Domestic dogs respond correctly to verbal cues issued by an artificial agent

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Abstract

Human-canine communication technology for the home-alone domestic dog is in its infancy. Many criteria need to be fulfilled in order for successful communication to be achieved remotely via artificial agents. Notably, the dogs' capacity for correct behavioural responses to unimodal verbal cues is of primary consideration. Previous studies of verbal cues given to dogs alone in the test room have revealed a deterioration in correct behavioural responses in the absence of a source of attentional focus and reward. The present study demonstrates the ability of domestic pet dogs to respond correctly to an artificial agent. Positioned at average human eye level to replicate typical human-dog interaction, the agent issues a recall sound followed by two pre-recorded, owner spoken verbal cues known to each dog, and dispenses food rewards for correct behavioural responses. The agent was used to elicit behavioural responses in three test conditions; owner and experimenter present; experimenter present; and dog alone in the test room. During the fourth (baseline) condition, the same cues were given in person by the owner of each dog. The experiments comprised a familiarisation phase followed by a test phase of the four conditions, using a counterbalanced design. Data recorded included latency to correct response, number of errors before correct response given and behavioural welfare indicators during agent interaction. In all four conditions, at least 16/20 dogs performed the correct recall, cue 1 response, and cue 2 response sequence; there were no significant differences in the number of dogs who responded correctly to the sequence between the four conditions ($p = 0.972$). The order of test conditions had no effect on the dogs' performances ($p = 0.675$). Significantly shorter response times were observed when cues were given in person than from the agent ($p = 0.001$). Behavioural indicators of poor welfare recorded were in response to owners leaving the test room, rather than as a direct result of agent interaction. Dogs left alone in the test room approached and responded correctly to verbal cues issued from an artificial agent, where rapid generalisation of learned behaviours and adjustment to the condition was achieved.

Keywords: Dog, Dog-human communication, Dog training, Unimodal verbal cues, Artificial Agent, Welfare

1. Introduction

Domestic dogs (*Canis familiaris*) respond to multimodal stimuli during communication and in training with humans where cues are sent and received based on collective visual, auditory and olfactory components (Rowe, 2005). Information provided within a specific social and environmental context will condition a required response then contingent upon a package of stimuli for its performance (Mills, 2005). As multimodal cues provide several elements of salience, they are typically used when training pet dogs general obedience behaviours (Lindsay, 2005). Subsequently, for learned behaviours to become controlled by a unimodal component (verbal cue), literature suggests that it is necessary to systematically fade out the remaining controlling stimuli (Reid, 1996). Multimodal communication is however, ubiquitous in many instances of human-human interaction (Knap et al., 2014) and a wide spectrum of body language is often unknowingly used during verbal communication with dogs, increasing difficulty of unimodal training for both species. Furthermore, once a behaviour is under the control of a verbal cue, additional training (proofing) is often needed in order to generalise responses to wider domains (Braem and Mills, 2010). Verbal cues have been shown to be less salient to dogs than visual signals during training; Skyrme and Mills (2010) reported that in pet dogs trained to perform a novel behaviour using both cue types, the verbal cue was overshadowed by its visual counterpart, and Scandurra et al. (2016) found significantly more correct responses to visual than verbal signals in behaviours previously trained bimodally. Working dogs are however, already trained to respond to unimodal auditory, verbal or visual cues (McConnell and Baylis, 1985; McConnell, 1990; Bozkurt et al., 2014), and pet dogs have shown this ability following specific training (Gergely et al. 2014; Fugazza and Miklósi, 2015). Seminal research has also revealed remarkable word learning abilities in individual cases (Warden and Warner, 1928; Kaminski et al., 2004; Pilley and Reid, 2004), although dog and human understanding of words may be incomparable (Markman and Abelev, 2004; Prichard et al., 2018).

