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Exploring a Framework for Matching to Sample with Visual stimuli in Dogs (Canis familiaris)

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of

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Abstract

Dogs have been studied for their olfactory abilities, yet their capacity for same-modal visual matching to stimuli remains underexplored. Research focused on scent detection, and cross-modal odour matching. However, little attention was given to visual matchings. This study investigated dogs' ability to match visual stimuli. Two monitors were used: one displaying a single image, and the other divided into four quadrants. Four dogs were trained to select the stimuli on the second monitor as displayed on the first. In the discrimination task, an errorless learning approach was implemented, where the correct stimuli were presented at full brightness while the incorrect shape was dimmed. As the stages progressed, the incorrect shape's brightness increased. All dogs successfully matched to sample at low brightness, and they were able to perform better than chance. However, they didn't meet the criteria to discriminate between shapes when both were presented at full brightness. After discontinuing errorless learning, the dogs went under a pure conditional discrimination test. Almost all dogs performed better than chance, while there were some significant findings specific to each dog. The findings contribute to understanding canine visual perception and contribute to a methodological framework for visual-visual matching tasks. Future studies may refine these methods to enhance canine performance in discrimination learning.

Acknowledgements

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Chapter 1 Introduction

Introduction

Dogs (Canis familiaris) serve as valuable models for researching developmental milestones due to the variety of behaviours and skills identified in previous research. (Byosiere & Chouinard, 2018). Dogs have been shown to have incredible socio-cognitive abilities through various studies. These studies involved cross-modal approaches to visual ability intertwined with olfactory experiments (Miklösi et al., 1998). Some of these experiments on dogs used discrimination tests with basic visual cues, gestures, human interactions, including photographed images (Kaminski et al., 2009). To test for animals' ability to discriminate and match for visual stimuli requires the identification of conceptual behaviour (Sherry et al., 2015). Conceptual behaviour could be derived from concept learning mechanisms concerning sameness (Katz et al., 2021). The concept of sameness requires judging whether two given items were identical, and the ability to do so is not bound to the specific stimuli in question (Lazarowski et al., 2021). Investigating this concept could be essential in exploring the evolution of non-human animals and their behaviour. Previous studies have been conducted on non-human primates that were phylogenetically the closest species to humans; this involved both the auditory–visual intermodal matching-to-sample (AVMTS) as well as visual-visual intramodal matching-to-sample (VVMTS). (Hashiya & Kojima, 2001) Non-human animals such as dogs have been identified with greater accuracy in identifying visual cues better than any other non-human animals. (Kaminski et al., 2009)

Research conducted extensively on the differences between human and dogs' visual perception deals with the major differences in the visual composition amongst dogs (Pongrácz et al., 2017). This included various aspects of visual perception skills, visual capacity, their overpowering sense of smell against vision, brightness discrimination and also their spatial resolution of the visual system. A clear way to identify differences in their performances, and their use of visual input must be standardized. On exploring visual inputs, the use of touch screen that allow the subjects to interact and choose their preferred responses has been effective in a previous study (Range et al., 2008). This study provided the sampled dogs with pictures depicting young women posing in different stances. The dogs had to identify if the picture portrayed the woman directing towards her left or right side with either her extended arm, head turning, or glance. In this study, researchers developed a computer-automated touchscreen testing process that allowed researchers to evaluate dogs' visual discrimination while excluding social cueing (Range et al., 2008). Their study included 4 trained dogs who were to discern between a set of dog pictures and a set of landscape pictures. Their apparatus was set up in such a way that the feeder was at the bottom of the touch screen, allowing the participants to receive reinforcements once the correct response was chosen. This seemed like an effective strategy to use for my current study; however, this study still had some limitations. The study involved static images of gestures, movements, and postures at proximity, which allowed the dogs to examine them carefully before providing their responses. Which questions the use of visual imagery and the stimuli specifically needed for this current study. However, the current study aims to identify the dog's ability to match to sample and their discriminatory behaviour. Touch screens could provide visual categorisation to dogs while testing for discriminatory behaviours. This is one of the major reasons to utilize touch screens in this study and identify the ability of dogs to classify photographs as a means of natural stimuli.

Identity Matching to stimuli

There are several ways in which the matching differences, and a sample occur. Over the past years, different research methods have been tested on different animal species to identify their ability to match a sample. MTS and same or different conditional discriminations were commonly used to show evidence of learning an abstract idea of sameness or identity. (Lazarowski, 2021) The concept of sameness is relevant in the scenario of matching tasks. This concept was investigated by various researchers. They have increased their contribution in recognising the ability to form the concept of similarity with different species.

Pigeons were extensively used to identify the ability of non-human animals to develop abstract concepts (Katz & Wright, 2006) and their underlying mechanisms related to MTS training. Learning occurs when the subjects are rapidly exposed to the abstract concepts and experiments associated to it. This would show researchers that it could be used effectively by applying that previous knowledge rather than trial and error learning. Furthermore, exposure to manual presentation of stimuli more frequently would enable individuals with learnt abstract concepts to recognise newly introduced stimuli and identify how a new object or situation relates to those they have already encountered, even though the stimuli involved were different from those in the previous situation (Zentall, 2023). Same/different discrimination tasks allow for testing the ability to detect identical stimuli. Although these studies suggest that domestic dogs (Canis familiaris) were recognised as model animals in perceptual research, minimal research has shown their ability in identity matching among similar stimuli. Furthermore, this makes them a valuable asset in this study and the approach to the concept of same/different association.

Visual stimuli discrimination

Dogs possess an impressive ability to discriminate between different visual stimuli, which has been widely studied through Behavioural and cognitive experiments. Research has shown that dogs can differentiate objects based on features such as size, shape, and colour. For instance, Byosiere et al. (2018) explored dogs' ability to discriminate between geometric shapes and found that training and reinforcement strategies significantly enhance their performance in these tasks. These findings underline the role of experience and learning in shaping dogs' visual discrimination abilities.

In addition to shape and size discrimination, studies have also focused on dogs' ability to perceive and differentiate between colours, despite their dichromatic vision. (Neitz et al.,1989) demonstrated that dogs were sensitive to blue and yellow wavelengths but have difficulty distinguishing red and green. This knowledge has practical implications for designing experiments involving colour-based stimuli as it plays a major role in differentiating similar stimuli while using identity matching techniques.

Visual stimuli discrimination tasks have also incorporated naturalistic and artificial objects to evaluate how dogs process complex visual patterns. For example, Range et al. (2008) found that dogs could successfully categorize images of animals and landscapes, suggesting that their visual discrimination extends beyond simple features to include broader categorical distinctions. The results of such studies not only contribute to understanding canine vision but also provide insights into how dogs learn and apply discrimination skills in real-world contexts. In terms of matching and discrimination between physical objects, dogs have displayed abstract concept formation skills through optimal training. This concept was investigated through the same traditional methods as previous studies using match to sample and relational match-to-sample. This study mainly aimed to train dogs to be able to classify same/different associations. (Scagel & Mercado, 2023) This study suggested that dogs exhibited behaviours that could be described as willingness in participation and their ability to learn through specific dog training methods. Moreover, dogs have a widespread availability, making them a potential participant for research. This is a main reason for subjecting dogs to a study for visual-visual matching to sample. However, this study used 3-dimensional dog toys which could be previously familiar to all dogs, and there lies a gap in understanding dogs' ability to match among novel stimuli.

These investigations into visual discrimination between different stimuli provide a foundation for exploring more advanced cognitive tasks, such as matching-to-sample procedures, which build upon dogs' fundamental ability to distinguish between distinct visual elements.

Visual matching to stimuli and discrimination between multiple identical stimuli

Dogs' ability to visually match and discriminate stimuli has been a topic of significant interest, with studies highlighting their capacity for complex visual processing. Matching-to-sample (MTS) tasks, where dogs identify identical stimuli among alternatives, have been used to evaluate their cognitive and perceptual abilities. Wallis et al. (2017) demonstrated the success of using touchscreen technology for these tasks, enabling dogs to distinguish between various visual stimuli such as shapes, colours, and images. This method has proven useful for bias-free and standardised assessment of their visual abilities.

Further research by Range et al. (2008) found that dogs could visually categorise natural stimuli, such as distinguishing between objects and landscapes. Such findings suggest that dogs were capable of generalising and applying abstract concepts to their decision-making processes during discrimination tasks. Similarly, Byosiere et al. (2018) examined dogs' abilities to discriminate between subtle variations in size, shape, and colour, reinforcing the idea that their visual discrimination is highly adaptive and influenced by training and reinforcement strategies. Research focusing on the discrimination of identical stimuli highlights the importance of reinforcement and structured training. The use of innovative tools like touchscreen systems could further expand the understanding of these abilities, allowing for controlled testing of cognitive processing across different breeds and contexts.

Another notable study by Krichbaum et.al. (2021) utilized delayed matching-to-sample (DMTS) tasks to assess working memory and decision-making in dogs. These tasks required dogs to remember a stimulus over a delay before matching it, showcasing their ability to integrate memory with discrimination skills. The study also explored the role of exclusion learning, where dogs correctly identified unfamiliar stimuli by eliminating known options.

These findings collectively emphasize the advanced visual discrimination and matching abilities of dogs, while raising questions about inter-breed differences, the influence of genetics, and the impact of training on these skills. Continued exploration in this field may reveal deeper insights into the mechanisms underlying dogs' visual and cognitive capacities.

Cross modal Association

Cross-modal association refers to the ability to integrate information from multiple sensory modalities, such as combining visual and olfactory cues. This ability has been studied in dogs to better understand how they use their sensory systems collaboratively to solve cognitive tasks

A notable study by Kaminski et al. (2012) explored how dogs respond to human pointing gestures, combining visual (gesture) and spatial information. Findings revealed that dogs could map visual instructions to specific physical locations, emphasizing their ability to associate and act upon cues from different sensory sources.

Moreover, cross-modal recognition tasks have been employed to evaluate dogs' social cognition. For instance, Adachi et al. (2007) showed that dogs could match human facial expressions with corresponding vocal tones (e.g., happy face with happy voice), indicating their capacity to link auditory and visual information.

These studies not only showcase the advanced sensory integration abilities of dogs but also provide insights into their adaptive Behaviour in complex environments. Understanding cross-modal association has significant implications for training programs and Behavioural assessments, as it helps reveal how dogs perceive and process multisensory information. However, the discrimination tasks are important in understanding how animals perceive any provided information and their ability to distinguish between specific variables.

Errorless learning

The methods commonly employed in stimulus matching and discrimination tasks with dogs have often relied on trial-and-error learning. While effective in some cases, these methods may not be optimal for minimizing errors during training. An alternative approach, errorless learning, has been shown to reduce incorrect responses by preventing errors during the learning process (Handley et al., 2023). Errorless learning is defined as a training procedure where the subject is gradually guided toward the correct response, often through techniques like stimulus fading and stimulus control, to minimize the likelihood of errors.

In errorless learning, the discriminative stimulus (SD) is initially presented with noticeable features that were likely to control behaviour (For example, smaller size, dim or brighter colour, high or low contrasts.). The stimulus indicating no reinforcement (S-delta) is diminished or gradually introduced over trials in order to minimise incorrect responses. As the subject's accuracy improves, the SD and S-delta were adjusted to resemble one another more closely, this means either adjusting the noticeable features such as brightness or illumination of both the stimuli were presented in the similar way to each other. This increases the task's difficulty while maintaining a higher rate of correct responses (Terrace, 1963). For example, Terrace's foundational work with pigeons involved training them to discriminate between two colours using a fading procedure: the green (S-delta) was initially presented at a low light intensity and gradually increased in prominence as the pigeons learned to respond exclusively to the red (S+). This method ensured minimal errors during training. Errorless learning has since been applied to train dogs in various contexts. For instance, it was used successfully to teach dogs to detect SARS-CoV-2 through olfactory discrimination (Leal, 2021; Vesgra et al., 2021).

These studies incorporated stimulus fading, where the distinctive visual features of the incorrect stimulus (S-Delta), such as its brightness, contrast or size were gradually decreased across trials in order to minimize errors during learning (Terrace, 1963; Handley et al., 2023). Although, research has demonstrated that dogs can visually discriminate between stimuli of varying colours and brightness. This only provides a foundation for applying errorless learning in visual tasks.

The current study investigated the canine visual-visual matching to sample using a dual-screen paradigm. Moreover, the study also examined the dog's ability to discriminate and match static visual stimuli when presented at varying levels of brightness. The errorless learning approach was employed to refine training methodologies from previous studies. This method is used as a training tool to optimize learning while minimizing errors, rather than as the primary focus of the research. Hence, the hypothesis was that the dogs utilised in this study would be able to effectively match and discriminate between similar stimuli. Moreover, as research progressed, the focus switched to the ability of dogs to discriminate between the brightness of stimuli and it aimed to investigate the effect of lower brightness of a non-matching stimulus to that of a brighter matching stimulus that may or may not increase the dog's ability to match to sample and discrimination. The findings from this research would provide insights into the usability of touchscreen-based experimental designs for assessing conceptual learning in dogs.

Chapter 2 Methodology

Method

Subjects

Five pet dogs were included in this study (See Table 1). These dogs, aged between 3 and 8 years. These dogs were recruited through an initial screening procedure. The initial screening was performed through the SDRG team that allowed dog owners to be volunteer in letting their pet dogs to be a part of this experiment. The dogs were segregated based on their availability and feasibility of the dog owner's schedule. The dogs that had passed the initial screening procedure were allowed to enter an initial interview at the laboratory before familiarising themselves with the experiment. To be included in the study, dogs had to demonstrate motivation to work for food. The dogs also needed to adapt to working in unfamiliar environments without their owner present. Dogs showing anxiety-related Behaviours (e.g., whining, not eating, or tucked tails) were excluded from the study.

