

DOMESTIC DOGS' UNDERSTANDING OF  
HUMAN EMOTIONAL CUES

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## Abstract

Past research has focused on the ability of domestic dogs to recognise human communicative cues such as human pointing, eye gaze, attachment behaviour, social learning, and responses to affective stimuli. However, there is still much to be learned about dogs' ability to recognise human emotions. The main objective of this study was to investigate whether domestic dogs understood the emotions expressed by a human experimenter. I examined four emotions (anger, sadness, fear, happiness) and three types of expressions (dynamic, unimodal, bimodal) in four studies. The four studies covered the following: (1) dogs' response to commands accompanied by dynamic expressions of human happiness and anger; (2) dogs' social referencing of human expressions of fear and happiness, and one control "confused" expression; (3) dogs' and human infants' preferential looking to angry, happy and sad human faces when listening to a matching emotion voice. In addition, infants' facial expressions were analysed to examine whether their facial expressions differed as a result of the affective displays they viewed, and one additional control experiment was conducted to examine dogs' ability to perform gender-matching of human faces to voices, and (4) dogs' and young adult humans' physiological (cortisol levels) and behavioural response to human infant crying, human infant babbling, and white noise. In Study 1, I found that dogs have differential responses to the experimenter's happy and angry expressions emanating from the body, face or voice cues during the emoting phase, but not when left alone with food. In Study 2, dogs responded differentially to happiness and fearful expressions, but had similar responses to both fearful and control conditions, suggesting that they might not have understood the fearful expression meaningfully. Results from Study 3 showed that both dogs and infants looked less at sad faces (irrespective of the

matching voice), and had no preference for looking at either happy or angry faces. Also, infants displayed a sad expression when viewing a sad face. For the gender-matching task, dogs were able to match male faces to voices, but not for female stimuli. Finally in Study 4, I found that both dogs and humans had increased cortisol levels after listening to a human infant crying but not to babbling or white noise. Dogs also showed a combination of alert and submissive behaviour when listening to crying. In conclusion, the results provided some evidence that dogs tended to respond differently to human emotional expressions and, similar to humans, may have an aversion to human expressions of sadness, indicating the presence of emotional contagion, a form of rudimentary empathy.

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## Chapter 1: General Introduction

### Dogs as social models

Domestic dogs (*Canis familiaris*) are members of the *Canidae* family and originated from wolves (*Canis lupus*). Scientists disagree over the timing and location of dog domestication for decades. Different genetic analyses of modern dogs and wolves have suggested that domestic dogs emerged in Europe (Thalmann et al., 2013), China (Savolainen, Zhang, Luo, Lundeberg, & Leitner, 2002), or the Middle East (vonHoldt et al., 2010) anywhere from 10,000 to more than 30,000 years ago.

It is widely believed that wolves might have been kept as pets, and those successful in human interactions (e.g. those who showed attentiveness and solicitousness) would pass on these traits to their young and thereby, enhancing their survival (Clutton-Brock, 1995). Humans eventually domesticated wolves over thousands of years to what we recognise today as the domestic dog (Coppinger & Coppinger, 2001; Scott & Fuller, 1965). Archaeologists discovered dog cemeteries all over the world in the past 12,000 to 14,000 years (Morey, 2006). The graves were located in close proximity to human cemeteries, and the closeness reflected the dog's status in a family and the special bond they had with their human owners.

2011–2012 APPA National Pet Owners Survey in the United States statistics reported that there are approximately 78.2 million dogs in 46% of households with an equal proportion of male to female dogs in the US (American Pet Products Association, 2013). The same survey reported that cats are the most preferred companion animal followed closely by domestic dogs. Around the world, statistics obtained from the pet food industry report on the frequency of dog ownership, for example, 8.5 million dogs

in the UK (Pet Food Manufacturers' Association, 2013), 73.6 million in Europe (European Pet Food Industry Federation, 2010), 3.4 million in Australia (36% of households) (Australian Companion Animal Council, 2010), and approximately 700,000 in New Zealand (approximately 33% of households) (The New Zealand Companion Animal Council Inc, 2011). The large number of dogs in our society today reflects the special and unique bond between humans and dogs.

Dogs are primarily valued for companionship rather than for meat, brute force, or guard duties in contrast to previous centuries (Cooper et al., 2003). Indeed, the relationship we have with our dogs can be divided into three categories: "dominionistic," "humanistic," or "protectionistic" (Blouin, 2013). Owners in the latter two categories value their dogs for their close attachments and as valuable companions, while those in the former category have relatively low regard for their pets, valuing them primarily for the uses they provide, such as protection. A recent online survey found that dog owners believe that their dogs possess relatively sophisticated social and cognitive skills (e.g. emotional understanding and problem solving), with one quarter of dog owners agreeing or agreeing strongly that dogs are smarter than most people (Howell, Toukhsati, Conduit, & Bennett, 2013b). The special bond we have with our dogs is also shown in the media, because dogs are the number one choice when advertising products unrelated to dogs or other animals. In this respect, dogs are ahead of horses, birds, and cats (Spears, Mowen, & Chakraborty, 1996). Dogs' appearance in an advertisement is considered natural and instinctive when paired with humans, thus spreading the advertisement's mass appeal (Lancendorfer, Atkin, & Reece, 2008; Mayo, Mayo, & Helms, 2009) (see Appendix A).

Many studies have investigated the benefits of having pets in one's life. Parents of kindergarten boys and girls who are highly attached to their pets reported fewer behavioural problems from their children (Melson, Peet, & Sparks, 1991). Having a dog present at work, at home, or when completing challenging tasks appears to attenuate stress levels, and improves well-being. Having a dog in therapy has enabled children diagnosed with pervasive development disorders to be more focused, exhibit more playful behaviour and more awareness of their social environment compared to non-social toys (a ball) or a robotic dog (Martin & Farnum, 2002). Office workers experienced a decline in self-reported stress levels when their dogs accompanied them to work compared to those who left their dogs at home or with non-owners (Barker, Knisely, Barker, Cobb, & Schubert, 2012). When completing a challenging arithmetic task, adults had lower stress levels (lower heart rate and blood pressure levels) with their dog's present compared to having a friend or spouse with them (Allen, Blascovich, & Mendes, 2002; Allen, Blascovich, Tomaka, & Kelsey, 1991).

The presence of a dog also helps us to appear more likeable. In one study, participants were asked to rate people in photos on four dimensions: approachability, happiness, relaxation and as well as a general rating of the photo (Rossbach & Wilson, 1992). Results showed that people appear more approachable, happier, and that the picture was "better" when accompanied by a dog.

Physiologically, when humans interact with dogs, it leads to an increase in  $\beta$ -endorphins, oxytocin, prolactin, phenylacetic acid (a metabolite of  $\beta$ -phenylethylamine), and dopamine. These are hormones that make us feel good in both dogs and humans (Nagasawa, Kikusui, Onaka, & Ohta, 2009; Odendaal, 2000; Odendaal & Meintjes, 2003). A review of animal-assisted therapy with dogs, lists the health benefits for

humans, including reducing blood pressure, reducing aggression and agitation, and promoting social behaviour in people with dementia (Filan & Llewellyn-Jones, 2006). Nevertheless, having pets is not necessarily beneficial to one's health. One retrospective survey with older adults in Australia found that those with pets had more symptoms of depression, poorer physical health and higher rates of using pain relief medication compared to those living without pets (Parslow, Jorm, Christensen, Rodgers, & Jacomb, 2005), although it is quite possible that these negative symptoms led individuals to obtain dogs rather than dogs leading to an increase in negative symptomatology. However, some researchers are sceptical of studies claiming health benefits on having a pet, claiming that there are insufficient scientific controls at present, such as a lack of randomised controls, incomplete representation samples, incorrect statistical methodology, incorrect results interpretation, errors in inferences about direction of causality, and dependence on pet owner's self-reports (Herzog, 2011; Koivusilta & Ojanlatva, 2006).

Nonetheless, studies have shown that the bond between a dog and owner also extends to the animal themselves. One study showed that when reunited with a familiar person, laboratory dogs became more active with more tail wagging, increased oxytocin, and decreased cortisol levels after 25 minutes of separation (Rehn, Handlin, Uvnas-Moberg, & Keeling, 2014). Furthermore, oxytocin levels were higher and cortisol levels lower, when the familiar individual greeted the dog using both their voice and touch compared to a voice-alone greeting. The increase in oxytocin levels and decrease in cortisol levels indicates better health and overall well-being in the dog.

Some argue that the adaptations made by earlier primitive dogs to their living situations, from canine packs to life with humans, and the environmental selection

pressures when living with humans, have led dogs to develop social-cognitive abilities that are comparable to those of young human infants (Hare & Tomasello, 2005; Miklosi, Topal, & Csanyi, 2004; Miklosi, 2007). The social skills found in domestic dogs as a result of domestication and close contact from humans makes them an ideal model to study social cognition in domesticated animal models (Miklosi, Topal, & Csanyi, 2007; Topal et al., 2009). Below, I examine some of these social cognitive abilities such as attachment, human-directed communication, social learning, and response to facial and/or emotive stimuli.

### **Attachment**

The attachment bond between an owner and a dog has been reported anecdotally from owners (Archer, 1997; Kurdek, 2008), and also tested in laboratories (Gasci, Topal, Miklosi, Doka, & Csanyi, 2001; Nagasawa, Mogi, & Kikusui, 2009; Topal, Miklosi, Csanyi, & Doka, 1998). Researchers found that both male and female pet and non-pet owners believed that dogs can “sense” human emotions (Vitulli, 2006). Both pet and non-pet owners believed that dogs are capable of feeling primary emotions (Morris, Knight, & Lesley, 2012). In this survey, all dog owners believed that their dogs were capable of feeling fear, and 97% believed that their dogs were capable of feeling anger, joy, and curiosity. The researchers suggest that owners’ beliefs indicate emotional attachment to their pet rather than simple ownership of a pet.

An important aspect of relations is the extent of *attachment* between individuals. In humans, the child’s attachment to a parent has often been studied. A strong attachment bond provides the child with the foundations for emotional development and their social interactions (Ainsworth & Bowlby, 1991). Ainsworth and Bell (1970)

studied attachment by examining 1-year olds' behavioural responses when separated from, or reunited with, a parent and a stranger, a test commonly known as Ainsworth's Strange Situation Test (ASST).

Attachment has been studied in nonhuman primates and in companion animals (e.g. cats and dogs). Young adult rhesus monkeys (*Macaca mulatta*) showed depressive-like behaviours when separated from their families and were housed individually (Suomi, Eisele, Grady, & Harlow, 1975). When tested with a modified ASST, domestic cats showed attachment behaviour towards their owners after reunion (Edwards, Heiblum, Tejada, & Galindo, 2007). Gasci et al. (2001) tested 60 shelter dogs with a modified ASST and found that rescue dogs that had human contact for 10 minutes before the start of the test, exhibited more contact-seeking and attachment-like behaviours towards the handlers compared to unhandled dogs. Similarly, Topal et al. (1998) tested attachment with dog-owner dyads and found similar attachment outcomes analogous to human children. The attachment behaviour revealed in the modified ASST was observed in puppies as young as 16 weeks old but not in heavily socialised wolves (Topal et al., 2005). The attachment behaviour shown by dogs is also reciprocated by their human owners. In one study, dog owners had higher urinary oxytocin levels after observing a longer gaze from their dogs (Nagasawa, Kikusui, et al., 2009), suggesting the presence of a social bond between dog and owner. In summary, these studies indicate that dogs appear to 'enjoy' human interactions by seeking contact after a brief separation, and likewise so do humans.

## **Human – directed cues for communication**

Communication studies with animals have mainly concentrated on a variety of companion/domestic animals and wild animals, such as horses, goats, cats, dogs, elephants, dingoes, wolves, and non-human primates, and used pointing and gaze direction from human experimenters or conspecifics (Itakura & Tanaka, 1998; Kaminski, Riedel, Call, & Tomasello, 2005; McKinley & Sambrook, 2000; Miklosi, Pongracz, Lakatos, Topal, & Csanyi, 2005; Proops, Walton, & McComb, 2010; Smet & Byrne, 2013; Smith & Litchfield, 2010; Udell, Dorey, & Wynne, 2008). The success of these animals following gaze or pointing by humans is thought to be an indication of cognitive ability, and in the case of dogs, the evolutionary consequences of domestication and enculturation by humans. Yet, there are conflicting reports that showed wolves (Miklosi et al., 2003; Viranyi et al., 2008) and nonhuman primates (Anderson, Montant, & Schmitt, 1996; Anderson, Sallaberry, & Barbier, 1995; Herrmann & Tomasello, 2006) are not capable of following human pointing gestures in object-choice tasks, either because of limitations in their mental or visual perspective-taking, or because they are lacking in readiness to look at the human face for cues. However, the non-performance in non-human primates could have been due to inconsistent methodology (central versus peripheral setup) in the pointing tasks, and the setup change showed that they can perform equally well to dogs (Mulcahy & Call, 2009; Mulcahy & Hedge, 2012).

Many studies have provided strong support for canine understanding human cues. Canine success in following human cues is considered superior compared to other species (e.g. wolves, goats, capuchin monkeys, rhesus monkeys, chimpanzees, orangutans, and seals) when following a human pointing to retrieve a piece of food (see

Miklosi & Soproni, 2006 for a review). The ability to follow pointing is not limited to adult dogs, but also exists in puppies (Howell & Bennett, 2011b). Even when the pointing was varied such as in cross-pointing (e.g. distal, long, forward, elbow), asymmetric pointing (Soproni, Miklosi, Topal, & Csanyi, 2002), or when pointing included gazing and tapping (Hare, Brown, Williamson, & Tomasello, 2002), dogs were just as successful in following pointing. Thus, dogs learned to locate hidden food following a familiar and unfamiliar human gesture but were less successful in learning to understand inanimate or similar sized tokens as gestures (Udell, Giglio, & Wynne, 2008). In addition to pointing gestures, dogs were more successful in retrieving the ball if the owner had their eyes open, or head and body were oriented towards the ball compared to either cue on its own (Gasci, Miklosi, Varga, Topal, & Csanyi, 2004).

For verbal commands, the frequency and pitch of a command can convey different emotions (Banse & Scherer, 1996), which in turn affects obedience. One study showed that when commands were uttered in a high-pitched friendly voice, dogs searched for food more actively compared to a low-pitched command (Scheider, Grassmann, Kaminski, & Tomasello, 2011). A retrospective study with service dogs and their owners found that a loud and clear voice, as well as nonverbal elements such as gesture, posture and facial expression, are important for service dogs' obedience to commands (Dalibard, 2009).

Researchers have also investigated humans' eye gaze as a source of information to dogs. Dogs have demonstrated good recognition of human eyes for cues and directions. For instance, dogs used eye contact as a cue for when to eat a forbidden treat, taking the treat only when the experimenter had their eyes closed or were distracted, but not when the experimenter's eyes were open (Call, Brauer, Kaminski, & Tomasello,

2003). Schwab and Huber (2006) found that dogs obeyed the instruction to lie down and laid down the longest when the owner paid attention to them compared to other conditions (watching television, reading a book, back turned, or left the room). When faced with a new task to solve, untrained pet dogs often gazed and looked at human experimenters more often than trained dogs (Marshall-Pescini, Valsecchi, Petak, Accorsi, & Prato-Previde, 2008). Marshall-Pescini et al. (2008) suggested that gaze can be interpreted as a gesture for help. One study found that highly sociable dogs gazed longer at the human experimenter's face during a food extinction trial compared to less sociable dogs (Jakovcevic, Mustaca, & Bentosela, 2012). The more sociable dogs are probably more predisposed to human interaction and thus experienced greater reinforcement by gazing at humans. Results from these studies demonstrate that dogs are good at understanding human social cues and the human eyes in particular.

### **Social learning**

Dogs learn from conspecifics easily, as demonstrated by research using puppies and their mothers as teachers in a narcotic-testing study (Slabbert & Rasa, 1997). Likewise, dogs demonstrate flexibility in executing an action (using a paw to open a food container rather than their mouth) after watching a demonstrator dog perform the same action (Range, Viranyi, & Huber, 2007).

Other studies have provided evidence that dogs learn equally well from human experimenters. Range et al. (2009) investigated the differences between dogs and human experimenters as teachers. In their study, pet dogs and trained dogs (agility or search and rescue) were required to open the lid of a box to obtain food after observing either a human or another dog do so. They found that although dogs learnt equally well

from both demonstrators, the trained dogs were more attentive towards humans compared to dog demonstrators. In another study, dogs were required to obtain food by going around a V-shaped fence in two conditions (inside fence, and outside fence) (Pongracz et al., 2001). Dogs were able to retrieve food easily in the 'inside fence' condition. Although dogs initially had difficulty in the 'outside fence' condition, they were significantly faster after observing humans demonstrate the correct route. Both studies provided evidence that dogs were capable of learning either by observation or imitation from humans in problem-solving and decision-making situations.

The behavioural responses from learning situations have been further validated with a recent study observing canine brain responses. Functional magnetic resonance imaging (fMRI) was used to monitor the brain activity of two awake unrestrained female dogs when observing reward hand signals (Berns, Brooks, & Spivak, 2012). They found that the caudate nucleus (responsible for dopamine release) showed increased activity when the dogs observed their handlers' hand signals for reward. Increased dopamine suggests the presence of happiness (Klein, 2006).

When faced with novel objects or tasks in problem-solving situations, dogs show some degree of success in learning how to use the novel item. Dogs were able to search for hidden food using the bowl's reflection in a mirror (Howell, Toukhsati, Conduit, & Bennett, 2013a), and using boards to retrieve food in a means-end task (Range, Hentrup, & Viranyi, 2011). Although dogs are very good when reading human social and communicative behaviour, they are less successful when solving problems in the asocial, physical domain. For instance, dogs are poor in the invisible displacement task in object permanence studies, relying on the use of simple local rules (e.g. the adjacency rule) instead (Collier-Baker, Davis, & Suddendorf, 2004; Fiset & LeBlanc,

2007; Watson et al., 2001). Similarly, they demonstrate a gravity bias (i.e. searching for food directly beneath a tube, even though the tube was diagonally connected to box) (Osthaus, Slater, & Lea, 2003), or infer the location of food if only indirect causal information is available from the human experimenter (Brauer, Kaminski, Riedel, Call, & Tomasello, 2006).

### **Responses to facial and/or emotive stimuli**

Animals such as sheep and pigs have been studied for positive and negative affect. Paul, Harding, and Mendl (2005) proposed measuring the animal's emotional experience via cognitive, behavioural, physiological, and subjective components. One review suggested that sheep experienced emotions similar to humans, because they used similar environmental appraisal mechanisms to humans, such as suddenness, familiarity, predictability, consistency with expectations, and locus of control (Veissier, Boissy, Désiré, & Greiveldinger, 2009).

Canine responses to emotive stimuli have been reported in some studies. Canine face processing was explored in a study involving upright, or inverted still photographs of human, monkey, and dog faces with neutral expressions (Guo, Meints, Hall, Hall, & Mills, 2009). Eye and head movements were measured for gaze preference. Results showed that dogs demonstrated a left-side gaze bias towards images of human faces but not to monkey faces or dog faces. The canine tendency for a left-side gaze bias was hypothesised to be helpful for dogs to gauge human emotions because emotions are expressed more intensely on the left side of the face (Elfenbein & Ambady, 2002). Another study tested six dogs on four image categories (human, dog, item, letter) using

an infrared-based eye-tracking system (Somppi, Törnqvist, Hänninen, Krause, & Vainio, 2012), finding that dogs focussed their attention on informative regions (face and eyes), and preferred to look at conspecifics over other categories, with longer looking times at familiar over novel stimuli. Using the same system, the researchers found that dogs spent more time looking at the eye region, and preferred looking at familiar conspecifics or humans faces compared to unfamiliar faces (Somppi, Törnqvist, Hänninen, Krause, & Vainio, 2013).

Evidence for lateralisation in dogs has been further supported by visual hemifield, olfaction, and tail-wagging studies. One study presented two-dimensional silhouettes (cat, snake, dog) while the dog was feeding from a bowl and found that dogs showed a bias to turn their head left with the cat and snake stimuli (Siniscalchi, Sasso, Pepe, Vallortigara, & Quaranta, 2010). They also reacted faster and took a longer time to resume feeding when the stimulus was presented in the left visual hemifield. Images shown in the left visual hemifield and the left-side turning provided evidence that the right side of the brain is more responsive to threatening and alarming stimuli (similar to humans). Another study presented various odours ranging from non-aversive (food, lemon) to arousing (adrenaline, veterinary sweat odorants) to laboratory dogs (Siniscalchi et al., 2011). Dogs consistently used their right nostril for arousing stimuli, which suggests that the arousing stimuli were processed in the right side of the brain. Odours are processed ipsilaterally in the brain, unlike the optic nerves that fully cross in the dog's brain (Fogle & Wilson, 1992). When dogs were in the presence of their owner or an unfamiliar human, they wagged their tail consistently to the right, but the tail wagged to the left when the dog was alone or with an unfamiliar dog (Quaranta, Siniscalchi, & Vallortigara, 2007). They also showed a left-side facial lateralisation

(more movement in the left eyebrow) when reunited with their owners but not for non-social positive stimuli (attractive toys), which is consistent with attachment to the owner (Nagasawa, Kawai, Mogi, & Kikusui, 2013). Taken in sum, the findings from lateralisation studies with multiple cues (odour, visual) indicate that the right side of the dog's brain is more responsive to emotionally evocative stimuli whether they are threatening, or alarming, and that dogs do respond to conspecifics and naturally available emotive stimuli.

In addition to lateralisation studies, behavioural studies also support the claim that dogs respond to human emotive stimuli in a dynamic setting. Vas, Topal, Gasci, Miklosi, and Csanyi (2005) had a human stranger approach a dog with definite signs of friendliness (happiness) or threat (anger). In the friendly approach, the experimenter called out the dog's name, maintained eye contact, and walked at a normal walking speed. In the threatening approach, the experimenter walked "slowly and haltingly (one step in every 4 s) with slightly bent upper body and she was looking steadily into the eyes of the dog without any verbal communication" (Vas et al., 2005, p. 102). Results showed that dogs displayed active interest (contact-seeking behaviour) in the friendly condition and avoidance or aggression (gaze aversion) in the threat condition; suggesting that dogs can differentiate positive and negative human behavioural cues in a dynamic environment. This study was replicated, but with the owner and experimenter performing both friendly and threatening gestures (Gyori, Gasci, & Miklosi, 2010). Dogs were more likely to avert their gaze, barked, or growled longer, and showed less contact-seeking when someone approached them in a threatening manner compared to a friendly manner.

Dogs are also alert when observing other social conditions (e.g. generous behaviour and unfairness), with dogs choosing to obtain food from a generous person compared to a miserly person, even when they only heard voices without physical gestures (Marshall-Pescini, Passalacqua, Ferrario, Valsecchi, & Prato-Previde, 2011). Similarly, dogs preferred a “nice” human who allowed a dog to win in a tug-of-war game compared to one who did not allow the dog to win (Kundey et al., 2011). In an inequity aversion task, dogs were trained to offer their paw to the experimenter for a treat. When another dog was rewarded and they were not, dogs refused to offer their paw earlier and hesitated longer to obey human commands (Range, Horn, Viranyi, & Huber, 2009). This lack of cooperation could indicate that dogs were jealous when they were unfairly treated compared to another dog.

## Command and obedience

Many dog owners are encouraged to attend numerous dog training sessions ranging from puppy school, to basic training classes, and competition (e.g. agility, obedience and rally-o) (Lindsay, 2008; Scott & Fuller, 1965). In these classes, dog trainers teach owners to use voice, body, and hand gestures to command obedience from their dogs. Similarly, dogs trained for disaster research are capable of working off-lead, and the trainers/handlers could command the dogs using voice and hand signals (Hammond, 2006). For positive reinforcement, humans generally use their voice for praising, hand gestures such as stroking, or rewarding their dog either with a toy, social activity, or food (Mills, 1997).

Humans often communicate with dogs using verbal commands (e.g. name-calling, and basic commands such as 'Sit', 'Down', and 'Paw'). In a survey with service dog owners, researchers found that the owner's vocal strength was important for the dogs to carry out their commands (Dalibard, 2009), rather than intonation or elocution. In addition to being loud and attention-getting, verbal commands are clearly discriminative stimuli (Young, 1991). Mills, Fukuzawa and Cooper (2005) posit that a command word has many other attributes which may also affect performance within the training context. Dogs can discriminate the central features of a command which leads to their obedience, for example changes in phonemes in "Sit" commands (Fukuzawa, Mills, & Cooper, 2005b). The less-familiar sounding "Sit" (e.g. CHit [tʃ|t], sAt [sæt], and siK [s|k]) command elicits less obedience. In contrast, when the emotional content (sad, happy, angry, neutral) of the commands "Sit" and "Come" was varied, it did not result in dogs obeying for longer (although canine obedience tended to be better when given in a neutral or happy tone) (Mills et al., 2005). Nevertheless, the latter study had

limited experimental power with only 10 dogs, suggesting a larger study might reveal that dogs respond differently to emotion in commands. Indeed, in a larger unpublished study, dogs waited longer to eat the treat when the experimenter uttered an angry “Leave” command compared to a happy command (Ruffman & Morris-Trainor, 2011).

Acoustic features such as frequency and pitch in a verbal command also express different emotions (Banse & Scherer, 1996), and can affect obedience. Happy expressions are softer, slower, and involve more gradual changes in the voice over time, whereas anger has higher fundamental frequencies, more tense speech, and shorter pauses (Juslin & Laukka, 2003; Scherer, 1986). Pitch is an important feature in an acoustic profile that influences canine obedience and performance on searching tasks irrespective of whether the sound is a human-uttered command or a tone from an instrument (e.g. whistles and speakers). Low-pitched tones from a whistle or a speaker (one long note descending in pitch) are effective in getting herding or laboratory-raised dogs to stay or wait, while high pitched tones (four short notes rising in pitch) encourage dogs to come (McConnell & Baylis, 1985; McConnell, 1990). When dogs heard commands uttered in a high pitch in a pointing task, they were significantly faster and made more correct choices for food, compared to commands uttered in a low pitch (Pettersson, Kaminski, Herrmann, & Tomasello, 2011; Scheider et al., 2011).

In addition to verbal commands, non-verbal information is considered important in commanding obedience. In one study, adherence to commands was worse if the speaker was partly obscured, was wearing sunglasses, had her back turned, and when the speaker was further from the dog (Fukuzawa, Mills, & Cooper, 2005a). Similar poor adherence to a command was obtained when the experimenter was out of sight or when the experimenter faced another human (Viranyi, Topal, Gasci, Miklosi, & Csanyi,

2004). Obedience responses also declined when a 2-second pause was included after calling the dog's name (Braem & Mills, 2010). Canine obedience towards a particular command also depends on whether they could observe a human's eyes. When a human was watching the food, dogs obeyed the command to leave the food (Call et al., 2003) or lie down (Schwab & Huber, 2006), but not when the human's back was turned, eyes were closed, or the human was engaged in another activity (e.g. reading a book or watching television). In sum, these nonverbal features moderated canine responsiveness to the command.

In addition, dogs respond differently towards bimodal commands. For example, the researchers found that when a command was uttered in foreboding tone combined with hand gestures (stop, approach, pointing), dogs did not search for food, unlike when the same gestures were paired with a cooperative voice (Pettersson et al., 2011). Ostensive cues such as tone of voice (dog's name in high-pitch tone) and eye contact need to be present for dogs to understand what is required of them (Kaminski, Schulz, & Tomasello, 2012).

Other contextual factors such as lighting also influence canine obedience to a command. One study manipulated the lighting in the room - light versus dark, and illumination around food or human - and measured canine latency to leave the food (Kaminski, Pitsch, & Tomasello, 2012). Dogs stole more food when the room was dark and were less likely to steal when the food was illuminated. Researchers in another study manipulated the auditory (silent and noisy) and visual (opaque and transparent) cues (Brauer et al., 2012). Dogs chose the silent over the noisy tunnel, but there was no preference between the opaque side of a tunnel (which would hide dogs) and the transparent side (which would *not* hide dogs). That is, the researchers noted that dogs

did not hide their approach when they could not see a human present. In sum, results from these studies suggest that dogs are aware of humans' vision towards them and the food, thus making their move towards food only when dogs perceive that human vision is occluded. Further, dogs seem to be aware of the auditory cues that might alert a human to their actions.

### **Social referencing**

Social referencing, a form of referential communication, is often tested in an ambiguous situation and requires a reference towards another to guide one's actions (Klennert, Emde, Butterfield, & Campos, 1986; Stenberg & Hagekull, 2007). For instance, a mother expresses either fear or happiness toward an object and then observes a human infant's reaction to the object. The ability to respond differentially to maternal signals begins to appear towards the end of a human infant's first year of life (Rosen, Adamson, & Bakeman, 1992).