Pet dog obedience training occurs in close proximity to a human whose attentional focus (eye contact, head and body positioning), provides reliable indication to the dog that verbal cues are intended for them and that their responses will be acknowledged and rewarded appropriately (e.g., Kaminski et al. 2012). Previous research has revealed the impact on the ability to respond correctly to verbal cues when subsequent, systematic removal of attention and multimodal information, using varied dissociative actions has been applied (Fukuzawa et al., 2005; Pongracz et al., 2003; Virányi et al., 2004). Fukuzawa et al. (2005a; 2005b) found a significant decline in responses to tape recorded cues, to cues given by the experimenter partially obscured by a screen, and when the experimenter's back was turned to the dog, compared to when those cues were given in person, and poor responses when cue phonemes were altered slightly. Similarly, Virányi et al. (2004) found a significant deterioration in responses to verbal cues when human attention and cue were incongruent (eye contact or head position focused away from dogs) during cue delivery. The salience of ostensive cues (eye contact, name calling) preceding pointing and gazing gestures during dog or puppy-human cooperative food locating tasks is also well established (Miklósi et al., 1998; Kaminski et al., 2012; Duranton et al., 2017). In contrast, Rossano and colleagues (2014) found that unimodal human vocalisations can be used referentially in a similar task, with the experimenter out of sight but present in the room, nonetheless.

Therefore, it is perhaps unsurprising that poor responses to unimodal verbal cues have been recorded when dogs have been left alone in the test room. Pongracz et al. (2003) compared responses between verbal cues given in person and issued to dogs alone via a loud speaker placed behind a screen, finding a significant decline in correct responses to the latter. More recent research has revealed the positive impact of a remote-controlled treat dispenser to ameliorate handler dissociation (distance) by enabling food rewards to be delivered to dogs stationed in close proximity to a device (Gerencsér et al., 2016).

Technology designed for human-dog remote interaction will, amongst many other factors, be dependent on rudimentary conditioning of dogs to unimodal verbal cues issued from a novel agent. Rapid generalisation of social competence towards artificial agents following positive (food acquisition) interactions has been found in dogs (Gergely et al. 2013; Gergely et al., 2015; Abdai et al., 2015; Gergely et al. 2016). Gergely and colleagues (2013) used an unidentified moving object (UMO; remote controlled car) as a social agent that retrieved inaccessible food from a box when dogs glanced at the agent. Repeated exposures revealed that goal directed interactivity is key in the rapid development and maintenance of social behaviour towards a novel agent rather than familiarity of embodiment, such as human or dog-like physical features (Abdai et al., 2018). The UMO was later deployed to indicate the location of hidden food (Gergely et al., 2015), revealing the dogs' ability to utilise indications from a UMO as effectively as from a human informant.

Both evolutionary and ontogenetic mechanisms may contribute to this social flexibility (Miklósi et al., 2004) the latter likely enhanced by early learning, training, socialisation and habituation; key contributors to neural and behavioural plasticity in adult dogs (Scott and Fuller 1965; Taborsky and Oliviera, 2012). Plasticity promotes curiosity, novelty seeking and the motivation to learn and achieve goals (Berlyne, 1960), shaping positive emotive states (Harding et al., 2004; Boissy et al., 2007; McGowan et al., 2014) thus, good welfare (Duncan, 2005). Dog-human interactivity using positive reinforcement may facilitate preparation for, and positive cognitive bias toward technological advancements (Rooney and Cowan, 2011; Starling et al., 2014; Abdai and Miklósi, 2018).

The aim of the present study was to establish whether domestic pet dogs could approach (recall to) an artificial agent when requested and respond correctly to two pre-recorded owner spoken verbal cues as reliably as to their owners in person. Dogs were tested with the agent in three conditions; with experimenter and owner present, with experimenter present only, and crucially, in response to previous research and in light of current innovation, whilst dogs were alone in the test room. A baseline condition of dog-owner interaction was used. Given the novelty of agent use, it was also critical to measure behavioural indicators of welfare during interaction with the agent.

2. Materials and methods

2.1. Ethics statement

Data were collected while the primary author was a student at University Centre Sparsholt, Sparsholt College Hampshire, UK. Ethical approval for this observational non-invasive study was gained from the Ethics Committee, University Centre Sparsholt. The study was carried out under the ethical guidelines published by the Association of the study of Animal Behaviour (ASAB). Owner participation was voluntary.