Table 1 *Subject Information*

Dog	Age (years)	Breed	Sex	De-sexed
Darla*	8	New Zealand heading dog	F	Yes
Atlas*	4	Husky mixed Border Collie	M	Yes
Cairo*	8	Golden retriever	F	Yes
Gizzy*	6	Tricolour border collie	M	Yes
Cloud+	3	Huntaway	F	Yes

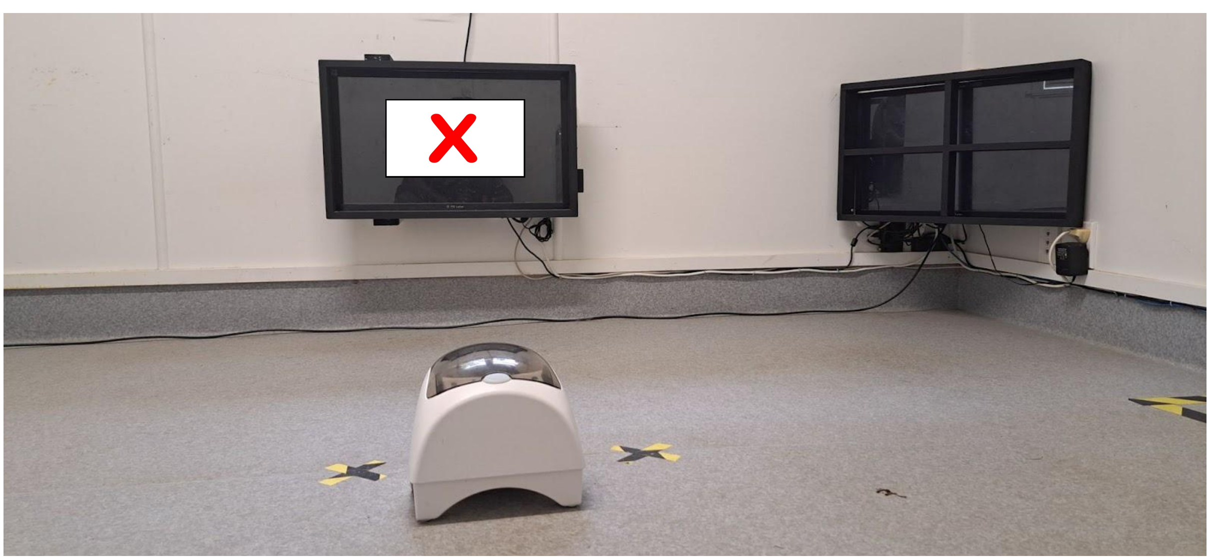
Note. * Subjects who had been used in previous scent detection work

Note. + Subjects who did not participate in the experiment past the initial training stage

Apparatus setup

The experiment was conducted using a customised apparatus designed to train dogs to perform visual-visual stimulus matching. The setup included two monitors positioned side by side in an experiment room (refer to figure 1 below). Screen 1 on left was the sample screen, while Screen 2 displayed the comparison stimuli. Screen 2 was designed to display images within a box quadrant arrangement, each quadrant measuring approximately 960x480 pixels. On screen 1, displayed only one image within the same frame size of 960x480 Pixels placed exactly at the centre of the screen. On screen 2, an image was only displayed if there was a response from screen 1. A feeder - positioned 100 cm from the centre of Screen 1 and 140 cm diagonally from Screen 2 - was used to deliver food reinforcement to the dogs. The room was equipped with cameras to monitor the dogs' behaviour during training, while the controlling computer was placed in an adjacent room to prevent interference with the dog's independent performance.

Figure 1 *Apparatus arrangement for Sample Screen training*



Above image shows Screen 1 lit with the sample image cross while the other screen is awaiting response from screen 1.

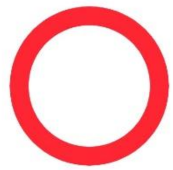
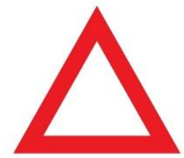
Figure 2 *Apparatus arrangement for Sample and comparison screen training*

Image displaying experimental setup with all apparatus. Above shows Screen 2 lit with the matching image cross from screen 1.

Stimuli

The stimuli consisted of the three basic shapes (cross, circle, and triangle). Only the shape cross was used for the training phase. All shapes appeared red on a white background. Each of these shapes was measured to fit into one box quadrant with dimensions of 960x480 pixels. (Refer to figure 2 below).

Table 2 *Stimuli images*

		
Cross	Circle	Triangle

Matching to sample task

Pre-Experiment Phase

Before the commencement of training, dogs were allowed to explore the experiment room and become familiar with the environment. This period lasted for at least 5 minutes to allow the dogs to freely explore in the experiment room.

Training Phase

The training of the dogs followed a backward chaining procedure, starting with the reinforcement of behaviour in response to Screen 2 and progressing to the use of Screen 1 as the sample screen.

The experimental protocol for this study originally involved three stages:

- Stage 1: Training Screen 2 Image Selection
- Stage 2: Training Screen 1 Image Selection
- Stage 3: Matching to Sample with Multiple Lit Quadrants

At each stage the dogs were allowed to perform the experiment on their own. At all times, when the dog selects an incorrect response, that specific trial was repeated until it is correct. This was termed as the error-correction procedure. If the dog took more time than needed to move along with the experiment, they were prompted by the experimenter. Technically, if the dogs took more than 60 seconds to independently work with the apparatus, they were prompted to move into the direction of the apparatus. The typical prompts involved the experimenter to stand near the apparatus, or pointing towards the apparatus to engage in the desired behaviour.

Stage 1: Training Screen 2 Image Selection

In the initial phase, dogs were trained to perform a nose-touch Behaviour on Screen 2. A single quadrant on Screen 2 was lit with a randomly selected quadrant with the Cross image (refer to figure 3) for each trial, and the dog was required to touch the lit quadrant to receive a food reward. The reinforcement was delivered via the feeder, triggered by the dog's touch on the lit quadrant. During this stage, the experimenter shaped the behaviour by reinforcing closer approximations towards the monitor and eventually providing reinforcement to touch the lit quadrant. Training continued until the dog was able to touch the correct quadrant in their first attempt for every trial on at least 18 out of 20 trials in two consecutive sessions.

Stage 2: Training Screen 1 Image Selection

Once dogs were proficient with Screen 2, the next phase involved training them to touch the image on Screen 1. The training focused on forming a Behaviour chain. This chain began when Screen 1 displayed an image (a cross), the dog must only touch the centre of the image with its nose. This touch was directly detected by the screen. This caused screen 1 to go blank. At the same time, Screen 2 was activated and displayed the same image as Screen 1, but positioned randomly in one of its four quadrants.

To proceed, the dog had to touch the centre of the image displayed on Screen 2. When the image was touched correctly, a chiming bell sound and automatic kibble delivery reinforced the Behaviour. If the dog touched any inactive parts of either screen (such as outside the boundaries of the image on Screen 1 or an incorrect quadrant on Screen 2) the apparatus stays inactive. Touching incorrect quadrants produced no sound, no food, and no response, while the lit stimuli remained active until correctly selected.

The intertrial interval (the time between trials) varied depending on the dog's performance and natural pace. The trial resumed once the dog finished consuming the reinforcement and returned to interact with Screen 1.

As mentioned earlier, prompts were also provided at this stage just like the previous stage. Gradual fading of prompts was used to enhance independent behaviour, with the trainer using minimal gestures (e.g., pointing or walking toward the screen) only when necessary. Dogs were considered ready to move to the next phase once they could complete the chain of behaviours (touching Screen 1 and then moving to Screen 2) independently with at least 18 out of 20 correct responses across three consecutive sessions. All trials were manually recorded on a sheet of paper with the first attempt being the only response taken into account. Which means that even when the trial may be repeated due to incorrect matching, the first attempt that leads to incorrect matching is marked as an incorrect response. Hence, the dog should be able to match to stimuli correctly at their first attempt for at least 18 trials within three consecutive sessions.

Stage 3: Matching to Sample with Multiple Lit Quadrants

Once dogs had mastered the basic chain of behaviours, the experiment progressed to a more complex task involving multiple lit quadrants on Screen 2. Ultimately, the aim was to find out if dogs were able to match to stimuli independently and correctly. At this stage, the experimenter introduces a probe test. The probe test aims to analyse the dog's capability in discriminating between two similar stimuli. This way we could find the baseline matching rates before the actual training. The probe test ensured the levels at which dogs performed better than chance while also assessing the extent of their visual ability to match to stimuli and discrimination skills. When dogs were at the probe test, they went through the same procedure as stage 2, but this time all trials moved without repeating and only three sessions were administered for each dog. Based on the results, this training procedure was altered. After the probe test, the dogs were able to reach only about 50 to 60% of correct responses. Hence, they must require training to achieve the 80% accuracy in matching to stimuli and discriminate between two stimuli. If they had passed this test with more than 80% accuracy, it could be proved that dogs were capable enough to visually match to stimuli and discriminate between similar stimuli. In this first probe test, an image of either a circle or a triangle was shown on Screen 1 at full brightness, followed by its matching image and one non-matching image on Screen 2.

After the probe test, which consisted of three sessions and which provided a baseline in utilising brightness discrimination tasks as a n enhancement, they were trained in the method called errorless learning. Errorless learning was implemented with the brightness of the non-matching incorrect image gradually increasing across phases. At this stage, screen 2 (Comparison screen) introduces each non-matching stimulus at low brightness closer to the brightness of a black screen, while the matching image is presented at full brightness. In Phase 1, the non-matching stimulus was presented at 25% brightness, with the matching stimulus at full opacity. Subsequent phases involved incrementally increasing the brightness of the non-matching image by 12 to 13% higher than the previous phase, while maintaining the full brightness of the matching image. For this study, the non-matching image brightness was split as different phases. The phases were adjusted for the study at 25% brightness initially, and then once they mastered that phase, they were trained with 50% brightness, then with 75% and then finally onto 100% brightness. However, with regards to reaching mastery criteria, if the dogs fail to reach mastery criteria from the second phase at 50% brightness, they went down to another phase breakdown. In this case, brightness increments were adjusted to a finer scale: 25% → 37% → 50% → 63% → 75% → 87% → 100%. This aided in a gradual transition, allowing for more incremental learning. The mastery criteria for dogs were for each shape they had to match at least 8 out of 10 trials equally for circle and triangle (16 out of 20 trials in total per session) in two out of three consecutive sessions to progress to the next phase. Due to time constraints, all dogs were tested only till they reached 63% and they were not tested at any of the other phases.

Pure Conditional Discrimination

Nearing the end of the study, the errorless learning procedure was entirely terminated. The dogs worked up to 8 sessions with both the stimuli presented with 100% opacity. These sessions also utilized the same error correction procedure wherein if the dogs had selected an incorrect response, the trial was repeated. This stage was crucial in identifying the dog's capability in matching to stimuli and also their ability to perform conditional discrimination. This stage was where the dogs were tested for their performance in matching to stimuli without any visual brightness cues. Due to time constraints, the research had to be concluded quickly, as it exceeded the allotted timeframe for experimental analysis. The dogs were tested after completing only part of Stage 3, despite not meeting the criteria for errorless learning.

Data Analysis

The data analysis utilised visual and statistical methods of depiction. The Visual analysis was illustrated with line graphs for the percentages of correct responses for each visual stimulus across all stages of the study. The statistical analysis used here was through calculating the confidence intervals of trials with the help of an online statistical calculator Epitools. (Sergeant, 2018).

Chapter 3 Results

Results

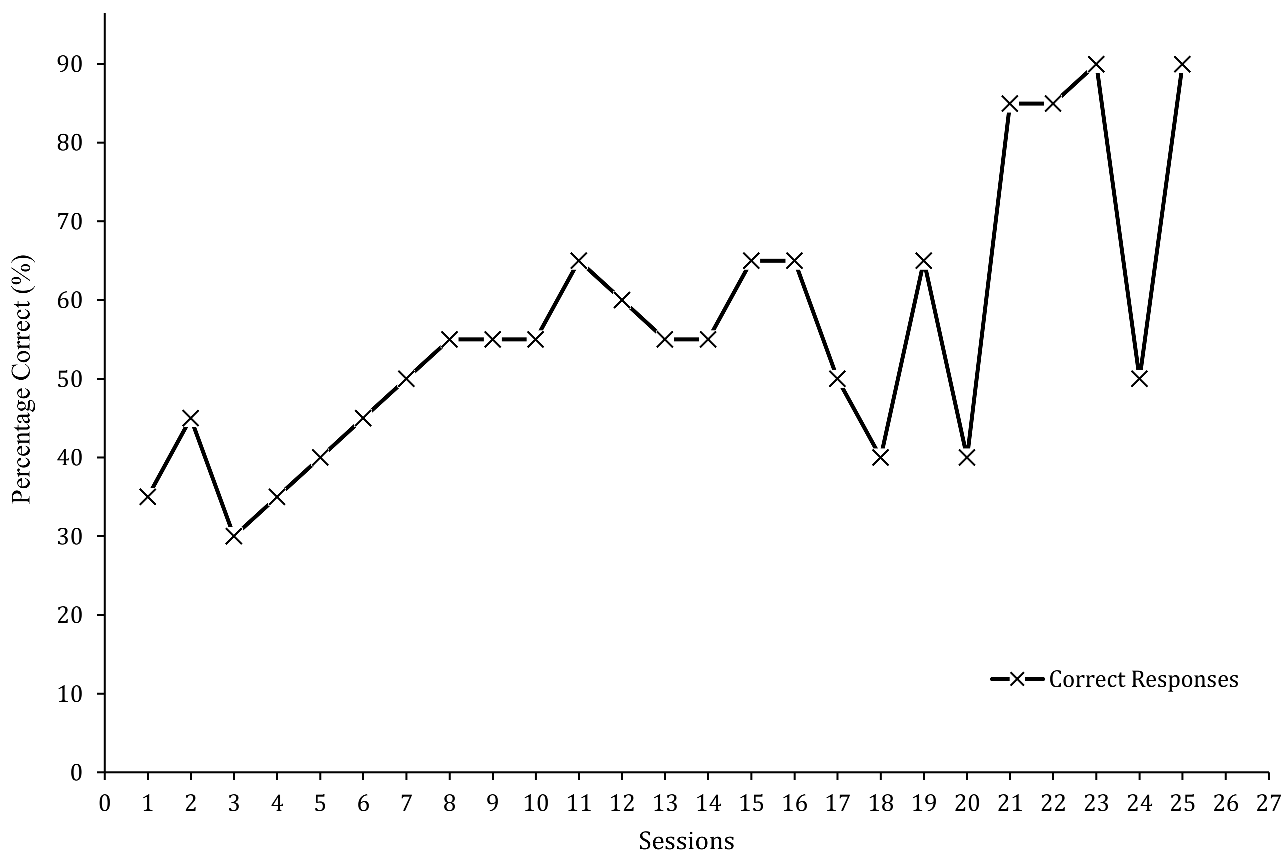
Once, all the dogs were familiarised with the experiment, they were trained to activate the touch screen and receive reinforcement from the feeder. In Stage 1 we trained dogs to select the stimulus presented on screen 2 and then the feeder was activated for reinforcement. This Stage 1 concluded when all dogs learnt to select the correctly lit stimulus on the screen for visual stimuli and used their noses to operate the touch system. Cloud was the only dog new to the study, while the others had already progressed to the final stage. As a result, Cloud had no usable data and was excluded from the study. After this the dogs underwent stage 2 training, here the dog's selected stimulus on screen 1 and then selected the same stimulus on screen 2 to receive reinforcement. The data was recorded when the dogs attempted a correct response. Correct responses were recorded if the dogs correctly selected the stimulus on screen 1 and selected screen 2 in their first attempt for every trial. hence, this training led them to complete the sample to comparison screen behaviour chain. This is where the initial sessions were recorded along with their accuracy data.

Stimulus selection behaviour chain and accuracy rates of response

When the subjects began training on selecting stimulus on both screens to complete the behaviour chain, their individual performances were recorded. The mastery criteria for this stage were that in about three consecutive sessions all dogs should have performed at or above 80% accuracy in selecting the correct response. Darla reached mastery criteria after 30 sessions, Cairo after 25 sessions, and Atlas after 25 sessions. Darla began Stage 2 with approximately 35% accuracy, improving to 60% by Session 11. Between Sessions 16 and 21, her performance fluctuated significantly, with accuracy varying across the sessions. However, from Sessions 21 to 23, her accuracy plateaued at around 60%. Starting in Session 24, Darla's accuracy gradually increased, and by Session 30, she reached mastery criteria and progressed to the next stage. See Figure 3.

Figure 3

Darla data on stage 2 selecting stimulus cross on both screens



From Figure 4, it could be seen that Cairo initially started with 30% accuracy, which dropped to 20%. As the sessions progressed, there was a steady improvement until Session 9, when his accuracy dipped back to 50%. From Session 14 onward, Cairo's accuracy increased steadily, reaching 60% by Session 14 and peaking at 70% by Session 19. By Session 26, he achieved 80% accuracy and moved on to the next stage by Session 30.

