Props and setup: Dog is outfitted with ear protection. Trainer is standing or seated beside mock bore on platform with mock RF coil inside. Chin rest is affixed to mock RF coil. Have dog walk up ramp or hup and lay down.
Session Duration: 15 min
Cue(s): presentation of chin rest (object), "rest" (verbal), entering bore (behavioral)
1. Chin contact for 1-12 seconds, with and without distraction
2. Chin contact for 16-37 seconds, with and without distraction
3. Chin contact for 41-60 seconds, with and without distraction
4. Chin contact for 66-88 seconds, with and without distraction
5. [Final] Chin contact for 107+ seconds, with and without distraction

16. Introduce scanner noise (duration initially reduced)
Props and setup: Dog is outfitted with ear protection. Trainer is seated or standing beside elevated mock bore with mock RF knee coil affixed inside. **Introduce noise at 0-40dB.**
Session Duration: 15-30 min
Cue(s): presentation of chin rest (object), "rest" (verbal), entering bore (behavioral)
1. Chin contact for 1-12 seconds, with and without distraction
2. Chin contact for 16-37 seconds, with and without distraction
3. Chin contact for 41-60 seconds, with and without distraction
4. Chin contact for 66-88 seconds, with and without distraction
5. [Final] Chin contact for 107+ seconds, with and without distraction

17. Build duration to 2m 30s
Props and setup: Dog is outfitted with ear protection. Trainer is seated or standing beside elevated mock bore with mock RF knee coil affixed inside. **Titrate noise between 41-70dB.**
Session Duration: 15-30 min
Cue(s): presentation of chin rest (object), "rest" (verbal), entering bore (behavioral)
1. Chin contact for 1-37 seconds, with and without distraction
2. Chin contact for 41-88 seconds, with and without distraction
3. Chin contact for 97-107 (1'37"-1'47") seconds, with and without distraction
4. Chin contact for 117-129 seconds, with and without distraction
5. [Final] Chin contact for 142+ seconds, with and without distraction

18. Build duration to 4m
Props and setup: Dog is outfitted with ear protection. Trainer is seated or standing beside elevated mock bore with mock RF knee coil affixed inside. **Titrate noise between 60-90dB.**
Session Duration: 15-30 min
Cue(s): presentation of chin rest (object), "rest" (verbal), entering bore (behavioral)

1. Chin contact for 1-107 seconds (1”-1’47”), with and without distraction
2. Chin contact for 117-142 seconds (1’57”-2’22”), with and without distraction
3. Chin contact for 156-189 seconds (2’36”-3’09”), with and without distraction
4. Chin contact for 208-229 seconds (3’28”-3’49”), with and without distraction
5. [Final] Chin contact for 240+ seconds ($\geq$4’), with and without distraction

<u>19. Build duration to 5m</u>

Props and setup: Dog is outfitted with ear protection. Trainer is seated or standing beside elevated mock bore with mock RF knee coil affixed inside. **Noise 80-110dB.**

Session Duration: 15-30 min

Cue(s): presentation of chin rest (object), “rest” (verbal), entering bore (behavioral)

1. Chin contact for 1-120 seconds (1”-2’), with and without distraction
2. Chin contact for 129-189 seconds (2’09”-3’09”), with and without distraction
3. Chin contact for 208-229 seconds (3’28”-3’49”), with and without distraction
4. Chin contact for 252-277 seconds (4’12”-4’37”), with and without distraction
5. [Final] Chin contact for 300+ seconds (5’), with and without distraction

Transfer Training Plan:
Transfer Tests at Five Distinct Locations & Final Transfer Scanning Session at AU MRI Research Center

Aims:

- Execute a several bouts of a 5-minute motionless down/stay and chin rest in mock MRI (elevation, bore, RF coil, audio, ear protection) in five dissimilar locations across campus
- Execute final stationing behavior (5-minute motionless down/stay and chin rest) during a 60-minute session of structural and functional data acquisition in the Siemens Verio open-bore 3T MRI scanner at the AU MRI Research Center.

Training Frequency and Session Duration:

- Once per week for 30-60 minutes

Procedure and Materials:

Follow steps of each session according to listed increment progressions; the final criterion is a 5-minute motionless down/stay and chin rest in each of the above specified locations. The training will be video recorded and transcribed to analog data (session increment repetitions and durations) before the next transfer session is conducted.