2.2. Animals

Animals were twenty pet domestic dogs (12 males and eight females), age range 1 - 9 years (mean age 4.2 years), of various breeds (17 pure breeds and three mixed breeds), predominantly working types, with the highest numbers comprising Labrador Retrievers (n=5), German Shepherds (n=4), and Border Collies (n=3); 18/20 dogs were highly trained in obedience, and 14/20 additionally in competitive sports, with two at UK championship levels. Criteria for participation was a history of positive reinforcement training using food as a reward; reliability in at least two behaviours on verbal cue and previously trained by the owner, reliability of recall to a specific learned sound or verbal cue, and good physical health. Dogs diagnosed with separation anxiety were not eligible for participation. The behaviours chosen by the owners and issued to the dogs were “Sit” and “Down” (9/20); “Sit” and “Speak” (4/20); “Spin” and “Sit” (3/20); “Down” and “Speak” (2/20); “Sit” and “Paw” (1/20); “Down” and ”Back” (1/20). No dog had previous exposure to a treat dispenser, treat dispensing / audio device, or interactive artificial agent of any kind. Dogs were tested individually, with owners participating in the familiarisation phase and two of the four test conditions. Each dog-owner dyad attended one session when all testing occurred, lasting no longer than one hour in duration. Participants were recruited in response to a Facebook post via a page set up exclusively for the project and the post was shared to a leading dog training club's page to ensure that dogs would meet the required criteria.

2.3. Materials

2.3.1. Agent

The agent (Fig. 1) comprised the following: Treat & Train® wireless remote-controlled treat dispenser, modified by removal of the food collection dish and addition of a Marsboy® Bluetooth® wireless speaker, and a GoPro® Hero 4 video camera, to remotely monitor and record the dogs' attentional focus and responses. Food rewards inside the dispenser were Pepperami® sausage cut into 1cm diameter and approximately 3-4mm depth pieces. The agent was mounted at a height of 1.5 metres on an Allcam TP941 tripod portable floor stand, modified by the addition of two Part King® heavy duty black universal wall mounting shelf brackets. A Casa Pura® Palermo non slip protective mat was placed in front of the agent for dogs' comfort. Equipment to record owner verbal cues and recall sounds, and control and monitor the agent, comprised an Apple MacBook Pro® computer, Apple iPhone® 6, GoPro® Hero 4 iPhone application, iTunes® application, and GarageBand® application. A second video camera, GoPro® Hero 5, was positioned at the back of the test room to capture general behaviour.

Fig. 1. The agent; a commercial treat dispensing device modified by removal of the food collection dish and addition of a speaker and camera.

2.3.2. Test facilities

The test facilities (Fig. 2) comprised a main hall, and an adjacent room with open window to enable the owner / experimenter absent conditions (AE and AO), where monitoring of the dog via the iPhone GoPro® camera application, Bluetooth® connection, and remote control of the agent was achieved. The facilities were novel to all participants.

Fig. 2. Test facilities. The experimental layout was consistent between all four test conditions.

2.3.3. Event ethogram

An ethogram was used to record event behaviours during agent interaction as possible indicators of poor welfare (Table 1).

Behaviour	**Definition**
Body Shake	A movement of the body from side to side in a very rapid motion
Lip lick	Opening the mouth and passing the tongue over the lips
Scratch	Using a paw to make contact with neck / ear / muzzle / body, rubbing the area in a rapid motion
Yawn	Opening the mouth wide and inhaling deeply
Vocalisation	A bark, whine or howling sound emitted from the throat
Heavy panting	Shallow, fast, audible breathing, open mouth, tongue exposed
Excessive salivation	Accumulation of saliva around the outside of the mouth
Ears flattened	Ears pulled back away from the face, and flat to the head
Tail tuck	Tail lowered and tucked between the hind legs
Head lowered	Head lowered in line with the body, usually with flat ears / tucked tail
Hyper vigilance	Body and ears raised, eyes and movement focused on owner exit point. May emit whining sound from the throat concurrently
Freeze	Standing still in place, body stiff, or with a hind leg shaking

Table 1. Event ethogram of dog behaviours which may indicate poor welfare during agent interaction.