Social referencing requires gaze modulation, emotional expression, and communication about a particular object between two individuals (Russell, Bard, & Adamson, 1997). Social referencing has three variables; the modality cue, the informant and the particular emotion expressed. Studies have investigated facial expressions (Sorice, Emde, Campos, & Klennert, 1985), vocal expressions (Mumme, Fernald, & Herrera, 1996), as well as combined facial and vocal signals (Kim, Walden, & Knieps, 2010) with similar conclusions. First, studies with a familiar (parent) (Rosen et al., 1992) or unfamiliar (experimenter) person (Klennert et al., 1986) as the informant produce similar responses in infants. Second, researchers generally compare infants'

responses to a positive affective display (e.g. happy) toward an object, versus a negative affective display (e.g. fear). Such research has shown that infants' behaviour and expressive responses towards an ambiguous toy vary as a function of the message conveyed. Third, positive expressions (visual, vocal or both) tend to encourage approach behaviour in infants towards an object, whereas fearful or angry expressions tend to discourage approach behaviour (Kim et al., 2010; Rosen et al., 1992; Sorce et al., 1985; Stenberg & Hagekull, 2007).

Studies involving nonhuman primates such as chimpanzees (*Pan troglodytes*), (Itakura, 1995; Russell et al., 1997), and macaques (*Macaca sylvanus*) (Roberts, McComb, & Ruffman, 2008) have provided evidence that social referencing can occur both within and between species. Infant chimpanzees witnessed happy or fearful expressions toward a familiar object by a human caregiver (Russell et al., 1997). The infant chimpanzees avoided the object when a fearful expression was given, but looked longer at the object when a happy expression was given. Infant macaques also responded to their mother's expression of fear toward a rubber snake (Roberts et al., 2008). The researchers compared the infants' behavioural actions when there was no snake versus a snake present, and found that older infant macaques looked at their mother more frequently when she had spotted and responded to the snake. In contrast, younger infants looked at their mother equally in both conditions.

Because dogs have been domesticated, one might assume that they could reference a human experimenter's facial or vocal gestures, and therefore, regulate their behaviour towards an object. In one study, dogs were encouraged to select a box after witnessing an experimenter react either happily toward the box (which contained sausages), in a disgusted manner toward the box (which contained garlic) or in a neutral

fashion (when the box contained wood shavings) (Buttelmann & Tomasello, 2013). The researchers repeated the study outdoors as a control for scent cues with a sub-group from the earlier study. Results from both studies showed that when the choice was between a box the experimenter had reacted happily toward, and a box he had responded in a disgusted manner toward, dogs were more likely to choose the box the experimenter had reacted happily toward. However, there was no preference for either box when the experimenter displayed happiness versus a neutral expression. The poor performance when happy and neutral expressions were paired is thought to have been due to the still face in the neutral condition. The researchers posited that the still face may have caused a negative effect on the dogs. A second study obtained inconsistent findings using similar methodology. When owners expressed negative versus neutral expressions, dogs chose a box randomly, but when the owner expressed positive versus neutral expressions, dogs chose the box the owner had reacted happily toward (Merola, Prato-Previde, Lazzaroni, & Marshall-Pescini, 2013). These inconsistent findings suggest that the neutral expression is confusing to dogs.

Two studies tested social referencing in dogs using a fan with green ribbons as the ambiguous stimulus (Merola, Prato-Previde, & Marshall-Pescini, 2011, 2012) with familiar and unfamiliar informants presenting expressions to dogs. Dog owners presented the expressions in the first study (Merola et al., 2011), and in the second study, the informants were either the owners (“familiar”) or the experimenter (“unfamiliar”) (Merola et al., 2012). Dogs explored the fan when the emoter (regardless of familiarity) expressed happiness and were less willing to explore the fan when the emoter displayed a fearful expression. Expressions were conveyed through a combination of facial, vocal and bodily cues. The consistent findings over these two

studies suggest that the emoter's familiarity to the dog is not crucial to whether they socially reference in ambiguous situations. However, in a follow-up study, when the emoter displayed happiness toward one box and fear toward another, dogs chose a box randomly when the emoter was a stranger, but chose insightfully when the emoter was the owner (Merola et al., 2013). The researchers argue that dogs are more familiar with their owner's expression of happiness compared to that of the stranger, this time, suggesting that dogs might perform somewhat better when the informant is familiar. Another issue concerns interpretation of canine success on this task. To this end, canine reluctance to explore the fan can be perceived as insightful (indicating an understanding of the threat conveyed by fear and the absence of threat conveyed by happiness) or non-insightful (with a fearful expression creating fear in the dog, either through emotional contagion or confusion, leading the dog to avoid the object).

### **Preferential looking**

Emotion processing ability in preverbal infants has been studied with visual preference (habituation tasks) and intermodal matching tasks. In preference tasks, affective expressions are presented either in pairs or successively to the observer, and if the observer shows a preference for one expression by gazing at it for longer over several trials, it is then assumed that they can discriminate between the two expressions (Grossmann, 2010). In matching tasks, infants must detect the correspondence between visual and auditory information (Walker-Andrews, 1997). These techniques have also been adapted to gauge animals' ability to match auditory and visual representations. The preferential looking paradigm is appropriate for animals since it

does not require initial task training and requires minimal habituation to the experimental setting (Izumi, 2013).

In non-human primates, preferential looking has been used to demonstrate that rhesus monkeys match conspecific faces to their calls (Ghazanfar & Logothetis, 2003). Rhesus monkeys also successfully match conspecific faces and voices, and familiar human faces and voices (Sliwa, Duhamel, Pascalis, & Wirth, 2011) as do capuchin monkeys (Evans, Howell, & Westergaard, 2005). This ability has also been demonstrated in pigeons' recognition of photographs depicting familiar conspecifics (Wilkinson, Specht, & Huber, 2010). Likewise, dogs have shown a preference for looking at familiar conspecific and human faces compared to unfamiliar ones (Somppi et al., 2013), although they also prefer to look at novel images and human faces, compared to dog faces and inanimate everyday objects (e.g. chair, spoon) (Racca et al., 2010). Dogs can also size-match conspecific images (Farago et al., 2010; Taylor, Reby, & McComb, 2010), and match life-sized replicas of dogs (Taylor, Reby, & McComb, 2011) to resynthesised dog growls.

The preferential looking paradigm has also been used with sheep. Sheep prefer to look at calm faces of conspecifics, even when the calm face is of an unfamiliar sheep and the distressed face is of a familiar sheep (Tate, Fischer, Leigh, & Kendrick, 2006), suggesting a valenced response to the emotional expressions of other sheep. Somewhat similar results have been obtained with dogs. For instance, dogs were trained to select their owner's smiling face, and tested with strangers' smiling and blank faces (Nagasawa, Murai, Mogi, & Kikusui, 2011). Dogs demonstrated a preference for the

smiling face, although the preference was limited to faces of the same gender as the owner.

Human infants begin to generalise their discrimination of emotional expressions across different individuals between 5 to 7 months of age (de Haan & Nelson, 1998; Leppänen & Nelson, 2006), although there are studies providing evidence that younger infants (as young as 10 weeks old) respond differently towards affective information (Haviland & Lelwica, 1987; LaBarbera, Izard, Vietze, & Parisi, 1976; Montague & Walker-Andrews, 2001). Several studies indicate that infants could match affective facial displays that correspond to vocal displays (LaBarbera et al., 1976; Montague & Walker-Andrews, 2002; Montague & Walker-Andrews, 2001; Schwartz, Izard, & Ansul, 1985; Soken & Pick, 1992, 1999; Walker, 1982; Walker-Andrews & Lennon, 1991). In addition, infants sometimes display preferences for certain facial emotions over others when faces are presented simultaneously.

Table 1.1 summarises these results. Of particular interest are the summaries at the bottom of the table, which show the percentage of studies indicating a preference for one emotion over another when preferences arose (i.e. ignoring studies in which there was no difference).

Table 1.1

*Summary of findings for intermodal matching tasks*

Studies	Matching of face to voice?	Preference for an affective expression			Infants' age (in months)	Emoter
		Happy- Sad	Happy- Angry	Sad- Angry		
<i>Using familiar persons as emoters</i>						
Montague & Walker- Andrews 2002	Yes	Happy			5	Mother
Montague & Walker- Andrews 2002	No		ND		5	Mother
Montague & Walker- Andrews 2002	No	ND	ND		5	Father
Kahana-Kalman & Walker-Andrews 2001	Yes	Happy			3.5	Mother
<i>Using unfamiliar persons as emoters</i>						
Montague & Walker- Andrews 2002	No	ND	ND		5	Men and women
Soken & Pick 1999	No	Happy			7	Woman
Soken & Pick 1999	Yes		Happy	Angry	7	Woman
Soken & Pick 1992	No		Happy		7	Woman
Soken & Pick 1992	Yes		Happy		7	Point light illumination
Walker 1982	Yes	Happy			5 and 7	Woman

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Walker 1982	No		ND		7	Woman
Walker-Andrews 1986	No		ND		5	Woman
Walker-Andrews 1986	Yes		ND		7	Woman
Schwartz et al. 1985	No		ND	Sad	5	Women
Kahana-Kalman & Walker-Andrews 2001	No	ND			3.5	Women
Vaillant-Molina & Bahrick 2013	Yes	ND			5	Infants aged 7.5 to 8.5 months
Vaillant-Molina & Bahrick 2013	No	ND			3.5	Infants aged 7.5 to 8.5 months
Summary	41% Matching	100% Happy	100% Happy	No Preference		

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Note. Angry = greater looking at angry faces, Happy = greater looking at happy faces, Sad = greater looking at sad faces, ND = No difference.

These results indicate a clear trend for human infants to look more at happy faces when paired with either sad or angry faces, and for no preference when sad and angry are paired.

While some researchers proposed that infants' facial expression matches the affective display and indicates what they are experiencing (Camras, Oster, Campos, Miyake, & Bradshaw, 1992) as a form of reaction and therefore an expression of contagion, there are others who found little or no evidence of matching between infants' facial expression and the face they look at (Haviland & Lelwica, 1987; Montague & Walker-Andrews, 2001). Yet, even when infants' facial expressions don't match that of the face they view, they do tend to react to the faces they view. For instance, when viewing an angry face, 10-week-old infants showed anger to some extent, but also no movement ("freezing behaviour") and reduced interest (Haviland & Lelwica, 1987). Infants observing a sad face had more facial lability compared to happy and baseline trials (D'Entremont & Muir, 1997; Montague & Walker-Andrews, 2001; Termine & Izard, 1988). Even 10-week-old infants "mouthed" more (lip and tongue sucking and pushing the lips in and out) and averted their gaze when their mothers displayed a sad expression (Haviland & Lelwica, 1987). After viewing a happy face for three consecutive times in a peekaboo game, infants who viewed a sad face showed a systematic downward trend in looking with increases in interest/surprise expressions (Montague & Walker-Andrews, 2001). The researchers suspected that infants may be responding to the meaning or valence in the expression. Studies have reported that infants' smiled less often, averted their gaze, and grimaced more often when viewing a sad expression (D'Entremont & Muir, 1997, 1999; Termine & Izard, 1988). The behaviours (reduced looking time and greater lability, and mouthing) shown by these

infants when a sad expression was displayed have been argued to indicate an aversion towards the sad expression (Izard, 1991). In contrast to sadness, the increased vigour demonstrated in the angry condition might reflect the unique function of anger, one that includes vigilance and high arousal to a potentially stressful event (Izard, 1993). However, such arguments suggest that, when angry and sad faces are paired, infants should look away from sad faces and toward angry faces, yet Table 1.1 indicates no such trend.

### **Distinguishing gender**

Most preferential looking studies use adult females as posers, and include both familiar (mother) or unfamiliar (paid actress) individuals. Infants are more expressive when viewing their mothers' expressions compared to fathers (Montague & Walker-Andrews, 2002). In addition, studies have suggested that infants between 2 and 6.5 months of age could gender-match when they listened to a voice, or when matching a face to a matching gender voice (Miller, 1983; Patterson & Werker, 2002; Walker-Andrews, Bahrick, Raglioni, & Diaz, 1991), although the 2-month-olds have a preference for female voices. Gender differences are also detected in both pet and shelter dogs. Pet dogs look more at a stranger's smiling face when paired with a blank face if the stranger was the same gender to their owner (Nagasawa et al., 2011). Dogs living in shelters respond more favourably to a female person (yawning more often and spending more time with a relaxed, head-up posture) compared to a male person (Hennessy, Williams, Miller, Douglas, & Voith, 1998), and are less relaxed (looking and barking more often, and less likely to approach) when the stranger standing in front of their cage is a human male compared to a female (Lore & Eisenberg, 1986; Wells &

Hepper, 1999). Although shelter dogs seem to prefer females, there are no clear gender differences in affiliative and play behaviours, and attachment to male versus female owners (Prato-Previde, Fallani, & Valsecchi, 2006).

## **Empathy**

Empathy includes sub-components such as emotional contagion, identification, theory of mind, perspective-taking and cognitive empathy (Preston & de Waal, 2002). Contagion refers to a rudimentary component of empathy, for instance, when one individual's distress creates feelings of distress in another. Cognitive empathy, perspective-taking and theory of mind broadly refer to the ability to recognise what mental state another is experiencing.

Researchers have argued that nonhuman primates, rodents, pigeons, and chickens all experience a form of empathy (e.g., emotional contagion). For instance, researchers have examined one individual's response to a conspecific experiencing acute stressors such as electric shocks in rats (Church, 1959) and pigeons (Watanabe & Ono, 1986), a trapped cage-mate of a mouse (Bartal, Decety, & Mason, 2011), injections to a mouse's paw or fellow chimpanzees (Langford et al., 2006; Parr, 2001), attacks from biting flies on mice (Kavaliers, Colwell, & Choleris, 2003), and air puffs to a chicken's chicks (Edgar, Lowe, Paul, & Nicol, 2011). All such scenarios have been argued to create concern or distress in the observer, and have been argued to provide evidence of emotional contagion, a rudimentary component of empathy when one individual's affective state creates a similar state in another (Preston & de Waal, 2002). Whether the distress emanates from kin or non-kin, conspecific distress has been argued to facilitate empathy, altruism, or caregiving in the observer (Preston, 2013).

One way that researchers have examined empathy is through contagious yawning. It has been proposed that contagious yawning might indicate self-awareness, empathic processing, and mental state attribution (Platek, Critton, Myers, & Gallup Jr., 2003). In their study, Platek et al. (2003) found that humans who displayed more contagious yawning were better at self-recognition and theory of mind, two abilities that contribute to complex empathy. Contagious yawning has since been reported in non-human primates such as gelada baboons (*Theropithecus gelada*) (Palagi, Leone, Mancini, & Ferrari, 2009), bonobos (*Pan paniscus*) (Demuru & Palagi, 2012), stump-tail macaques (*Macaca arctoides*) (Paukner & Anderson, 2006), and chimpanzees (Anderson, Myowa-Yamakoshi, & Matsuzawa, 2004; Campbell, Carter, Proctor, Eisenberg, & de Waal, 2009; Madsen, Persson, Sayehli, Lenninger, & Sonesson, 2013). The conclusions derived from these studies suggest the presence of empathy in these primates, because the subjects yawned when viewing a video (or animation) of a conspecific yawning, but not when the conspecific just opened his/her mouth.

Using similar methodology, children diagnosed with autism spectrum disorder (ASD) did not yawn when seeing another person yawn (Senju et al., 2007) whereas typically developing and age-matched children did yawn more frequently during or right after observing another person yawning. The researchers claimed that contagious yawning is impaired in ASD children and related to reduced empathic development. On the other hand, 2-year-old children who viewed yawning images and videos of their mother did not display contagious yawning (Millen & Anderson, 2011). Likewise, red-footed tortoises (*Geochelone carbonaria*) did not show any evidence of contagious yawning after watching a conspecific yawning (Wilkinson, Sebanz, Mandl, & Huber, 2011).

Similar to primates, past studies have provided some evidence that dogs experience emotional contagion when observing or listening to a human yawn (both owners and strangers) but not in control conditions (open mouth / gaping) (Joly-Mascheroni, Senju, & Shepherd, 2008; Madsen & Persson, 2013; Romero, Konno, & Hasegawa, 2013; Silva, Bessa, & de Sousa, 2012). However, this suggestion has been disputed by others, for they found little evidence of yawning and instead suggested that yawning is a result of low level contagion or non-conscious mimicry (Harr, Gilbert, & Phillips, 2009; O'Hara & Reeve, 2011; Yoon & Tennie, 2010). Nonetheless, studies that failed to demonstrate contagious yawning with dogs were procedurally different (e.g. videos instead of live person) (Harr et al., 2009), and used rescue dogs instead of pets (O'Hara & Reeve, 2011), which may have influenced the outcome. For instance, a real person may emit stronger cues than a recording (Call et al., 2003), and rescue dogs might lack the emotional closeness or attachment bond to humans, unlike pet dogs to their owners.

In sum, contagious yawning is one means of examining empathy and rich claims have been made such that yawning might signal a theory of mind. In contrast, yawning might indicate emotional contagion (with some species predisposed to yawn or feel tired when observing others do likewise), with no deeper insight.

Another insight relevant to empathy is mirror self-recognition. Recognising oneself in a mirror might reveal a distinction between self and other, and with this insight in place, could signal the beginnings of a capacity to reflect on (and empathise with) another's mental state as distinct from one's own. Thus, mirror self-recognition (MSR) has been considered as evidence for self-awareness, although this claim has been disputed by others (Suddendorf & Butler, 2013, 2014). An odourless mark is placed

onto the animal's body without its knowledge, and a mirror is placed in the animal's living quarters. If the animal successfully recognises the mark on its body (i.e. touches or scratches the mark), it is inferred that the animal recognised itself in the mirror (Gallup Jr., 1998), or that the animal has an idea or expectation of what it looks like (Nielsen, Suddendorf, & Slaughter, 2006). Thus far, chimpanzees (Gallup, 1970), rhesus monkeys (Rajala, Reininger, Lancaster, & Populin, 2010), one gorilla (*Gorilla gorilla*) (Patterson & Cohn, 1994), two bottlenose dolphin (*Tursiops truncatus*) (Reiss & Marino, 2001), one Asian elephant (*Elephas maximus*) (Plotnik, de Waal, & Reiss, 2006), and five European magpies (*Pica pica*) (Prior, Schwarz, & Güntürkün, 2008) have demonstrated success in MSR, but not dogs (Howell & Bennett, 2011a; Zazzo, 1979). Human children demonstrate success with MSR when a mark is placed on their face at about 1.5 to 2 years of age (Amsterdam, 1972), but not on other parts of their body (e.g. stickers on leg)s (Nielsen et al., 2006). Before children recognise themselves in the mirror, they often view the image as though they are viewing another child (e.g. attempting to play with the image). Likewise, dogs often respond to the image with raised hackles and/or play bows, indicating that dogs viewed their own image as a conspecific, and are curious or fearful (Howell & Bennett, 2011a; Zazzo, 1979). Interestingly, although dogs seem unable to recognise themselves in a mirror, they can use a mirror to find an object, for instance, to obtain a favourite toy from the owner's reflection or to find hidden food (Howell et al., 2013a).

When dogs' response to human distress has been tested directly, results are inconclusive. Dogs have been shown to become submissive (licking, nuzzling) towards a crying human but not when the person is humming (Custance & Mayer, 2012). However, the researchers of this study point out that their finding is consistent with

emotional contagion in dogs, but also acknowledge a more parsimonious explanation involving a previous learning history in which dogs have been rewarded for approaching distressed human companions. In a second study, a human who pretended to be trapped under a bookcase or who feigned a heart attack did not elicit any kind of helping response from dogs (Macpherson & Roberts, 2006). The researchers reasoned that dogs fail to recognise the urgency or distress presented in the two scenarios and therefore did not seek help from a bystander.

Human empathy has sometimes been studied by examining responses to human infant crying. Infants generally cry when they are in need of attention from pain, hunger or distress (Choonara, 1999). Adults can differentiate the urgency of crying and find crying aversive (Boukydis & Burgess, 1982; Zahn-Waxler, Radke-Yarrow, Wagner, & Chapman, 1992), and as a result, pay more attention to the crying infant (Boukydis & Burgess, 1982). Crying is thought to be an innate releaser of empathy, the most salient expression of negative emotions in infancy, and the most powerful in promoting proximity and caregiving behaviour from adults (Bell & Ainsworth, 1972; Murray, 1985). When both men and women listen to an infant crying, their stress hormone cortisol increases regardless of parenting experience or age (Fleming, Corter, Stallings, & Steiner, 2002; Giardino, Gonzalez, Steiner, & Fleming, 2008). Although cortisol is a general stress hormone, a recent review suggests that cortisol plays a prominent role in facilitating activation of the social brain (e.g. the amygdala, anterior cingulate cortex, and ventromedial prefrontal cortex), boosting empathy and lowering callousness (Shirtcliff et al., 2009). For instance, mothers with higher baseline cortisol levels are more attentive and responsive to their infants (Giardino et al., 2008), and the release of cortisol is “contagious” between highly empathic observers and stressed participants

despite not being related (Buchanan, Bagley, Stansfield, & Preston, 2012). Thus, more than other sounds, crying is particularly likely to elicit cortisol because it conveys distress (Murray, 1985).

Despite there being no current evidence, a long history of domestication suggests that dogs might be particularly likely to show empathy towards humans. Dogs are attached to their human caregivers (Nagasawa, Kikusui, et al., 2009; Prato-Previde, Custance, Spiezio, & Sabatini, 2003), are attentive to human eyes (Call et al., 2003; Schwab & Huber, 2006), and can use human gestures such as pointing and gazing to find food (Miklosi & Soproni, 2006; Udell, Giglio, et al., 2008). It is likely either that dogs have been domesticated because they demonstrate such characteristics, and/or that these qualities have been selected for in breeding.

## **Aims and hypotheses**

Recent research on dogs has focused on their ability to recognise human communicative cues (e.g. pointing, eye gaze, and social cognition generally). However, there is still much that is unknown about canine ability to recognise human emotions. The main objective in this study was to investigate whether domestic dogs understand the emotions expressed by a human experimenter. Specifically, I examined four emotions (anger, sadness, fear, happiness) and three types of expressions (dynamic, unimodal, bimodal) in four studies. I also examined canine behavioural and physiological responses to discrete human emotional expressions. In addition, I made comparisons as to whether canine responses were similar to those of humans' and therefore, have included humans in two studies.

My experiments covered four main areas: (1) canine response to commands accompanied by dynamic expressions of human happiness and anger, (2) canine social referencing of humans' expressions of fear and happiness, and one additional control "confused" expression, (3) canine and human infants' preferential looking to angry, happy and sad human faces, human infants' facial expressions analysis, and canine gender-matching, and (4) canine and human physiological and behavioural response to human infant crying, human infant babbling, and white noise. The emotions for each study are listed in the table below (Table 1.2).

Table 1.2

*Four emotions tested in four studies*

Name of study	Anger	Fear	Happiness	Sadness	Control Expressions
Study 1: Command and Obedience	✓		✓		
Study 2: Social Referencing		✓	✓		✓
Study 3: Preferential Looking	✓		✓	✓	
Study 4: Empathy				✓	✓

*Study 1: Command and obedience*

Past studies have demonstrated the influence of both verbal and nonverbal commands, contextual factors and emotional tone on obedience. To date, research has been conducted for verbal commands alone, verbal commands paired with eye gaze, and verbal commands paired with hand gestures (Call et al., 2003; Kaminski, Schulz, et al., 2012; McConnell, 1990; Mills et al., 2005; Pettersson et al., 2011; Ruffman & Morris-Trainor, 2011; Scheider et al., 2011). Uttering the commands in full view of dogs may have resulted in unavoidable cues akin to the ‘Clever Hans’ effect. Hans was a horse whose trainer claimed could perform arithmetic tasks, but who in fact, responded to subtle behavioural cues of the trainer (Pfungst, 1911). Study 1 investigated which specific emotional cues might influence canine obedience to a command. Two emotions were compared – anger and happiness – with the aim to examine whether dogs would wait for longer when told to “leave” a piece of food when the command was accompanied by anger. Dogs were trained initially to leave a piece of food when given the command, “Leave”, spoken in a neutral tone, before progressing to the test phase. In the test phase, I manipulated the emotional cue such that emotion was expressed only in the body and hands, only in facial expressions, or only in vocal tone. Dogs were then left alone with the food and the dependent variable was how long they waited before taking the food.

*Study 2: Social referencing*

In my second experiment, I examined canine referencing of human emotional expressions. Social referencing studies typically employ one positive (e.g. happiness) and one negative (e.g. fear) emotion. However, the contrast between these two emotions is not sufficiently robust when examining dogs because the emotions represent the two extreme ends of an emotional scale, and the positive emotion is likely to be much more familiar to the observer. Familiarity with an expression does seem to play a role in deciding which box or object a dog will select (Buttelmann & Tomasello, 2013; Merola et al., 2011, 2012).

The aim of this study was to investigate whether dogs could successfully interpret a 'social referencing' cue (either happiness or fear) toward an object, but unlike in previous studies, included one additional control cue. Fearful expressions are most likely to be unfamiliar to dogs, and thus they may not understand the meaning of such expressions. A likely response when confused, is that dogs will become wary and avoid contact with an object as in Merola et al. (2011, 2012). Therefore, an important control for potential canine confusion is for the experimenter to respond toward the toy in a way that, like fear, is unfamiliar, but unlike fear, conveys no emotional content about the object. The control expression selected in the present study involved the experimenter pretending to be a chicken. Although somewhat bizarre and humorous to a knowledgeable human, this expression would be unfamiliar and confusing to a dog, yet would convey no emotional content about the object. The question was whether dogs would show a similar level of wariness toward the toy as when the experimenter reacted fearfully.

*Study 3: Preferential looking*

Study 3 examined canine and human infant matching of emotional faces to voices. Because there was little evidence of matching or attention to the vocal cue in this study, I also examined participants' preference for one face over another. Studies employing the preferential looking paradigm have traditionally used one positive and one negative facial expression (e.g. happy-sad or happy-angry), and thus far, two infant studies have paired two negative emotions (angry-sad). Therefore, in addition to pairings of happy and sad faces, as well as happy and angry faces, I included one negatively valenced pair in my study (angry-sad). Dogs and 7-month-olds human infants were presented with two human facial expressions simultaneously (either happy and sad, happy and angry, or sad and angry), while listening to a matching happy, sad, or angry human voice. My interest was, first, in whether dogs and human infants looked more at the emotion-consistent face, and if they didn't show matching, whether dogs and infants had a preference for looking at certain emotion faces over others.

In addition to measuring looking time at an affective display, I also analysed infants' facial expressions using emotion recognition software. Infants' facial expressions could be an indicator of their own emotional response towards the expression after viewing an affective display.

I also examined a separate group of dogs to determine whether they could gender-match a human male or female voice to a face. Dogs were presented pairs of male and female faces displaying neutral expressions, while listening to either a male or female voice uttering a sentence in a neutral voice.

*Study 4: Empathy*

Previous studies have not examined canine physiological and behavioural responding to human infants' distress, yet this measure has the potential to reveal not just canine emotional contagion, but the first clear evidence of cross-species empathy. To this end, I examined whether dogs and humans show a similar physiological response to human infant crying. I tested 75 dogs and 74 humans when listening to one of three sounds, each played at 82 dB: human infant crying, human infant babbling, or white noise. White noise and babbling were control stimuli. Cortisol was measured before and after crying, with an interest in the extent of cortisol increase. I also coded canine behavior (alertness and submissiveness) while the sound was played, and instructed humans to rate the sound's aversiveness. Dog owners were present throughout, though they were sensorily isolated and did not interact with dogs.

I had three main hypotheses. First, given dogs' attachment to humans, I hypothesized that they would respond with increased interest (alertness) to infant crying and babbling, similar to humans. Second, even at relatively low volumes, exposure to uncontrollable white noise is aversive, eliciting submissive behaviour (shaking, stimulus avoidance, increased heart rate) in horses and dogs (Beerda, Schilder, Van Hooff, & De Vries, 1997; Christensen, Keeling, & Nielsen, 2005), so that I anticipated dogs would be submissive when listening to white noise. Likewise, if dogs found infant crying aversive, I expected them to display submissiveness when listening to crying. Third, because cortisol plays a prominent role in facilitating empathy (Shirtcliff et al., 2009), I expected that infant crying would be more likely to elicit a cortisol response than the other sounds. I did not expect a cortisol increase in dogs or humans to white noise, because evidence from past studies shows that only volumes greater than 90dB elicit

cortisol (Beerda et al., 1997; Beerda, Schilder, van Hooff, de Vries, & Mol, 1998; Lundberg & Frankenhaeuser, 1978; Miki, Kawamorita, Araga, Musha, & Sudo, 1998). Similarly, I did not anticipate an increase in cortisol to babbling because babbling facilitates interaction and affiliation rather than stress (Elowson, Snowdon, & Lazaro-Perea, 1998; Snowdon, 1997). Finally, I examined a subset of dogs to determine whether those lacking experience with infants still responded empathically to infant crying.