- Audio playback file — clips of a 3-4 scan sequence (actual protocol, randomize order)
- Portable Bluetooth speaker and ear bud headphones
- Platform
- Agility tunnel and sandbags
- Mock RF coil
- Chin rest
- Ear protection
- 15-channel Knee Coil
- Siemens Verio open-bore 3T MRI scanner

Transfer and Test Locations:

L1 – Golden House Field (outdoors, low auditory distraction/low social distraction)
L2 – Thach Hall or Haley Center (indoors, low auditory/moderate social)
L2 – Student Center Bus Stop (outdoors, moderate auditory/high social)
L4 – Student Center (indoors, high auditory/high social)
L5 – AU Facilities Water Plant (indoors, high auditory/low social)
MRI – 3T scanner at the Auburn University Research MRI Center

Measures:

- Probe duration
- Number of final criterion reps $\geq$ 5 min
- Average station duration

Five sessions of mock MRI stationing in elevated mock coil and bore, with ear protection and scan audio. At each location, settle dog into mock bore and reinforce a 30” chin rest. Next, probe for duration (reinforce at 5min or when dog breaks). Conduct repeated bouts of 1-5-minute chin rest reps for 60 minutes.

Transfer: Elevated chin rest in mock bore and RF coil with ear protection and scan audio

Props and setup: Trainer is seated/standing beside mock bore (agility tunnel) with mock RF coil inside. Chin rest is affixed to mock RF coil.

Session Duration: 30 min

Cue(s): "rest" (verbal), enter bore (behavioral)

1. Chin rest for 1 minute (0-60")
2. Chin rest for 2 minutes (61-120")
3. Chin rest for 3 minutes (121-180")
4. Chin rest for 4 minutes (181-240")
5. [Final] Chin rest for 5+ minutes (241-300")

Test:

Final transfer test session at AU MRI Research Center. Settle dog into scanner and conduct 30-minute scan protocol. If possible, play audio of each scan prior to initiation over console intercom. Approximately one-minute breaks between scans; dog may stay in bore or exit between scans.

Transfer Week 6: MRI

Test: Chin rest in 3T MRI and RF extremity coil with ear protection

Props and setup: Trainer is seated/standing at end of MRI bore facing dog.

Session Duration: 60 min

Cue(s): "rest" (verbal)

1. Chin rest for 0-1 minute (0-60")
2. Chin rest for 1-2 minutes (61-120")
3. Chin rest for 3-4 minutes (121-180")
4. Chin rest for 4-5 minutes (181-240")
5. [Final] Chin rest for 5+ minutes (241-300")

Operant Duration Increment Reference Chart
(10% Stepwise Increase)

- 1
- 1
- 1
- 1
- 1
- 2
- 2
- 2
- 2
- 2
- 3
- 3
- 3
- 3
- 4
- 4
- 5
- 5
- 6
- 6
- 7
- 7
- 8
- 9
- 10
- 11
- 12
- 13
- 14
- 16
- 17
- 19
- 21
- 23
- 26
- 28
- 31
- 34
- 37
- 41
- 45
- 50
- 55
- **60 – 1 minute**
- 66
- 73
- 80
- 88
- 97
- 107
- **117 ~ 2 minutes**
- 129
- 142
- 156
- **172 ~ 3 minutes**
- 189
- 208
- **229 ~ 4 minutes**
- 252
- 277
- **304 ~ 5 minutes**

Minutes	Seconds
1	60
2	120
3	180
4	240
5	300

Appendix B: Training Worksheets

CC SESSION

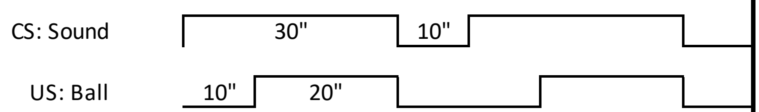
Dog:	
Date:	
Start Time:	
End Time:	
Observer:	

SESSION ID

PLAYBACK VOLUME (dB)

SESSION INFORMATION
Location:
Scans:
Ear protection:

CC DELAY MODEL



(i.e., 10" CS alone, 20" CS + US, 10" delay)

TRIAL	10" CS		20" CS + US		10" DELAY	Cued
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

NOTES

Open Environment

Dog:	
Date:	
Session Rep:	
Start Time:	
End Time:	
Observer:	

SESSION ID
OE_1

GOAL BEHAVIOR
Charging the clicker/capture attention

		TIME (minutes)			
STEP		1	2	3	**TOTAL**
1	Rapid repetitions of click-then-treat events for attention *				
2					
3					
4					
5					
	TOTAL				

NOTES
Training aids:
Location:
Reinforcer:

* Rapid repetitions of click-then-treat (C/T) events for attention (body orientation towards trainer and/or eye contact; treats are tossed to reset dog's position).