2.4. Experimental design and procedure

The experiment comprised two phases, a familiarisation phase, followed by a test phase of four conditions; owner only (OO) (baseline), agent, experimenter, owner (AEO), agent and experimenter (AE) and agent only (AO) (Fig. 3). These conditions allowed the following to be investigated: any effects of the owner / experimenter's presence in the room during interaction with the agent; the dogs' ability to differentiate attentional focus and verbal cues issued by either the agent or the owner; the dogs' ability to direct attentional focus towards the agent when left alone in the test room; the dogs' tendency to hesitate or look to their owner for feedback prior to or during interaction with the agent; comparisons between responses to owners cues in person and those issued by the agent; and behavioural welfare indicators during agent interaction in all conditions. To help counteract any possible order effect established by the repeated measures, the four conditions were randomised as part of a counterbalanced design to form four groups of five dogs each: Group A: Condition sequence OO-AEO-AE-AO; Group B: Condition sequence AEO-AE-AO-OO; Group C: Condition sequence AE-AO-OO-AEO; Group D: Condition sequence AO-OO-AEO-AE.

Fig. 3. Participant Alfie in all four test conditions; agent, experimenter and owner (AEO), agent and experimenter (AE), Agent only (AO) and baseline owner only (OO).

2.4.1. Familiarisation phase

Before testing, all dog-owner dyads experienced a familiarisation phase detailed as follows:

Step one: The owner and dog entered the test room and the dog was let off-lead to investigate the room.

Step two: The agent was placed on the floor of the test room. When the dog approached and looked at the agent, the experimenter marked the looking with a “Yes” and triggered the agent by remote control to dispense food. Step three: The agent was placed on its stand and step two was repeated. Step four:

Standing away from the agent, the owner gave their dog the two chosen verbal cues in order to demonstrate that they would meet baseline criteria. The owner was static and gave no eye contact to the dog to ensure unimodal cue delivery. The owner rewarded the dog with treats from their hand for correct responses. Step five: The owner stood next to the agent and repeated step four, the experimenter triggered the agent by remote control to dispense food for correct responses. Step six: The experimenter recorded the owner's two chosen verbal cues (exactly as they had been spoken in the demonstration), and their recall sound or cue, into the experimenter's computer while seated at the table. Step seven: The owner walked their dog to the agent and stood as in step five, now silent. The experimenter triggered the two verbal cues from the agent's speaker and triggered the agent by remote control to dispense food for correct responses. Step eight: With the experimenter and owner seated at the table, the dog by their side, the experimenter triggered the recall sound from the agent and when the dog approached and looked up at the agent, the experimenter triggered the agent by remote control to dispense food. Once the dog had eaten the food, the dog was called back to the table and the test phase was initiated.

Criteria to fulfil the familiarisation phase was that each dog had achieved one correct response to each of the two verbal cues given by the agent with owner standing next to the agent, and one successful recall approach, with experimenter and owner present in the room. Every dog gave the correct responses in the set pattern given above before continuing on to the test phase.

2.4.2. Test phase

Tests were then carried out in the four conditions. In each condition the criteria of a test was to perform three sequential behaviours; 1) approach and look up at owner / agent, 2) respond correctly to cue 1, 3) respond correctly to cue 2. Cues were issued in the same order throughout conditions.

2.4.2.1. Conditions

Owner Interaction Only (OO) (baseline).

The owner positioned their dog in a sit-stay and walked approximately three to four metres in front of them; the dog was facing the owner, the agent to the dog's left side. Facing the dog and standing static without eye contact the owner gave their recall sound (a chosen verbal cue, e.g., "come" or artificial sound e.g., a whistle). The approach was rewarded with food from the owner's hand. With the dog in front of them and remaining static with no eye contact, the owner gave their first verbal cue, a correct response was rewarded with food from the owner's hand. The owner gave their second verbal cue and a correct response was rewarded with food from the owner's hand. Food was the same as from the agent.

Agent, Experimenter and Owner (AEO)

With the owner, experimenter, and dog stationed at the table, approximately three metres away from the agent and facing it, the experimenter triggered the recall sound (to match the dog's baseline recall sound) from the agent. When the dog approached and looked up at the agent, the experimenter triggered the agent by remote control to dispense food immediately. When the dog finished eating the food and was in front of the agent looking up at it, the experimenter triggered the first verbal cue. When the dog responded correctly, the experimenter triggered the agent by remote control to dispense food. When the dog finished eating the food and again looked up at the agent, the experimenter triggered the second verbal cue, and the same protocols were applied as in the first verbal cue.