## Chapter 2: Command and obedience

### Introduction

Humans often issue a command to their dogs (e.g. to fetch or sit), and expect obedience to the command. Past studies have shown that verbal commands are affected by acoustic features (e.g. frequency and pitch) (McConnell, 1990; Scheider et al., 2011), pauses (Braem & Mills, 2010), phonemic properties (Fukuzawa et al., 2005b), emotional tone (Mills et al., 2005), and loudness (Dalibard, 2009). Canine obedience to a particular command is also affected by non-verbal features (e.g. speaker's distance, body posture and eye gaze (Call et al., 2003; Fukuzawa et al., 2005a; Schwab & Huber, 2006)). In addition, when different command tones were paired with hand gestures, dogs searched for food more actively following a cooperative command compared to a foreboding command (Pettersson et al., 2011).

### **Aim and hypotheses**

Past studies have demonstrated the influence of both verbal and nonverbal commands, contextual factors and emotional tone on obedience. To date, research has been conducted for verbal commands alone, verbal commands paired with eye gaze, and verbal commands paired with hand gestures (Call et al., 2003; Kaminski, Schulz, et al., 2012; McConnell, 1990; Mills et al., 2005; Pettersson et al., 2011; Ruffman & Morris-Trainor, 2011; Scheider et al., 2011). Uttering the commands in full view of dogs may have resulted in unavoidable cues akin to the ‘Clever Hans’ effect. Hans was a horse whose trainer claimed could perform arithmetic tasks, but who in fact, responded to subtle behavioural cues of the trainer (Pfungst, 1911). Study 1 investigated which specific emotional cues might influence canine obedience to a command. Two emotions were compared – anger and happiness – with the aim to examine whether dogs would wait for longer when told to “leave” a piece of food when the command was accompanied by anger. Dogs were trained initially to leave a piece of food when given the command, “Leave”, spoken in a neutral tone, before progressing to the test phase. In the test phase, I manipulated the emotional cue such that emotion was expressed only in the body and hands, only in facial expressions, or only in vocal tone. Dogs were then left alone with the food and the dependent variable was how long they waited before taking the food.

## **Method**

### *Participants*

Eighty-eight dogs (58 females,  $M = 5.20$  years,  $SD = 3.31$ , 14 intact) participated in this study (Appendix B). Dogs were recruited from advertisements placed in the university newsletter, local canine clubs and flyers distributed to dog owners from the local city council. Dog owners were given a petrol voucher as compensation for participating in the study.

### *Experimental design*

The study was a mixed design with one between-subjects variable (Cue: body, face, voice) and one within-subjects variable (Emotion: angry, happy). Each dog was randomly allocated to one cue and to both emotions. Out of the 88 dogs, 29 were presented with bodily expressions, 29 with vocal expressions, and 30 with facial expressions.

### *Materials*

For this study, I used Saveloy sausages purchased from the local supermarket as the food treat and a white box measuring 30cm by 23cm by 23cm as a food plate. I had separate items for each cue - a wooden plank (50cm x 40cm x 1cm) and a plain steel pole (1cm diameter, 1.6m tall) to cover the experimenter's face for the body condition, a 60cm x 50cm plain cardboard sheet to hide the experimenter's body for the face condition, and all items were used to hide the experimenter's face and body for the vocal condition.

*Procedure*

I tested the dogs without their owner present in an experimental room measuring 3.0m by 3.2m. Dogs were instructed to sit approximately one metre from the food (see Appendix C), because one study found that dogs tended to obey the command better at a one metre distance compared to two to four metres (Fukuzawa & Hayashi, 2013). During the training trial, I uttered “Leave” in a neutral voice, placed a piece of sausage on the white box, and waited for 10 seconds. If the dog attempted to eat the food before 10 seconds, I uttered a firm “No” and restarted the trial. If the dog waited for 10 seconds, I then brought the food to him/her and said “Good boy/girl” in a cheerful voice. The experimental trial commenced after the dog had successfully completed three consecutive training trials. In the experimental trial, I expressed one emotion for five seconds (e.g. angry face), and left the room for one minute. During this time, dogs were videotaped, with the variable of interest being their latency to take the piece of food. This process was then repeated such that dogs were given another round of training trials, and following adherence to the command, “Leave”, issued in a neutral voice, the second trial (e.g. happy face). Descriptions of each cue and emotion in the experimental trials are provided in Table 2.1.

Table 2.1

*Description of the cue and respective emotional valence for Study 1*

Type	Cue	Vocal tone	Angry emotion	Happy emotion
<i>Body</i>	Face was hidden behind a wooden plank.	Neutral	Stomped right foot, widened foot stance, clenched left fist, and pointed toward dog using right index finger.	Arms hung loosely in front, open palms, feet normally apart.
<i>Face</i>	Face was visible, but rest of body hidden behind cardboard.	Neutral	Eyebrows were pulled down and inward; vertical crease between the brows; eyes narrowed, taking on a hard, staring look; lips closed tightly, and turned down at the corners, flared nostrils.	Lower eyelids were slightly raised, crinkling around the outer edges of the eyes; lip corners moved up and out with upper teeth exposed; cheeks were raised with an apple-like bulge; head slightly tilted to the side.
<i>Voice</i>	Body and face completely hidden from sight.	Either happy or angry tone.	Vocal tone was short and sharp, and repeated twice. The pitch descended rapidly.	Pleasant voice, repeated twice, with gentle roll in pitch.

*Emotion expression consistency*

First, I carried out an analysis to determine whether the emotional cues were interpreted by young adults as intended. The 88 dogs produced 176 video recordings, but 10 video recordings were excluded due to incorrect positioning of the video camera. The remaining 166 videos were presented to 18 university students (14 females,  $M = 22$  years,  $SD = 2.83$ ). Participants were asked to identify the emotion expressed in each of the recordings and to select one emotion from six options: “Anger, Disgust, Fear, Happy, Sad, Surprise”. A binomial test showed that participants were able to identify emotions at a level above chance responding (chance = 16.7% correct). Participants were successful at identifying both emotions in the facial expression and vocal commands – that is, the most commonly selected response was the appropriate one for each expression category (Table 2.2).

For the body condition, although participants could successfully identify the angry expression, the majority of the participants identified the “happy” expression as sad, while it was also identified as disgusted, fearful or surprised. This result is similar to that in previous research. Unlike angry postures, a happy posture (or elated joy) has been found to have low accuracy ratings and has been confused with sadness, and surprise (Banziger, Mortillaro, & Scherer, 2012; Dael, Mortillaro, & Scherer, 2012; Visch, Goudbeek, & Mortillaro, 2013). Although some confusion was expected, it is nevertheless of interest to compare canine responses to angry versus happy bodily postures because the happy bodily posture was clearly not perceived as angry by young adults.

Table 2.2.

*Mean number of correct responses for the categorisation of expressions in Study 1*

Cue	Expression	Mean number of correct responses (max = 18)	Mean correct response (%)	<i>p</i> value (one-tailed)
Body	Happy	0.82	5	.10
Body	Angry	13.69	76	< .001
Face	Happy	17.21	96	< .001
Face	Angry	12.00	67	< .001
Voice	Happy	13.79	77	< .001
Voice	Angry	15.03	84	< .001

*Measured variables and analysis*

Two coders coded canine behaviour. The coding was divided into two phases: while the experimenter emoted during the experimental trial, and when the dog was left alone with the food. For the emoting phase, the behavioural variables included number of times looking at the food, time spent looking at the food, number of times looking at the experimenter, time spent looking at the experimenter's face, time spent moving to the experimenter, and overall interest in the experimenter and food for each emotion and cue. In the alone phase, canine latency to eating the food was measured when the dog was left alone for one minute and after the experimenter left the room for each emotional cue. When coding canine behaviour when left alone with the food, the primary coder initially coded without volume and thus was blind to the conditions (and hypothesis). I was the second coder, and coded 33% of the dogs for inter-rater reliability. The primary coder's coding was used in all analyses and the inter-rater correlations between the two coders were good (Table 2.3).

Table 2.3

*Inter-rater correlations for each measured variable for both phases in Study 1*

Phase	Item	Inter-rater correlation, $r_s$
While Emoting	Number of times looked at food	.90
	Time spent looked at food	.86
	Number of times looked at experimenter	.83
	Time spent looked at experimenter's face	.71
	Time spent moving to the experimenter	.95
	Overall interest in food	.87
	Overall interest in experimenter	.89
Alone with food	Latency to eat the food	.98

## Results

The assumption of normality was tested via examination of the raw data. Review of Shapiro-Wilk's test for normality (all  $ps < .001$ ) and the histograms suggested that the data were non-normal. For this reason, non-parametric analyses (Wilcoxon Signed-Rank test) were used.

### *Canine behaviour during emoting*

Figure 2.1 displays the looking duration towards the food and the experimenter for the different emotional cues. Across the three cues, dogs looked longer at the food when a happy expression was displayed across the three cues,  $Z = 3.47, p < .001, r = .39$  (Wilcoxon Signed-ranks test). In contrast, dogs looked longer at the experimenter when an angry expression was displayed across the three cues,  $Z = 2.32, p < .02, r = .26$ .

Subsequently, each cue was analysed using Wilcoxon Signed-rank tests with Holms correction for multiple comparisons ( $p = .02$ ). For the bodily cues, dogs looked at the food longer when the experimenter displayed happiness compared to anger,  $Z = 3.00, p < .01, r = .58$ . There were no significant differences to looking at food following the happy and angry expressions for either the face cue,  $Z = 0.38, p = .71, r = .07$ , or the vocal cue,  $Z = 1.99, p = .05, r = .38$ . Dogs looked longer at the experimenter when she displayed an angry expression compared to happiness,  $Z = 2.31, p = .02, r = .44$ . There were no significant differences to looking at the experimenter for the happy or angry bodily cues,  $Z = 1.85, p = .06, r = .36$ , or vocal cues,  $Z = 0.29, p = .77, r = .06$ .

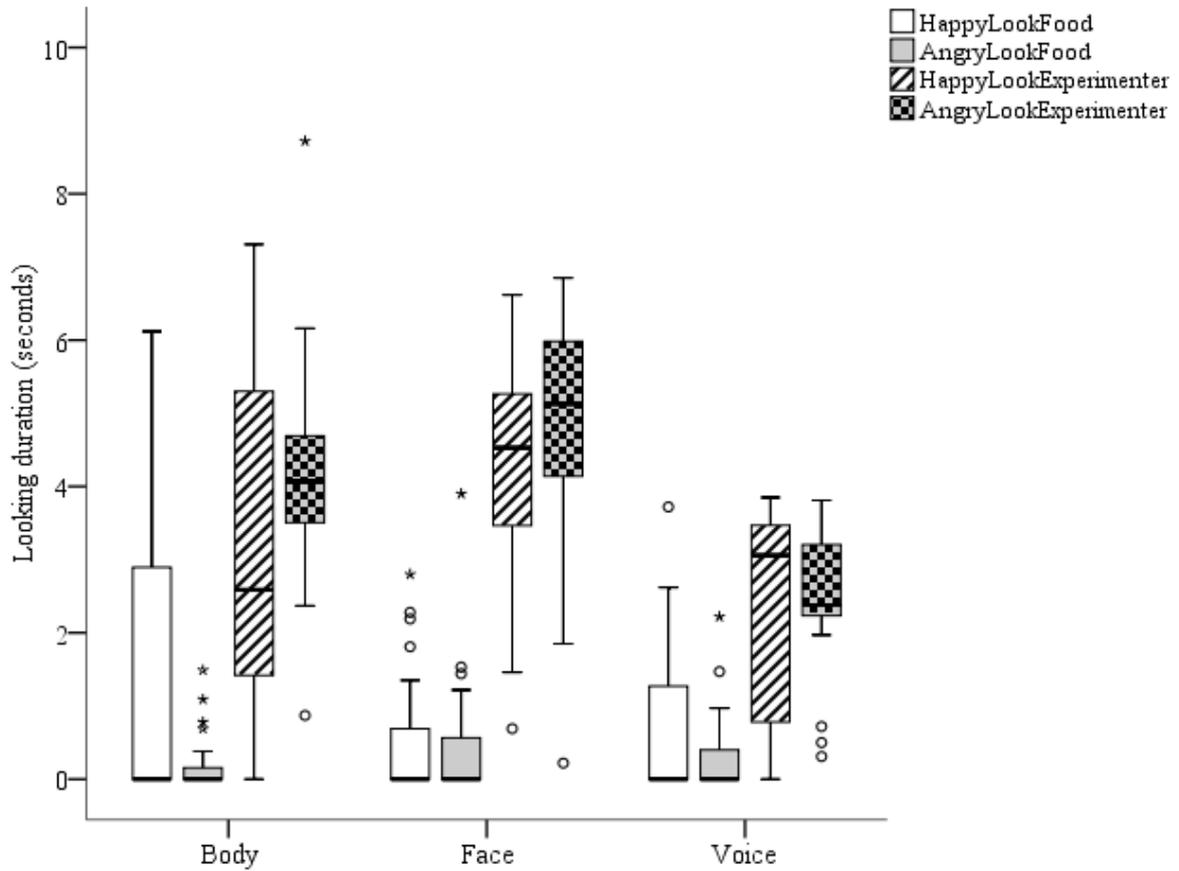
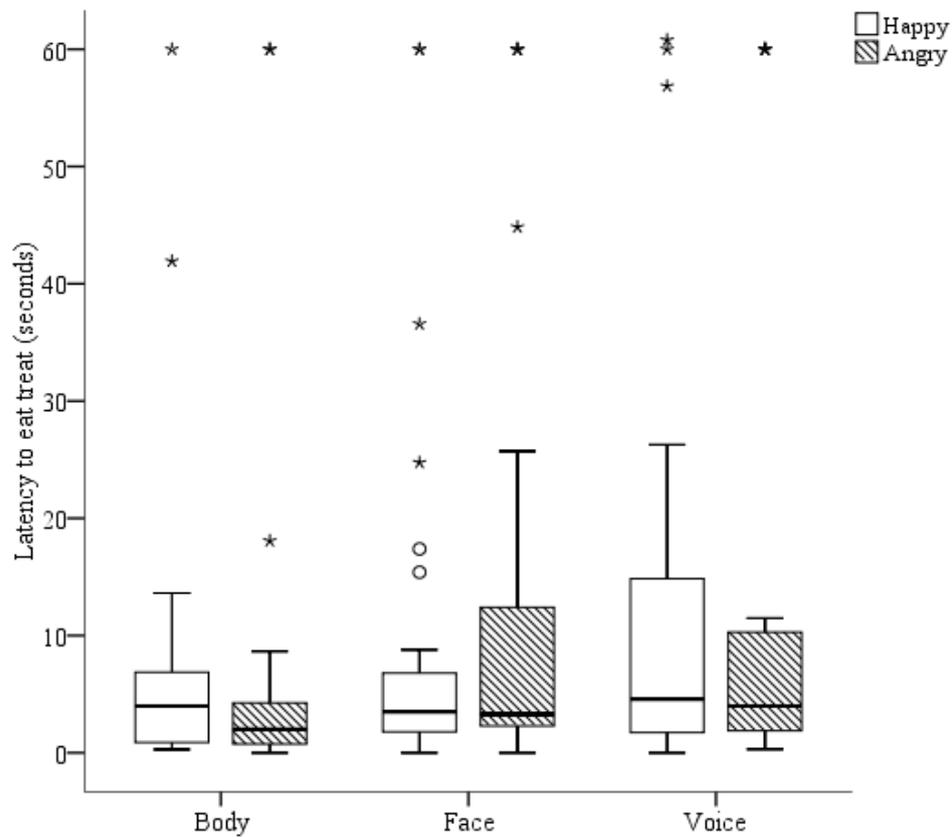


Figure 2.1. Box and whisker plot displaying canine looking at either food or experimenter following the happy and angry expressions ( $n = 88$ ) in the three conditions (Body, Face, Voice).

*When left alone with treat*

Out of the 88 dogs that participated, 10 dogs were excluded from analysis because they did not eat the food in both experimental trials (2 for body, 1 for face, 7 for voice), leaving 78 dogs for analysis. There was no significant differences in latency to eat the food after receiving the happy versus angry emotion cue in any of the three conditions, all  $ps > .32$  (Wilcoxon Signed-Rank test) (*Figure 2.2*).



*Figure 2.2.* Box and whisker plot displaying canine median latency to eating the treat following the happy and angry expressions ( $n = 78$ ) in the three conditions (Body, Face, Voice).

*Effect sizes and power analysis*

While emoting, the effect sizes were small in the body and voice conditions when looking at food, both  $r_s < .05$ , while there was a large effect in the face condition,  $r = .71$ . There was also a large effect in the voice condition when looking at the experimenter's face,  $r = .77$ , but small effect sizes in the body and face condition, both  $r_s < .06$ . When left alone with the treat, there was a moderate effect size for all cues, all  $r_s > .16$ . To achieve significance ( $g = .80$  using  $\alpha = .05$  (Cohen, 1988)), I would need to test 968 dogs for the body cue, 688 for the facial cue and 564 dogs for the vocal cue. The upshot of these analyses is that it is unlikely that the results would have become significant with the addition of a few more dogs.

*Acoustic analysis for the verbal commands*

To examine whether the vocal commands possessed the typical characteristics of angry and sad utterances, I analysed the happy and angry verbal commands using Praat software (version 5.3.45) (Boersma & Weenink, 2012), examining the following parameters: (a) duration for both utterances, (b) fundamental frequency (F0: cross-correlation method, 125 ms time window, 50-1,000 Hz frequency range), (c) mean intensity (50 to 100 mean energy), and (d) formant frequencies (F1-5: burg method, 25 ms time window, maximum frequency 5,500 Hz, maximum 5 formants). The data were normally distributed.

Table 2.4 describes the acoustic parameters for both happy and angry verbal commands. Almost all acoustic parameters for the angry versus happy voice commands were significantly different, all  $ps < .01$ . The angry command consisted of higher mean fundamental frequency, higher pitch standard deviation, higher mean intensity, and shorter duration to utter the command. The result of this acoustic analysis is similar to past findings on happy and angry utterances (Juslin & Laukka, 2003; Scherer, 1986), indicating they were typical happy and angry utterances.

Likewise, the pitch contour in the angry command was observed rising rapidly whereas the pitch of the happy commands decreased on a gentle slope, similar to Scherer (1986) (see Appendix D and Appendix E).

Table 2.4

*Mean values for each acoustic parameters for vocal cue in Study 1*

Type	Happy <i>M</i> ( <i>SD</i> )	Angry <i>M</i> ( <i>SD</i> )	<i>t</i> value	<i>p</i> value
Duration for both utterances (s)	2.76 (.24)	2.19 (.20)	-9.53	< 0.001
Fundamental frequency (Hz)	339.67 (23.70)	424.58 (78.35)	5.59	< 0.001
SD in frequency (Hz)	26.91 (26.95)	134.29 (35.17)	13.05	< 0.001
Minimum frequency (Hz)	301.38 (22.01)	231.97 (71.23)	-5.01	< 0.001
Maximum frequency (Hz)	396.80 (82.09)	600.09 (75.56)	9.81	< 0.001
Mean intensity (dB)	61.27 (4.31)	76.14 (1.49)	17.56	< 0.001
First formant	434.80 (66.11)	636.62 (66.02)	11.63	< 0.001
Second formant	2019.67 (315.79)	2306.23 (131.31)	4.51	< 0.001

## Discussion

When left alone, there was no difference in how long dogs waited before eating the treat irrespective of whether the command to leave the food was accompanied by a happy or angry expression emanating from the body, face or voice. Nonetheless, canine behaviour differed when observing the experimenter display an emotion with a specific cue. For instance, dogs were more likely to move towards the experimenter when the experimenter stomped her feet, balled her left fist and pointed using her right index finger indicating anger, whereas they chose to look at the food longer when her body was relaxed with arms hanging loosely. Dogs also looked longer at the experimenter's face when her facial expression was angry compared to happy, but longer at the food when they heard a pleasant happy voice compared to an angry voice. These distinct behavioural differences for all three cues suggest that dogs demonstrated some level of understanding of the two emotions (i.e. they recognised that the expressions were different). However, the behavioural difference during emoting does not imply that dogs understand the emotions in a meaningful way (i.e., that they understood and responded to the emotion underlying the expression). The canine response to anger could simply be perceived as reflecting interest or confusion, because dogs approached or looked at the experimenter longer when she was angry.

Similar to Mills et al. (2005), the emotional tone in a command was not effective in getting the dog to obey a command when left alone with the food. Thus, unlike other studies (McConnell & Baylis, 1985; McConnell, 1990; Pettersson et al., 2011; Scheider et al., 2011), pitch did not contribute towards obedience. Furthermore, similar to Juslin and Lauka (2003) and Scherer (1986), the acoustic profiles of the angry and happy vocal commands were typical happy and angry utterances, and therefore different from

each other, with anger having a higher pitch and intensity compared to happiness. Consequently, despite the vocal commands having characteristic features of anger and happiness, and despite the fact that human participants were mostly accurate when identifying the angry and happy expressions, the expressions did not affect canine latencies to take the food.

Nor did canine latencies differ according to the nonverbal signals available in the body and face conditions. Nevertheless, dogs do use at least some nonverbal communicative signs to communicate with conspecifics and humans, so these signals are important for them. In the present study, the dogs were unable to view the experimenter's eyes in the body and voice conditions, and in previous research, an inability to see a human's eye gaze has led to higher disobedience (Call et al., 2003; Schwab & Huber, 2006). Likewise, past studies suggest that humans rely on combined facial and bodily gestures more than any other cues when making judgments about human communicative behaviour (Ambady & Rosenthal, 1992; Gunes & Piccardi, 2007). Canine reliance on eye contact and tone of voice to determine what is required of them (Kaminski, Schulz, et al., 2012), combined with the occlusion of such cues in the present study, may have hindered understanding of the commands.

One possible limitation in this study was that canine exposure to the cue was too short (five seconds) for comprehension. However, this seems unlikely because dogs did respond differently to the happy and angry cues in all three conditions while the experimenter was emoting. Lack of familiarity with the experimenter may have also contributed to the poor performance, as demonstrated in another study (Merola et al., 2013). In the present study, the experimenter took responsibility for the angry and happy commands in order to standardise (so far as is possible) the expressions, yet dogs

are likely to have been more familiar with their owner's expressions of happiness and anger compared to a stranger. The downside of using owner expressions is that it is impossible to control for differences in believability and intensity between different owners. However, a future experiment might explore this possibility.

In sum, dogs did not wait longer to take the food following an angry command compared to a happy command. In addition, the behavioural differences in canine responding during emoting (e.g. approaching the experimenter versus looking at the food) could therefore reflect a non-insightful response to the different perceptual qualities of the angry and happy commands. For instance, dogs might have been attracted by the experimenter's higher animation, or may have become more physically aroused when the experimenter expressed anger. Unlike anger, happy expressions were considerably less animated (e.g. relaxed with arms hanging loosely, smiling face, or softer, slower, speech).

## Chapter 3: Social Referencing

### Introduction

Social referencing, a form of referential communication, is often tested in an ambiguous situation in which one uses an emotional expression to help guide the actions of another person (Klennert et al., 1986; Stenberg & Hagekull, 2007). For instance, an experimenter expresses either fear or happiness toward an object and then observes a human infant's reaction to the object.

Studies have provided evidence that when placed in an ambiguous situation, both human infants and non-human animals (e.g. primates, dogs) looked to or referenced either a familiar (parent) or an unfamiliar (experimenter) individual who expressed an emotional reaction to a stimulus (Buttelmann & Tomasello, 2013; Kim et al., 2010; Merola et al., 2011, 2012; Roberts et al., 2008; Rosen et al., 1992; Russell et al., 1997). Studies typically employ one positive and one negative emotion (e.g. happiness versus fear), and expressions are conveyed through a combination of facial, vocal and bodily cues. After observing the emoter, the infant or animal either approaches the object when the emoter displayed a positive reaction or avoids the object when the emoter reacted negatively towards the object.

### **Aim and hypothesis**

In my second experiment, I examined canine referencing of human emotional expressions. As stated above, social referencing studies typically employ one positive (e.g. happiness) and one negative (e.g. fear) emotion. However, the contrast between these two emotions is not sufficiently robust when examining dogs because the emotions represent the two extreme ends of an emotional scale, and the positive emotion is likely to be much more familiar to the observer. Familiarity with an expression does seem to play a role in deciding which box or object a dog will select (Buttelmann & Tomasello, 2013; Merola et al., 2011, 2012).

The aim of this study was to investigate whether dogs could successfully interpret a 'social referencing' cue (either happiness or fear) toward an object, but unlike in previous studies, included one additional control cue. Fearful expressions are most likely to be unfamiliar to dogs, and thus they may not understand the meaning of such expressions. A likely response when confused, is that dogs will become wary and avoid contact with an object as in Merola et al. (2011, 2012). Therefore, an important control for potential canine confusion is for the experimenter to respond toward the toy in a way that, like fear, is unfamiliar, but unlike fear, conveys no emotional content about the object. The control expression selected in the present study involved the experimenter pretending to be a chicken. Although somewhat bizarre and humorous to a knowledgeable human, this expression would be unfamiliar and confusing to a dog, yet would convey no emotional content about the object. The question was whether dogs would show a similar level of wariness toward the toy as when the experimenter reacted fearfully.

## **Method**

### *Participants*

One hundred and fourteen dogs (69 females,  $M = 5.24$  years,  $SD = 3.13$ ) participated in this study (Appendix F). Dogs were recruited from advertisements placed in the university newsletter, local canine clubs and flyers distributed to dog owners from the local city council. Dog owners were given a petrol voucher as compensation for participating in the study, and dogs received sausage pieces as reward at completion. Only four dogs had experience with a similar toy robot at home.

### *Experimental design*

The experimental design was a between-subjects design, with each dog participating in only one of the three conditions (either happiness, fearful, or control), with random allocation to condition. Out of the 114 dogs, 37 were presented with happiness, 38 with fear, and 39 with control conditions.

### *Materials*

The ambiguous toys were two remote-controlled toy robots. Each robot was 30cm tall and 18cm wide, and had moving arms and legs, and a helmet (see Appendix H). When the remote was activated, the robot glided forward with a soft mechanical hissing sound. The robots glided out from a makeshift garage (30cm x 50cm x 40cm cardboard box with two A4 sheets of paper as doors).

*Procedure*

At the beginning, the dog was given 10 minutes to explore the experimental area in the presence of the owner (3.0m x 3.2m) (see Appendix G). No food was provided to the dog, and water was provided *ad libitum*. The owner was then separated from the dog and waited in another room before the start of the experiment.

The experimenter sat on the floor facing the dog, and parallel to the makeshift garage placed on the floor, calling out the dog's name to get its attention and without bringing any attention to the garage. While the dog was attending to her, the experimenter pressed the remote control hidden in her left palm for the robot to emerge from the garage. As the toy glided towards the dog, the experimenter displayed either a happy, fearful or the control expression for approximately 20 seconds. The experimenter alternated her gaze between the toy and the dog to indicate her expression referred to the toy. After the emotional display, the experimenter left the room for one minute, leaving the dog alone with the toy.

The happy expression included smiling, a pleasant face, tilting the head slightly on both sides, and pointing towards the robot. The experimenter moved towards the dog calmly, and after the 'happy' display, she stood and left the room calmly too. The fearful expression consisted of widely opened eyes, a furrowed brow, pulled-back lips, a slightly opened mouth, loud audible sounds such as gasps, and shrieks, and pointing towards the robot while the experimenter moved towards the dog and away from the toy rapidly. The experimenter then stood up, glanced briefly at the toy and left the room quickly. In the control condition, the experimenter mimicked a chicken – tucking her fingers under each armpit and flapping her arms, making audible clucking noises, tilting her head from side to side, and duck-walking in circles from the garage towards the

opposite wall. She did not look at the dog or the toy throughout the expression and left the room without making eye contact with the dog or toy.

*Emotion expression analysis*

To check on human interpretations of the experimenter's emotional presentations in this experiment, I presented 89 videos (78%) taken during emoting to 20 university students (18 females,  $M = 19.5$  years,  $SD = 2.03$ ) to determine whether the portrayed expressions were correctly identified. Participants were asked to identify one emotion from seven options "Anger, Disgust, Fear, Happy, Sad, Surprise, Other" for each video. They were informed that the emotion expressions were at times clearly identifiable and sometimes not. Participants were generally successful at identifying all three expressions. A binomial test showed that participants were able to identify emotions at a level above chance responding (chance = 14.3% correct), including the control condition identified as "other" (Table 3.1). In general, fear was harder to identify than happiness, a result that mimics general findings for facial expressions of emotions (Young, Perrett, Calder, Sprengelmeyer, & Ekman, 2010).