Open Environment

Dog:	
Date:	
Session Rep:	
Start Time:	
End Time:	
Observer:	

SESSION ID
OE_2

GOAL BEHAVIOR
Capture chin target to towel
Cues: presentation of towel

		TIME (minutes)					
	STEP	1	2	3	4	5	**TOTAL**
1	Look at towel						
2	Investigate towel (sniff, not touching)						
3	Nose-to-towel contact *						
4	Brief chin-to-towel contact						
5	Build towel contact duration to 2+ seconds						
	TOTAL						

NOTES
Training aids:
Location:
Reinforcer:

* May rub treat on towel to start behavior

Open Environment

Dog:	
Date:	
Session Rep:	
Start Time:	
End Time:	
Observer:	

SESSION ID
OE_3

GOAL BEHAVIOR
Chin-to-towel target with duration (short), add cue
Cues: presentation of towel, "rest"

TIME (minutes)

	STEP	1	2	3	4	5	**TOTAL**
1	Chin contact for 1-2 seconds						
2	Chin contact for 3 seconds						
3	Chin contact for 4 seconds						
4	Chin contact for 5 seconds						
5	Chin contact for 7+ seconds						
	TOTAL						

NOTES
Training aids:
Location:
Reinforcer:

Open Environment

Dog:	
Date:	
Session Rep:	
Start Time:	
End Time:	
Observer:	

SESSION ID
OE_4

GOAL BEHAVIOR
Chin rest on towel in a down (add distraction)
Cues: presentation of towel, "rest"

		TIME (minutes)					
	STEP	1	2	3	4	5	**TOTAL**
1	Chin contact for 1-5 seconds, with and without distraction						
2	Chin contact for 6-7 seconds, with and without distraction						
3	Chin contact for 8 seconds, with and without distraction						
4	Chin contact for 9-10 seconds, with and without distraction						
5	Chin contact for 11+ seconds, with and without distraction						
	TOTAL						

NOTES
Training aids:
Location:
Reinforcer:

Open Environment

Dog:	
Date:	
Session Rep:	
Start Time:	
End Time:	
Observer:	

SESSION ID
OE_5

GOAL BEHAVIOR
Chin rest on towel with distance
Cues: presentation of towel, "rest"

TIME (minutes)

	STEP	1	2	3	4	5	6	7	8	9	10	**TOTAL**
1	Chin contact for 1-3 seconds											
2	Chin contact for 4-8 seconds											
3	Chin contact for 9-11 seconds											
4	Chin contact for 12-14 seconds											
5	Chin contact for 16+ seconds											
	TOTAL											

NOTES
Training aids:
Location:
Reinforcer:

Open Environment

Dog:	
Date:	
Session Rep:	
Start Time:	
End Time:	
Observer:	

SESSION ID
OE_6

GOAL BEHAVIOR
Chin rest on towel with duration (long), and distance
Cues: presentation of towel, "rest"

TIME (minutes)

	STEP	1	2	3	4	5	6	7	8	9	10	**TOTAL**
1	Chin contact for 1-11 seconds											
2	Chin contact for 12-16 seconds											
3	Chin contact for 17-19 seconds											
4	Chin contact for 21-23 seconds											
5	Chin contact for 26+ seconds											
	TOTAL											

NOTES
Training aids:
Location:
Reinforcer:

Open Environment

Dog:	
Date:	
Session Rep:	
Start Time:	
End Time:	
Observer:	

SESSION ID
OE_7

GOAL BEHAVIOR
Chin rest in foam chin rest (duration initially reduced)
Cues: presentation of towel * or chin rest, "rest"

TIME (minutes)

	STEP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	**TOTAL**
1	Investigate apparatus																
2	Chin contact for 1-10 seconds																
3	Chin contact for 11-21 seconds																
4	Chin contact for 23-31 seconds																
5	Chin contact for 41+ seconds																
	TOTAL																

NOTES
Training aids:
Location:
Reinforcer:

* May place towel on foam chin rest for some initial reps to help transition

Open Environment

Dog:	
Date:	
Session Rep:	
Start Time:	
End Time:	
Observer:	

SESSION ID
OE_8

GOAL BEHAVIOR
Chin rest in foam chin rest with distraction (increase duration)
Cues: presentation of chin rest, "rest"

TIME (minutes)

	STEP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	**TOTAL**
1	Chin contact for 1-23 seconds, with and without distraction																
2	Chin contact for 26-31 seconds, with and without distraction																
3	Chin contact for 34-45 seconds, with and without distraction																
4	Chin contact for 50-60 seconds, with and without distraction																
5	Chin contact for 73+ seconds, with and without distraction																
	TOTAL																