Agent and Experimenter Present (AE)

The experimenter instructed the owner to exit the test room and enter the adjacent room, closing the door behind them and remaining out of sight. The experimenter recalled the dog to the table and with the dog again stationed next to the experimenter at the table and facing the agent, the experimenter repeated the tests exactly as in the AEO condition, using the same protocols.

Agent Only (AO)

The experimenter exited the test room, joining the owner in the adjacent room, closing the door behind them, leaving the dog alone and remaining out of sight. From here, the experimenter monitored the dog's behaviour via the agent's camera, on the iPhone® GoPro® application. The experimenter then repeated the tests as in the AEO / AE conditions, using the same protocols. Note: Dogs could not be stationed at the table to begin the AO condition, as the experimenter was not present in the room, thus dogs approached the agent from whichever position they were in at the time.

2.5. Data collection and analysis

Testing was carried out from August 2017 to October 2017. Behavioural responses during the test phases were recorded on two GoPro® Hero video cameras for later analysis on an iMac® computer. Responses recorded for each dog, in every condition were as follows:

1: Number of recall repetitions required to approach (max 5 repetitions).

2: Number of hesitations to approach (hesitation = momentary orientation / head or body movement toward agent or owner without locomotion).

3: Number of pre-approach gazes to owner / experimenter (gaze = orientation of head toward owner with eye contact).

4: Latencies to approach (seconds, 5 maximum).

5: Number of errors before correct response to the first verbal cue (max 5 repetitions).

6: Latencies to the correct response to the first verbal cue (seconds, 5 maximum).

7: Number of errors before correct response to the second verbal cue (max 5 repetitions).

8: Latencies to the correct response to the second verbal cue (seconds, 5 maximum).

9: Event behaviours as possible indicators of poor welfare during agent interaction.

Statistical analysis focuses only on the test phase. To investigate effects of the experimental conditions on the dogs' responses as listed above (1-9), Chi-Square goodness of fit tests were used. The critical P-value used throughout analysis was 0.05; the software was Minitab 18.

3. Results

3.1 Familiarisation phase

All twenty dogs fulfilled the familiarisation criteria (100% success rate) in order to participate in the test phase.

3.2 Test phase

Approaches to the owner / agent, with subsequent correct responses to both cues given by the owner / agent (recall – cue 1 response – cue 2 response) were consistently achieved, with no significant difference found between the four conditions (χ^2 (3, N= 68) = 0.235, p= .972) (Fig. 4).