Figure 4

Cairo data on stage 2 selecting stimulus cross on both screens

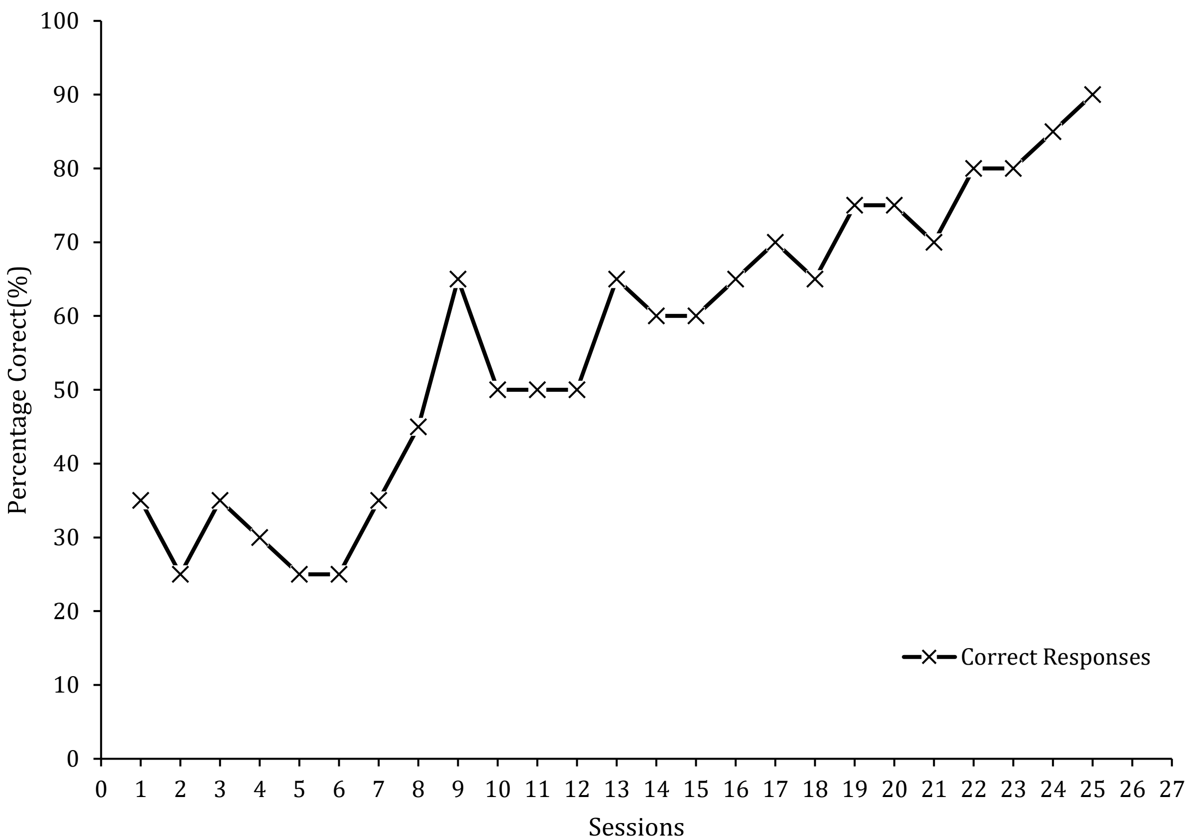
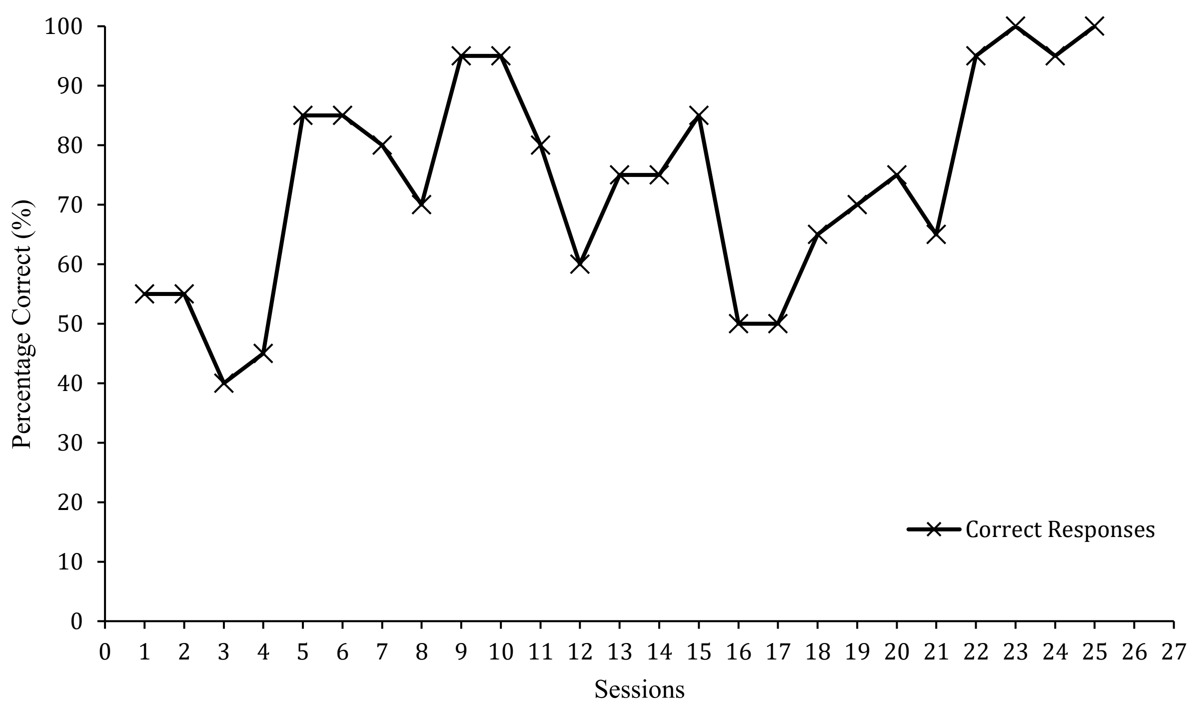


Figure 5 displays Atlas performance at this stage. Atlas started Stage 2 with 55% accuracy, but his performance fluctuated significantly across sessions. At Session 3, Atlas was left alone in the experimental room, which led to inconsistent errors. His accuracy showed some improvement between Sessions 5 and 7, and again between Sessions 9 and 10, but he did not meet mastery criteria. This indicated that Atlas didn't demonstrate the behaviour chain efficiently in selecting stimulus from screen 1 to screen 2 during these sessions. From Sessions 17 to 25, his performance steadily improved, and by Sessions 23 to 25, Atlas reached the 80% accuracy threshold, thus achieving mastery and moving on to the next stage.

Figure 5

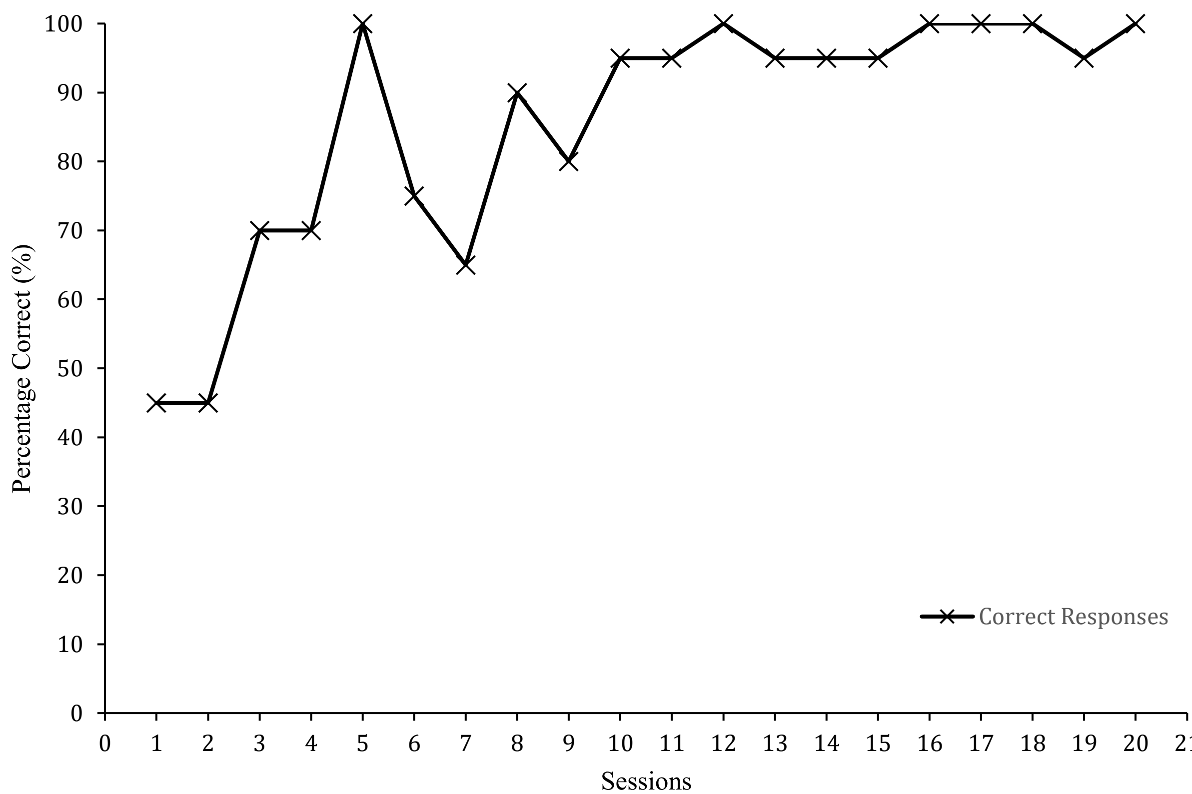
Atlas data on stage 2 selecting the stimulus cross on both screens



Gizzy began stage 2 with about 45% accuracy, and then his accuracy of hitting the correct response increased drastically. He progressed much quickly to about 80% accuracy by session 8. He was consistently hitting the correct response with 80% accuracy, slowly by session 17 he was already well above criteria. Hence, this stage was terminated by 20 sessions and then he moved onto stage 3. (Look at Figure 6).

Figure 6

Gizzy data on stage 2 selecting the stimulus cross on both screens

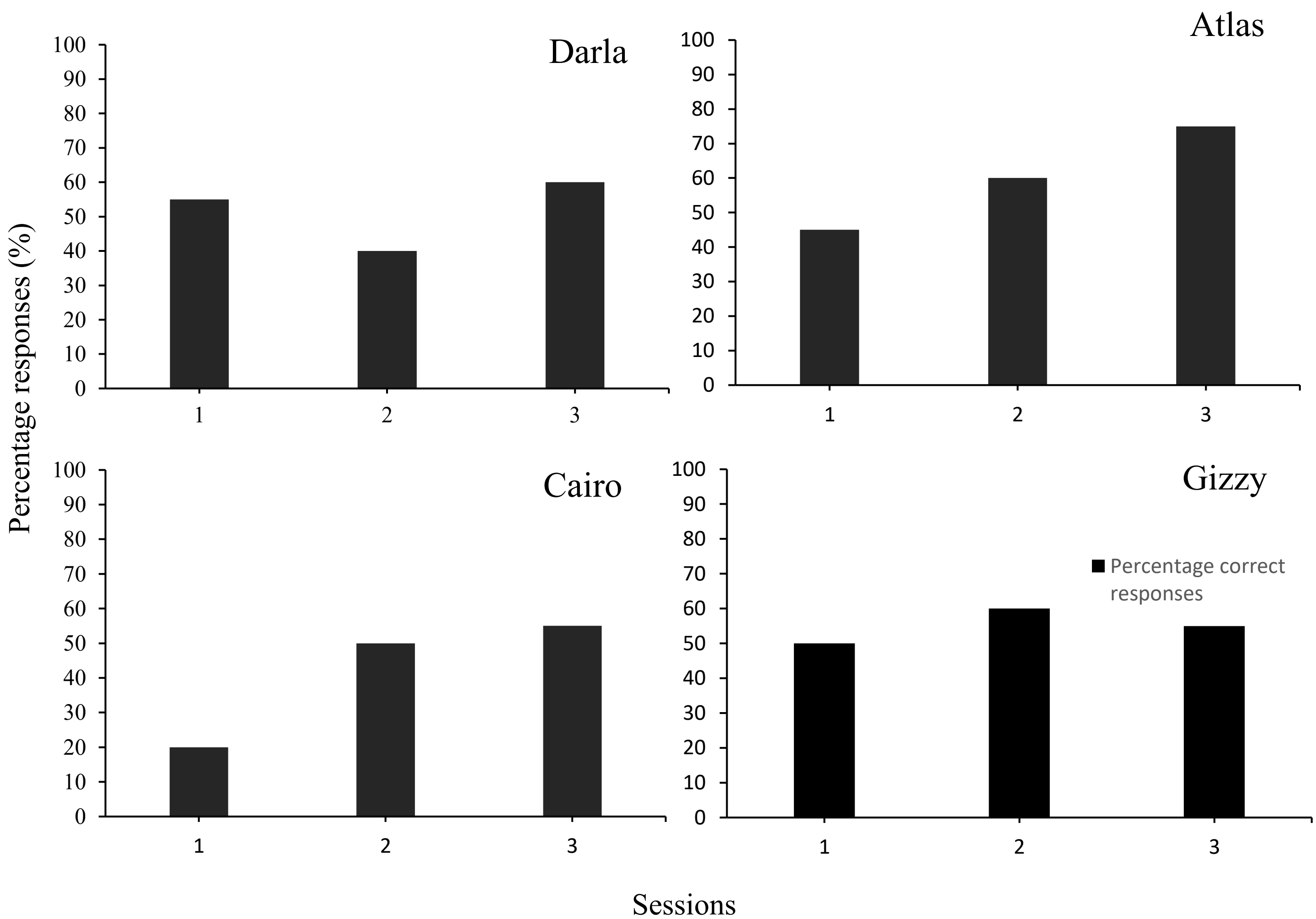


Single subject probe test results for each dog before visual MTS and discrimination

Stage 1 and 2 was completed by four dogs – Darla, Cairo, Atlas and Gizzy. All these dogs moved on to train in stage 3, the aim of this study was to test the capability of dogs in visual matching to stimuli and visual discrimination. A probe test for the dogs showed that dogs were unable to match to stimuli while discriminating between only two stimuli. This probe test provided a baseline to providing a mastery criteria and a plan to utilise the errorless learning technique to advance in dog ability to match to stimuli. Below shows each dogs' performance in these probe tests. In these probe tests it is visually clear that none of the dogs had more than 50% accuracy in all sessions. This showed that dogs needed more than 3 sessions and needed to be investigated if they performed better than chance in all sessions. Except for Darla, all the other dogs showed consistent improvement in attaining correct responses as sessions increased.