An additional 25 dogs (totalling to 114 dogs) were tested after the emotion expression analysis. The categorisation responses on the emotional expressions identified from the 89 videos were clearly identifiable, thus not requiring validation.

Table 3.1

*Mean number of correct responses for the categorisation of expressions in Study 2*

Expression	Mean number of correct responses (max = 20)	Mean correct response (%)	<i>p</i> value (one-tailed)
Happy	18.5	93	< .001
Fearful	12.6	63	< .001
Control	17.3	86	< .001

### *Measured variables*

All behavioural coding was conducted by two coders. The primary coder was blind to the conditions and to the hypothesis, and was not involved in collecting data. I coded 33% of the dogs for inter-rater reliability. The coding was divided into two parts; during emoting and when alone with the toy. The variables coded during emoting were time spent looking at the experimenter's face and at the toy, number of looks at the toy, and overall interest in the experimenter and toy. At every 2-second interval, interest was coded on the basis of canine gaze, that is, whether dogs looked towards the experimenter, the toy, or toward something else (e.g. not looking at toy or experimenter), with interest towards a target coded as 1 (present) or 0 (not present). The variables coded when dogs were left alone with the toy were number of looks at the toy, time spent looking at the toy, overall interest in the toy (coded every 2 seconds as above), and proximity to the toy. For proximity, the room was divided into three subsections (close to toy, close to door, in-between area) and canine position in the room was coded. The inter-rater correlations between the two coders were good (Table 3.2).

Table 3.2

*Inter-rater correlations for each measured variable for both phases in Study 2*

Phase	Item	Inter-rater correlation, $r_s$
While emoting	Looking at experimenter's face	.72
	Looking at toy	.94
	Number of looks at the toy	.98
	Interest in the toy	.95
	Interest in the experimenter	.92
Alone with toy	Interest in the toy	.95
	Interest in the experimenter	.95
	Proximity to the toy	.93
	Proximity to the door	.91
	Proximity to in-between area (not close to toy or door)	.94

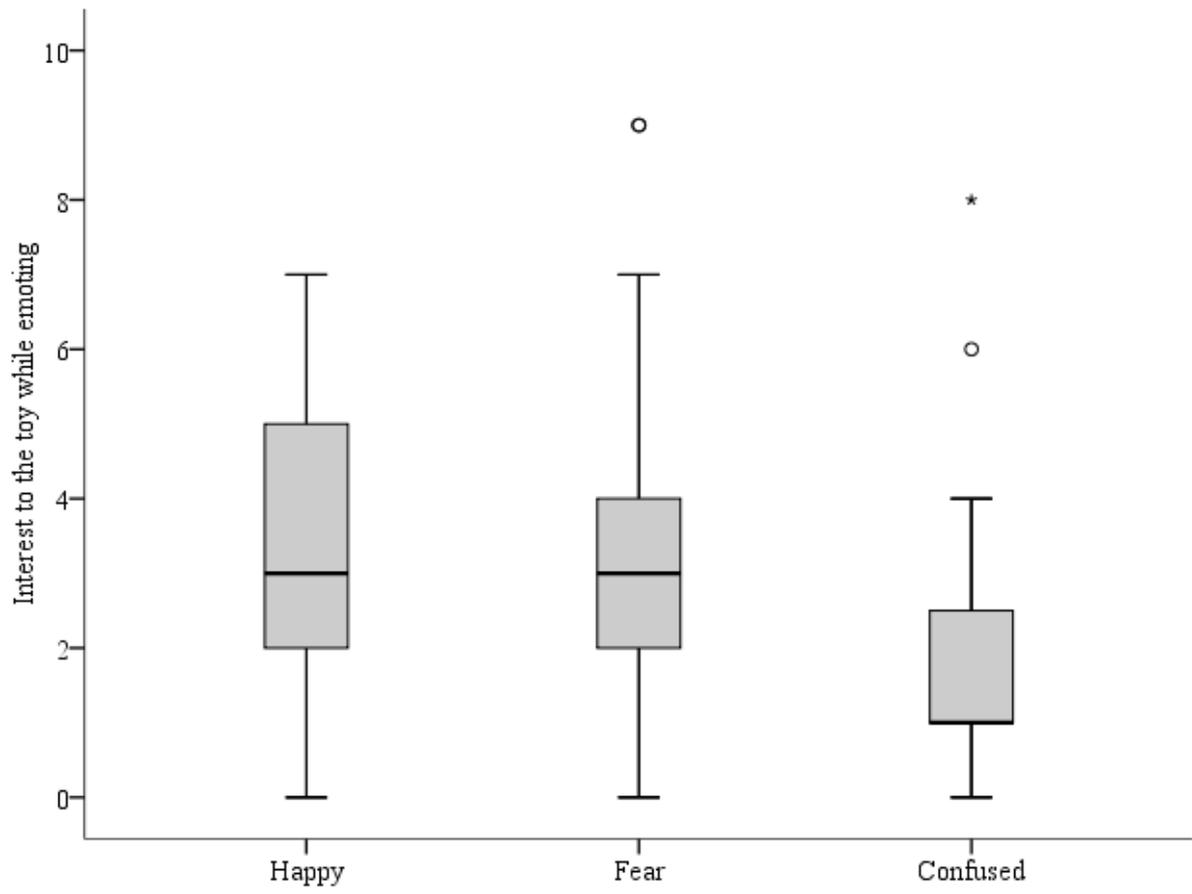
## Results

The raw data were examined for normality. Review of Shapiro-Wilk's test for normality (all  $ps < .01$ ) and the histograms suggested that the data were non-normal. For this reason, non-parametric analyses were used.

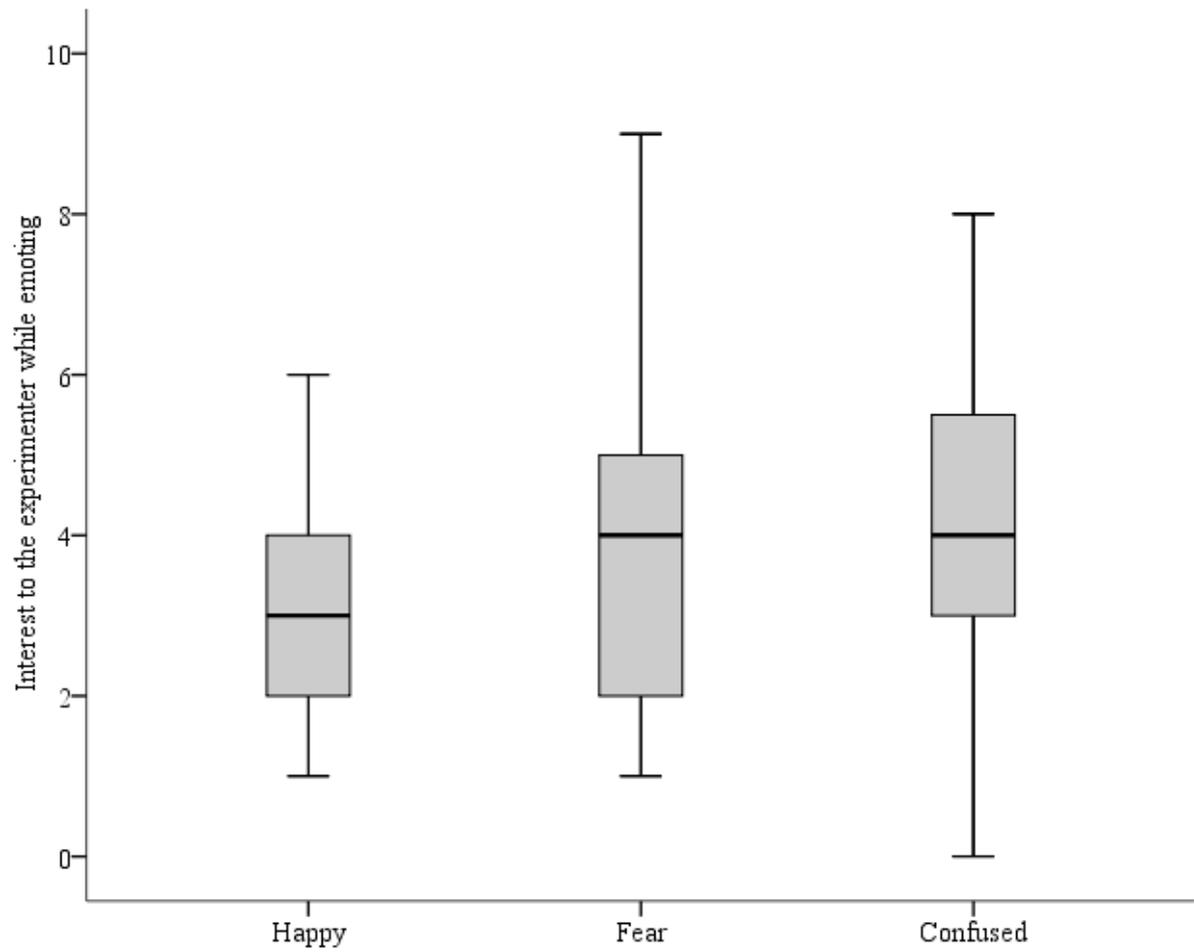
### *During emoting*

Figure 3.1 and Figure 3.2 show canine attention towards the toy and the experimenter. Dogs attended to the toy differently across the three expressions,  $p < .01$  (Kruskal-Wallis Test). Each pair was then analysed using Mann-Whitney U tests with Holms correction for multiple comparisons ( $p = .02$ ). Dogs paid more attention to the toy when the experimenter looked happy compared to the control condition,  $U = 399.50$ ,  $p < .01$ ,  $r = .39$  and when fearful compared to the control,  $U = 410.50$ ,  $p < .01$ ,  $r = .39$ . In contrast, there was no difference in attention to the toy in the happy and fearful conditions,  $U = 671.00$ ,  $p = .73$ ,  $r = .04$ .

Canine attention to the experimenter was also significantly different across the three expressions,  $p < .01$  (Kruskal-Wallis Test). Dogs paid more attention to the experimenter in the control compared to happy condition,  $U = 431.50$ ,  $p < .01$ ,  $r = .35$ . There was no significant difference between the fear and happy conditions,  $U = 501.50$ ,  $p = .03$ ,  $r = .25$ , or the fear and control conditions,  $U = 657.50$ ,  $p = .39$ ,  $r = .10$ .



*Figure 3.1.* Box and whisker plot displaying canine median interest to the toy in the three conditions.



*Figure 3.2.* Box and whisker plot displaying canine median interest to the experimenter in the three conditions.

*Alone with toy*

Canine interest in the toy was significantly different between the three conditions,  $p = .02$  (Kruskal-Wallis Test). Each pair was then analysed using Mann-Whitney U tests with Holms correction for multiple comparisons ( $p = .02$ ). Dogs were more interested in the toy in the fear,  $U = 477.50$ ,  $p < .01$ ,  $r = .28$ , and control conditions,  $U = 491.50$ ,  $p < .02$ ,  $r = .28$ , compared to the happy condition. There was no difference in interest toward the toy in the fear and control conditions,  $U = 718.00$ ,  $p = .81$ ,  $r = .03$  (Figure 3.3). None of the other variables such as number of looks at the toy, and time spent looking at the toy were significantly different in the three conditions, all  $ps > .13$  (Kruskal-Wallis Test).

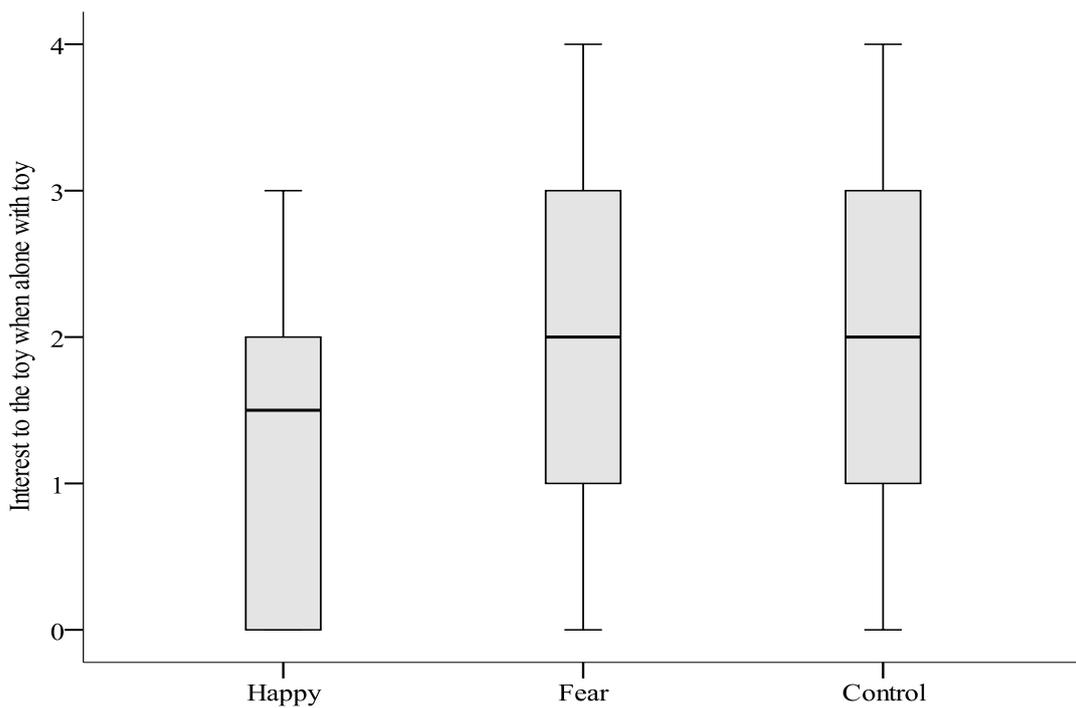


Figure 3.3. Box and whisker plot displaying canine median interest to the toy in the three conditions when the dog was left alone with the toy.

There was no difference in canine proximity to the toy across the three conditions,  $p > .33$  (Kruskal-Wallis Test), with only non-significant and weak trends for dogs to spend more time near the toy when the experimenter had expressed happiness ( $Mdn = 3.28$  seconds) compared to fear ( $Mdn = 1.89$  seconds) or the control condition ( $Mdn = 2.97$  seconds) (Figure 3.4).

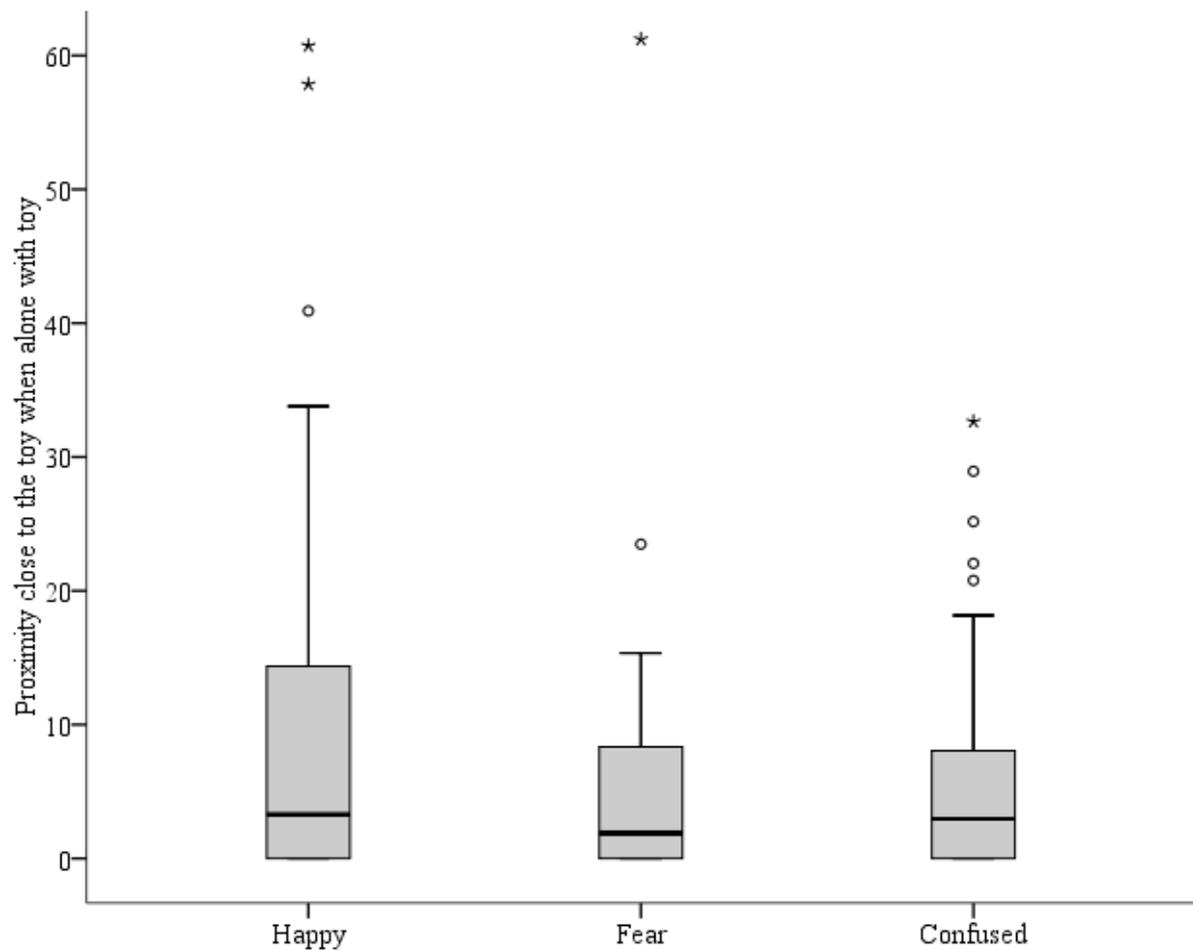


Figure 3.4. Box and whisker plot displaying canine median interest spent at proximity close to toy when the dog was left alone with the toy.

## Discussion

There were two main findings from this study. First, dogs were more attentive to the experimenter when she was displaying the control and fearful expressions compared to when happy, with no difference between the control and fear conditions. Second, when dogs were left alone with the toy, they showed more interest towards the toy in both the fear and control conditions compared to the happy condition, and again, with no difference between control and fear.

Dogs' greater attention to the experimenter during the emoting phase of the fear and control conditions suggests that their differential reaction in the happy and fear conditions may have stemmed from greater interest or confusion when confronted with the fearful expression (and the control expression). That is, the greater attention can be perceived as an attempt to *gain more information* about the situation because they failed to understand the emotional cues in the fear and control conditions. The greater interest could also be interpreted as increased wariness or *anxiety* towards the unknown object, after observing the initial referencing. Zarbaty and Lamb (1985) found that uncertainty promotes referencing in human infants - 'uncertain' infants who were unclear about the emotional expressions from the emoter looked longer at the fearful face but were less likely to approach the adult, compared to 'certain' infants who were more likely to approach the adult and less likely to approach the object (toy spider).

The control expression did not communicate meaningful information about the toy, and thus might have created more looks of interest towards the experimenter, with dogs seeking information, compared to the other two emotional expressions. However, the results showed that the control expression generated similar levels of attention to the

experimenter as the fearful expression. The similar response to the control and fearful expressions suggests that dogs may not have understood that the experimenter's fear should make them wary of the toy because dogs displayed similar behaviour toward the experimenter and toy even in the control condition when the experimenter's reaction should not communicate caution towards the toy.

In attempting to reconcile the present results with those of past studies, three variables should be considered: who does the emoting (owner versus a stranger), what kind of toy is used, and the duration of the emotional display. First, in the present study, dogs may have chosen to ignore the expressions by a stranger and/or had heightened anxiety due to the owner's presence in another room. Zaratany and Lamb (1985) proposed that human infants have a 'selectivity postulate', which meant that familiarity with primary caregivers would make messages from the caregiver a more powerful behavioural regulator of the infant's behaviour (as opposed to messages from a stranger). However, this is unlikely in the present study because there were distinct attentional differences towards the toy and the emoter between the three expressions, showing dogs were responding to the experimenter's display. In addition, canine research utilising the *owners* as emoters indicates similar outcomes to the present study (a greater likelihood of approaching the toy following a happy versus a fearful display) (Buttelmann & Tomasello, 2013; Merola et al., 2013, 2012).

Second, the robot itself may not have been sufficiently interesting or large to be perceived as a threat to the dog. The stimulus in social referencing studies generally evokes some degree of fear (Merola et al., 2011; Sorce et al., 1985). Yet again, the differential reaction of dogs in the three conditions suggests this was not responsible for the present results. That is, dogs were least interested in the toy after witnessing the

experimenter expressing happiness towards it, but maintained an interest towards the toy in both the fear and control conditions.

Third, it is possible that the duration of the expression was too short. In the present study, the experimenter stopped displaying an emotional expression when the toy stopped moving, a procedure similar to human infants' social referencing studies (Kim et al., 2010; Klinnert et al., 1986). Nevertheless the expression in the present study was displayed for about 20 seconds, but the duration in human infant studies was longer – Klinnert et al. (1986) used one minute, and Kim et al. (2010) used 30 seconds, similar to Merola et al.'s (2011) study with dogs. Yet, despite the shorter duration in the present study, the distinct behavioural differences shown across the three conditions, and the similarity in canine responding in the present study and Merola et al. (2011) in the happy and fear conditions, suggests that cue duration was not the critical factor.

In summary, the findings of the present study make it uncertain whether dogs really understand the emotion conveyed in happy versus fearful cues. Dogs might simply become confused by fearful expressions, becoming anxious, and then avoid exploration of the environment.

## Chapter 4: Preferential Looking

### Introduction

Emotion processing ability in preverbal infants has been studied with preference tasks or habituation tasks (typically with visual displays) or intermodal matching tasks. In habituation tasks, the observer stops responding to one stimulus after repeated presentations. While in preference tasks, affective expressions are presented either in pairs or successively to the observer, and if the observer shows a preference for one expression by gazing at it for longer over several trials, it is then assumed that they can discriminate between the two expressions (Grossmann, 2010). In intermodal matching tasks, observers must detect the correspondence between visual and auditory information, typically demonstrated by more looking at one of two visual stimuli when listening to a matching auditory stimulus (Walker-Andrews, 1997).

Several studies have shown that human infants prefer looking at affective facial displays that correspond to vocal displays. Thus, infants aged between 3.5 to 7 months of age tend to match vocal and facial displays of happiness, sadness and anger. However, infants also show a preference for looking at certain facial expressions over others. Infant performance on such studies was summarised in Table 1.1. Infants tend to look more at happy faces when happy faces are paired with either angry or sad faces, and to show no preference when angry and sad faces are paired. Soken and Pick (1999) posited that infants looked longer at angry faces because they are familiar with anger and preferred to look at the familiar emotion. In contrast, Schwartz et al. (1985) proposed that infants find an angry face more aversive than a sad face, and therefore

looked at a sad face which is less aversive to them. Irrespective of such arguments, there is no clear pattern overall when anger and sadness are paired.

Infants' response when viewing affective displays is also of interest, and infants' facial expressions could be an indicator of their own emotional response towards the expression. For instance, infants displayed freezing ("no movement") while viewing angry expressions and "mouthing" (lip and tongue sucking and pushing the lips in and out) when observing their mother's sad expression (Haviland & Lelwica, 1987). Studies have also reported that infants smiled less often, averted their gaze, and grimaced more often when viewing a sad expression (D'Entremont & Muir, 1997, 1999; Termine & Izard, 1988).

Most studies presented participants with affective expressions from a female emoter, be it a familiar (mother) or an unfamiliar (stranger) person. Although studies have shown that infants could match a face to a voice of the same gender (Miller, 1983; Patterson & Werker, 2002; Walker-Andrews et al., 1991), canine ability in this area has yet to be examined. Nonetheless, studies indicate that dogs can discriminate between genders in humans because they behave differently to a male compared to a female. For example, dogs appear more relaxed and less aggressive (less barking, more likely to approach, more yawning, with a relaxed, head-up posture) towards females compared to males (Hennessy et al., 1998; Lore & Eisenberg, 1986; Wells & Hepper, 1999).

### **Aim and hypothesis**

Study 3 examined canine and human infant matching of emotional faces to voices. Because there was little evidence of matching or attention to the vocal cue in this study, I also examined participants' preference for one face over another. Studies employing the preferential looking paradigm have traditionally used one positive and one negative facial expression (e.g. happy-sad or happy-angry), and thus far, two infant studies have paired two negative emotions (angry-sad). Therefore, in addition to pairings of happy and sad faces, as well as happy and angry faces, I included one negatively valenced pair in my study (angry-sad). Dogs and 7-month-olds human infants were presented with two human facial expressions simultaneously (either happy and sad, happy and angry, or sad and angry), while listening to a matching happy, sad, or angry human voice. My interest was, first, in whether dogs and human infants looked more at the emotion-consistent face, and if they didn't show matching, whether dogs and infants had a preference for looking at certain emotion faces over others.

In addition to measuring looking time at an affective display, I also analysed infants' facial expressions using emotion recognition software. Infants' facial expressions could be an indicator of their own emotional response towards the expression after viewing an affective display.

I also examined a separate group of dogs to determine whether they could gender-match a human male or female voice to a face. Dogs were presented pairs of male and female faces displaying neutral expressions, while listening to either a male or female voice uttering a sentence in a neutral voice.

## Method

### *Participants*

Ninety-seven pet dogs (60 females,  $M = 5.22$  years,  $SD = 3.35$ ) of different breeds participated in this study (Appendix I). Fifty-two dogs participated in the emotion task and 45 dogs participated in the gender task. Of the 97 dogs, 87 lived with two or more people, 26 were adopted, and 21 were intact. Dogs were recruited from advertisements placed in the university newsletter, local canine clubs and flyers distributed to dog owners from the local city council. Dog owners were given a petrol voucher as compensation for participating in the study and dogs received sausage pieces as a reward upon completion.

Twenty-four human infants (10 females) participated in the task ( $M = 7.16$  months,  $SD = 0.85$ ) (Appendix J). Twenty infants were European New Zealanders while four infants were mixed-parentage (Maori, Chinese). All infants were born healthy and full-term with the exception of one infant born pre-term. The participants were volunteers or were referrals from previous participants. Each participant received a petrol voucher and a toy for their participation. The infants came from primarily middle-class families in which at least one parent had a university education and was working full-time.

### *Experimental design*

This experiment employed a mixed design, with each participant matching either happy, sad and angry emotion faces to emotion voices (emotion was a repeated-measures variable), or matching male and female voices to male and female faces

(gender was a repeated-measures variable), and condition – emotion vs. gender – was a between-subjects variable).

### *Materials*

*Facial expressions.* The full-coloured facial expressions were still photographs sourced from a public sharing website. The images were edited using Adobe Photoshop CS4 to minimise the natural background, and re-sized to 1024 x 972 resolutions (96dpi). The happy expressions included a wide smile with visible teeth and a “Duchenne smile” (eyes crinkled and hair away from the face). The angry expressions had brows pointing downward toward the centre, a wrinkled forehead, visible teeth, raised cheeks, and an index finger pointing forward. The sad expressions included crying with visible tears, redness on the cheeks, eyes and nose, the eyes brows raised toward the centre, and lowered mouth corners. The neutral face was relaxed without any facial muscles contracting or any other facial movements.

*Vocal expressions.* The recordings used in this experiment were made in stereo at 44100 Hz with a 32-bit float. The recording equipment included a Crown PZM-185 boundary microphone, a line mixer Phonic MU1002, and audio software (Audacity version 1.3.13). The distance between the microphone and the speaker was 0.75m and the noise level in the room when quiet was 30 decibels (dB). Each speaker was recorded individually in a 5.0m x 3.5m room. They were given two short content-free sentences: "Hat sundig pron you venzy. Fee gott laish jonkill gosterr" (Banse & Scherer, 1996, p. 619). The sentences were accompanied with matching scenarios for each emotion (Table 4.1). Each speaker made multiple recordings for the six emotions (anger, disgust, fear, happiness, sadness, neutral) and was instructed not to produce recognisable and overt verbal items such as “yuck”, or “yippee!” in their speech (Sauter, Eisner, Calder,

& Scott, 2010). The recordings were edited using Audacity to remove background noises, and shortened to five seconds. Each five-second recording was analysed with Praat version 5.3.45 (Boersma & Weenink, 2012) to determine the average fundamental frequency (F0: cross-correlation method, 125 ms time window, 50-1,000 Hz frequency range), intensity, harmonics to noise ratio (HNR), and formants (F1-5: burg method, 25 ms time window, maximum frequency 5,500 Hz, maximum 5 formants) for each emotion.