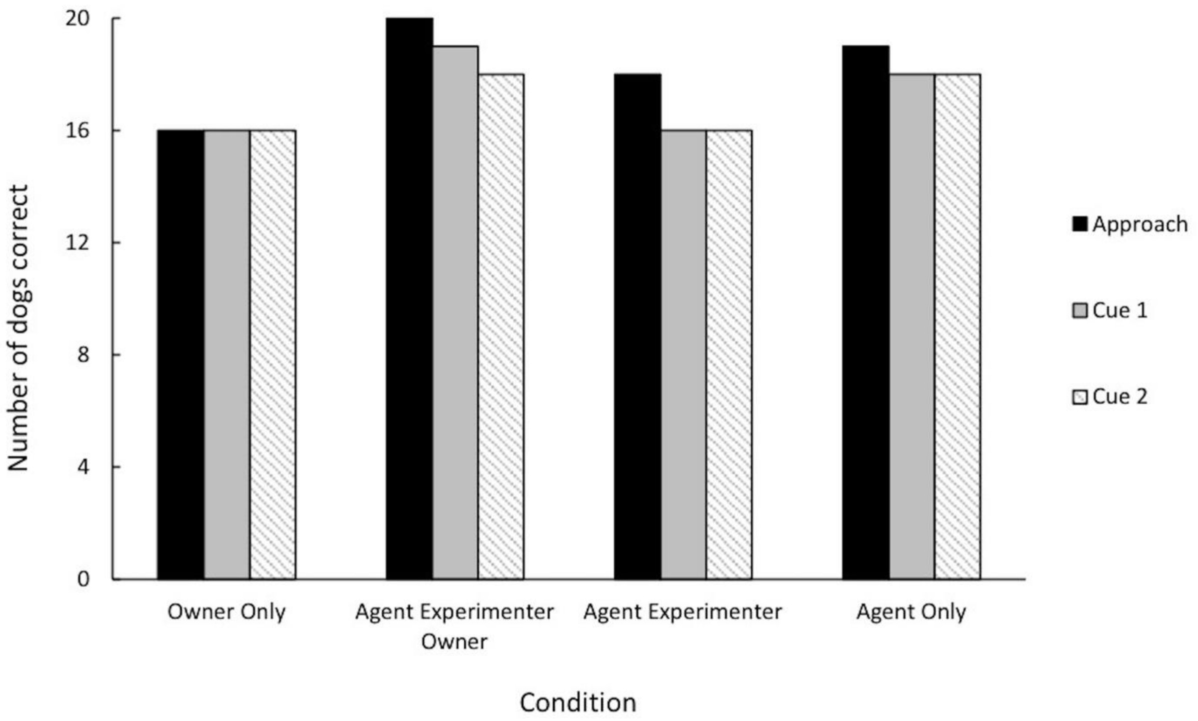

Fig. 4. Number of dogs that achieved approaches and correct responses to cues in each condition.

The order of test conditions did not have any effect on the dogs' performances (χ^2 (3, N= 68) = 1.52, p= .675). Analysis of achievement at each of the three sequential behaviours revealed a high rate of correct responses to each request and consistency between the four conditions; a) approaches (χ^2 (3, N= 73) = 0.479, p= .923; b) cue 1 χ^2 (3, N= 69) = 0.391, p= .942; c) cue 2 χ^2 (3, N= 68) = 0.235, p= .972. In all conditions, where approach and looking up was achieved, correct responses to cues were similarly achieved (e.g., AO approach = 95% correct, cue 1 = 90% correct, cue 2 = correct 90%). Where approaches were not achieved (maximally in OO), cues were not provided, thus behavioural responses were not performed. Analysis of the number of errors in each condition before a correct response to each sequential cue revealed a higher proportion of dogs performing correctly during their first test than those requiring repeated tests to achieve the same (Table 2). Correct responses at first tests, or at subsequent tests were consistent between conditions (χ^2 (3, N= 51) = 0.215, p= .975). Additionally, Two-Proportion tests run for each condition showed no significant difference between the proportion of dogs successful during first tests vs those successful following repeated tests (Condition OO - Z = 0.48; N = 28; p = 0.631; Condition AEO - Z = -0.32; N = 27; p = 0.749; Condition AE - Z = 1.68; N = 26; p = 0.093; Condition AO - Z = -0.80; N = 28; p = 0.426).

Condition	Number of dogs correct at first test (thus excluded from further tests in condition)	Number of dogs correct at repeated tests (maximum five tests)	Number of dogs Failed
OO	12/20	4/8	4/8
AEO	13/20	5/7	2/7
AE	14/20	2/6	4/6
AO	12/20	6/8	2/8

Table 2. Number of dogs correct at test one, number of dogs requiring repeated tests to perform the correct sequential behaviours, number of dogs failed.

Latencies to approaches were not consistent; maximal in both of the owner absent conditions (AE and AO) and minimal in the baseline condition (OO) (χ^2 (3, N= 61) = 16.14, p = .001). This is in part likely due to the fact that several of the dogs were focused on the owner / experimenter exit point as they exited the room, thus recall to the agent was achieved after visible exit point vigilance had subsided. However, mean approach latencies (sec) between the four conditions were consistent (OO = 4.9; AEO = 2.72; AE = 3.61; AO = 3.47) (χ^2 (3, N= 14) = 0.669, p = .880). Hesitations (momentary orientations / head or body movement without locomotion) to approach were consistent between the four conditions (χ^2 (3, N= 49) = 7.57, p = .056). Additionally, consistency was found between conditions where dogs who did hesitate did also subsequently approach (100% of dogs in AEO and AE, 80% in OO, 88% in AO). Median hesitations between conditions did not differ significantly (χ^2 (3, N= 6) = 0.666, p = .881). Gazes back to the experimenter / owner pre-approach to the agent in AEO and AE or toward the owner in OO were not consistent between the three relevant conditions; maximal in OO and minimal in AE (χ^2 (2, N= 57) = 8, p = .018). Median gazes between conditions however, did not differ significantly (χ^2 (2, N= 9.5) = 1.63, p = .442). All of the dogs who gazed back during the agent conditions subsequently approached the agent without any feedback from the experimenter / owner. Latencies to correct behavioural responses to verbal cues were also not consistent between the four conditions. Latencies were maximal in AEO and AE, and minimal in OO (χ^2 (3, N= 61) = 20.29, p= .001), showing that responses were faster when cues were given in person than from the agent. However, mean latencies between the four conditions were consistent (OO = 2.7, AEO = 2.98, AE = 2.88 AO = 3.76) (χ^2 (3, N= 12.32) = 0.213, p = .975). Event behaviours were also not consistent between conditions. Events were maximal in AE and AO and minimal in OO and AEO (χ^2 (3, N= 142) = 111.9, p = .001). Such events comprised primarily of hyper vigilance to the owner / experimenter exit point as they left the dog alone in the test room (53% of events) and vocalisations related or non-related to the former (43%), with 4% other. Nevertheless, Two-Proportion tests run for both owner absent conditions (AE and AO) revealed a significantly higher number of dogs presenting event behaviours with subsequent correct performances, than those presenting event behaviours with fails (Condition AE; Z = -2.83; N = 18; p = 0.005); Condition AO;