Figure 7

Probe test for visual MTS and Discrimination

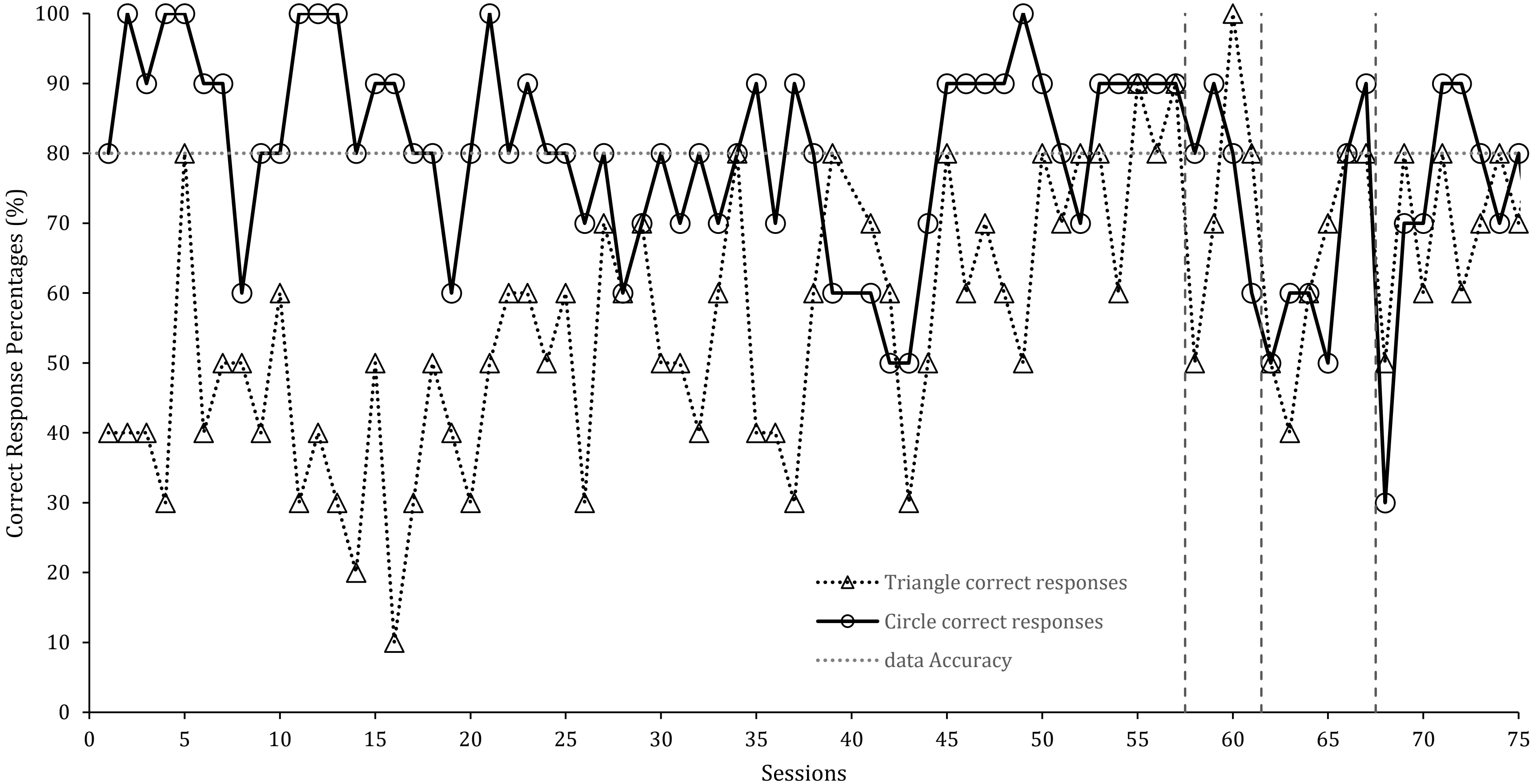


Single subject results for visual matching to sample and discrimination between two stimuli

Atlas' Performance: In the initial sessions of errorless learning, Atlas consistently preferred the circle stimulus, achieving 100% accuracy for circle trials but with lower accuracy for the triangle trials. There were several sessions where both the circle and triangle were chosen correctly at or above 80% accuracy. By Session 52, Atlas was selecting both stimuli with equal frequency and accuracy, and by Session 55, he reached mastery criteria (above 80% accuracy for both stimuli) and moved on to the next phase. In this phase, the brightness of the incorrect stimulus was set to 50%. Based on set criteria at methodology Atlas was unable to progress through this stage even after 6 consecutive sessions, hence, he reverted to the 25% brightness phase. Within just six sessions, he reached mastery at 25% brightness and progressed to the broken down 37% brightness phase. Atlas was unable to progress after the 37% brightness phase before moving to the pure conditional discrimination stage.

Figure 8

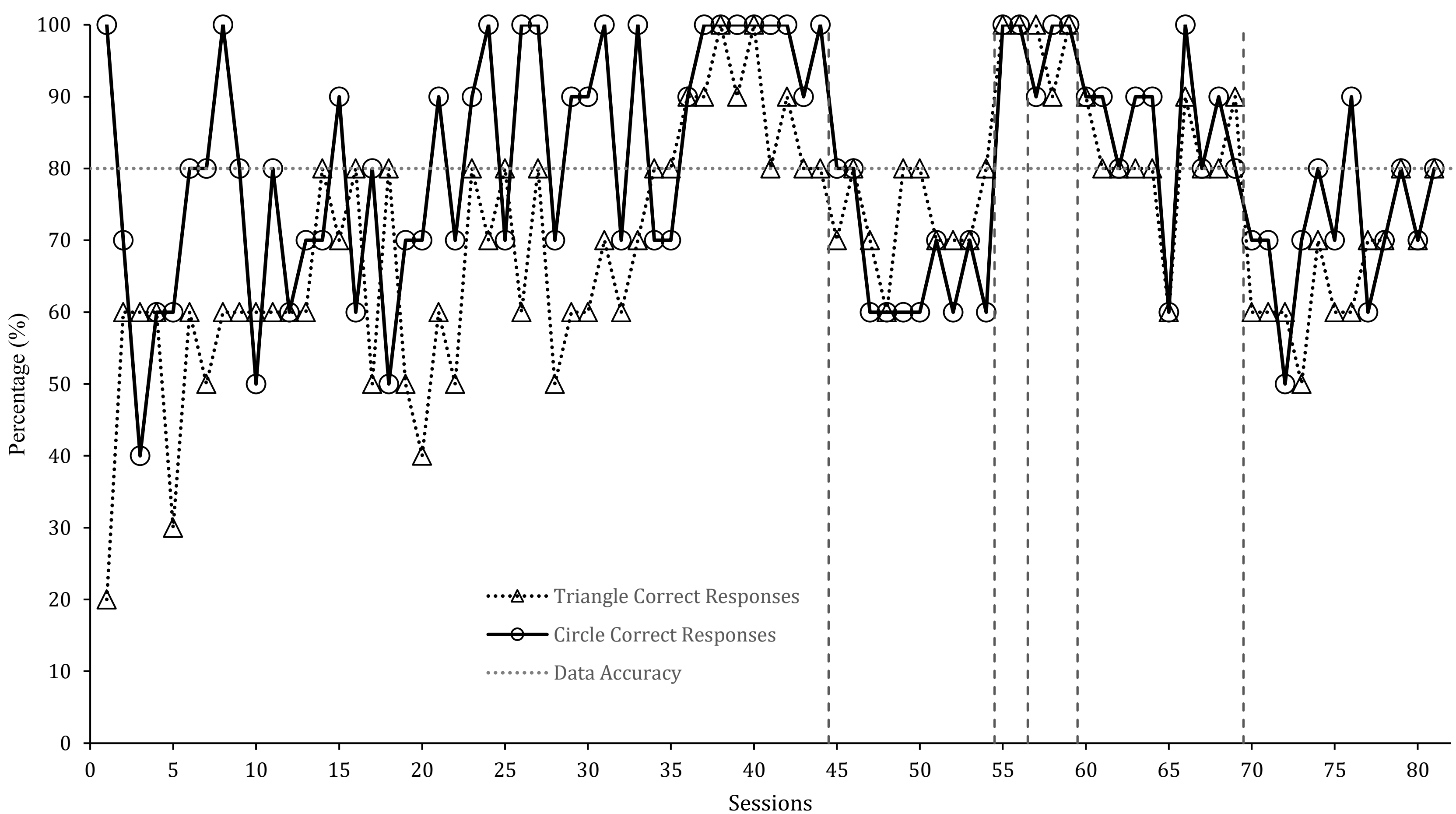
Atlas data at stage 3 matching to two different stimuli across different stimuli



Cairo's Performance: Cairo's performance was more variable but still consistent. Cairo reached 80% accuracy on at least one of the stimuli in most trials, but to meet the mastery criteria, both the circle and triangle stimuli had to be chosen with equal accuracy over two consecutive sessions. On the overall scale Cairo maintained around 60% accuracy for both stimuli from the initial stage of the experiment. From Sessions 14 Cairo showed significant improvement, with either the circle or triangle being selected at or above 80% accuracy. Cairo then moved to the 50% brightness phase (Sessions 45-54). Just like Atlas, Cairo didn't meet the passing criteria, hence she moved down to 25% brightness phase at Session 55, where she quickly achieved mastery and progressed to the 37% brightness phase. Soon, that breakdown had helped her to progress back to 50% brightness before terminating the experiment.

Figure 9

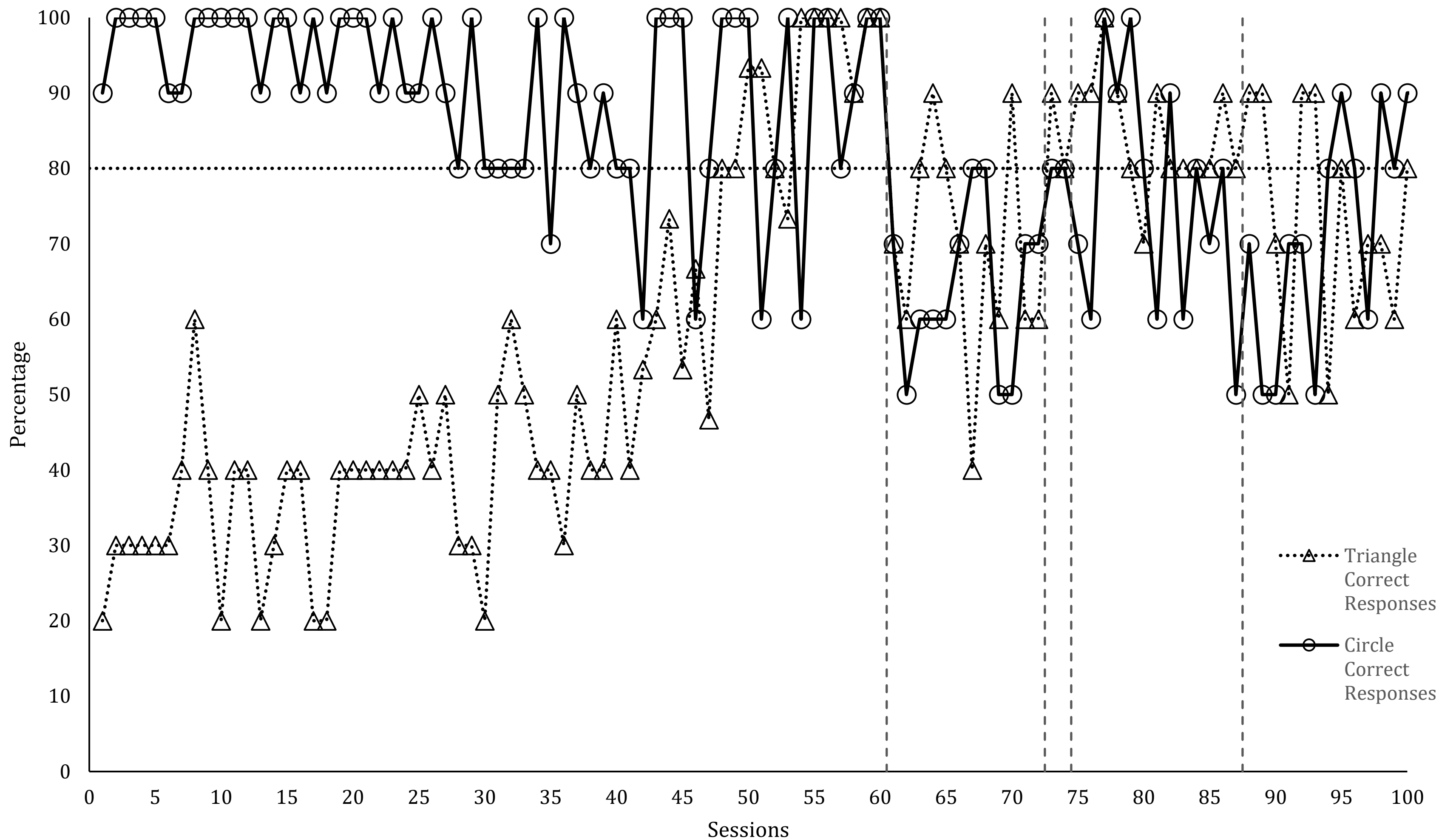
Cairo data at stage 3 matching to two different stimuli across different stimuli



Darla's Performance: Darla consistently performed well with the circle stimulus, achieving over 80% accuracy early on. She initially struggled with the triangle but improved after 40 sessions, reaching 80% accuracy for both shapes by Session 48. From Sessions 54 to 59, she maintained accuracy above 80%, meeting the mastery criteria for 25% brightness. However, at 50% brightness, her performance declined, leading to a temporary return to 25% brightness at Session 73. She quickly mastered this level and progressed through 37% brightness, reaching over 90% accuracy in three sessions. Before the experiment was terminated Darla was working at 50% brightness discrimination just like Cairo. This shows that the number of trials was not enough to show that Darla could progress to full brightness discrimination.