Table 4.1

*Scenarios for positive and negative emotions for vocal expressions in Study 3*

Emotions	Scenarios
Happiness	You won the jackpot.
Anger	You saw your friend being unfairly treated and pushed over by a bully.
Sadness	Your long time pet died.
Fear	You heard a dog growling when you were walking in a dark alley.
Disgust	You put your hand in someone else's vomit.
Neutral	You are having a regular day at work.

*Validation of facial expressions and vocal recordings.* The facial expressions and voice recordings were presented individually to 16 university students (7 females,  $M = 22$  years,  $SD = 2.83$ ). Participants were asked to identify the emotion from three possible choices “anger, happy, sad”. Using a 90% agreement criterion, participants identified 28 (out of 32) faces, and 29 (out of 32) vocal recordings. For the emotion task, I chose 16 out of 28 faces (Gender: 7 males, 9 females, and Ethnic group: 10 Caucasian, 4 Asians, 2 Latin Americans), and four male and female voices each (6 Caucasians, 1 Pacific Islander, 1 Asian). For the gender task, I chose six males and females faces each (9 Caucasians, 3 Asians), and three males and females voices each (5 Caucasians, 1 Asian) for the Gender task.

*Experimental area.* The experimental area consisted of a chair, three black 2.0m x 2.0m felt covered walls, two 48cm computer monitor screens, one computer to run the computer program, two audio speakers and two video cameras (see Appendix K and Appendix L). The black walls were placed to the front, left and right of the participant. Both computer monitors were placed on the front black wall at a 1.0m height from the floor and the distance between the two monitors was 0.3m. That same wall also contained a pinhole between the two computer monitors for inconspicuous and close-up video recording. Another video camera was placed on top and at the middle of the front black wall for wide-angle recording. Each audio speaker was placed behind each computer monitor and hidden from the participant. The loudness of each vocal recording was measured using a Digitech sound level meter, QM 1588, 1.8 metres from the chair, and comprised an average loudness of 65 dB. The facial and vocal expressions were presented using specially written software.

*Procedure*

Dog owners were blindfolded, and held onto their dog's collar lightly. Dogs sat between their owner's knees at a 1.8m distance equidistant from the two computer monitors. Shorter dogs were placed on their owner's knees at a 1.5m distance equidistant from the two monitors. Similar to dog owners, the infant's parent was also blindfolded. Parents held their infants on their lap at a 1.5m distance from the two monitors. Infants and shorter dogs were placed closer to the monitors due to the limited flexibility in positioning the video camera, and for a clearer view of their eye movements and facial expressions.

Each trial started with a clicking tone for one second. The clicking tone was to attract participants' attention. One voice recording was played for five seconds and the computer monitors remained blank (e.g. angry male voice). The voice recording was then repeated for another five seconds (angry male voice) and two faces were shown simultaneously on both computer monitors (angry male, happy male). Then a different tone was played for one second and the computer monitors went blank to indicate the end of that trial. This format was repeated for the remaining five trials. To maintain interest, for the human infants, the tones at the beginning and end of each trial were substituted with animal sounds (e.g. bird chirps, cow moos) and the blank monitors with still cartoon images (e.g. Winnie the Pooh).

For the emotion task, each participant was given two trials per emotion, totalling six trials altogether. Each trial contained one voice recording expressing one emotion and two different faces of the same gender expressing two different emotions. One face matched the voice. For example, an angry male voice was paired with an angry male face and a happy male face, or a sad female voice was paired with an angry female face

and a sad female face. The matching face position (either left or right) was counterbalanced. The emotion trials were randomised and the combinations of faces displayed on the left- and right-hand monitors consisted of happy-sad, happy-angry, sad-angry, sad-happy, angry-happy, and angry-sad.

A separate group of dogs were given the gender task in which male or female voices were paired with a male and female face. There were three trials for male voices and three for female voices, making it six trials altogether. In each trial the voice and faces were “neutral” (i.e. non-emotional). For example, a male neutral voice was paired with a male neutral face and a female neutral face. All trials were randomised.

#### *Measured variables*

All behavioural coding was conducted by two coders. The primary coder was blind to the conditions and to the hypothesis. I coded 33% of the videos for inter-rater reliability. The primary coder measured canine and infant time spent looking at the left and right screens, time spent looking away from the screens, and time spent looking at the owner or parent. The inter-rater correlations between the two coders were good: looking duration at the left screen -  $r_s = .91$ , looking duration at the right screen -  $r_s = .94$ ; looking away -  $r_s = .86$  and looking at parent/owner -  $r_s = .95$ . The primary coder's ratings were used in the analyses.

Human infant emotional expressions during each trial were examined from videos of their facial action units (Ekman & Friesen, 1976) using the Computer Expression Recognition Toolbox (CERT) (Littlewort et al., 2011). CERT measures changes to facial expressions comprising 19 component movements in facial

musculature, the so-called “action units” (AUs), and regarded as “phonemes” of facial expressions (Ekman & Friesen, 1978).

CERT software processes data obtained either from live video, video files or individual images. The software analyses the  $320 \times 240$  video images in real time at approximately 10 frames per second and detects the  $(x, y)$  locations of 10 facial feature points for the 19 AUs, as well as 3-D orientation of the head (yaw, pitch, roll) (Appendix M) and has an algorithm that recognises six different prototypical facial expressions (happiness, sadness, surprise, anger, disgust, and fear) (Littlewort et al., 2012). On testing the robustness of this system, Littlewort et al. (2012) reported that CERT achieves an accuracy of nearly 80% and an average recognition performance of 90% (probability of correctness on a two-alternative forced choice (2AFC) task between one positive and one negative example) when analysing facial actions. Young infants make nearly all the muscle movements that are used by adults to express the primary emotions (Ekman & Oster, 1979) so that CERT provides a means of examining infants’ reactions when viewing facial expressions.

## Results

The raw data for both canine and human infants were examined for normality. Review of Shapiro-Wilk's test for normality (all  $ps < .05$ ) and the histograms suggested that the data were non-normal. For this reason, non-parametric analyses were used.

### *Emotion task*

Fifty dogs (two were excluded for not viewing any of the pairs in the six trials) and 24 human infants participated in this task. No data was lost from the infant group. The time spent looking at the matching image (e.g. looking time at angry male face after listening to angry male voice) and mismatching image (e.g. looking time at happy male face after listening to angry male voice) were measured for both dogs (*Figure 4.1*) and human infants to identify any evidence of matching (*Figure 4.2*).

When a sad voice was accompanied by a happy face paired with a sad face, dogs looked longer at the happy face,  $Z = 1.96, p < .05, r = .28$  (Wilcoxon Signed-Rank Test). The same finding was present in infants,  $Z = 3.29, p < .01, r = .67$  and in addition, they looked longer at the happy face when sad and happy faces were paired with a happy voice,  $Z = 3.56, p < .01, r = .73$ . When a happy voice was accompanied by a happy face paired with an angry face, human infants tended to look longer at the angry face,  $Z = 2.04, p = .04, r = .42$ .

When an angry face was paired with a sad face, dogs tended to look longer at the angry face irrespective of whether the voice matched or mismatched the angry face,  $Z = 2.00, p < .05, r = .28$  and  $Z = 3.25, p < .01, r = .46$  respectively. Likewise, human infants also looked longer at the angry face when it was paired with a sad face

irrespective of the voice,  $Z = 2.39, p = .02, r = .49$  and  $Z = 2.69, p < .01, r = .55$  respectively.

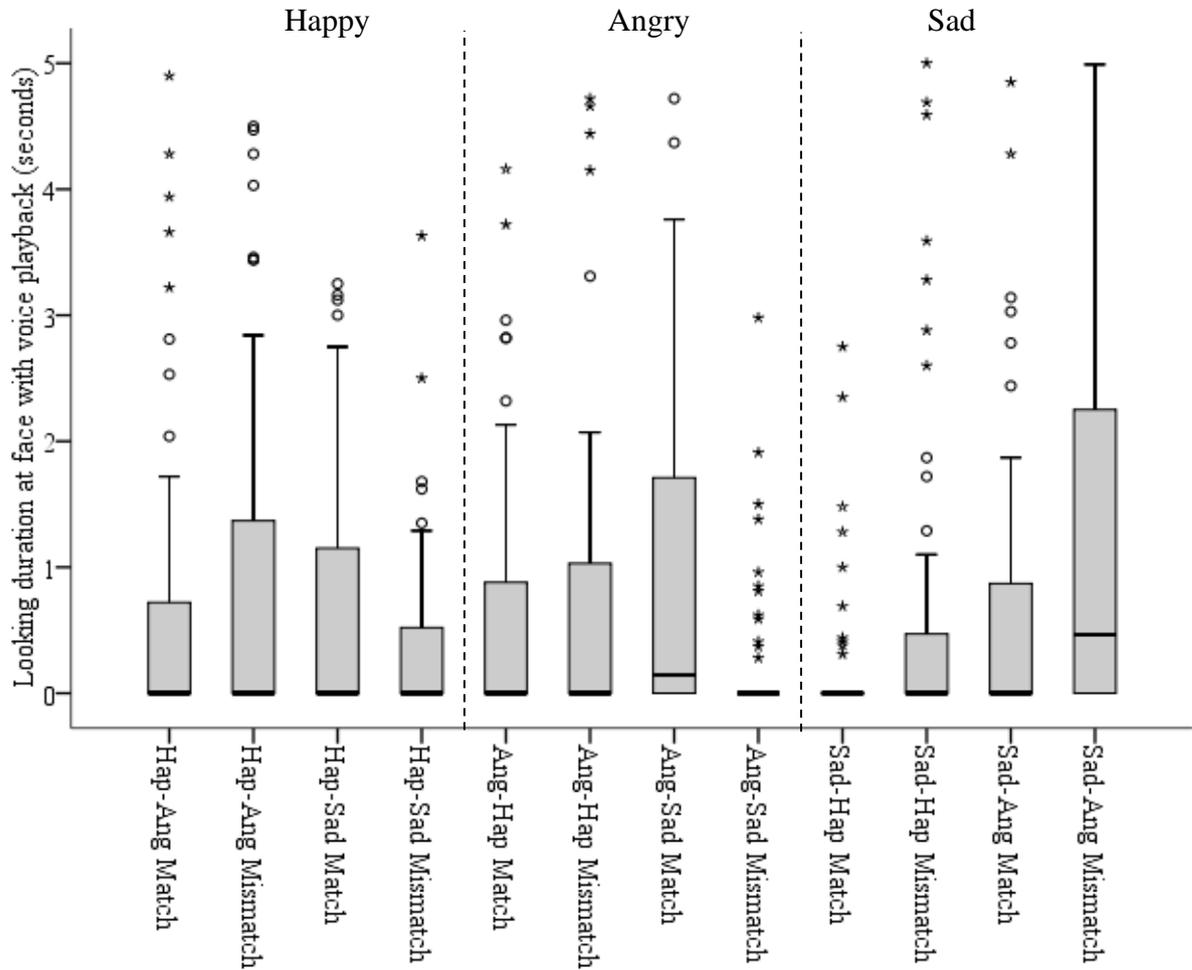


Figure 4.1. Box and whisker plot displaying canine median interest for each emotion pair ( $n = 50$ ) (Hap-Ang, Hap-Sad, Ang-Hap, Ang-Sad, Sad-Hap, and Sad-Ang).

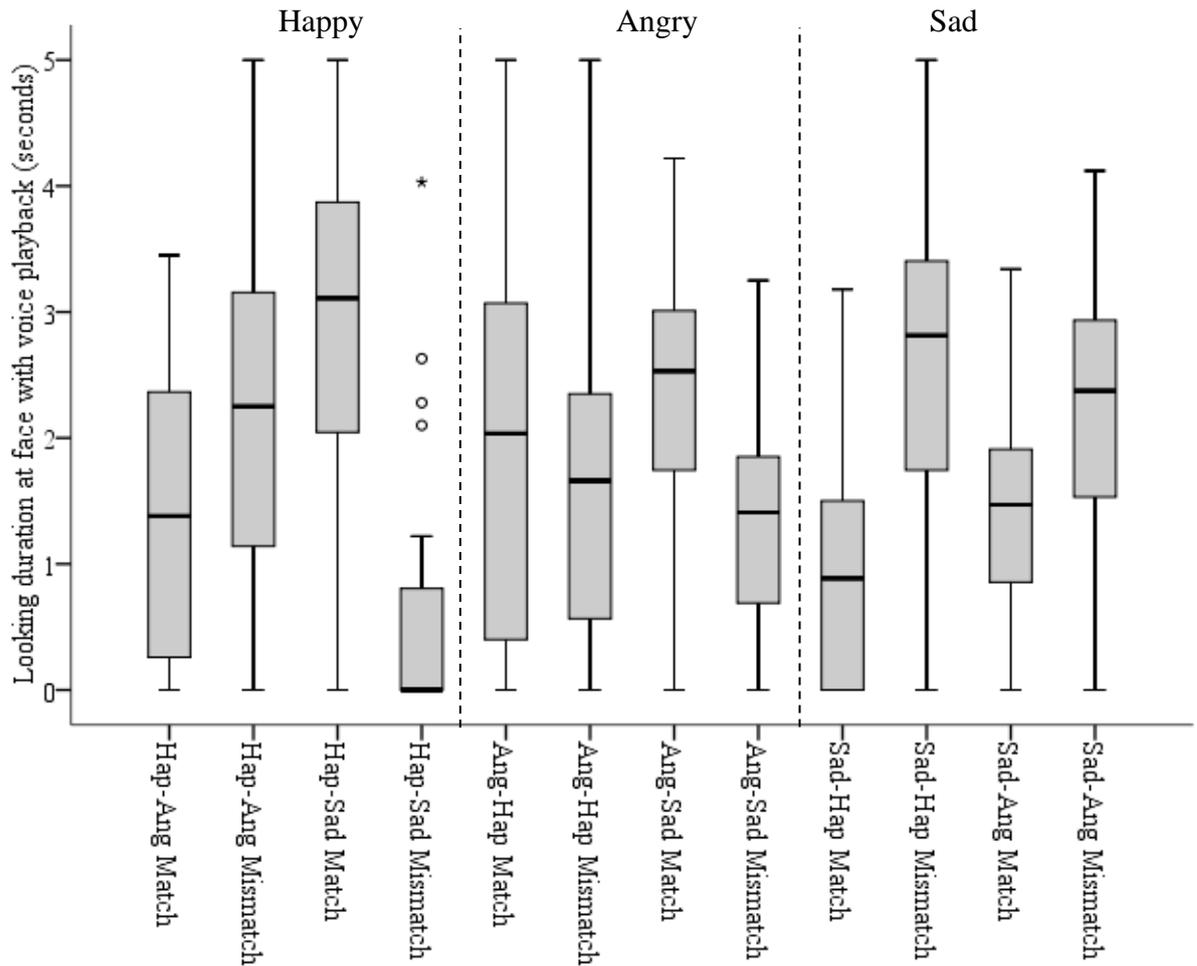


Figure 4.2. Box and whisker plot displaying human infants' median interest for each emotion pair ( $n = 24$ ).

These results suggest that neither dogs nor infants were matching emotion faces to emotion voices, but instead, tended to look toward angry and happy faces, and away from sad faces. For this reason, I examined total looking time at sad faces, happy faces, and angry faces, irrespective of matching.

Both dogs and human infants tended to look differently at the three types of emotional faces, both  $ps < .01$  (Friedman's Two-way analysis of variance by ranks). Further, both dogs and human infants looked least at the sad face when compared to both the happy and the angry faces,  $Z = 2.66, p < .01, r = .38$  and  $Z = 4.16, p < .01, r = .59$  respectively (Wilcoxon Signed-Rank Test), and similar for infants,  $Z = 4.14, p < .01, r = .85$  and  $Z = 3.66, p < .01, r = .75$  respectively. There was no preference in looking when the happy and angry faces were paired  $Z = 1.70, p = .09, r = .24$  and  $Z = .89, p = .38, r = .18$  respectively for dogs and infants (*Figure 4.3*). That is, both dogs and infants demonstrated the same pattern of looking, tending to look at happy faces when paired with sad faces, and angry faces when paired with sad faces.

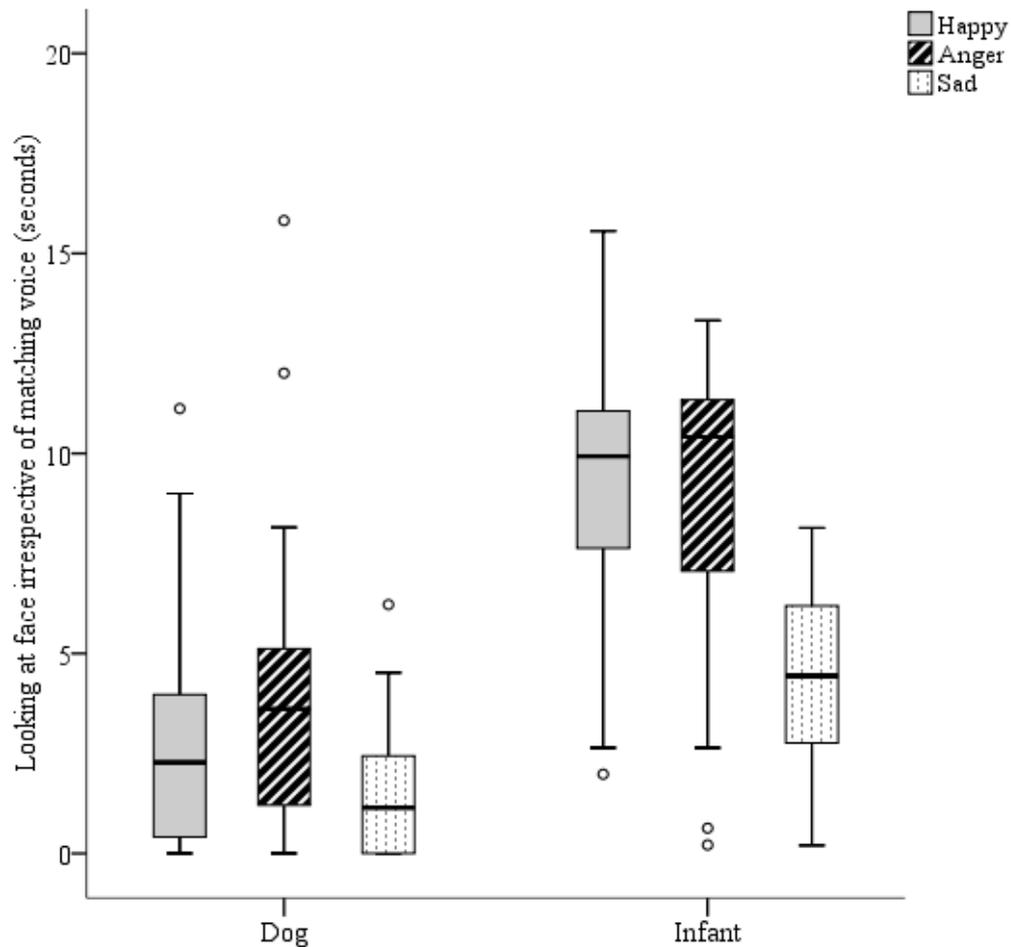
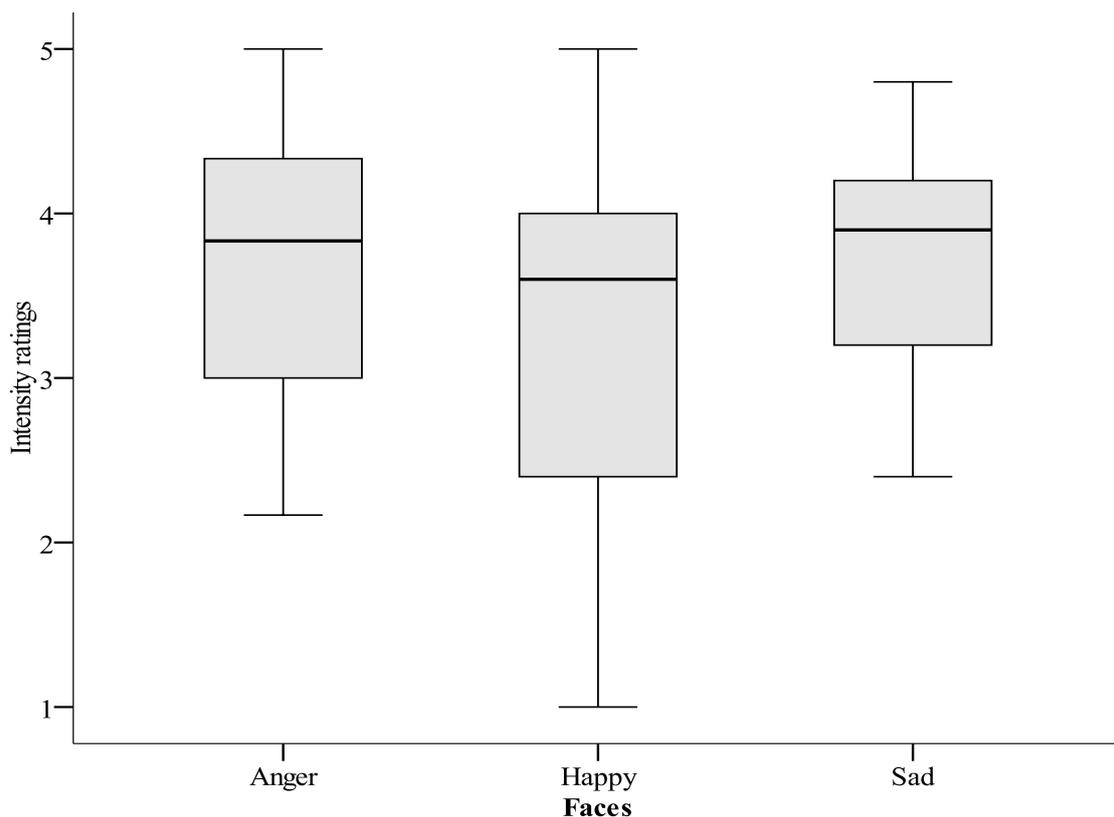


Figure 4.3. Box and whisker plot displaying canine and human infants' median interest for an emotion face (regardless of matching).

The other two variables - time spent looking away from the screen, and time spent looking at owner or parent – were not significantly different for the three emotion faces for either dogs or human infants, all  $ps > .07$  (Wilcoxon Signed-Rank Test).

*Emotion intensity*

One possibility is that emotion preferences stemmed from the intensity of the expressions. For this reason, I presented the 16 faces used in the emotion task to 18 university students (8 females,  $M = 28.8$  years,  $SD = 2.96$ ) to determine whether one emotion face was more intense compared to the others. Participants were asked to rate the intensity on a 5-point Likert scale, ranging from 1 (not intense) to 5 (very intense). The intensity ratings were not normally distributed, and were therefore analysed using non-parametric analysis (see *Figure 4.4*). There was no difference in intensity ratings between happy and angry faces,  $p = .10$ , happy and sad faces,  $p = .09$ , and angry and sad faces,  $p = .96$  (Wilcoxon Signed-Rank Test).



*Figure 4.4.* Box and whisker plot displaying intensity ratings for angry, happy, sad faces rated by university students ( $n = 18$ ).

*Gender task*

Forty-five dogs participated in this task, with one dog excluded for not viewing any faces. Past research found that canine attention was directed towards male faces and/or voices compared to female stimuli (Hennessy et al., 1998; Lore & Eisenberg, 1986; Wells & Hepper, 1999). For this reason, I used signal detection analysis to examine gender-matching. The looking time for each gender was calculated using signal detection theory (SDT) (Hits – False Alarms) because SDT attributes responses to a combination of sensitivity and bias (Swets, 1996).

Using a one-sample *t*-test, dogs correctly matched the male voice to the male face,  $t(43) = 2.68, p = .01$ , but did not match the female voice to the female face,  $t(43) = 1.03, p = .31$ . Overall, dogs correctly matched the combined male and female voices,  $t(43) = 2.41, p = .02$ , but this was clearly driven by male stimuli rather than female stimuli (*Figure 4.5*). Thus, dogs evinced some ability to gender-match stimuli, but were not consistent across both male and female stimuli.

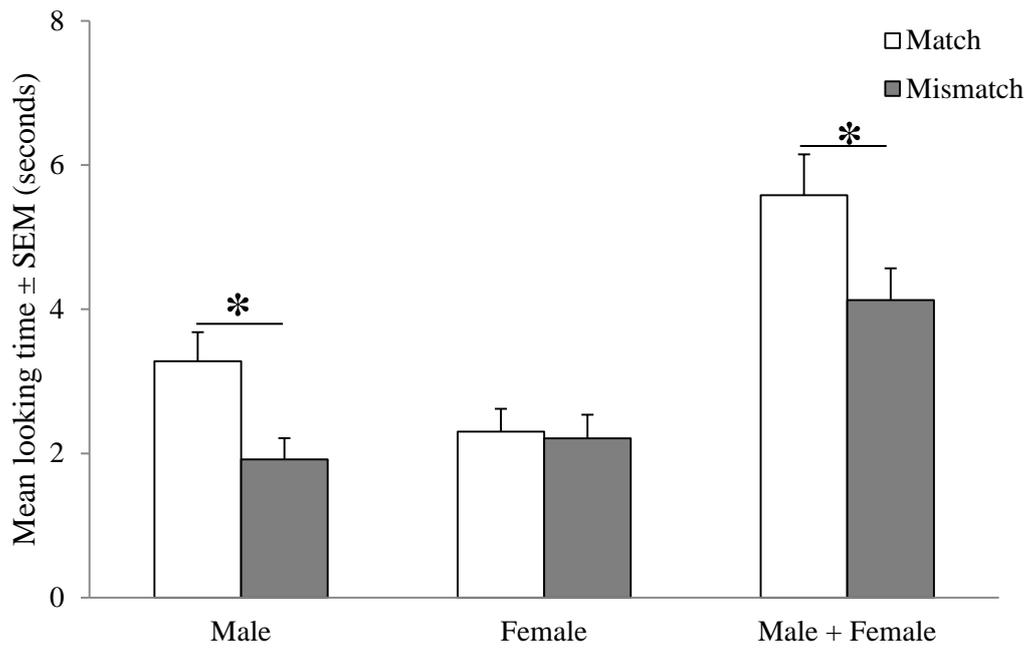


Figure 4.5. Canine mean looking time for matching and mismatching for Male, Female, and Male + Female faces and voices. \*  $p < .05$ .

*Human infants' facial expressions*

Changes in facial musculature in the upper face region (e.g. the brow) and the lower face region (e.g. the mouth) are found in a range of emotional expressions (e.g. anger, fear, or sadness) (see Matsumoto, Keltner, Shiota, O'Sullivan, & Frank, 2008 for a meta-analysis review). I separated human infant facial expressions into two phases - auditory only, and both auditory and facial stimuli. For the auditory only phase, infants' facial expressions were compared for each emotion pairing (e.g. when a sad voice was being played, I compared infants' facial expressions when they listened to the sad voice compared to a happy voice). The emotion task consisted of six pairs in total (e.g. angry-happy, happy-sad, angry-sad). There were two main interests in the auditory plus visual phase. First, I was interested in the response to the mismatched face when listening to another non-matching emotion voice (e.g. Ang-Hap faces to Hap voice, and Sad-Hap faces to Sad voice). A difference in infants' facial expressions indicates a response to the emotion resulting from the uncommon emotion. Second, the response to the faces could indicate mimicking, and therefore I compared infants' facial expressions when viewing a face (e.g. Ang-Hap face to Hap voice and Ang-Sad face to Sad voice). The data from CERT were normally distributed so that all subsequent analyses were conducted using parametric analysis.

For the auditory only phase, infants showed greater surprise when they listened to the sad voice compared to happy voice (i.e. greater outer brow raise, widened eyes, fear brow), all  $ps < .04$ . For the auditory plus visual phase, when infants viewed an angry face and listened to a happy voice, they demonstrated evidence of fear (i.e. greater lip stretching,  $t = 2.52, p = .02$ , and head pitching - forward and backward motion,  $t = 2.55, p = .02$ ). Infants again looked fearful when they viewed an angry face

and listened to a sad voice; greater 'fear brow', lip raising, lip stretching, and head yaw (sideways head movement as if turning away), all  $ps < .04$ .

When infants viewed a happy face and listened to an angry voice, their jaws dropped more often,  $p = .04$ , suggesting a surprised expression. When they viewed a sad face, they expressed sadness or anger (greater chin raise, lip tightening, lip pressing, lip raising), all  $ps < .05$ .

These analyses must be treated with some caution because for each analysis there were many possible significant results. That is, for each analysis I examined the 19 AUs, plus the six basic emotions. There was, therefore, a high probability of obtaining some Type 1 errors (i.e. a significant finding obtained through chance). Thus, consistency across numerous action units is of more interest than individual action units. With this caution in mind, there was some indication that infants might have felt (a) surprise when hearing a sad voice, (b) sadness or anger when viewing sad faces, and (c) fear when viewing angry faces.