Z = -4.38; N = 24; p = 0.001). Thus, in conditions AE and AO, for 77% and 83% of dogs respectively, event behaviours did not inhibit performance. Furthermore, 5/20 individuals contributed >10 event behaviours each in the AE and AO conditions, displaying higher levels of owner attachment thus hyper vigilance towards the owner exit point when left alone in the room, than the other participants.

4. Discussion

The aim of the present study was to determine domestic dogs' ability to generalise an established approach (recall) and unimodal verbal cue responsiveness to an artificial agent, and perform for the agent as reliably as for an owner. Repeated measures tested the effects of owner / experimenter presence / absence on performance with the agent and short-term impacts of agent interaction on welfare. In contrast to previous findings of poor responses to unimodal verbal cues (Fukuzawa et al., 2005a; 2005b) particularly when issued to dogs alone in the test room (Pongracz et al., 2003; Gerenscer et al., 2016), results in the present study revealed the ability of dogs to respond correctly in all conditions. Dogs responded as reliably to the agent as to their owners and during agent interaction, the location of the owner did not affect performance. The primary methodological difference (and aim) in our study compared to those discussed, was that we were testing responsiveness to an artificial agent, which, acting as a human / owner substitute, facilitated sufficient attentional focus for the delivery of verbal cues and rewards for correct responses. Previous studies were focused on the impacts of multimodal information removal on performance rather than the provision of an alternative attention source. Such attention has been shown to be critical in successful dog-human cooperation (e.g., Miklósi et al. 2003), thus the approach and looking up behaviour was the first criterion of each test sequence to reach and where this criterion was not met, no attempts were made to issue verbal cues. The timing of triggering the verbal cues was equally as important and the experimenter did so only when the dogs' attention was fully focused on the agent. In line with the findings of Gergely and colleagues (2013; 2015), social competence towards the agent was rapidly achieved initially following food acquisition and subsequently, during interactivity. Dogs were able to differentiate the source of the recall sound and the verbal cues (McConnell, 1990; Aspinall and Cappello, 2015) thus, owner /

experimenter presence or absence in the room was not conflicting with the agent and did not inhibit performance. While some dogs gazed back at their owners pre-approach to the agent therefore, without any feedback, they subsequently approached.

Four dogs failed to approach their owners following the recall sound in baseline; 2/4 were in sequence group one, where baseline was the first condition and here, the dogs remained in their sit-stay. Either through specific and prior training, they appeared to be waiting for a subsequent cue, or they were reliant upon multimodal information to accompany the recall cue in order to respond. The other 2/4 were in sequence groups where agent interaction had preceded baseline, and in these cases the dogs went to the agent rather than the owner when recalled by the owner. Subsequent recall attempts by the owner resulted in gazing at the owner but remaining in front of the agent. Owner recall was not demonstrated to the experimenter during the familiarisation phase as it had been reported by all owners to be reliable, however, such demonstration would in hindsight have been a useful addition to the methodology. Results from the latter two dogs could however, also support findings on device attachment in several species; domestic dogs (Yin et al., 2008), rhesus monkeys (Harlow et al., 1950) and humans (Konok et al., 2017) and perhaps these welfare implications require further examination.