Figure 10

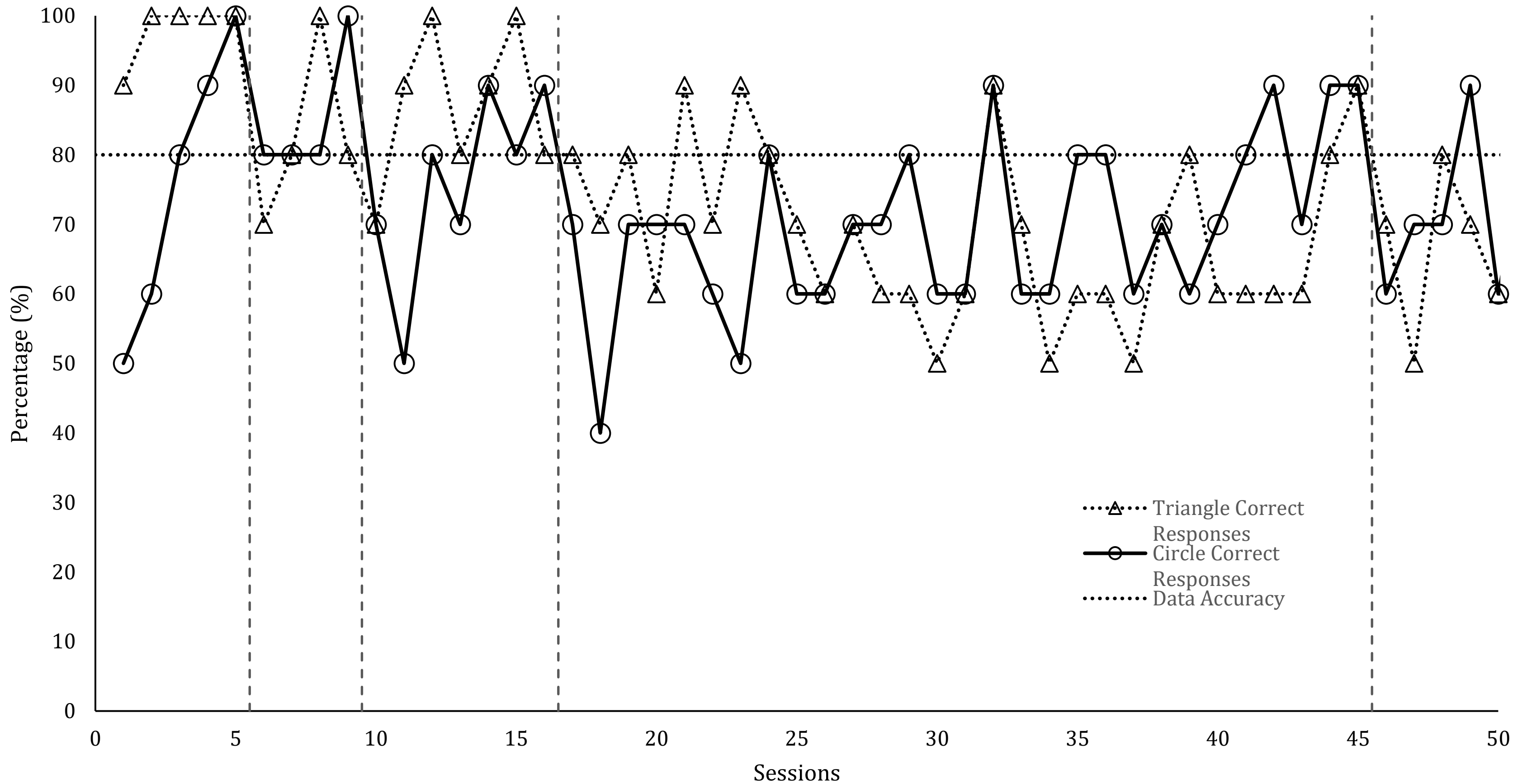
Darla data at stage 3 matching to two different stimuli across different stimuli



Gizzy's Performance: Initially, triangle was selected more correctly than circle stimulus. Triangle stimuli were selected well above the criteria for all sessions conducted at 25% brightness for incorrect stimuli. This phase lasted for only for 5 sessions in which Gizzy improved drastically matching both the stimuli correctly above 80% accuracy for the last three sessions consecutively. He was still consistent in matching to both the stimuli after moving the incorrect stimuli to 37% brightness. It is only after moving to 50% brightness on incorrect stimuli Gizzy had lower success rate in selecting correct response for circle, however, Triangle stimuli was still above 80% accuracy across all sessions. The longest run in obtaining the correct responses for both the stimuli took place at 63% brightness for incorrect stimuli. This phase lasted for about 28 sessions until progressing onto the final phase. After passing the criteria for 63% brightness, Gizzy was the only one to progress onto 75% brightness. However, due to time constraints only a few sessions were conducted at this stage.

Figure 11

Gizzy data at stage 3 matching to two different stimuli across different stimuli

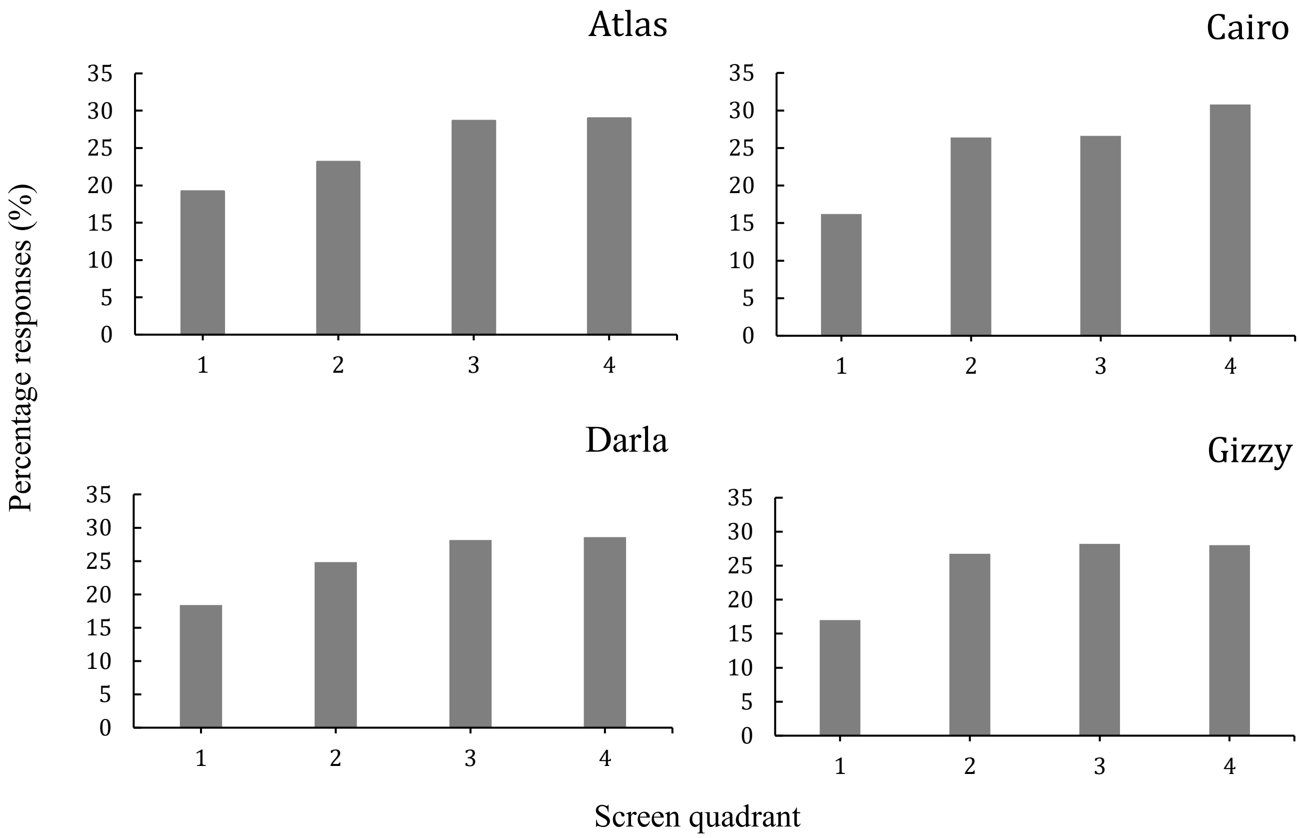


Quadrant position bias

As shown in Figure 3, All the dogs displayed a consistent bias towards the bottom quadrants of the touchscreen. Specifically, quadrant 4, which is at the bottom right corner of the screen. Almost all the dogs exhibited the same proportion of responses for this quadrant. Interestingly, Gizzy had more proportion of selection responses on quadrant 3 than in 4 whilst the other dogs had more proportion of responses on quadrant 4. Quadrant 1 was the least responded target by all dogs. From the graphs it could be evident that quadrant 1, which is the 1st and topmost quadrant on the screen, figuratively scored the lowest percentage response when compared to other quadrants. Additionally, Cairo was the only dog that showed more preference towards the right side of the screen where quadrants 2 and 4 were situated, this shows that almost equally Cairo had selected responses towards the right side of the screen and the left side bottom quadrant.

Figure 12

percentage of responses each dog made to each screen quadrant

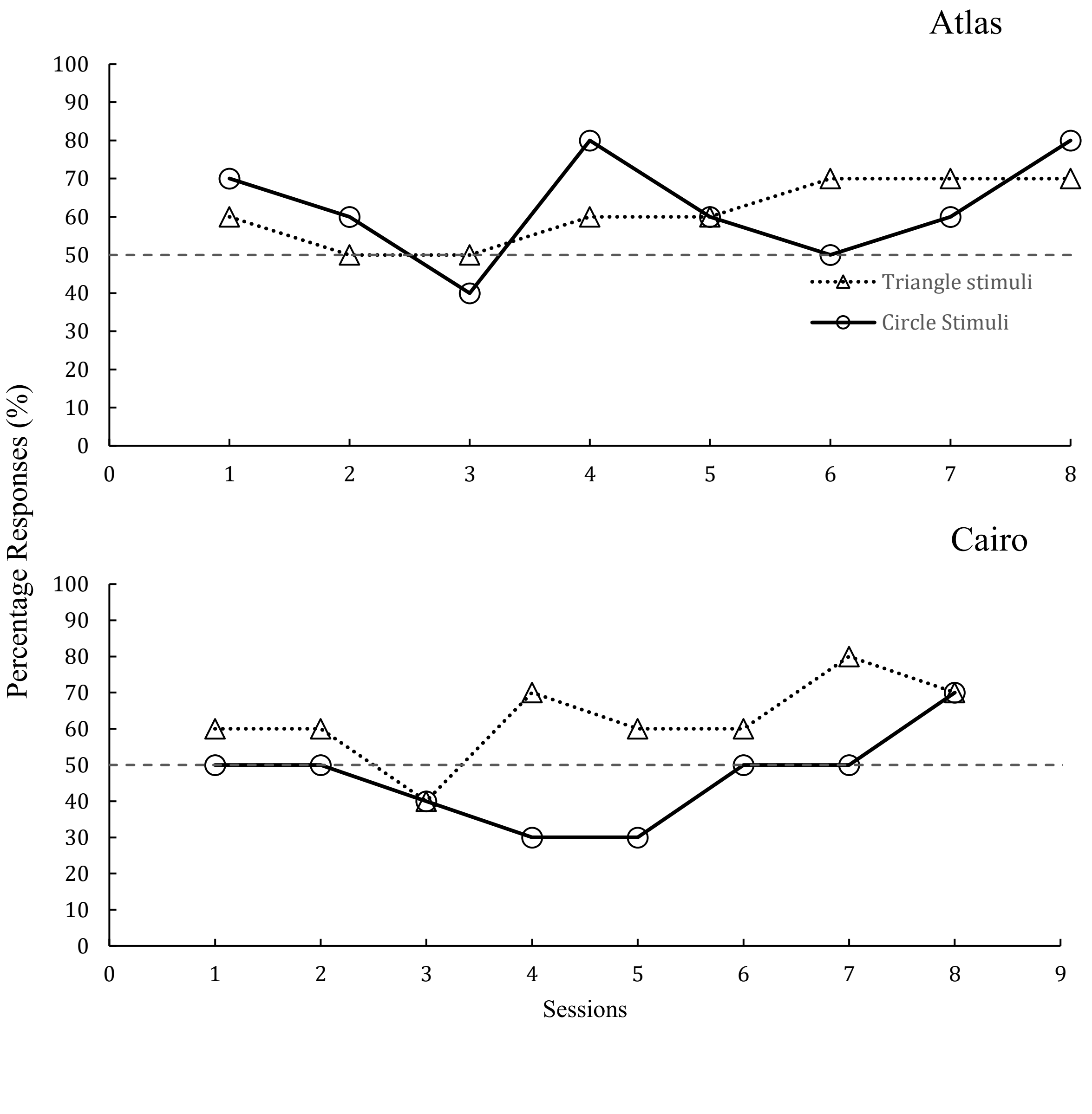


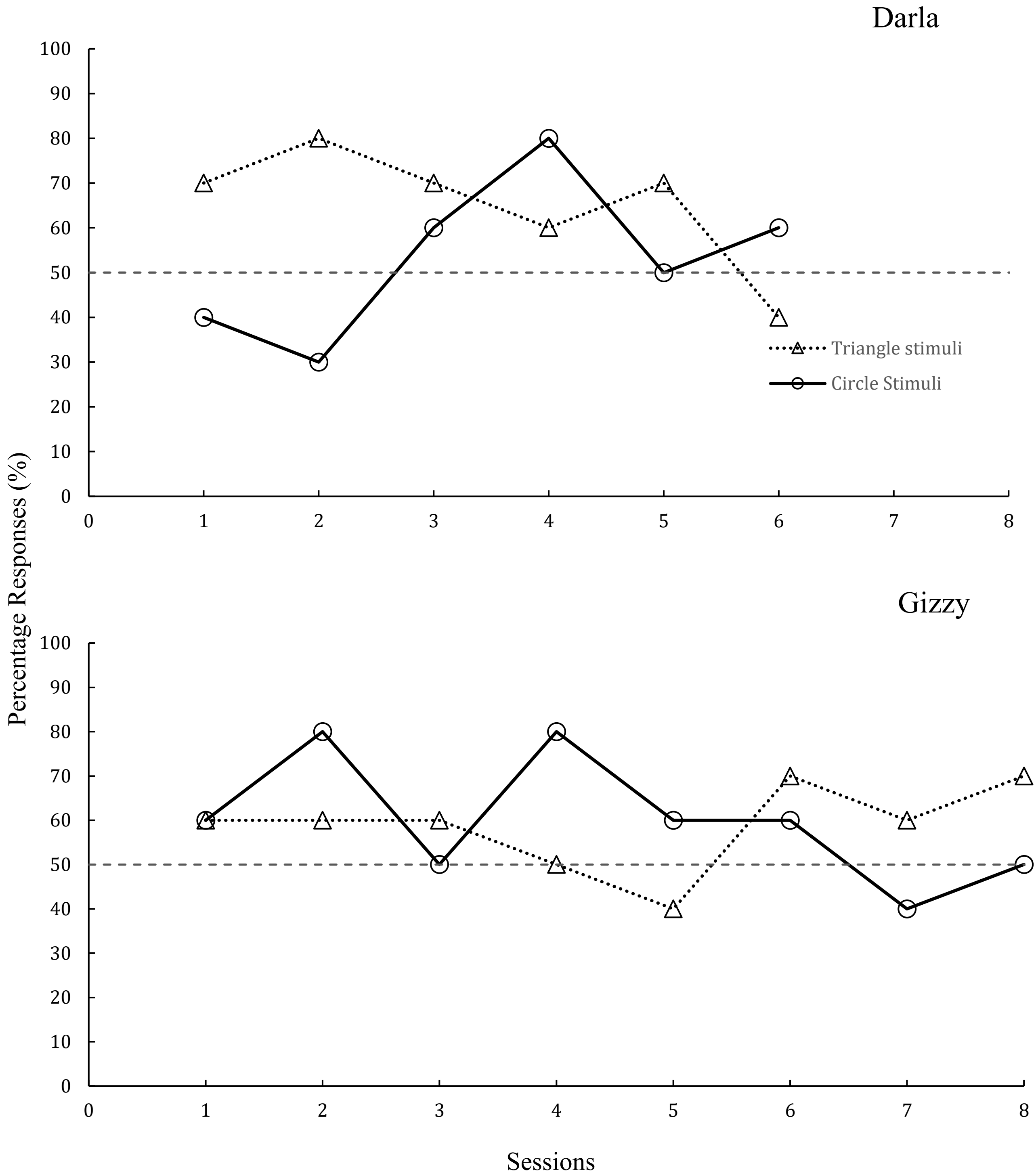
Single subject results for Pure conditional discrimination

Below describes all the dogs' performance at this stage. 6 sessions were administered for Darla and the other dogs attended 8 sessions. Almost all the dogs performed well above the 50% chance performance line.