## Discussion

This study was originally intended to shed light on matching of voices to faces. However, there was not much evidence of matching. For the gender-matching task, dogs showed some evidence of matching male faces to voices, but not female stimuli. For the emotion-matching task, neither dogs nor infants matched stimuli. Instead, looking seemed to be guided by preferences to look at certain emotion types of faces over others.

Both dogs and infants tended to look away from sad faces when paired with happy or angry faces. In contrast, when happy and angry faces were paired together, there was no preference for either dogs or infants to look at either. Overall, dogs and infants looked significantly less at sad faces relative to both happy and angry faces. Such tendencies can be seen either as a preference for looking at happy and angry faces, or as an aversion to look at sad faces. Interestingly, past studies of human infants have demonstrated similar looking preferences (refer to Table 1.1 for summary of past research). That is, just like dogs, human infants tend to look at happy rather than sad faces, angry rather than sad faces, and to display no preference when angry and sad are paired. Infants might prefer to look at happy faces because it is pleasing to do so, and might look at angry faces because of their perceived threat value. In general, angry faces tend to capture attention (Fox et al., 2000; Ruffman, Ng, & Jenkin, 2009). But when an infant views both happy and angry facial expressions together, both expressions tend to attract attention (Montague & Walker-Andrews, 2001), which probably explains the lack of a difference in looking at either emotion.

One of the possible reasons for the lack of looking at sad faces is that both dogs and human infants are seeking to reduce stressful visual information from the sad faces

(Grossmann, 2010; Nesse, 1990). Infants shifting attention away from a parent's sad still face has been considered to be a way to reducing negative feelings. This idea gains further support from infants' reactions when viewing sad expressions, wherein they demonstrated greater chin raise, lip tightening, lip pressing, right lip raising, and moved their faces away from the screen. The present study result is also consistent with previous studies, which have shown that when infants view a sad expression on their mother's face, they play less, have greater gaze aversion, less smiling, and increased grimacing (D'Entremont & Muir, 1997, 1999). Likewise, when witnessing an adult frowning or crying, infants become more agitated and distressed (D'Entremont & Muir, 1999; Kahana-Kalman & Walker-Andrews, 2001).

Although infants did not show a preference for happy or angry expressions, they displayed a fearful expression (greater 'fear brow', right lip raising, lip stretching) when viewing an angry face, probably because the angry expression is considered threatening, eliciting vigilance and high arousal to a potentially stressful event (Izard, 1993).

For the gender-matching task, dogs showed some evidence of matching male faces to voices, but not female stimuli. This finding supports previous findings that dogs were more vigilant with males but not females, with shelter dogs behaving more aggressively and being less relaxed when a male human stood in front of them compared to a female human (Lore & Eisenberg, 1986; Wells & Hepper, 1999).

There are two possible limitations to this study: first, the study used still images and, second, dogs were not familiar with the emoter. One could argue that the still images and vocal expressions did not provide sufficient information to the participants, unlike dynamic stimuli. Two studies showed that infants matched vocal and facial

emotions when using dynamic stimuli (Vaillant-Molina, Bahrick, & Flom, 2013; Walker-Andrews, 2008). Yet, most studies tested infants with still images and vocal expressions and the infants were able to match the emotions (Soken & Pick, 1992; Walker-Andrews & Lennon, 1991; Walker-Andrews, 1986). Likewise, use of a similar paradigm utilising still images was successful in dogs (Farago et al., 2010; Nagasawa et al., 2011; Taylor et al., 2011). Further, in my study, the participants had the opportunity to listen to the voice recording *twice* (before the faces were presented, and while the faces were presented), which should have assisted matching. Second, familiarity with the emoters may also relate to success in matching, because studies with infants indicate that familiarity seems to evoke stronger affect in an observer (Nagasawa et al., 2011; Walker-Andrews, Krogh-Jespersen, Mayhew, & Coffield, 2011). Nonetheless, familiarity was not a barrier to successful matching in studies with both infants and dogs (Racca et al., 2010; Soken & Pick, 1999; Walker-Andrews & Lennon, 1991). Thus, it remains something of a mystery why some previous studies have elicited emotion matching whereas the present study did not.

## Chapter 5: Empathy

### Introduction

Some studies propose that animals experience a form of empathy (e.g., emotional contagion) after observing conspecifics (kin or non-kin) in distress (Bartal et al., 2011; Edgar et al., 2011; Langford et al., 2006; Parr, 2001; Watanabe & Ono, 1986). Emotional contagion, is a rudimentary component of empathy when one individual's affective state creates a similar state in another (Preston & de Waal, 2002; Preston, 2013).

A long history of domestication makes the possibility of canine empathy toward humans plausible. Dogs are attached to human caregivers (Prato-Previde et al., 2003), are attentive to human eyes (Call et al., 2003), and can use gestures such as pointing and gazing to find food (Udell, Giglio, et al., 2008). Emotional contagion has been posited when explaining increased dog yawning after seeing or hearing a human yawn (Joly-Mascheroni et al., 2008; Madsen & Persson, 2013; Romero et al., 2013; Silva et al., 2012) (although see Harr et al., 2009; O'Hara & Reeve, 2011; Yoon & Tennie, 2010). However, claims of canine empathic responding have been mixed when considering human distress specifically. Dogs became submissive (licking, nuzzling) when a human pretended to cry (Custance & Mayer, 2012), potentially showing empathic responding. Yet even this study's authors acknowledge a less insightful explanation based on a learning history involving previous reward for empathic-like behaviour. Further, it is possible that rather than *offering* comfort, dogs *sought* comfort because they were confused and anxious following the human's expression of distress. Adding to this uncertainty over whether dogs are empathic towards distressed humans is another study

in which dogs did not seek help when observing their owner who feigned a heart attack or when trapped under a bookcase (Macpherson & Roberts, 2006).

When considering techniques to index canine empathy, it is helpful to turn to the human literature. Human empathy has been studied by examining responses to human infant crying. Humans can differentiate the urgency of crying (Boukydis & Burgess, 1982), find crying aversive (Boukydis & Burgess, 1982; Zahn-Waxler et al., 1992), and increase attention to crying (Boukydis & Burgess, 1982). Crying is thought to be an innate releaser of empathy, selected for in evolution (Murray, 1985). When men and women listen to an infant crying, their stress hormone *cortisol* increases regardless of parenting experience or age (Fleming et al., 2002; Giardino et al., 2008) and these responses are typically interpreted as empathy.

## Aim and hypotheses

Previous studies have not examined canine physiological and behavioural responding to human infants' distress, yet this measure has the potential to reveal not just canine emotional contagion, but the first clear evidence of cross-species empathy. To this end, I examined whether dogs and humans show a similar physiological response to human infant crying. I tested 75 dogs and 74 humans when listening to one of three sounds, each played at 82 dB: human infant crying, human infant babbling, or white noise. White noise and babbling were control stimuli. Cortisol was measured before and after crying, with an interest in the extent of cortisol increase. I also coded canine behavior (alertness and submissiveness) while the sound was played, and instructed humans to rate the sound's aversiveness. Dog owners were present throughout, though they were sensorily isolated and did not interact with dogs.

I had three main hypotheses. First, given dogs' attachment to humans, I hypothesized that they would respond with increased interest (alertness) to infant crying and babbling, similar to humans. Second, even at relatively low volumes, exposure to uncontrollable white noise is aversive, eliciting submissive behaviour (shaking, stimulus avoidance, increased heart rate) in horses and dogs (Beerda et al., 1997; Christensen et al., 2005), so that I anticipated dogs would be submissive when listening to white noise. Likewise, if dogs found infant crying aversive, I expected them to display submissiveness when listening to crying. Third, because cortisol plays a prominent role in facilitating empathy (Shirtcliff et al., 2009), I expected that infant crying would be more likely to elicit a cortisol response than the other sounds. I did not expect a cortisol increase in dogs or humans to white noise, because evidence from past studies shows that only volumes greater than 90dB elicit cortisol (Beerda et al., 1997, 1998; Lundberg

& Frankenhaeuser, 1978; Miki et al., 1998). Similarly, I did not anticipate an increase in cortisol to babbling because babbling facilitates interaction and affiliation rather than stress (Elowson et al., 1998; Snowdon, 1997). Finally, I examined a subset of dogs to determine whether those lacking experience with infants still responded empathically to infant crying.

### *Control stimuli testing*

My main interest was in canine responding to human infant crying. However, it is important to consider canine responding to control stimuli and to this end, I used human infant babbling and computer-generated white noise. Another possible control would be to reverse infant crying (and the other control sounds). Thus, I examined *reversed* versions of infant crying, infant babbling and white noise, presenting them to 19 university students not involved in the main study (10 females,  $M = 19.53$  years,  $SD = 1.43$ ). Participants were asked to identify the sound using two open-ended questions (What is making this sound?, and What is this (referring to their earlier answer) doing?). All participants were able to identify the reversed infant sounds correctly (i.e. reversed crying as crying, reversed babbling as babbling, and reversed white noise as radio static or machinery sounds). Because reversed crying was perceived in the same way as forwards crying, it would make a poor control for forwards crying. Thus, I used infant babbling and white noise as controls (see below).

## Method

### *Participants*

Ninety-two pet dogs (50 females,  $M = 5.08$  years,  $SD = 2.89$ ) of different breeds participated in this study (Appendix N). Of the 92 dogs, 75 lived with two or more people, 15 were currently living with children aged 12 and below, 56 were currently living in a multiple-dog household, and 20 were intact (i.e. not neutered). Dogs were recruited from advertisements placed in the university newsletter, local canine clubs and flyers distributed to dog owners from the local city council. Dog owners were given a petrol voucher as compensation for participating in the study. Owners were instructed not to feed or exercise their dog for at least two hours before coming to the lab.

Seventy-four university students (37 females,  $M = 21.41$  years,  $SD = 2.02$ ) were also recruited for this study (Appendix O). They were either compensated in cash or received partial course credit. Participants were in good health, not on steroid medications, had no mouth bleeding over the last week, and were instructed not to consume any alcohol or caffeine for the day, and to abstain from eating or smoking for at least one hour before testing.

### *Experimental design*

I used a mixed-subjects design with Condition (infant crying, infant babbling, white noise) as a between-subjects variable, and Cortisol level (baseline, post-stimulus) as a within-subjects variable. Each participant listened to one sound clip: infant crying, infant babbling, or computer-generated white noise and participants were randomly allocated to a condition.

*Materials*

*Sounds.* My main interest was in canine response to crying, a stimulus that has been shown to elicit empathy in humans (Fleming et al., 2002; Giardino et al., 2008; Murray, 1985). I chose infant babbling as a novel infant sound, because most of dogs tested were currently not living with young children, babbling and crying are both infant-generated sounds, and babbling occurs during the same time frame as infant crying. Because humans perceive crying as aversive (Murray, 1985), I chose white noise as a control stimulus given that both humans and animals also find it aversive (Beerda et al., 1997; Christensen et al., 2005; Lundberg & Frankenhaeuser, 1978; Miki et al., 1998).

There were 20 auditory stimuli in total – five different human infants crying, five different human infants babbling, and 10 clips of computer-generated white noise. The crying and babbling sounds were recordings from male and female infants of Caucasian or Asian ethnicities between the ages of two and six months obtained from a public sharing website. The white noise was recorded with an amplifier and microphone, and then manipulated to have similar frequency modulations (pitch rising and falling) and mean intensity to the five crying and five babbling stimuli (making 10 white noise clips). All recordings were edited using Audacity audio software (version 1.3.13). I removed high frequencies (above 1,000 Hz) in infant cries ( $M = 408$  Hz) to enhance similarity with babbling ( $M = 389$  Hz). I did not manipulate the mean fundamental frequency further so as to avoid a loss of context and valence in the sounds.

Each auditory stimulus was originally 20 seconds and was looped to create a clip 13 minutes long. The sounds were played from a computer through two external

speakers. The participant was situated three meters from the speakers and separated by an opaque barrier (120cm high x 10cm wide). Sounds were randomly allocated to each participant, played for 13 minutes and were followed by five minutes of silence.

Previous research indicates that salivary cortisol levels accelerate 12 minutes after the onset of an auditory stressor and peak at 18 minutes (Beerda et al., 1997).

*Acoustical measurements.* The mean loudness of all clips was approximately 82 dB (crying  $M = 82.6$  dB, babbling  $M = 82.1$  dB, white noise  $M = 81.6$  dB) but the loudness oscillated continuously as described above. All auditory stimuli were further analysed using Praat software (version 5.3.45) (Boersma & Weenink, 2012), and adhered to the following parameters: (a) duration per utterance, (b) fundamental frequency (F0: cross-correlation method, 125 ms time window, 20-5,000 Hz frequency range), and (c) formant frequencies (F1-5: burg method, 25 ms time window, maximum frequency 5,500 Hz, maximum 5 formants). The infant cries were considered to be normal with a mean F0 under 500Hz (Boukydis & Burgess, 1982; Green, Jones, & Gustafson, 1987; Rautava et al., 2007). Further, as expected, there were non-linear characteristics found in both infant cries and babbling such as hyperphonation, vibrato/glottal roll, and subharmonics (Rautava et al., 2007). When comparing cries to babbles, there were no significant differences in duration per utterance, minimum pitch, fundamental frequency, or the first three formants (all  $ps \geq .20$ ).

*Salivary cortisol collection and measurement.* Plasma and salivary cortisol levels are highly correlated in dogs (Kobelt, Hemsworth, Barnett, & Butler, 2003; Vincent & Michell, 1992) so that I measured cortisol from saliva. To elicit a salivary response, dogs smelled a bag of wet cat food or a box full of sausages for 10 seconds or until the dog had shown visual signs of salivating (Wenger-Riggenbach et al., 2010).

No food was given prior to saliva collection. The dog's lips and cheeks were lifted, and swabbed with cotton. Swabbing never exceeded four minutes, as procedures over four minutes influence the cortisol concentration (Kobelt et al., 2003). Cortisol samples were taken twice: once at baseline (pre-stimulus) at 40 minutes after entering the lab, and once, 18 minutes after the onset of the auditory stimulus.

For humans, saliva was collected using a passive drool technique. This method is considered to be the least invasive and results in the cleanest sample possible (Granger et al., 2007). Participants gently mimicked a chewing motion, letting saliva pool in their mouths, before spitting it through a straw and into a labelled vial.

Collected saliva was stored in a lab refrigerator at 4°C for no more than six hours before transferring it to a freezer at -70°C on the same day as collection. All vials were sent to the same external laboratory and cortisol levels were tested with enzyme-linked immunosorbent assay (ELISA). A minimum amount of 200 µL was collected per sample. Samples between 50 µL to 200 µL were diluted before analysis. The saliva-coated cotton was centrifuged for 15 minutes at 4000 revolutions per minute (RPM) before testing with the enzyme (Lewis, Manley, Whitlow, & Elder, 1992). The assay sensitivity range was 1.0 nmol/L; the within-assay imprecision (CV) was 13.6% at 7.4 nmol/L (n = 200), and the between-assay CV was 7.8% at 22 nmol/L (n = 200).

Lab analysis showed that canine cortisol levels ranged from 0.7 to 44.0 nmol/L for all 92 dogs. To eliminate outliers, I examined previous studies using a similar methodology to the present study: domestic dogs tested in a laboratory (Beerda et al., 1997, 1998; Bergeron et al., 2002; Dreschel & Granger, 2009; Pastore et al., 2011). Dogs in these studies had a mean cortisol level of 8.20 nmol/L (*SD* = 3.46). On this

basis, outliers in the present study included any dog whose baseline cortisol level measured more than two standard deviations over this mean value (15.12 nmol/L). Seventeen dogs were excluded on this basis – two in the babbling condition, nine in the crying condition, and six in the white noise condition – leaving 75 dogs remaining (38 females,  $M = 5.11$  years,  $SD = 2.98$ ).

### *Procedure*

Both human participants and dog owners were informed that they would be listening to a sound and cortisol levels in saliva would be measured, but not which sound stimulus they would be listening to themselves.

*Dogs.* The exact nature of diurnal rhythms has not been established in dogs (Kemppainen & Sartin, 1984; Kobelt et al., 2003) so that they were tested between 0900 and 1900 hours at the owner's convenience. Upon arriving at the lab, the dog was given 40 minutes to explore the room (3.0m x 6.5m), including the experimental area (3.0m x 3.2m) (see Appendix P), while the owner filled in a questionnaire about the dog's behaviour. In the first 40 minutes, both owner and experimenter actively petted and attended to the dog to lower potential stress (Hennessy et al., 1998). No food was provided to the dog, and water was provided *ad libitum*.

After taking the first saliva sample, the dog's collar was attached to a wall-fixed lead 3.0m long in the experimental area. The owner sat on a chair in a corner of the experimental area wearing headphones and watching a movie played on a laptop, and was explicitly instructed to ignore his/her dog. The experimenter played the auditory stimulus on a computer within the room but outside the experimental area, and after 18

minutes, took the second saliva sample. The dog received a treat (sausage pieces) at the end of the experiment.

*Humans.* All human participants were tested between 1600 and 1700 hours to control for circadian rhythm. When participants first arrived at the lab, they were asked to rinse their mouth with tap water to remove food particles, and then given a drink of water. The participant then rested for 10 minutes before providing the baseline saliva sample. After the first saliva sample was taken, the participant sat in the middle of the experimental area and the experimenter played one auditory stimulus, with the second saliva sample taken after the 18th minute. The participant ended the experiment by rating the sound on an 11-point Likert scale, ranging from 0 (extremely pleasant) to 10 (extremely aversive), and responding to a daily activity questionnaire.

#### *Measured variables*

Following coding of canine behaviour and emotional states in a previous study (Custance & Mayer, 2012), I coded canine submissiveness and alertness separately as either 0 (not present) or 1 (present) at five-second intervals after stimulus onset. Submissiveness was identified when the dog looked mildly worried or concerned, the dog's body and head were lowered, the ears were held flat and back, the tail was lowered and sometimes slightly between their legs or wagging rapidly side-to-side, the tongue protruded slightly, or the dog raised one leg in a hesitant or placating manner. Alertness was characterized by ears pricked and forward, body slightly raised, stiffened legs, staring, and tail held up horizontally or higher. There was a consistent trend for the data to reach plateau after three minutes so that I subsequently analysed just the first three minutes.

I also coded owner behaviour while dogs listened to the sound in terms of whether the owner was (a) looking toward the sound, (b) looking towards their dog, and (c) looking uncomfortable (e.g. shifting in seat uneasily, pressing headphones to ears to block out sounds). One coder, blind to the hypotheses and conditions, coded all of the data and a second coder coded 33% of the data.

Other measured variables included coding canine responses towards the sound (looking at the source, approaching the sound), toward their owner (looking at the owner, approaching the owner, touching the owner), and passive activity (not directed at either the owner or the sound) at each five-second interval. In addition, I measured time spent at three zones in the experimental area (the area closest to sound, the area closest to the owner, and an in-between area). As above, these variables were also analysed for the first three minutes because the data reached plateau at the fourth minute.

Furthermore, a primary coder blind to the condition and hypothesis coded all of the data, and I coded 33% of the dogs for inter-rater reliability. The inter-rater correlations between the two coders were mostly good with the exception of “approaching the owner” (see Table 5.1). Ratings for approaching the owner were therefore not examined further. The primary coder’s ratings were used in the analyses.

Table 5.1

*Inter-rater correlations for variables in Study 4*

Phase	Item	Inter-rater correlation, $r_s$
Canine behaviour	Submissiveness	.70
	Alertness	.74
	Looked at sound	.96
	Approached sound	.96
	Looked at owner	.88
	Approached owner	.52
	Touched owner	.94
	Passive (not directed at sound or owner)	.93
Owner's discomfort	Looked at sound	.93
	Looked at dog	.91
	Perceived discomfort	1.0
Zone	Closest to sound	.98
	Closest to owner	.96
	In-between area (not close to sound or owner)	.94

## Results

The raw canine behavioural, sound ratings from humans, and cortisol data for both canine and humans were examined for normality. For the behavioural data, review of Shapiro-Wilk's test for normality (all  $p$ s < .01) and the histograms suggested that the data were non-normal, and therefore non-parametric analyses were used. In contrast, parametric analyses were used for the sound rating and cortisol data because Shapiro-Wilk's test for normality (all  $p$ s > .09) and visual inspection of the histograms showed that the data were normally distributed.

### *Canine alertness and submissiveness*

There was a significant difference in alertness across the three conditions,  $p = .04$  (Kruskal-Wallis test), with dogs more alert when listening to both crying,  $U = 177.00$ ,  $p = .02$ ,  $r = .33$ , and babbling,  $U = 217.50$ ,  $p = .04$ ,  $r = .28$  compared to white noise (Mann-Whitney U test), but with no difference between crying and babbling,  $U = 309.50$ ,  $p = .78$ ,  $r = .04$ . Second, there was a difference in submissiveness in the three conditions,  $p = .01$  (Kruskal-Wallis test), with dogs more submissive when listening to crying,  $U = 197.50$ ,  $p = .01$ ,  $r = .37$ , and white noise,  $U = 202.00$ ,  $p = .01$ ,  $r = .35$  compared to babbling, but no difference between crying and white noise  $U = 280.00$ ,  $p = .87$ ,  $r = .02$ . Thus, the canine behavioural response to crying was a unique combination of submissiveness and alertness, with that combination not repeated in either control condition (see *Figure 5.1 to Figure 5.4*). Likewise, when listening to crying, the 63 dogs in child-free households were more alert compared to white noise,  $p = .04$ , and more submissive compared to babbling,  $p = .02$ .

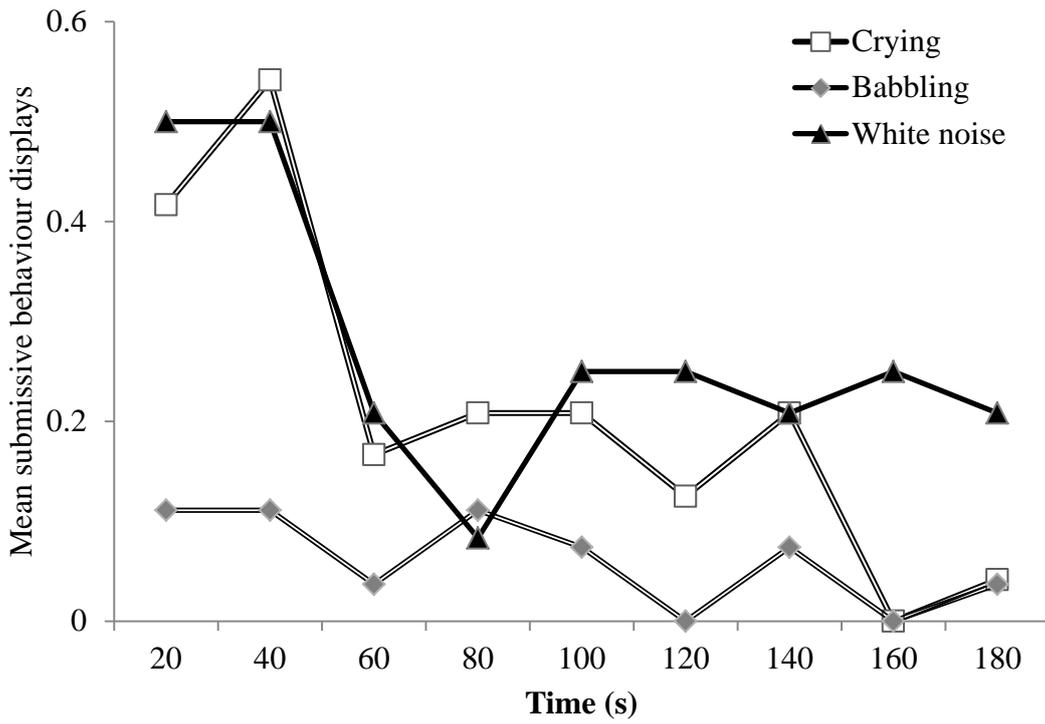


Figure 5.1. Mean submissive canine behaviour across time (3 minutes).

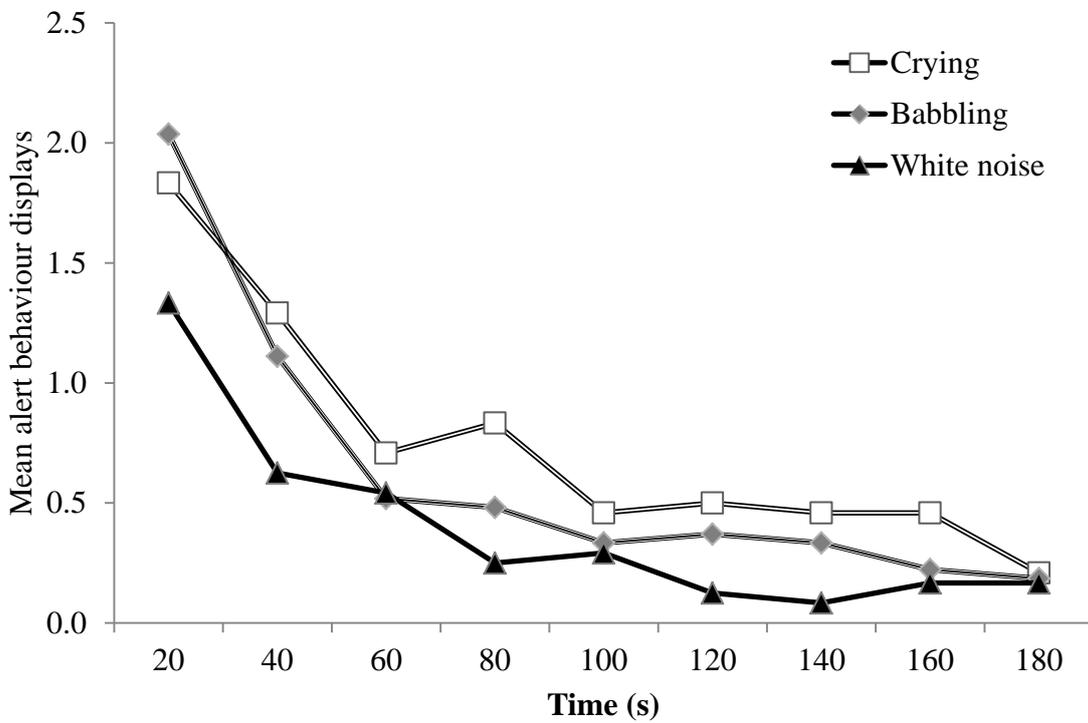
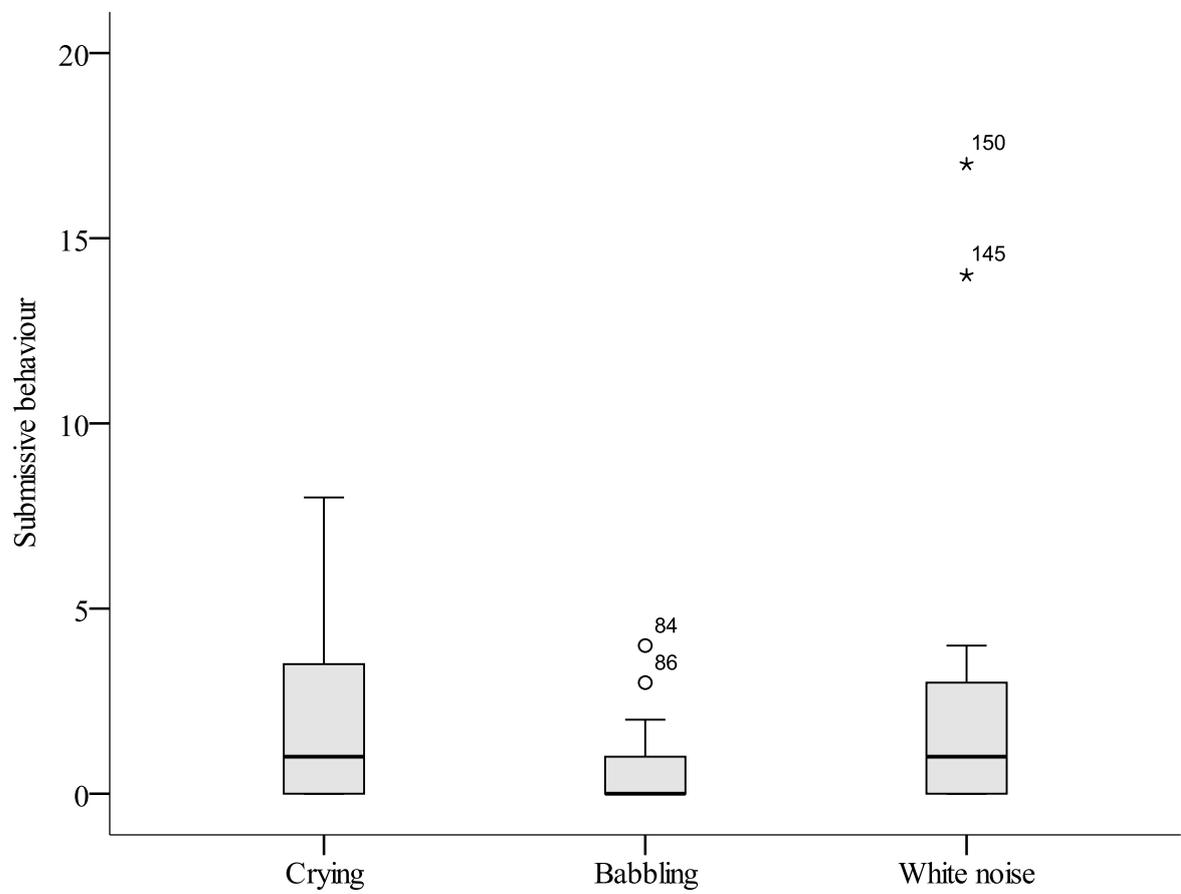
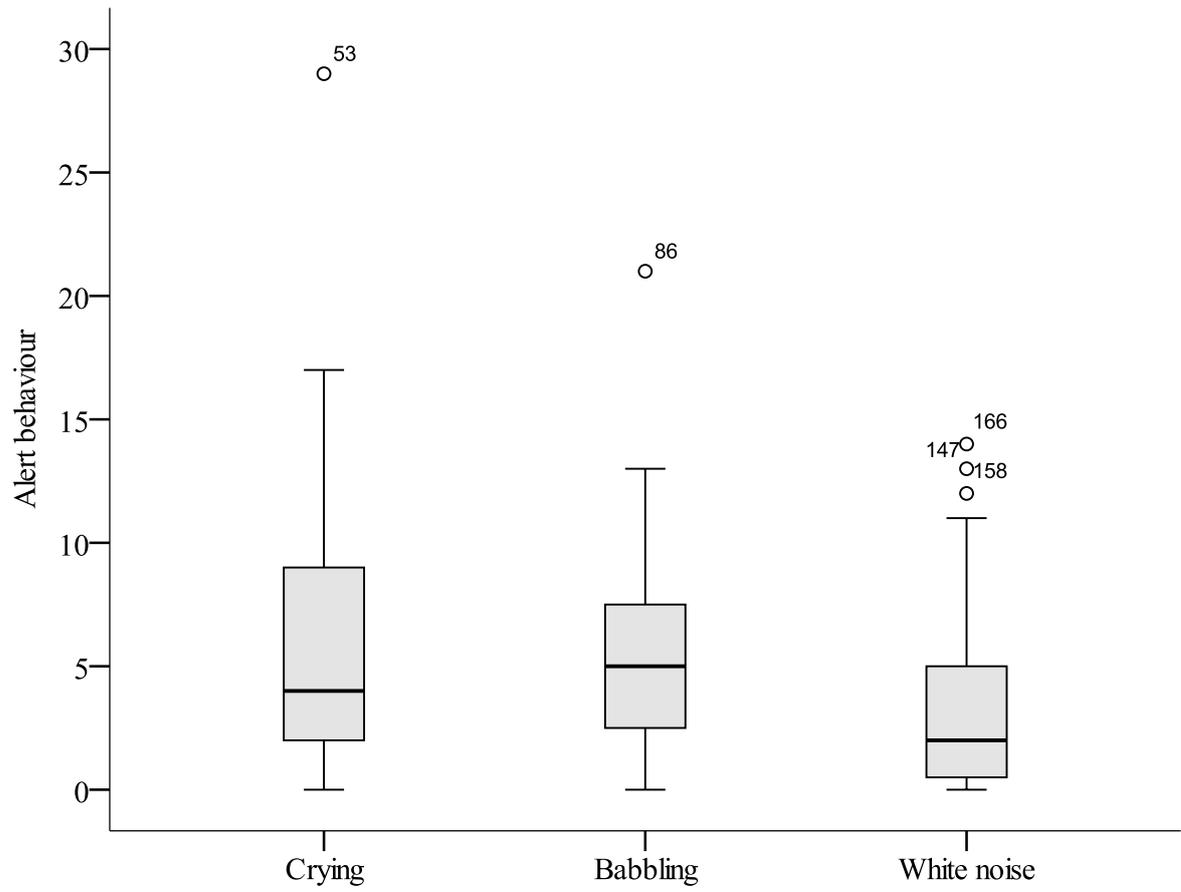