NOTES
Training aids:
Location:
Reinforcer:

MRI

Dog:	
Date:	
Session Rep:	
Start Time:	
End Time:	
Observer:	

SESSION ID
MRI_9

GOAL BEHAVIOR
Introduce elevation and mock bore (duration reduced)

TIME (minutes)

	STEP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	**TOTAL**
1	Lie down in bore *																
2	Chin contact in bore on ground (any duration)																
3	Hup into bore on table and lie down																
4	Chin contact for 1-12 seconds in bore on table																
5	Chin contact in bore on table for 16+ seconds																
	TOTAL																

NOTES
Training aids:
Location:
Reinforcer:

* May have dog lie down in the bore on the ground prior to elevating it to ease transition

MRI

Dog:	
Date:	
Session Rep:	
Start Time:	
End Time:	
Observer:	

SESSION ID
MRI_10

GOAL BEHAVIOR
Elevated chin rest with duration
Cues: entering bore, presetation of chin rest, "rest"

TIME (minutes)

	STEP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	**TOTAL**
1	Hup (jump) into bore on table and lie down																
2	Chin contact for 1-12 seconds while down in bore on table																
3	Chin contact for 16-23 seconds																
4	Chin contact for 26-45 seconds																
5	Chin contact for 60+ seconds																
	TOTAL																

NOTES
Training aids:
Location:
Reinforcer:

MRI

Dog:	
Date:	
Session Rep:	
Start Time:	
End Time:	
Observer:	

SESSION ID
MRI_11

GOAL BEHAVIOR
Introduce mock RF coil (no elevation, duration reduced) *
Cues: presetation of chin rest, "rest"

TIME (minutes)

	STEP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	**TOTAL**
1	Investigate apparatus																
2	Chin contact for 1-5 seconds																
3	Chin contact for 6-12 seconds																
4	Chin contact for 16-26 seconds																
5	Chin contact for 30+ seconds																
	TOTAL																

NOTES
Training aids:
Location:
Reinforcer:

* Mock head coil is on the ground. Use nose touch/food lure to guide dog’s head inside the coil and onto the chin rest.

MRI

Dog:	
Date:	
Session Rep:	
Start Time:	
End Time:	
Observer:	

SESSION ID
MRI_12

GOAL BEHAVIOR
Elevated chin rest in mock RF coil (duration reduced)
Cues: entering bore, presetation of chin rest, "rest"

TIME (minutes)

	STEP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	**TOTAL**
1	Chin contact for 1-5 seconds																
2	Chin contact for 6-12 seconds																
3	Chin contact for 16-26 seconds																
4	Chin contact for 28-37 seconds																
5	Chin contact for 50+ seconds																
	TOTAL																

NOTES
Training aids:
Location:
Reinforcer:

MRI

Dog:	
Date:	
Session Rep:	
Start Time:	
End Time:	
Observer:	

SESSION ID
MRI_13

GOAL BEHAVIOR
Elevated chin rest in mock RF coil with duration and distraction
Cues: entering bore, presetation of chin rest, "rest"

TIME (minutes)

	STEP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	**TOTAL**
1	Chin contact for 1-12 seconds, with and without distraction																
2	Chin contact for 16-37 seconds, with and without distraction																
3	Chin contact for 41-60 seconds, with and without distraction																
4	Chin contact for 66-88 seconds, with and without distraction (1'6" - 1'28")																
5	Chin contact for 100+ seconds, with and without distraction (≥1'40")																
	TOTAL																

NOTES
Training aids:
Location:
Reinforcer:

MRI

Dog:	
Date:	
Session Rep:	
Start Time:	
End Time:	
Observer:	

SESSION ID
MRI_14

GOAL BEHAVIOR
Introduce ear protection (duration reduced) *
Decibels (dB): NA

TIME (minutes)

	STEP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	**TOTAL**
1	Tolerate ear protection without movement																
2	Chin contact for 1-5 seconds																
3	Chin contact for 6-26 seconds																
4	Chin contact for 28-45 seconds																
5	Chin contact for 60+ seconds																
	TOTAL																

NOTES
Training aids:
Location:
Reinforcer:

* Trainer is standing/seated beside mock bore on table with mock RF coil inside. Chin rest is affixed to mock RF coil. Have dog walk up ramp or hup and lay down. Outfit dog with ear protection.