Interaction with the agent did not however, result in any behavioural indicators of poor welfare directly (Broom and Fraser, 2015) rather, such indicators were observed in response to the owners / experimenter leaving the room, where hyper vigilance to the exit point (53% of events) and vocalisations directed at the exit point (43% of events) were recorded. Most likely as attempts to reunite with owners (Miklósi, 2016), such behaviours did not however, inhibit subsequent responses, other than in one dog who was unable to leave the exit point and showing progressively worsening indicators of anxiety, was reunited with his owner and his testing terminated.

Consistently correct responses to cues from the agent in this study could be the result of rapidly learning the required sequence of cue 1, cue 2, through their performance during previous owner training, the familiarisation phase and throughout conditions; cues were always delivered in the same order. Indeed, it was noted that a small proportion of dogs performed the second cued behaviour pre-emptively, that is, as the second cue was being triggered, rather than after it was delivered. Repeated measures would compound the learned sequence theory, assuming that the sequence would improve responses over conditions, however, the fact that a higher proportion of dogs performed correctly in their first tests in all conditions than those requiring repeated tests, would not necessarily support this. Furthermore, the counterbalanced design was in place to ensure that baseline would not always be the first and most natural condition and no significant difference between the sequence groups was found. Prior training and the familiarisation phase are therefore, likely factors.

Nevertheless, latencies to correct responses were longer overall for the agent than for owners in person and given that only a small proportion of dogs performed in a pre-emptive manner, alternative suggestions should be considered. Shorter latencies for responses to owners cannot be explained by multimodal input; gestures or ostensive cues, as these were not provided. Most likely and simply, although generalisation of responses to the novel agent was rapid, cues given by owners were subject to longer reinforcement histories thus were performed faster (Braem and Mills, 2010). Transference of this knowledge and its application to the novel agent domain may have required greater cognitive control than in the baseline, resulting in longer response times (Hirsh, 1974; Toates, 1998). It should also be mentioned that dogs did not attempt to offer any other behaviours to the agent than those requested, which may support any of the theories discussed. Thus, in order to rule out a learned sequence response, the study is currently under repetition, using additional and randomized cues. The study is also examining the learning of sequences from the agent and transference of this knowledge to the owner.

When searching for participants in this study, many owners who were initially contacted reported that their dogs were not reliable in behaviours on verbal cue alone; indeed, such training is not typically included in formal class curriculums (The Kennel Club, 2019). In the absence of time to facilitate training to meet criteria for this project, a leading dog training club was contacted, and the resulting majority of participants were trained to levels well beyond the requirements for the experiment and therefore, did not necessarily represent the pet dog population in general. Intrinsic and extrinsic motivation in this sample through breed specifics (Serpell and Duffy, 2014) and / or positive reinforcement training using food as a reward (Rooney and Cowan, 2011; Gergely et al., 2014) throughout puppyhood and into adulthood may have facilitated great adaptability (Taborsky and Oliviera, 2012; Starling et al., 2014) and unusually high speeds of generalisation and performance. None of the dogs had any previous exposure to a food dispensing device or agent of this kind whatsoever and each of the dogs' responses were achieved within a one-hour, single timeframe. The novelty of the agent and the food it dispensed may therefore, have been highly salient (Reid, 1996; Oesterwind et al., 2016) and for individuals with these backgrounds, interaction criteria were likely quickly matched with competence (Meehan and Mench, 2007). As a preliminary study however, the sample was useful in determining substantial scope for current ongoing research by the authors, with the inclusion of dogs from varied backgrounds.

5. Conclusion

The results of this preliminary study show that dogs are able to approach and respond correctly to verbal cues issued by an artificial agent as reliably as to their owners in person, including when left alone in the test room. Responses may have been a result of the dogs learning the required sequence of behaviours during previous owner training and during the familiarisation phase and / or generalisation of behaviours to an entirely novel agent may have been unusually rapid among this particular sample. Current, ongoing research by the authors is implementing all of the further recommendations discussed.

6. Declarations of interest

The primary author (Nicky Shaw) filed a UK patent in July 2013 titled "A pet interaction device" and this patent was granted to the author in November 2018, patent number: GB2512674. No product in relation to the patent owned by the author currently exists nor is in development to the author's best knowledge.

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