Figure 5.2. Mean alert canine behaviour across time (3 minutes).



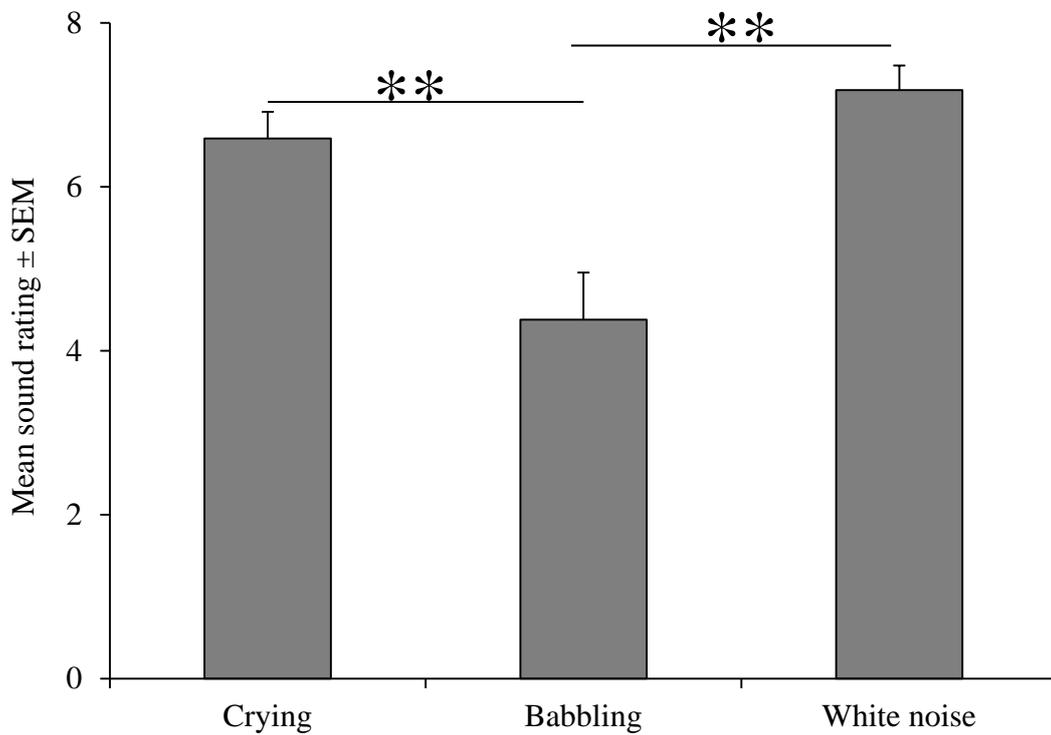
*Figure 5.3.* Box and whisker plot displaying canine median submissiveness when listening to crying, babbling, or white noise.



*Figure 5.4.* Box and whisker plot displaying canine median alertness when listening to crying, babbling, or white noise.

*Human aversiveness ratings*

Human ratings of sound aversiveness were examined using a one-way ANOVA with three levels (crying, white noise, babbling) (*Figure 5.5*). There was a significant difference in ratings,  $F(2, 71) = 13.49, p < .01$ , with crying,  $t = 3.47, p < .01$ , and white noise,  $t = 4.73, p < .01$ , more aversive than babbling, but with no difference between crying and white noise,  $t = 1.32, p = .92$ .



*Figure 5.5.* Mean sound ratings by humans ( $n = 74$ ) for crying, babbling or white noise (0 = extremely pleasant, 10 = extremely aversive). \*\*  $p < .01$ .

*Cortisol*

For each species, I used a 2 (Time: baseline, post-stimulus) x 3 (Condition: crying, babbling, white noise) mixed analysis of variance (ANOVA), with cortisol as the dependent measure, Time as a within-subjects factor, and Condition as a between-subjects factor (*Figure 5.6*). The interaction was of primary interest, and would indicate a differential stress response in the three conditions. For dogs, there was a main effect of Condition,  $F(2, 72) = 7.03, p = .02$ , qualified by the interaction,  $F(2, 72) = 4.95, p = .01$ . For humans, only the interaction was significant,  $F(2, 71) = 3.32, p = .04$ . Paired-samples *t*-tests indicated that both dogs,  $t = 2.25, p = .03$ , and humans,  $t = 2.48, p = .02$ , experienced a rise in cortisol from baseline (pre-stimulus) to post-stimulus after listening to crying. Cortisol did not change from baseline after listening to babbling or white noise in either species, all  $ps > .59$ .

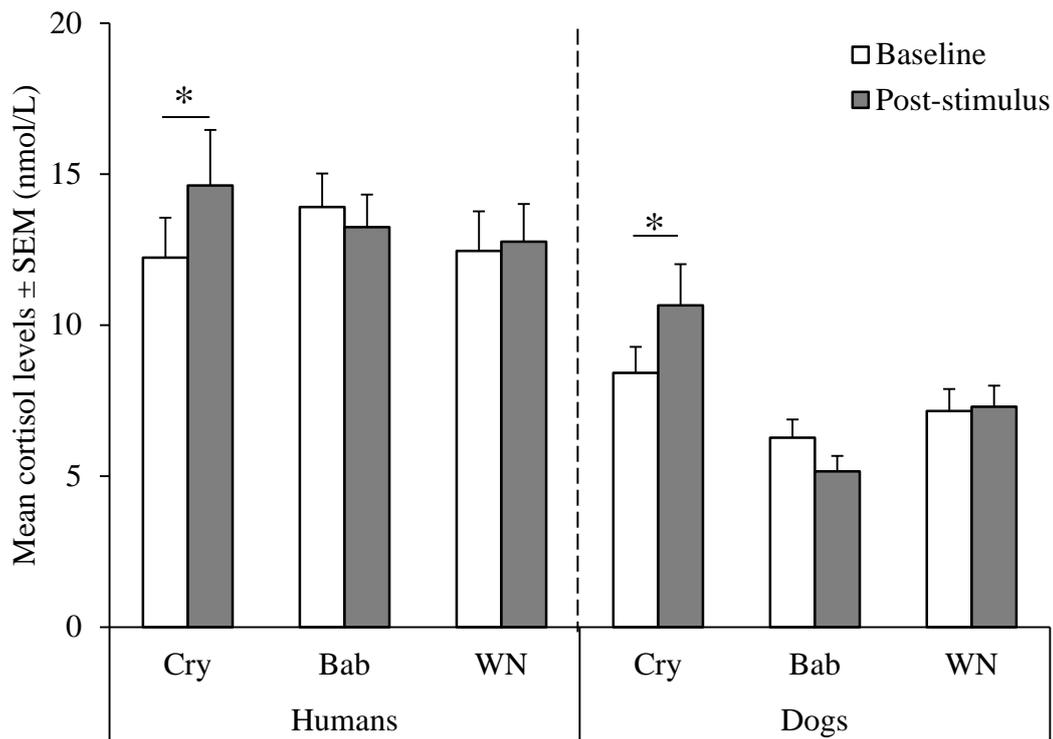


Figure 5.6. Cortisol response in humans and dogs. Mean cortisol levels of humans ( $n = 74$ ) and dogs ( $n = 75$ ) before and after listening to crying, babbling or white noise. \*  $p < .05$ . Cry = crying, Bab = babbling, WN = white noise.

I then repeated the ANOVA but excluded the 12 dogs that lived with children (3 crying, 5 babbling, 4 white noise). There was still a significant interaction,  $F(2, 60) = 6.38, p < .01$ , and dogs' cortisol still increased from baseline when listening to crying,  $t = 2.31, p = .03$ .

*Baseline cortisol levels*

To ensure initial stress levels were similar, I then compared pre-stimulus cortisol with a one-way analysis of variance with three levels corresponding to the three conditions (crying, white noise, babbling). For dogs, there was no difference in pre-stimulus cortisol levels in the three conditions,  $F(2, 72) = 2.20, p = .12$ , and the same was true for humans,  $F(2, 71) = 0.43, p = .65$ . There was a possibility that the canine cortisol response may have been a result of diurnal rhythms, although past research has not shown conclusive evidence on this matter (Kemppainen & Sartin, 1984; Kobelt et al., 2003). I coded canine diurnal rhythms (e.g. coding 9 am as 0, 10:30 am as 1.5, 2 pm as 5, etc). The time of day at which dogs were tested was unrelated to pre-stimulus cortisol levels, with neither a linear relation,  $F(1, 73) = 0.11, p = .75$ , nor a quadratic relation,  $F(2, 72) = 0.30, p = .75$ .

*Demographic variables influencing cortisol levels*

To examine whether demographic variables made a difference to cortisol levels, I repeated the initial analysis – a 2 (Time: pre-stimulus, post-stimulus) x 3 (Condition: crying, babbling, white noise) ANOVA – but included a third factor: either canine sex, hormonal status (intact, neutered), age group (1-1.99, 2-7.99, 8<sup>+</sup> years), number of dogs in the household (none versus 1 or more), or whether dogs had been re-homed. Level of cortisol was the dependent measure. A significant three-way interaction (e.g. Time x Condition x Sex) would indicate the rise in cortisol when listening to crying was modified by the third factor. However, none of the interactions approached significance (all  $F$ s < 0.60, all  $p$ s > .55), indicating the cortisol increase after listening to crying was unaffected by demographic variables. There were an insufficient number of different breeds in each condition to compare breeds.

*Discordancy*

I carried out additional analyses to determine whether the aversiveness of the crying stimuli stemmed from increased discordancy. Crying contains certain nonlinear acoustic features (hyperphonation, subharmonics, deterministic chaos) that contribute to discordancy. White noise does not contain pitch and therefore cannot be examined for discordancy. However, discordancy can be examined by comparing the presence of discordant features in crying versus babbling. Each crying and babbling clip was comprised of a series of individual cries or babbles. I broke each sound clip into these individual cries or babbles, then examined the percentage of cries/babbles that contained nonlinear acoustic features. Hyperphonation, subharmonics, and/or deterministic chaos were present in 50% of cries and 59% of babbles (i.e. were slightly more common in babbling than crying).

A second way to characterize discordancy involves the melody, that is, the changes in pitch (frequency) over time. I extracted the pitch tiers for each crying and babbling clip, and then synthesized these pitches using a sine wave (with the resulting stimulus sounding like a computer-generated hum changing in pitch over time). This way, the melody (harmonic series of frequencies) was preserved but each stimulus sounded like a computer-generated hum rather than crying or babbling. I also created a second batch of stimuli that restricted the frequency range so that instead of frequencies varying between 303 and 446Hz, each clip varied in a very narrow range between 380 and 400Hz. This narrow range does not allow for audible discordancies (e.g. hyperphonation), yet each clip still sounds like either crying or babbling. There were 30 clips in total: (a) the original 10 clips (5 crying, 5 babbling), (b) the 10 clips converted to sine waves (with full frequency range), and (c) the 10 clips with restricted frequency

range but maintaining the sound of crying or babbling. These clips were presented to 19 university students (not involved in the main study) (10 females,  $M = 19.53$  years,  $SD = 1.43$ ). Participants were asked to rate, “How much do you like listening to this sound?” on a scale of 0 (extremely pleasant) to 10 (extremely aversive). It was anticipated that when converted to sine waves, crying would not be rated as more aversive than babbling, but when the sounds of crying and babbling were preserved, crying would be rated as more aversive than babbling.

Results were as expected (*Figure 5.7*). The data were analyzed with a 3 (Type: sine wave, reduced pitch range, original) x 2 (Mood: crying, babbling) ANOVA, with rating as the dependent variable. The effect for Type was not significant,  $F(1, 18) = 1.08, p = .18$ , but the effect for Mood was significant,  $F(1, 18) = 126.33, p < .001$  (with crying rated as more aversive), as was the interaction,  $F(2, 36) = 80.32, p < .001$ . The interaction was explored with three  $t$ -tests. Crying was rated as significantly more aversive than babbling in the original sounds,  $t(18) = 10.35, p < .001$ , and when the pitch range was reduced but the sounds of crying and babbling were preserved,  $t(18) = 10.96, p < .001$ , but there was no difference in aversiveness ratings for the sine waves (when the melody was retained but the sound of crying or babbling was eliminated),  $t(18) = 0.74, p = .47$ . Thus, crying was perceived as substantially more aversive than babbling even when the pitch range was reduced considerably and across-time discordancies were eliminated. In contrast, there was no difference in the aversiveness of crying and babbling when the melody was retained but the sounds of crying or babbling were eliminated. Overall, the results indicate that crying is perceived as aversive, not because of discordancies, but because of the mood conveyed.

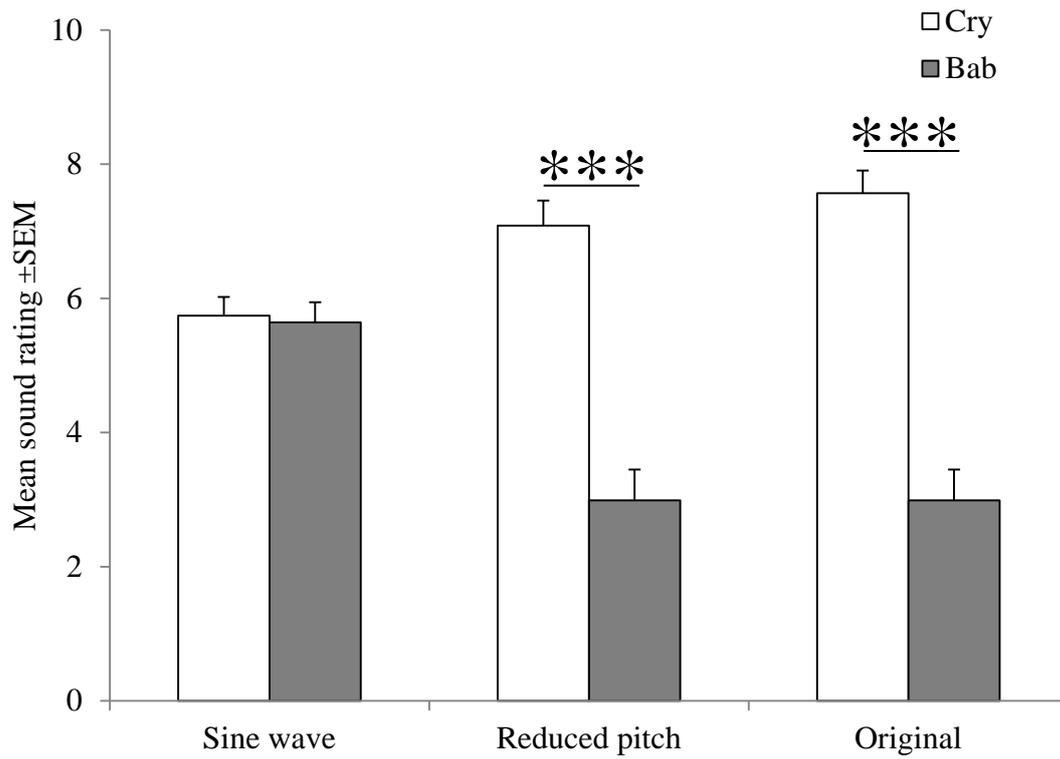


Figure 5.7. Mean sound ratings by humans ( $n = 19$ ) for sine wave, reduced pitch, and original clips for crying and babbling respectively (0 = extremely pleasant, 10 = extremely aversive). \*\*\*  $p < .001$

*Dog owners*

Dog owners were present throughout the experiment and were explicitly informed not to interact with their dogs. In addition, they were sensorily isolated - watching a dog documentary on a laptop while wearing headphones. Nonetheless, I examined the remote possibility that the owners may have primed their dogs towards the stimulus despite the sensory isolation. However, there was no difference in owners' attention to the documentary they watched, attention to the dog, or observer-rated levels of owner discomfort across the three conditions (Kruskal-Wallis test, all  $ps > .51$ ), indicating owners did not cue canine responses.

## Discussion

I found that only crying elicited an increase in cortisol from pre- to post-stimulus in dogs and humans, as well as a unique combination of behaviour in dogs involving submissiveness and alertness (Table 5.2). Indeed, the pattern of responding in dogs and humans was very similar; both found crying and white noise more aversive than babbling, and both showed an increase in cortisol only when listening to crying.

Table 5.2

*Summary of findings in Study 4*

	Cortisol (Change from pre- to post-stimulus)		Behaviour	
	Humans	Dogs	Alert	Submissive
			Dogs	Dogs
Infant crying	Increase	Increase	High	High
Infant babbling	No change	No change	High	Low
White noise	No change	No change	Low	High

*Note.* Cortisol was measured prior to the stimulus and 18 minutes after onset. Canine alertness and submissiveness towards the stimulus was coded by raters.

In humans, an increase in cortisol and attention is interpreted as a demonstration of emotional contagion, a component of empathy (Boukydis & Burgess, 1982; Fleming et al., 2002; Giardino et al., 2008). Is this also true for dogs? An alternative interpretation is that dogs have been previously rewarded for responding similarly to these stimuli. Several findings argue against this idea. First, if reward accounted for dogs' unique combination of alertness, submissiveness, and increased cortisol after

listening to crying, then one would expect them to show an increase in cortisol to either babbling (accompanying the similar level of alertness) or white noise (accompanying the similar level of submissiveness). This did not happen. Second, one would expect that dogs living without children would have limited opportunities for previous reward and, therefore, would not show a cortisol or behavioural response to crying, but they did. Third, it seems unlikely that dogs would have had much experience listening to white noise, or that humans would reward dogs for submissive behaviour to white noise. Submissiveness seems far more likely to stem from animals' response to uncontrollable, aversive stimuli such as white noise (Beerda et al., 1997, 1998; Christensen et al., 2005). If reward does not account for canine responses to white noise, it also seems less likely to account for canine responses in the other conditions.

Instead, the unique pattern of physiological and behavioural responding to crying is most consistent with (a) emotional contagion in dogs, providing the first evidence that dogs, like humans, experience a physiological response to human infant crying, and (b) the first clear evidence of cross-species empathy (i.e. canine responding to human distress). These results suggest that infant crying elicited a rudimentary form of empathy, *emotional contagion*, in dogs and humans (although they cannot speak to whether dogs have a theory of mind or cognitive empathy). Despite carefully controlling the acoustic characteristics of the three sounds, and although dogs and humans also found white noise aversive, only crying elicited cortisol. Crying is particularly likely to elicit cortisol because of its prominent role in empathy. Crying conveys distress, triggering activation of the social brain, and facilitating empathy (Murray, 1985; Shirtcliff et al., 2009), consistent with the notion that empathy has its roots in ancient mammalian neural systems (Preston, 2013).

## **Chapter 6: General Discussion**

### **Introduction**

The main objective of this study was to investigate whether domestic dogs understand the emotions expressed by an unknown human. Specifically, I examined four emotions (anger, sadness, fear, happiness) and three types of expressions (dynamic, unimodal, bimodal) in four studies. I also examined canine behavioural and physiological responses to discrete human emotional expressions. In addition, I compared whether canine responses were similar to those of humans and, therefore, included both young adults and infants in two studies (Studies 3 and 4). The studies are listed below, each with a brief description of the study (see Table 6.1).

Table 6.1

*Summary of studies and brief description of each study*

Study	Name of study	Brief description
1	Command and Obedience	An examination of canine compliance to obey a command when given with different emotional valence.
2	Social Referencing	An examination of canine social referencing of human expression of fear and happiness toward an object, and one additional control expression.
3	Preferential Looking	An examination of canine and human infants' preferential looking to angry, happy and sad human faces when listening to a voice matching in emotional expression. Human infants' facial expressions were also analysed to examine whether their facial expressions differed as a result of the affective displays they viewed. I also included an additional control examining canine ability to match emotionally neutral expressions of male and female human faces to voices.
4	Empathy (Emotional Contagion)	An examination of whether dogs and young adult humans show a similar physiological response (increase in salivary cortisol levels) to human infant crying, and of canine behaviour while the sound was played.

## **General findings**

Across the four studies, I found inconsistent results for whether domestic dogs have some form of understanding of human emotional expressions. These results are described below.

### *Study 1: Command and obedience*

This study examined canine compliance to obey a command when the auditory, bodily or facial expression was manipulated. When the experimenter expressed happiness in the body, face or voice, dogs were less interested in the experimenter and more interested in the food treats. In contrast, when the experimenter's facial expression was angry, they looked longer at her face, and approached her when her bodily expression displayed anger. Differential responding to dynamic expressions of happiness and anger might stem from greater familiarity with happiness (leading dogs to ignore the experimenter when happy) due to more frequent displays of happiness compared to anger in their own surroundings.

Importantly, familiarity with the two emotions does not imply that dogs understand them in a meaningful way (i.e., that they understood and responded to the emotion underlying the expression). For example, canine response to anger could simply be perceived as reflecting interest or confusion, because dogs approached or looked at the experimenter longer when she was angry. Also, they showed no difference in their behaviour when left alone with the treat irrespective of whether the command to leave the food was accompanied by a happy or angry expression emanating from the body, face or voice. The behavioural differences in canine responding during emoting (e.g. approaching the experimenter versus looking at the food) could therefore reflect a non-insightful response to the different perceptual qualities of the angry and happy

commands. For instance, dogs might have been attracted by the experimenter's higher animation, or may have become more physically aroused when the experimenter expressed anger. Unlike anger, happy expressions were considerably less animated (e.g. the experimenter was relaxed with arms hanging loosely, a smiling face, and spoke with softer, slower, speech).

*Study 2: Social referencing*

This study investigated canine social referencing of a human's expression of fear and happiness toward an object, and one additional control "confused" expression (the experimenter behaved like a chicken). The purpose was to examine whether the differential reaction of dogs to happy and fearful expressions in previous research (Merola et al., 2011, 2012) stemmed from a genuine understanding of the emotional information expressed by fear versus happiness, or from confusion regarding the fearful expression.

When the experimenter expressed happiness, dogs were observed as being less interested in the experimenter or the toy robot compared to the fearful or control condition. However, there was little evidence that dogs understood the fearful expression meaningfully. This is because they had similar high levels of interest to both the experimenter's expression and the toy, in the fearful and control conditions compared to when the experimenter expressed happiness. The control expression was unfamiliar and could generate confusion, yet it did not communicate anything meaningful about the toy (i.e. the experimenter did not look at the toy or the dog at all during emoting). The control expression tended to yield the same response in dogs (interest in the toy and the experimenter) as the fearful expression, consistent with the idea that dogs respond differently to fear (compared to happiness) because it is

unfamiliar and they are confused. That is, the greater attention to the experimenter and the toy in the fear and control conditions can be perceived as an attempt to gain more information about the situation.

In sum, the findings of the social referencing study are inconclusive whether dogs really understand the emotion conveyed in happy versus fearful cues. Dogs might simply be confused by fearful expressions, becoming anxious, and then avoiding exploration of the environment.

*Study 3: Preferential looking*

This study investigated canine looking duration at happy, angry and sad human faces when listening to a happy, angry or sad human voice. The same stimuli were also given to 7-month-old human infants and I analysed their facial expression when viewing an affective display using emotion recognition software. In addition, there was an additional control condition examining canine ability to gender-match emotionally neutral expressions of male and female human faces to male or female voices.

The results of this study showed that both dogs and 7-month-old human infants demonstrated an identical pattern of looking less at sad faces (irrespective of the matching voice), compared to happy and angry faces. This response is consistent with either a preference for happy and angry faces or an aversion to sad faces. When happy and angry facial expressions were paired, there was no difference in canine or infant looking at one expression over the other. This may have been the case because dogs and infants enjoy looking at happy faces, or look at angry faces because of their perceived threat value, which captures their attention.

One of the possible reasons for sadness aversion is that both dogs and human infants might try to reduce stressful visual information from the sad faces (Grossmann, 2010; Nesse, 1990). Indeed, when I examined human infants' facial expressions, they displayed a sad expression when viewing a sad face (greater chin raise, lip tightening, lip pressing, right lip raising, and moved their faces away from the screen). Thus, the present study is consistent with previous findings, which found that infants played less, had greater gaze aversion, less smiling, increased grimacing, became more agitated and distressed after viewing a sad expression on their mother's face or witnessing an adult frowning or crying (D'Entremont & Muir, 1997, 1999; Kahana-Kalman & Walker-Andrews, 2001). Nevertheless, the results of Study 3, on their own, do not demonstrate that infants find facial expressions of sadness aversive, although in combination with Study 4 (increased cortisol and stress when listening to sad expressions), might be more convincingly interpreted along these lines.