Figure 13

Pure conditional discrimination data for all dogs




Darla
Triangle stimuli
Circle Stimuli
Gizzy
Percentage Responses (%)
Sessions

Individually, when Atlas was tested directly onto the pure conditional discrimination which eliminated the errorless learning method at this stage, he was able to achieve perform above the 50% chance line and it was only barely below this line in only the third session for the shape circle, however, all the other sessions shows that Atlas performed it accurately more than the chance performance. Cairo also was steadily increasing in her performance; she began strong with performing above the chance performance line, which later was on edge for the rest of the sessions showing that she may have had relied on chance performance than the other dogs. On the other hand, Darla was able to achieve more correct responses for triangle stimuli in the beginning and then it shifted to circle stimuli.

95% Binomial Confidence Intervals for Each Dog across pure conditional discrimination sessions

Table 3 displays the 95% binomial confidence intervals (CI) for each dog's success rates for all sessions across the pure conditional discrimination sessions. The 95% CI represented below shows each dog lower and upper bound. From the table it is visible that both Atlas and Gizzy had displayed higher success rates with 95% CI [.53, .69] and 95% CI [.51, .67] respectfully, while Cairo displayed the lowest success rate for 95% CI of [.46,.62]

Table 3

95% Confidence Interval for correct response across trials run with pure conditional discrimination

C1	Observed Successes	Total Observation	CI Lower Bound	CI Upper Bound
Atlas	99	160	.53	.69
Cairo	87	160	.46	.62
Darla	71	120	.49	.68
Gizzy	95	160	.51	.67

Note. Null probability = .05

Chapter 4 Discussion

Discussion

This study examined dogs' ability to visually match stimuli and discriminate between similar visual stimuli. Additionally, it assessed the effectiveness of an errorless learning technique, where the incorrect stimulus was displayed at a lower brightness to facilitate discrimination. The primary objective was to train dogs to perform a visual matching task. Training began with a nose-touch response to stimuli on screen, progressing through a backward chaining procedure. Dogs first worked with the comparison screen before integrating the entire sequence with both the screens.

The experiment consisted of three stages. The first stage focused on introducing dogs to the apparatus, reinforcing their interaction with both screens, and establishing the Behavioural sequence required for the task. In the second stage, dogs were tested to see their response to a single stimulus, ensuring they could independently complete the chain. The final stage involved matching to sample, where dogs selected identical stimuli presented on two separate screens. Cloud didn’t pass stage 2 due to time constraints and didn’t continue with the experiment. The duration of training varied among dogs, after stage 2 all four dogs Atlas, Cairo, Darla and Gizzy moved on to stage 3. The errorless training procedure was implemented at the third stage, which led to dogs to hit the correct target more accurately than with pure conditional discrimination as found in the probe tests. At all trials the incorrect stimuli were presented at a lower brightness closer to the blank screen, allowing the dogs to select the more lit matching stimuli. The effects of this method, and the dog’s behaviour through this stage and all the other stages are described in detail below.

Training image selection for dogs

Results demonstrated that all participating dogs successfully completed the behaviour sequence chain of correctly selecting a identically visual stimulus presented on two screens, while also achieving brightness discrimination to an extent. The position of the visual stimuli was randomized across trials. All dogs achieved at least 80% accuracy in selecting the correct stimulus within a reasonable number of sessions. All dogs were able to finish up this stage between 20 to 30 sessions approximately. Gizzy had previously participated in an odour-to-visual matching study but did not meet the required criteria in that task, leading to his participation in this study focusing solely on visual matching.

Individual differences were observed in training progression. Atlas and Cairo advanced more quickly than Darla, though her consistent improvement suggests a steady learning process reinforced through training. Atlas displayed initial variability in performance, which may be attributed to external factors such as environmental conditions or prior experience. Similar observations have been made by Pongrácz et al. (2017), who highlighted the influence of perceptual and environmental factors in canine cognitive tasks.

Probe Test and its significance

After the dog were able to select the stimulus on screen, we needed to find out if they can perform matching to sample than just touching the lit quadrant through chance. At this probe test two stimuli were introduced, and they had to match to sample at their first attempt and if they don’t the trial moves on either way. This probe test mainly displayed that as the sessions increased the dogs would be able to perform not better but consistently in a similar way in matching to sample while discriminating similar stimuli. Moreover, this test doesn’t provide enough evidence if the proportion of correct responses was performed by chance or through selection behaviour that supports matching to stimuli or any discriminatory behaviour towards the presented stimuli.

Errorless Learning and Brightness Discrimination

The probe test is useful to identify a better framework in investigating dogs' ability to match to stimuli and discriminate identical stimuli. Once the probe test was over, the dogs went through the errorless learning method, this method was used mainly to minimize the errors made by chance attempt to select the correct stimuli. The probe tests were a reference point in finding out the dogs natural matching ability without any visual cues. This is helpful because it's data could be used to evaluate the usefulness of errorless learning method. At this stage dogs were presented with two stimuli—a circle and a triangle—where the incorrect stimulus was displayed at a lower brightness level. Initially, all dogs successfully completed training at 25% brightness discrimination. However, difficulties emerged when progressing to 50% brightness. For example, Atlas was unable to reach mastery at this level even after 50 sessions and had to return to the 25% brightness phase. Other dogs exhibited similar challenges.

To address these difficulties, brightness increments were modified. Instead of transitioning directly from 25% to 50%, an intermediate 37% brightness level was introduced. This gradual approach improved performance and allowed for a smoother transition to higher difficulty levels. These findings align with research by Byosiere et al. (2019), which examined the impact of luminance and brightness thresholds on canine visual discrimination. Their study showed that the dog's adaptability in learning brightness discrimination is not limited, and higher brightness provided more responses than lower luminescence. However, they also pointed out that the colour of the shape also plays a major role in dogs' visual abilities. This aligns with the current study where the dogs could identify visually distinct images presented at different levels of brightness. The results suggested that minor incremental changes in task difficulty can enhance learning outcomes.

Individual Differences

Performance varied across dogs, particularly in brightness discrimination. Atlas, Cairo, and Darla required modified brightness increments to progress, while Gizzy, who joined after these adjustments were implemented, advanced through all phases without difficulty. Darla exhibited greater proficiency with the circle stimulus but required additional sessions for the triangle, indicating a potential difference in stimulus salience. This observation supports findings from the foundational research by Terrace, in 1963 on the effects of light intensity that lead pigeons to select the colour that was illuminated with higher light intensity than the colour presented with lower brightness (Terrace,1963). This also elaborates the use of brightness increments and its ease of discrimination for dogs' visual capacity.

Cairo demonstrated significant variability in responses. In some trials, she exhibited position and shape biases, frequently selecting the same quadrant or the incorrect stimulus multiple times. Despite these errors, she ultimately met the mastery criteria with sufficient training sessions. Atlas showed a strong preference for the circle stimulus early in training and had difficulty discriminating against the triangle. Additionally, he struggled to transition beyond 37% brightness discrimination, whereas other dogs progressed more smoothly to higher levels. Byosiere et al. (2019) noted that brightness discrimination may impact every dog individual learning speed, some dogs may struggle to learn the discriminate only to a certain extent while other dogs may transition much more smoothly. Moreover, the number of sessions or trials when exceeded may reduce their dependence on reinforcement or any factor responsible for helping them performing a task (Range et al., 2008).

After going through all this errorless learning training, the dogs were tested with pure conditional discrimination. If we had to examine the difference and effectiveness of the errorless learning, the initial probe test could be used to evaluate this by comparing its results with the results from pure conditional discrimination sessions. From figure 7 the probe test results show that the dogs have been on borderline to the 50% chance line, suggesting that the dogs were unable to match to stimuli and discriminate better than chance. However, in figure 13, in almost all sessions all the dogs were above the 50% chance line, suggesting that the errorless learning training may be more effective in this task, however looking at the confidence intervals, it could be clear that not all dogs are above the 50% chance line and more sessions could have provided more details in confirming the effectiveness of this training method. .

Implications for Applied Behavioural Psychology

These findings contribute to the broader understanding of canine cognition and learning. The implementation of errorless learning suggests that minimizing errors may help enhance stimulus discrimination. However, there was no comparison made with traditional training such as using realistic images or other visual inputs in order to state this errorless learning could be an effective strategy. This could be studied as a principle that may be applied in training service animals or working dogs requiring precise visual discrimination.

Behavioural changes were also observed during training. Cairo and Darla developed a distinct spinning Behaviour before touching the screen, creating a circular movement pattern between the two screens and the reinforcement feeder. This Behaviour was consistent across sessions but disappeared when interacting with the second screen, suggesting a task-related motor pattern. Understanding such Behavioural adaptations could inform future training protocols.

Limitations and Future Directions

A key limitation of this study is the use of two-dimensional shapes as stimuli, moreover, the type of stimuli used were only two shapes and presented in the same red colour in white background. Dogs were found to have dichromatic vision (Neitz et.al.,1989), hence using one colour stimuli for all sessions limits the potential in testing for their colour vision perception. There was no investigation on the effects of size as well in this study, which is also a factor to consider for future research. Future research should systematically assess these factors to better understand their impact on learning. Additionally, adjustments to brightness opacity were made based on performance, introducing some variability in experimental conditions. The mastery criteria had some inconsistency, as only attempting three trials at 80% accuracy to move to next brightness discrimination level may not be an ideal strategy. This could be seen through the instability in the dog performance across each stage. Furthermore, standardizing these increments across all subjects may provide clearer insights into the effectiveness of errorless learning at different brightness levels.This study could be standardized with time trials and other time measures that aid in discovering the length of exposure to the stimulus would affect their performance.

Further research should also explore the effects of various types of stimuli in canine visual perception. Variability in responses to circle and triangle stimuli suggests that dogs may perceive certain shapes differently, influencing discrimination accuracy. Investigating these preferences could refine stimulus design in future experiments.

Conclusion

This study demonstrated succession in behavioural chaining that allowed for matching to sample training. The participated dogs underwent errorless learning training but did not complete it due to failing to meet performance criteria on an identity matching task with two stimuli. However, in the identity matching task with two stimuli the dogs demonstrated better than chance performance. The use of errorless learning helped to investigate brightness discrimination, but this may not be an effective training program for the visual matching to sample for dogs. To evaluate visual matching to sample in dogs, additional development in the use of errorless learning and carrying out an experimental analysis would be helpful for further research in this field. Overall, the findings from this study contribute to the field of visual matching to sample and visual discrimination with canines.

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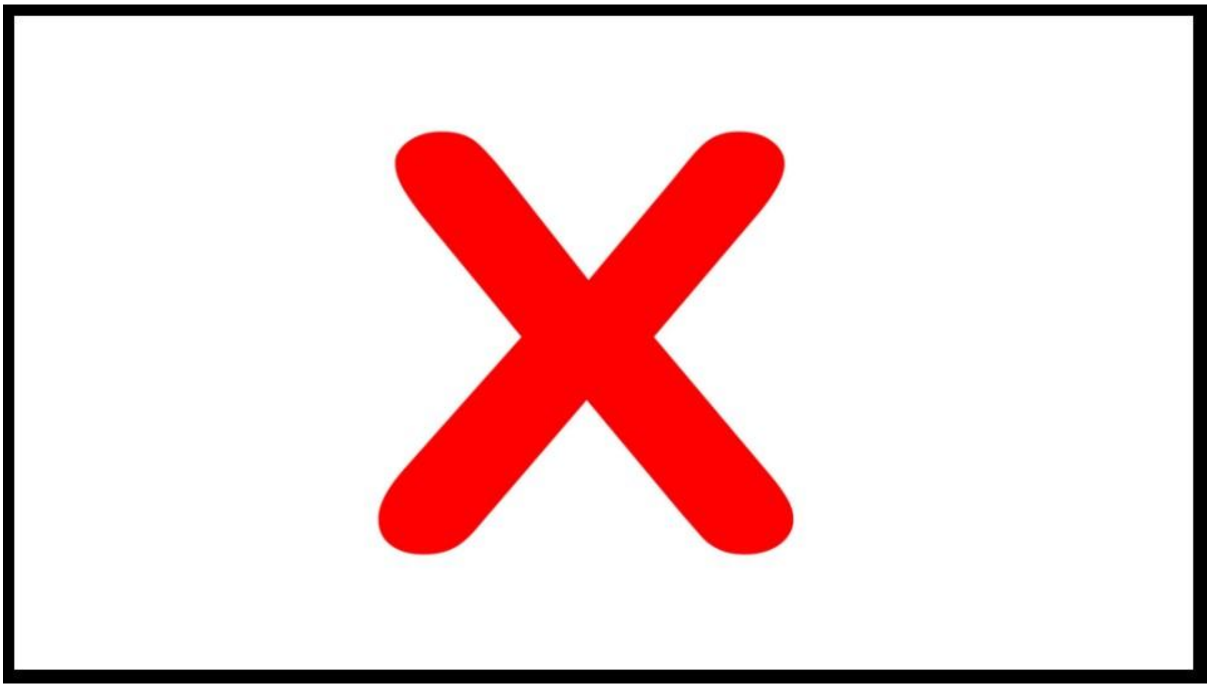
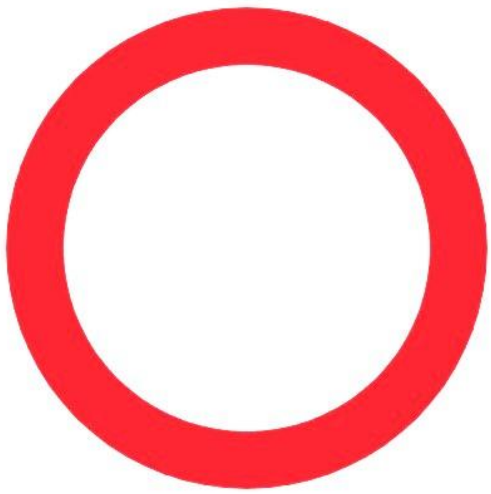
Appendices