MRI

Dog:	
Date:	
Session Rep:	
Start Time:	
End Time:	
Observer:	

SESSION ID
MRI_15

GOAL BEHAVIOR
Elevated chin rest in bore and mock RF coil with ear protection (increase duration, add distraction)
Decibels (dB): NA

TIME (minutes)

	STEP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	**TOTAL**
1	Chin contact for 1-12 seconds, with and without distraction																
2	Chin contact for 16-37 seconds, with and without distraction																
3	Chin contact for 41-60 seconds, with and without distraction																
4	Chin contact for 66-88 seconds (1'6"-1'28"), with and without distraction																
5	Chin contact for 107+ seconds ($\geq$1'47"), with and without distraction																
	TOTAL																

NOTES
Training aids:
Location:
Reinforcer:

MRI

Dog:	
Date:	
Session Rep:	
Start Time:	
End Time:	
Observer:	

SESSION ID
MRI_16

GOAL BEHAVIOR
Introduce scanner noise (duration initially reduced) *
Decibels (dB): 0-40

TIME (minutes)

STEP		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	**TOTAL**
1	Chin contact for 1-12 seconds																
2	Chin contact for 16-37 seconds																
3	Chin contact for 41-60 seconds																
4	Chin contact for 66-88 seconds (1'6"-1'28")																
5	Chin contact for 107+ seconds (≥1'47")																
	TOTAL																

NOTES
Training aids:
Location:
Reinforcer:

* Session duration 15-30 minutes

MRI

Dog:	
Date:	
Session Rep:	
Start Time:	
End Time:	
Observer:	

SESSION ID
MRI_17

GOAL BEHAVIOR
Build duration to 2'30" *
Decibels (dB): 41-70

TIME (minutes)

	STEP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	**TOTAL**
1	Chin contact for 1-37 seconds, with and without distraction																
2	Chin contact for 41-88 seconds, with and without distraction																
3	Chin contact for 97-107 seconds (1'37"-1'47"), with/without distraction																
4	Chin contact for 117-129 seconds (1'57"-2'09"), with/without distraction																
5	Chin contact for 150+ seconds (≥2'30"), with/without distraction																
	TOTAL																

NOTES
Training aids:
Location:
Reinforcer:

* Session duration 15-30 minutes, build distraction and distance

MRI

Dog:	
Date:	
Session Rep:	
Start Time:	
End Time:	
Observer:	

SESSION ID
MRI_18

GOAL BEHAVIOR
Build duration to 4' *
Decibels (dB): 60-90

TIME (minutes)

	STEP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	**TOTAL**
1	Chin contact for 1-107 seconds (1"-1'47"), with and without distraction																
2	Chin contact for 117-142 seconds (1'57"-2'22"), with/without distraction																
3	Chin contact for 156-189 seconds (2'36"-3'09"), with/without distraction																
4	Chin contact for 208-229 seconds (3'28"-3'49"), with/without distraction																
5	Chin contact for 240+ seconds (≥4'), with/without distraction																
	TOTAL																

NOTES
Training aids:
Location:
Reinforcer:

* Session duration 15-30 minutes, build distraction and distance

MRI

Dog:	
Date:	
Session Rep:	
Start Time:	
End Time:	
Observer:	

SESSION ID
MRI_19

GOAL BEHAVIOR
Build duration to 5' *
Decibels (dB): 80-110

TIME (minutes)

	STEP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	**TOTAL**
1	Chin contact for 1-120 seconds (1"-2'), with and without distraction																
2	Chin contact for 129-189 seconds (2'09"-3'09"), with/without distraction																
3	Chin contact for 208-229 seconds (3'28"-3'49"), with/without distraction																
4	Chin contact for 252-277 seconds (4'12"-4'37"), with/without distraction																
5	Chin contact for 300+ seconds (≥5'), with/without distraction																
	TOTAL																

NOTES
Training aids:
Location:
Reinforcer:

* Session duration 15-30 minutes, build distraction and distance

TRANSFER

Dog:	
Date:	
Start Time:	
End Time:	
Observer:	

SESSION ID
Transfer 1 2 3 4 5 (circle one)

SESSION INFORMATION
Location:
Playback Volume (dB):
Ear Protection:

TIME (minutes)

DURATION	SET	PROBE	0-9:59	10-19:59	20-30	**TOTAL**
30-120"						
121-180"						
181-240"						
241-299"						
300" +						
TOTAL						

NOTES
PROBE: Set to Probe Latency (S2P): Probe to Next Latency (P2N):

SET & PROBE procedures
SET: Reinforce first 30" station in new location.
PROBE: Reset dog to station (note latency) and record duration.