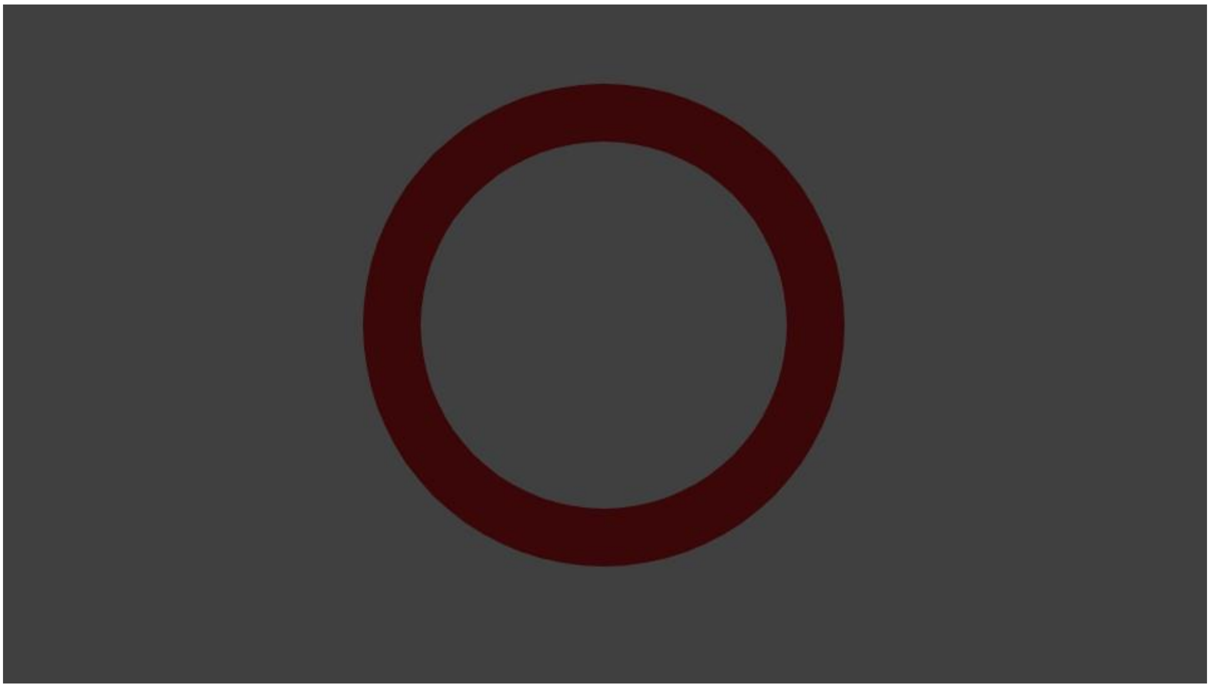
Appendix A: Image of a Cross



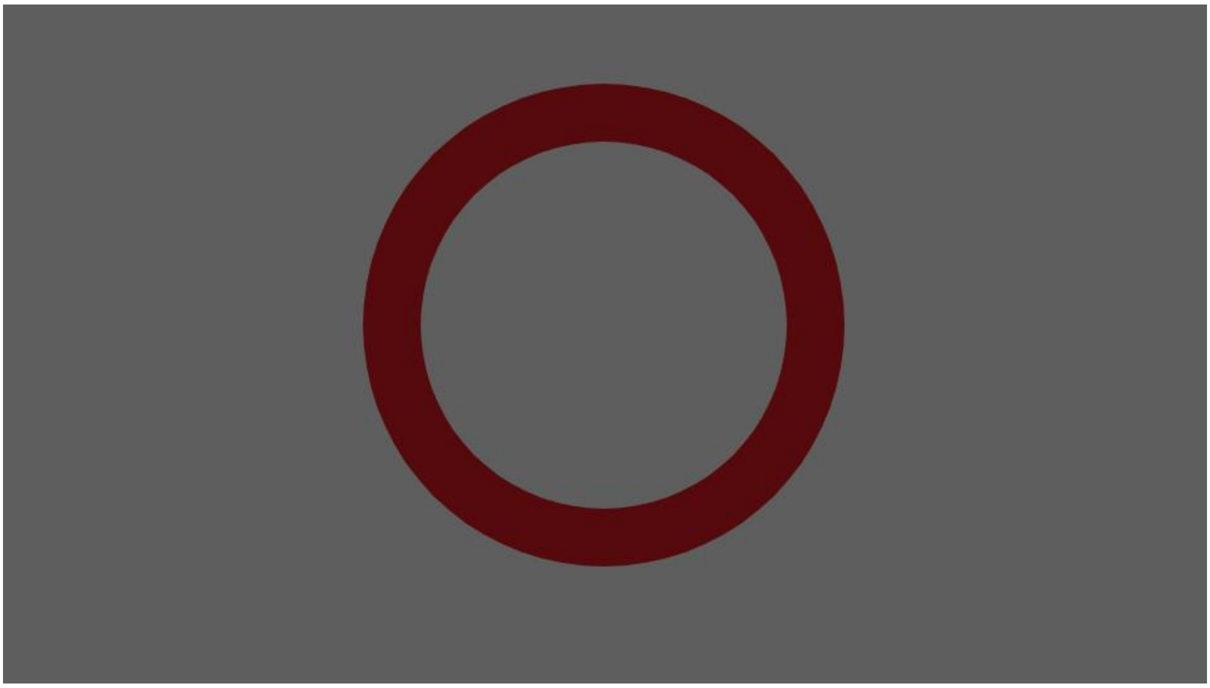
Appendix B: Image of a Circle at Full Brightness



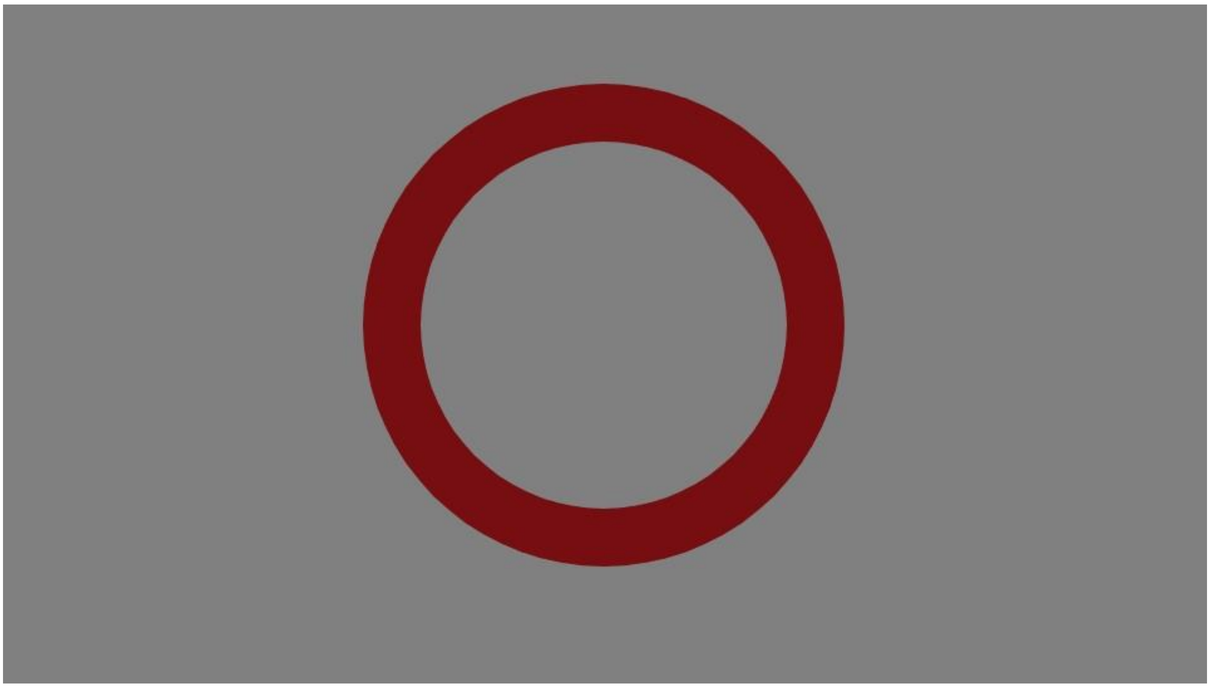
Appendix C: Image of a Circle at 25% Brightness



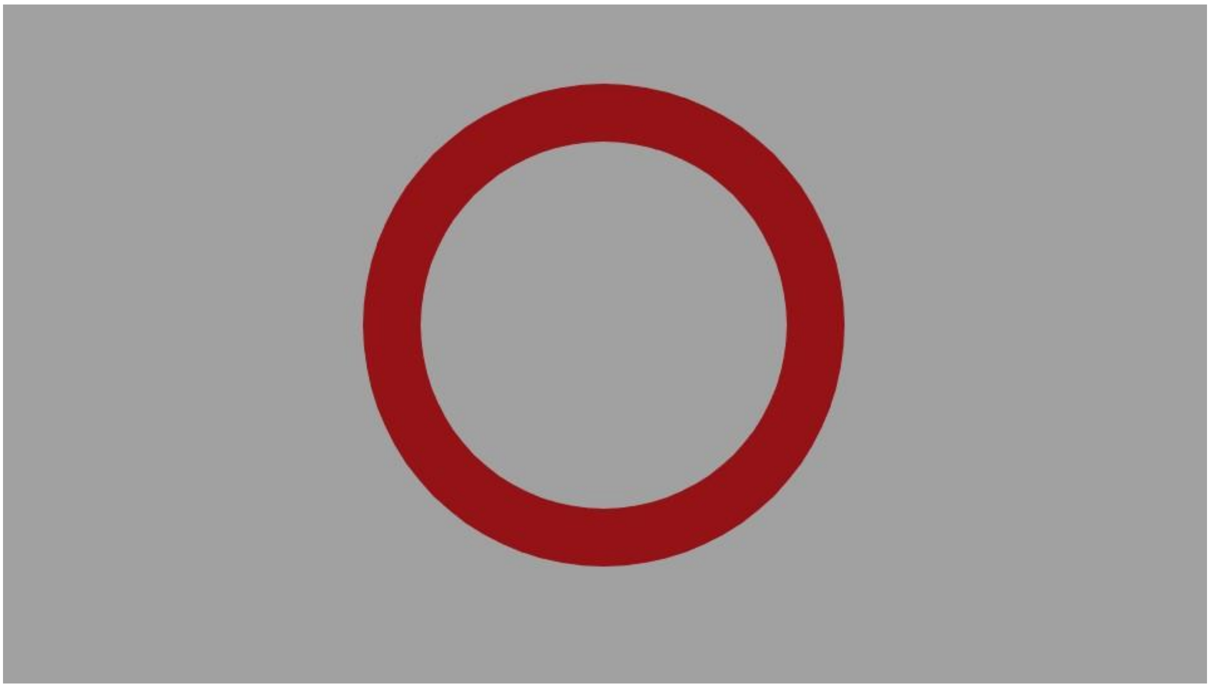
Appendix D: Image of a Circle at 37% Brightness



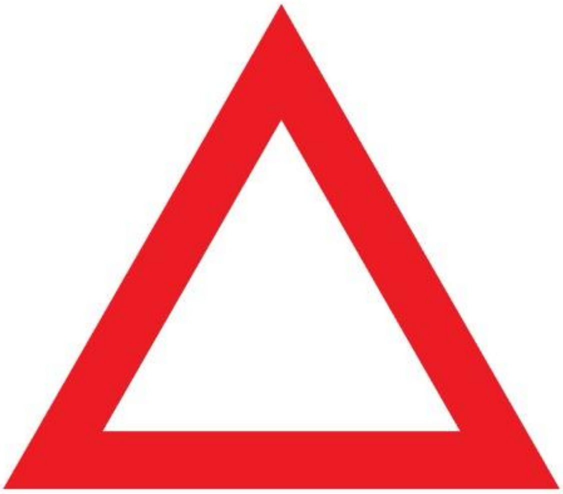
Appendix E: Image of a Circle at 50% Brightness



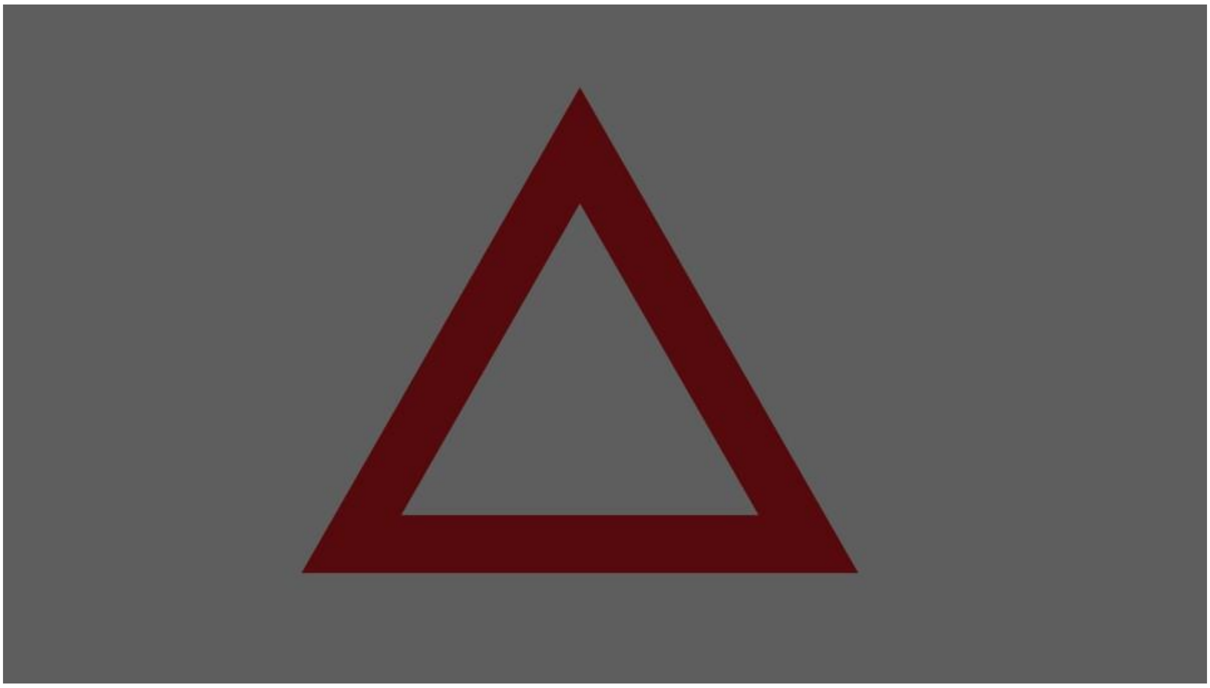
Appendix F: Image of a Circle at 63% Brightness



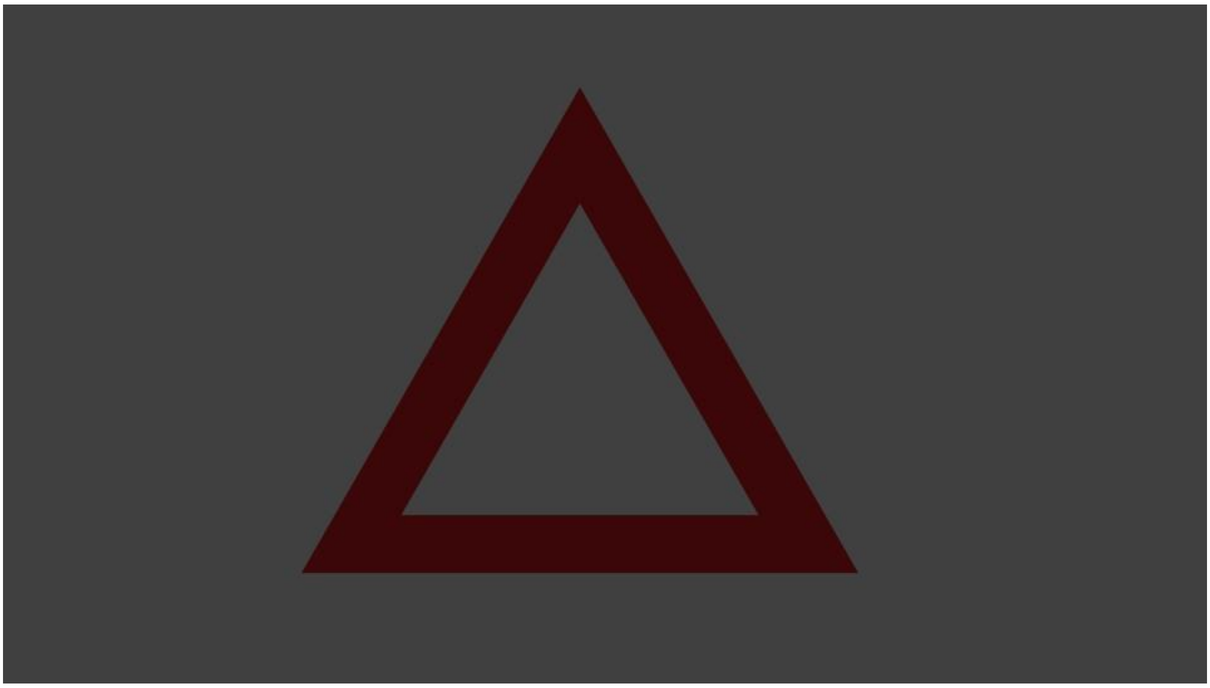
Appendix G: Image of a Triangle at Full Brightness



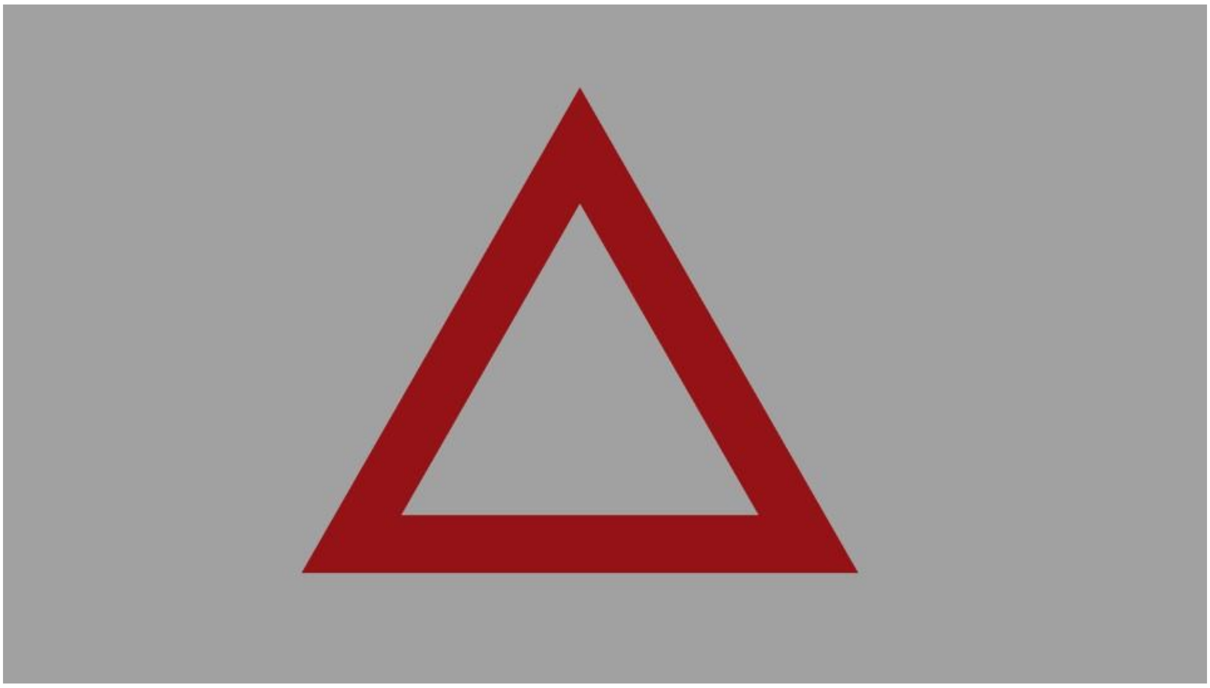
Appendix H: Image of a Triangle at 25% Brightness



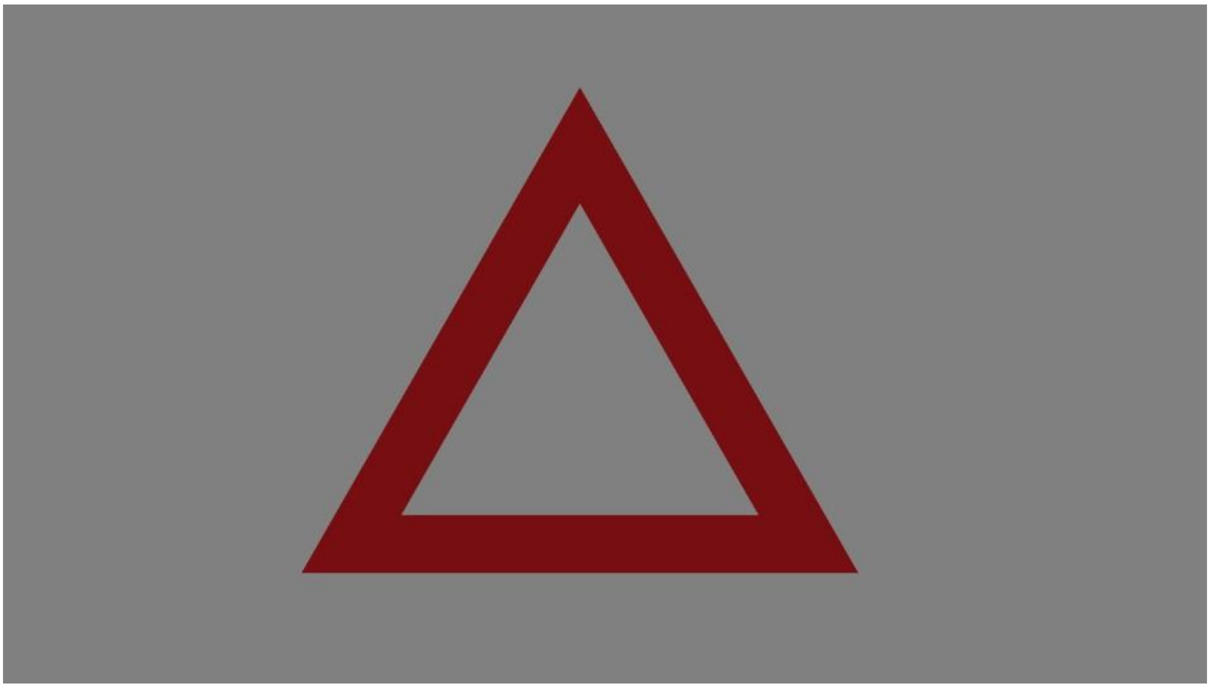
Appendix I: Image of a Triangle at 37% Brightness



Appendix J: Image of a Triangle at 50% Brightness



Appendix K: Image of a Triangle at 63% Brightness



Appendix L: Standard Operating Procedure for Training Dogs to Use Visual-Visual Stimulus Matching

Apparatus Setup:

The experiment room must be equipped with only the testing apparatus and any other distractive elements must be removed from the room before running any session. The apparatus consists mainly of 2 monitors, and a feeder. Position two monitors next to each other in the experiment room to serve as screens for displaying stimuli images. The room must have a door that closes and should be equipped with at least two cameras that show two different angles of the apparatus setup. The cameras or any other recording materials were out of reach from the dog. The computer(s) used to control the apparatus and monitor the dogs should be positioned in an adjacent room.

Pre-Experiment Phase:

1. Allow the participant dog to explore the experiment room and become accustomed to the environment, give the dog at least 5 minutes to explore the room and wait until they start exploring the apparatus.
2. Allow the dog to explore the room/apparatus and stand next to the monitors to let the dogs be comfortable with the main apparatus and the feeder.

Initial Training Phase:

The basic training hierarchy here utilises a backward chaining mechanism. This experiment requires the participant to touch and navigate between two identical monitors that display certain images. Hence, the training should include performing the nose touch behaviour and matching it to the stimulus through a backward chaining mechanism. While adminisitering this procedure, a general criterion should be that each step must be completed by the dog independently. Some of the dogs may require more than the a few training sessions before progressing to the next training stage. However, keep each training session under 10 minutes to administer optimal training for each dog present at the same day.

Stage 1 - Training screen 2 Image selection:

Initial training sessions for shaping nose touch behaviour: Initial training sessions should allow the dog to touch the screen to receive direct reinforcement from the feeder. On screen 2, a single, randomly chosen quadrant is lit while the others remain blank for each trial in a session; moreover, each session consists of 20 trials. There were four quadrants in which only one of the quadrants is lit with an image. Only the lit quadrant is touch-sensitive and provides reinforcement; touching the blank quadrants is programmed as no response. The dog must touch the lit quadrant to receive a reward.

1. Shaping Specific Nose touch behaviour: The goal is to shape the dogs' behaviour to touch a specific part of the screen to receive reinforcement from the feeder. Use the battery-operated feeder remote to dispense one kibble as reinforcement when the dog touches the lit quadrant of the screen. Initially, reinforce the dog for moving near the feeder. Gradually reinforce as the dog approaches the monitors. Continue reinforcing each successive approximation until the dog reliably touches the lit quadrant with its nose, triggering automatic reinforcement from screen 2.
2. Timing, Trials and Moving on: Once shaping is complete, the dogs must be able to differentiate between the lit areas or images projected on the quadrants and touching them leads to reinforcement. The dogs should touch the correctly lit quadrant for at least 18 trials out of 20 trials in at least two out of three consecutive sessions; if they reach this criterion, they were ready to start shaping screen 1 image selection with chaining mechanism.

Stage 2 - Training Screen 1 Image Selection:

1. Begin training with a single stimulus presentation on screen 1, then allow the dog to touch the image on screen 1. Once they touch the screen, screen 1 goes blank with a sound on screen 2, and it is lit with the same image as the one displayed on screen 1 in one of the randomly selected quadrants. Since previous training has been conducted with screen 2, the dogs should be able to touch the lit quadrant, which results in reinforcement.
2. No food reinforcement is provided when the dog touches screen 1, and training should be focused on training the behaviour chain on selecting screen 1 touch response to screen 2 touch response. Touch activation of the lit quadrant in screen 2 only functions as a reinforcer.
3. Chaining behaviour sequence for screen 1 to screen 2 behaviour: In order to train and allow the dog to engage in this chaining behaviour, some key prompts could be utilised. Prompt only when crucial, that is, when the dog doesn't engage in any nose touch behaviour at all. These prompts may not be touching the screen, instead, it could be a finger pointing at the screen and/or walking towards the screen to direct the dog to move towards the objective. However, fade the provided prompts so that independent matching to sample behaviour occurs without any interaction from the trainer. As the dogs were shaped for screen 2 earlier, it wouldn't be necessary to prompt them unless they repeatedly touched the blank screen three times. With this training, dogs must be able to voluntarily touch screen 1 and then move onto screen 2 and receive the reinforcement.
4. Main criteria: The dogs must meet the 18/20 trial accuracy threshold in three consecutive sessions before they can proceed to the next stage. The dogs must be able to touch screen 1 and immediately move to screen 2 without any prompting.

Stage 3: Training screen 2 Image selection, multiple lit quadrants:

1. Once the dogs meet the criteria for Training Screen 1 Image Selection, they begin matching identical stimuli on Screen 2.

   Probe test 1: In the probe test, one randomly selected image (B or C) is shown on Screen 1. After the dog touches it, both images (B and C) appear on Screen 2 in random positions. The dog must select the matching image in order to receive reinforcement from the feeder. Both images were presented at full opacity, and the trainer does not intervene.

   Correct responses were reinforced, while incorrect ones move to the next trial. This is a test phase with no accuracy criteria. If the dogs were able to correctly match the sample for 16 trials out of 20 trials, they can move onto the next probe test 2 with three different stimuli.

2. **Errorless learning:** If they fail to reach the criteria on this probe test, they are trained with the same newly introduced stimuli. There is no need for cues because the dogs are already trained to choose between screens 1 and 2 to receive food reinforcement. There are four opacity change ranges in this stage, and the criterion to advance is selecting the correct response for at least 16 out of 20 trials in two out of three consecutive sessions.

   Two quadrants display either Image B or C, while the other two quadrants remain blank. In every trial, the image positions are changed at random.

3. The dogs are trained using errorless learning techniques, with each phase seeing a progressive increase in the opacity of the non-matching stimulus. The criteria to progress from one phase to the next is achieving at least 16 out of 20 trials in two out of three consecutive sessions.

4. Errorless learning Opacity and its technique:

- **Phase 1 (25% opacity)**: Image B or C is randomly presented on Screen 1. On Screen 2, the correct matching image is fully visible at 100% opacity, while the non-matching image appears at 25% opacity. The two other quadrants remain blank.
- **Phase 2 (37% Opacity)**: Once the dog meets the criteria in Phase 1, the non-matching stimulus is increased to 37% opacity, while the identical matching stimulus remains at 100%.
- **Phase 3 (50% Opacity)**: Once the dog meets the criteria in Phase 2, the non-matching stimulus is increased to 50% opacity, while the matching stimulus remains at 100%.
- **Phase 4 (63% Opacity)**: Once the dog meets the criteria in Phase 3, the non-matching stimulus is increased to 63% opacity, while the matching stimulus remains at 100%.
- **Phase 5 (100% Opacity)**: In this phase, both stimuli were presented at full opacity. Continuing the same procedure, If they achieve the required criteria, they move onto the next probe test

Appendix M: Guidelines for Shaping

1.Introduction

This document outlines the basic training hierarchy for shaping by successive approximations. As a rule, each step must be completed 3 times in a row before progressing to the next stage of training. Some dogs, however, may require additional learning trials before progressing. Keep sessions short (5–10 minutes) and finish on a positive note when possible, to ensure that the process is enjoyable for the dog.

2. General Procedure

1. researcher is to position themselves near the apparatus, ideally near the monitors, avoiding the dog's gaze to reduce unintentional cueing. This will facilitate fading of the researcher's presence during later trials when the dog is required to be in the experimental room alone. Gestural prompts may be used to facilitate training, but these should be used only as needed as they must be faded out before training is complete.
2. Shaping of comparison screen touch
    1. Turn the apparatus off.
    2. Reinforce moving further and further away from the feeder until the dog is reliably approaching the comparison screen (near apparatus).
    3. Turn on the apparatus monitors

2. Reinforce any movement towards comparison screen monitors.

3. Reinforce movement of nose or head towards the monitors (as appropriate).

4. Reinforce any contact with the monitors (nose).

6. Reinforce movement of the dog that produces the touch and correct response sound.

7. Reinforce placing nose on comparison screen

8. Reinforce touching the comparison screen with your nose.

3. Shaping of sample screen touch

1. Turn apparatus on and start a session so that sample screen 1 is lit and a stimulus image is presented

2. Prompt and allow dog to touch screen 1

3. Prompt and allow dog to touch screen 2 after touching screen 1

4. Reinforce attending screen 2 alone

5. Repeat these steps until all prompts are not needed for the dogs to touch the screens on their own.

6. Reinforcements are automatic to correct responses on screen 2

7. Start by fading the prompts for each session. Prompt for all trials, then after each session, stop prompting for only the last trial, and then for the next session, stop prompting for both the last and second last trial. In the next session, the last three trials are not prompted and so on until all the trials of a session are not prompted.

8. Repeat this fading step until the dog performs well in each session, and prompting should be left with only when the dog takes a few seconds to touch the screen, and remaining trials are not prompted at all.

3. Reinforce attending to the apparatus (putting nose near any part of the front panel).

4. Reinforce placing nose near sample screen.

5. Reinforce placing the nose on the sample screen.

6. Reinforce touching the sample screen with your nose.