For the gender-matching task, dogs showed some evidence of matching male faces to voices, but not female stimuli. This finding supports previous findings that dogs were more vigilant with males than females, with shelter dogs behaving more aggressively and being less relaxed when a male human stood in front of them compared to a female human (Lore & Eisenberg, 1986; Wells & Hepper, 1999). The findings also demonstrate some (inconsistent) ability on the part of dogs to match facial and auditory stimuli. Dogs presumably were more consistent with emotional expressions because the emotional expressions presented salient visual information that tended to capture attention to a greater extent than the neutral expressions used in the gender-matching task.

*Study 4: Empathy*

This study investigated whether dogs and humans show a similar physiological response (increase in salivary cortisol) to human infant crying, as well as canine behaviour while the sound was played. Both dogs and young adult humans had increased cortisol levels after listening to human infant crying but not to human infant babbling or white noise. In addition, dogs showed a combination of alert and submissive behaviour after listening to a human infant crying compared to babbling and white noise. The increased cortisol levels and increased attention to crying are similar to past results with humans. Humans find crying aversive and typically increase attention to crying (Boukydis & Burgess, 1982; Zahn-Waxler et al., 1992), and when men and women listen to an infant crying, their stress hormone cortisol increases regardless of parenting experience or age (Fleming et al., 2002; Giardino et al., 2008). Human responses are typically interpreted as empathy. Likewise, empathy was proposed by researchers who found that 3-month-olds infants showed a mixture of approach (alert behaviour) and withdrawal (submissiveness, reduced looking time) when viewing a sad face (Field, Pickens, Fox, Gonzalez, & Nawrocki, 1998).

An alternative interpretation to these findings is that dogs have been previously rewarded for responding similarly (i.e. increased attention to sad human) to these stimuli. Several findings argue against this idea. First, if reward accounted for dogs' unique combination of alertness, submissiveness, and increased cortisol after listening to crying, then one would expect them to show an increase in cortisol to either babbling (accompanying the similar level of alertness) or white noise (accompanying the similar level of submissiveness), yet this did not happen. Second, one would expect that dogs living without children would have limited opportunities for previous reward and

experience, and therefore, would not show a cortisol or behavioural response to crying, but they did. Third, it seems unlikely that dogs would have had much experience listening to white noise, or that humans would reward dogs for submissive behaviour to white noise. Submissiveness seems far more likely to stem from animals' response to uncontrollable, aversive stimuli such as white noise (Beerda et al., 1997, 1998; Christensen et al., 2005). If reward does not account for canine responses to white noise, it also seems less likely to account for canine responses in the other conditions.

In this study, I carefully controlled the acoustic characteristics of the three sounds. I also included control stimuli in which the sound of crying or babbling was retained but the discordancies were reduced, or in which the melody (and discordancies) of crying or babbling were retained but the sound of crying or babbling was eliminated. The upshot of all such comparisons was that only crying was aversive, and that discordancies did not account for this result. Furthermore, I also obtained subjective evaluations from human participants on the forward and reversed sound stimuli. The participants rated both white noise and crying as being more aversive compared to babbling, although there was no difference between crying and white noise for both reversed and forward sounds. Therefore, if dogs were responding to aversiveness in the sound stimuli, there should be an increase in cortisol levels to white noise, but that did not happen.

Cortisol is a general stress hormone but also plays a prominent role in the experience of empathy (Preston, 2013; Shirtcliff et al., 2009), which likely explains why dogs and humans found white noise aversive but did not show an increase in cortisol. Thus, consistent with an aversion to sadness (Study 3), canine behaviour across the preferential looking and empathy studies suggests the presence of *emotional contagion*,

although the results cannot speak to whether dogs have a theory of mind or cognitive empathy.

### **Summary**

The main objective of my study was to investigate whether domestic dogs understand the emotions (anger, sadness, fear, happiness) expressed by an unknown human. In sum, dogs sometimes responded differently to different emotional expressions, but differential responding does not necessarily indicate their understanding the emotions meaningfully. For instance, dogs responded differently to angry and happy expressions (while the experimenter gave the commands) in Study 1, to happy and fearful expressions (to both the experimenter and the toy) in Study 2, and to angry/happy versus sad expressions, and male/ female stimuli in Study 3. Yet, in none of these studies was it clear that dogs responded meaningfully to emotional expressions. In Study 1, they did not wait for longer when alone with food, with the angry command. In Study 2, they did not respond differently to the fearful and control expressions. In Study 3, they did not match auditory and visual expressions for the affective displays. In Study 4, dogs and humans seemed to find infant crying equally aversive, although this might indicate only a rudimentary form of empathy, emotional contagion. Taken together, across the four studies, I found inconsistent results for whether domestic dogs have some form of understanding human emotional expressions for happiness, anger, sadness and fear.

## **Limitations**

There are some possible limitations of the studies, which are discussed below.

### *Duration of exposure to an emotional expression*

An overly short or long exposure to an emotional expression in the first three studies may have hindered canine comprehension for the displayed expression. Emotional expressions were given for five seconds in the command study, 20 seconds in the social referencing study, 5 (first phase) to 10 (first plus second phase) seconds in the preferential looking study, and 13 minutes in the empathy study. Therefore, the minimum duration of any emotional expression in my studies was 5 seconds long. Five seconds is within standard parameters for emotional expressions because previous studies have displayed still images for between 1.5 seconds (Somppi et al., 2013) to 30 seconds (Adachi, Kuwahata, & Fujita, 2007), and playbacks were between 0.24 seconds (McConnell, 1990) and 20 seconds (Farago et al., 2010). Nevertheless, it is unknown whether a longer duration might have improved canine performance.

In the social referencing study, the experimenter stopped displaying an emotional expression when the toy stopped moving, a procedure similar to human infants' social referencing studies (Kim et al., 2010; Klinnert et al., 1986). Although the expression was displayed for about 20 seconds, the duration in human infant studies was longer – Klinnert et al. (1986) used one minute, and Kim et al. (2010) and Merola et al. (2011) used 30 seconds. Although the 20-second display was shorter compared to these other studies, the distinct behavioural differences shown across the three conditions and the similarity in canine responding in the present study and Merola et al. (2011) in the happy and fear conditions suggest that the cue duration was not critical and has not adversely affected the outcome of this experiment.

*Familiarity with emoter*

It is highly likely that dogs are more familiar with their owner's expressions of happiness and anger compared to those of a stranger. Dogs may have chosen to ignore the expressions of a stranger and/or had heightened anxiety due to the owner's presence in another room (dogs and owners were separated in the social referencing and command studies, and owners were blindfolded in the preferential looking study). Lack of familiarity with the experimenter may have contributed to the poor performance, as demonstrated in one study (Merola et al., 2013).

Past studies often used familiar persons to display an emotional expression; be it a parent in infant studies (Kim et al., 2010; Montague & Walker-Andrews, 2001; Rosen et al., 1992; Sorce et al., 1985) or a dog owner in dog studies (Adachi et al., 2007; Merola et al., 2011; Nagasawa et al., 2011). Zarbaty and Lamb (1985) proposed that human infants have a 'selectivity postulate', meaning that familiarity with primary caregivers would make messages from the caregiver a more powerful behavioural regulator of the infant's behaviour (as opposed to messages from a stranger). This argument could also be applied to dogs, who have strong attachment bonds with their owners, with previous studies providing evidence that dogs (a) preferred to look longer at familiar conspecific and human faces (Somppi et al., 2013), and (b) respond better in a social referencing task when the expression was displayed by a familiar person compared to a stranger (Merola et al., 2013, 2012; Vas, Topal, Gyori, & Miklosi, 2008). Yet, unfamiliarity with the emoter might not have affected my findings because there were distinct attentional differences to the experimenter's expressions across four studies, implying that dogs were responding to the experimenter's display. In addition, previous canine research utilising the owners as emoters led to similar outcomes to my

findings (e.g. dogs showed a greater likelihood of approaching the toy following a happy versus a fearful display in a social referencing task) (Merola et al., 2013, 2012).

In Studies 1 and 2, I used experimenter rather than owner expressions for one main reason. It would have been impossible to control the intensity or validity of owner expressions, with some owners expressing emotions in a believable way (either intensely or more subtly), and others expressing emotions in an unbelievable way. In Study 3, I used unfamiliar adult male and female faces instead of owners, unlike other canine research (Adachi et al., 2007; Nagasawa et al., 2011). Again, the chosen faces were selected for uniformity in expressing an emotion. In Study 4, human infant expressions of crying were used because they are more intense and believable than simulated adult expressions. The use of non-owner expressions did not stop dogs from demonstrating differential responses in Study 2 (social referencing), Study 3 (preferential looking) or Study 4 (empathy).

#### *Object choice*

One could argue that the toy robot in the social referencing study may not have been sufficiently interesting or threatening to the dog. The stimulus in social referencing studies generally evokes some degree of fear (Merola et al., 2011; Sorce et al., 1985). However, the differential reaction of dogs when the experimenter expressed fear versus happiness suggests this was not responsible for my results. That is, dogs were least interested in the toy after witnessing the experimenter expressing happiness towards it, but maintained an interest or wariness towards the toy in both the fear and confused conditions.

*Still images*

One could argue that the still images and vocal expressions used in the preferential looking study did not provide sufficient information to the participants, unlike dynamic stimuli. Buttelman and Tomasello (2012) suggested that the still face in the neutral expression may have hindered dogs' ability to differentiate between happy and neutral expressions.

Two studies showed that infants matched vocal and facial emotions when using dynamic stimuli (Vaillant-Molina et al., 2013; Walker-Andrews, 2008). Nonetheless, most matching studies tested infants with still images, with considerable matching success by the infants (see Table 1.1 for a summary). Therefore, using still images and vocal expressions can be argued to have not adversely affected the results obtained. Likewise, canine performance on a similar paradigm has been successful when vocal playbacks and/or still images have been employed (Farago et al., 2010; Nagasawa et al., 2011; Taylor et al., 2011). Further, in my preferential looking study, the participants had the opportunity to listen to the voice recording twice, which should have assisted matching.

### **Directions for future research**

My research has only tested canine responding to female human emotional signals. I have not tested these dogs with a male human experimenter in social referencing or command/obedience tasks in a dynamic setting. Considering that past studies found that males attract a different response from dogs (Hennessy et al., 1998; Lore & Eisenberg, 1986; Wells & Hepper, 1999), it would be important to examine canine responding to male emotional signals.

I have tested companion pet dogs in my studies, and have yet to discover if dogs living in shelters or working dogs would perform similarly. An additional extension would be to conduct genetic testing in dogs using similar testing paradigms. Hare and Tomasello (2005) suggested comparing social skills and genetics between dogs which were more wolf-like and less wolf-like, to identify a more sociable dog for temperament and ability in using human communicative cues. The general public has been inundated with claims that certain dog breeds are better with children than others (Animal Planet, 2010; Eckstein, 2012; Flinn, 2013; Goldman, 2011; Milan, 2013). Although demographic data for dogs in the empathy study showed no significant difference for several variables (rehoming status, intact status, living with children), the large variation in cortisol levels and behaviour suggests that some dogs might have been more empathic than others. Identifying a possible gene marker might yield interesting results.

I have tested dogs using discrete primary emotions such as happiness, anger, fear, and sadness. It would be interesting to know whether dogs could recognise other discrete emotions such as disgust and surprise. These two emotions are more likely to be unfamiliar to dogs, compared to happiness or anger. Another possible extension

could include a combination of behaviour in expressing an emotion (e.g. tears and laughter when sad, or tears and frowning when angry). Because emotions are rarely expressed in their purest form, testing dogs with combinations could potentially yield interesting results. It would also be interesting to examine whether results would be improved when using two modalities versus one modality for expression (e.g. face and body, face and voice, body and voice in the command task). Ambady and Rosenthal (1992) showed that humans are more accurate in identifying an emotion expressed bimodally, particularly when combining face and body gestures.

Studies have shown that the right brain hemisphere of dogs is responsible for processing fear or threatening stimuli, whereas the left side processes pleasant experiences (Guo et al., 2009; Quaranta et al., 2007; Siniscalchi et al., 2011; Siniscalchi, Lusito, Sasso, & Quaranta, 2012; Siniscalchi et al., 2010). A further extension of the empathy study would be to measure the tympanic membrane temperature (TMT) in each ear. Lateralized differences in TMT might enable real-time monitoring of hemispheric activity in real-world conditions, and allows an examination of lateralized brain physiology during tasks demanding the processing and representation of emotional and/or motivational states (Propper & Brunyé, 2013). Taking ear temperature is painless and quick, and unstressful for the dog and the experimenter, compared to taking blood samples, or shaving bits of hair for heart rate vests and heart rate monitors. It could be potentially stressful to the dogs when an unknown human obtains physiological samples from them in an unknown location, and the additional stress could potentially confound the measurements. Thus, a less stressful procedure would be beneficial to the study, and less demanding of the dog.

### **Theoretical implications**

Broad and narrow definitions of empathy in humans and animals have been proposed by some researchers (de Vignemont & Singer, 2006; Decety & Jackson, 2004; Eisenberg & Fabes, 1990; Preston & de Waal, 2002; Shirtcliff et al., 2009). Many people believe that animals are not capable of experiencing empathy or sympathy (see Bekoff & Gruen, 1993, and Mitchell, Thompson, & Miles, 1997 for reviews), and scientists have been criticised for being anthropomorphic when describing animal behaviour, particularly when it is related to animal emotions. In humans, emotional recognition and learning is a step towards developing a sense of empathy (Preston, 2004). The learning process helps the individual to regulate its own emotions, from becoming overly distressed when perceiving distress in another, and is yet unable to help.

It has been found that newborn human infants cried when placed in the same room with other crying infants, and this behaviour has been considered as an empathic response (Sagi & Hoffman, 1976). Young children responding to mother's feigned injury and distress were also considered as empathic response, and a precursor to empathic development e.g. altruism, prosocial behaviour, and morality (Knafo, Zahn-Waxler, Van Hulle, Robinson, & Rhee, 2008; Zahn-Waxler & Radke-Yarrow, 1990). Similar empathic response in animals were reported such as when observing either kin or non-kin in distress in mammals e.g. primates, dolphins and rodents (Church, 1959; Parr, 2001; Reiss & Marino, 2001), and also in other animal species, e.g. birds (Edgar et al., 2011; Watanabe & Ono, 1986).

Further evidence on empathy having similar phylogenetic roots was revealed in neuroimaging studies, particularly of mirror neurons in the brain (see Hunter, Hurley, &

Taber, 2013 for a review). Researchers have postulated that mirror neurons are important in emotional interpersonal cognition. Studies on mirror neurons mechanism were found to be similar in both primates and humans (Fabbri-Destro & Rizzolatti, 2008; Iacoboni, 2009), suggesting that some forms of empathy are primarily dependent on subcortical neural structures that are phylogenetically conserved across mammalian species (Decety & Svetlova, 2012). Therefore, it is possible that mammals in general may share a mechanism for mobilising prosocial motivation in response to the distress of another individual. It appears that empathy is likely (in part) to be genetically encoded in animals as well as humans.

The results from my studies showed that dogs do respond differentially to human emotional expressions, although it is unclear how much dogs really understand them. Emotion recognition and learning may be the starting step towards developing cross-species empathy. Furthermore, results from Studies 3 and 4 suggest that dogs have an aversion to human expressions of sadness, which suggests the presence of emotional contagion, a rudimentary form of empathy.

Another crucial finding was from Study 4 which provides evidence on cross-species empathy (i.e. canine responding to human distress). Evidence from cross-species emotional ‘contagion’ or ‘resonance’ between animals further elucidates the origin of human empathy from an evolutionary perspective (Panksepp & Panksepp, 2013).

### **Practical applications**

The findings of my studies could be applied in enhancing current dog-owner relationship, to dogs in shelters, and in animal-assisted therapy. These applications are described below.

Dog owners often think that their dogs “understand” them and are empathic towards them. Canine aversion to sadness (looking away from sad faces, demonstrating stress when listening to sadness) is consistent with this view and such knowledge could potentially strengthen the dog-human attachment bond.

My findings could be applied to dogs living in shelters. The dogs living in shelters may have had a difficult environment (e.g. abuse) prior to living in the shelter, and as a result, face difficulty in forming bonds with humans. Handlers in the shelters could potentially test the dogs using affective stimuli. If handlers can identify which dogs are most responsive to human emotional signals, it might help to facilitate dog adoption because responsiveness to such signals is likely central to the human-dog attachment bond. Furthermore, responding to emotional cues will also assist handlers in identifying dogs suitable for a specific environment (e.g. living with children).

The gender-matching results indicate that dogs have some ability to perform gender matching, although more so for male than female stimuli. This is similar to past findings that dogs were less relaxed and showed some aggression to a male human compared to a female (Hennessy et al., 1998; Lore & Eisenberg, 1986; Wells & Hepper, 1999). Therefore, shelters could consider placing female caregivers with new entrants, instead of male caregivers to reduce aggression and facilitate initial adjustment to the shelter.

Although I did not find a *significant* decrease in canine cortisol levels after listening to human infant babbling, there were non-significant trends in this direction as well as a non-significant tendency for greater calm and relaxation when listening to babbling compared to crying and white noise. It is possible that with larger dog numbers, these trends would have become significant, and if so, there is potential in playing human infant babbling sounds to calm dogs in threatening or ambiguous situations (e.g. in veterinary clinics, shelters or new places) as an alternative to medication.

The presence of emotional contagion in dogs (Study 4) may lead to owners and handlers thinking that dogs are capable of full-blown empathy. One study found that dogs could not respond appropriately to an emotionally charged situation (e.g. seek help) (Macpherson & Roberts, 2006), suggesting they lack cognitive empathy.

Instead, the presence of emotional contagion might help to explain why dogs are usually perceived to “understand” human emotions. Dogs are a popular choice for animal-assisted therapy, particularly with vulnerable groups such as those with autism, disabilities or older adults. Studies report an improvement in such individuals in many areas, including improved social interaction, increased communication and use of language, decreased stress levels in children with autism (O’Haire, 2013), reduced anxiety in acute schizophrenic patients (Lang, Jansen, Wertenaer, Gallinat, & Rapp, 2010) and better overall health in dementia patients (Filan & Llewellyn-Jones, 2006). Due to dogs’ popularity in healthcare, they may be regularly exposed to human expressions of sadness during therapy. My findings suggest that dogs may find human expressions of sadness aversive, and that regular exposure to sadness may be detrimental to their overall health and wellbeing (e.g. sustained high cortisol levels). At

the same time, canine sensitivity to some emotional signals might lead to high expectations that dogs would recognise all human emotions, such as disgust, fear, and surprise. It is important for dog trainers and therapists to realise the limits in canine responding to, and understanding of, human emotional expressions.

### **Conclusion**

This thesis has examined canine responding to human emotional expressions. In all studies, dogs tended to respond differently to human emotional expressions, but it is unclear how much they really understand about such expressions. Nevertheless, there is some evidence that dogs, like humans, might have an aversion to human expressions of sadness.

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**Appendices**

*Appendix A. Advertisement with dogs in it examples*



Kate Moss with a Border Collie in a Burberry for Spring 2005 collection



Coco Rocha with a Weimaraner for Longchamp Spring 2012 collection

## Appendix B.

*Demographic data of participating dogs in Study 1*

No	Dog breed	Sex	Neutered	Age	Cue	Order1	Order2
1	American Red-nose pitbull	Female	Yes	5.56	Body	Angry	Happy
2	Labrador/Greyhound/collie/bully	Female	Yes	1.85	Body	Angry	Happy
3	Lab / collie	Female	Yes	1.64	Body	Angry	Happy
4	Lab huntaway cross	Male	Yes	7.00	Body	Angry	Happy
5	Bearded collie / border collie cross	Male	Yes	2.22	Body	Angry	Happy
6	Boxer	Female	Yes	9.22	Body	Angry	Happy
7	Schnauzer	Female	Yes	9.54	Body	Angry	Happy
8	German wire-haired pointer	Male	Yes	3.56	Body	Angry	Happy
9	Huntaway / Staffordshire Terrier	Male	Yes	5.48	Body	Angry	Happy
10	Border collie	Female	Yes	5.12	Body	Angry	Happy
11	Golden Retriever	Female	Yes	5.25	Body	Angry	Happy
12	Border Collie / Kelpie Cross	Female	Yes	10.00	Body	Angry	Happy
13	Collie / Husky / Heading	Female	Yes	2.42	Body	Angry	Happy
14	Labrador / Border collie	Female	No	2.37	Body	Happy	Angry
15	Mini fox terrier	Female	Yes	4.35	Body	Happy	Angry
16	Labrador / Staffordshire Terrier	Male	Yes	5.38	Body	Happy	Angry
17	Labrador	Female	Yes	4.32	Body	Happy	Angry
18	Border Collie	Female	Yes	1.73	Body	Happy	Angry
19	Beardie collie cross	Male	Yes	2.88	Body	Happy	Angry
20	German Shepherd	Male	Yes	2.75	Body	Happy	Angry
21	Border collie / German Shepard cross	Female	Yes	9.73	Body	Happy	Angry

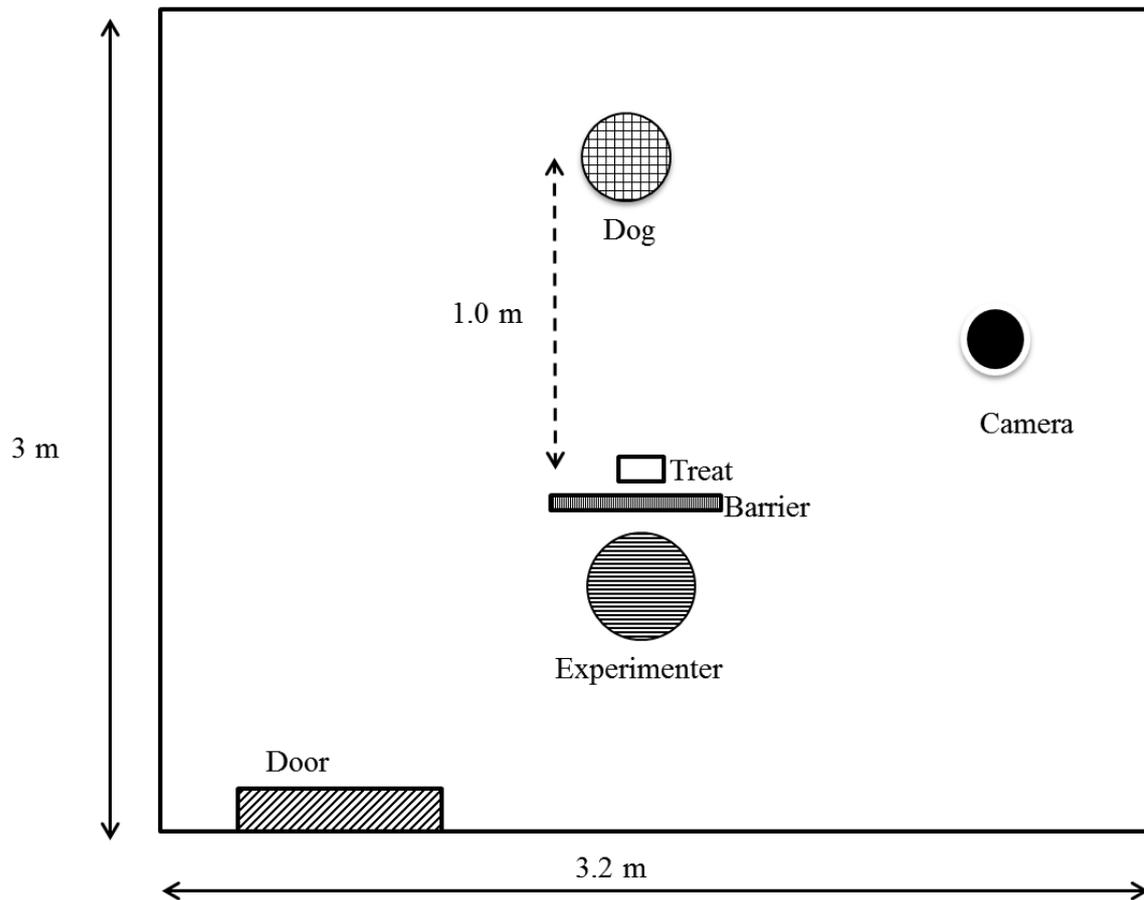
22	English Setter	Female	Yes	4.28	Body	Happy	Angry
23	Miniature poodle	Female	No	1.01	Body	Happy	Angry
24	Labrador	Female	Yes	8.39	Body	Happy	Angry
25	Staffy cross	Female	Yes	3.15	Body	Happy	Angry
26	Schnauzer, poodle, cavalier cross	Male	Yes	2.98	Body	Happy	Angry
27	German Shepherd	Female	Yes	4.59	Body	Happy	Angry
28	Lab cross	Male	Yes	11.34	Body	Happy	Angry
29	Collie / Husky / Heading	Female	No	6.98	Body	Happy	Angry
30	Labrador	Female	Yes	8.62	Face	Angry	Happy
31	Labrador / Huntaway	Male	Yes	5.72	Face	Angry	Happy
32	Labrador	Female	Yes	4.32	Face	Angry	Happy
33	Huntaway Collie cross	Female	No	1.75	Face	Angry	Happy
34	Border Collie	Female	Yes	5.95	Face	Angry	Happy
35	Bearded collie	Male	No	1.55	Face	Angry	Happy
36	Border collie/ Siberian Husky	Male	Yes	5.38	Face	Angry	Happy
37	Beardie collie cross	Female	Yes	4.88	Face	Angry	Happy
38	Lab cross	Female	Yes	1.25	Face	Angry	Happy
39	Lab cross	Male	Yes	8.65	Face	Angry	Happy
40	Fox terrier cross	Female	Yes	2.39	Face	Angry	Happy
41	Labrador	Female	Yes	7.92	Face	Angry	Happy
42	Labrador	Male	No	10.50	Face	Angry	Happy
43	Husky Labrador cross	Female	Yes	3.99	Face	Angry	Happy
44	Shetland Sheepdog	Female	Yes	10.02	Face	Angry	Happy
45	French mastiff	Female	Yes	2.71	Face	Happy	Angry
46	Labrador Retriever	Female	Yes	12.95	Face	Happy	Angry
47	Golden Retriever	Female	Yes	11.84	Face	Happy	Angry

48	Staffy	Female	No	2.55	Face	Happy	Angry
49	Border Collie	Female	No	7.14	Face	Happy	Angry
50	Griffon Bruxellois	Female	Yes	3.15	Face	Happy	Angry
51	Cocker spaniel	Male	No	1.04	Face	Happy	Angry
52	Golden Retriever	Male	Yes	7.76	Face	Happy	Angry
53	Miniature poodle / Tibetan terrier	Male	Yes	1.97	Face	Happy	Angry
54	Australian Shepherd	Male	Yes	3.49	Face	Happy	Angry
55	Weimardoodle	Female	Yes	2.57	Face	Happy	Angry
56	Scottish terrier	Female	Yes	1.99	Face	Happy	Angry
57	Collie cross	Male	Yes	4.61	Face	Happy	Angry
58	Red heeler cross	Female	Yes	10.32	Face	Happy	Angry
59	Collie / Husky / Heading	Male	Yes	2.42	Face	Happy	Angry
60	American Red-nose pitbull	Male	No	5.56	Voice	Angry	Happy
61	Spoodle	Male	Yes	4.79	Voice	Angry	Happy
62	Labrador	Female	Yes	10.97	Voice	Angry	Happy
63	Bichon Frise	Male	No	2.04	Voice	Angry	Happy
64	Huntaway cross	Male	Yes	1.74	Voice	Angry	Happy
65	Border Collie	Female	Yes	10.82	Voice	Angry	Happy
66	Labrador	Male	No	1.78	Voice	Angry	Happy
67	Golden Retriever	Female	Yes	2.18	Voice	Angry	Happy
68	Staffordshire bull terrier	Female	Yes	7.37	Voice	Angry	Happy
69	Jack Russell cross	Female	Yes	1.44	Voice	Angry	Happy
70	Lab cross	Female	Yes	5.33	Voice	Angry	Happy
71	Golden Retriever	Female	Yes	2.79	Voice	Angry	Happy
72	Golden Retriever	Male	Yes	5.25	Voice	Angry	Happy
73	Collie / Husky / Heading	Male	Yes	5.53	Voice	Angry	Happy

74	Labrador / Poodle	Female	Yes	2.48	Voice	Happy	Angry
75	Belgian Shepherd	Female	No	1.61	Voice	Happy	Angry
76	Golden Retriever	Female	Yes	1.78	Voice	Happy	Angry
77	Border Collie	Female	No	9.77	Voice	Happy	Angry
78	Border collie	Female	Yes	3.72	Voice	Happy	Angry
79	Schnauzer	Female	Yes	2.59	Voice	Happy	Angry
80	English Setter	Male	Yes	10.12	Voice	Happy	Angry
81	Border collie	Female	Yes	9.41	Voice	Happy	Angry
82	Labrador cross	Female	Yes	7.89	Voice	Happy	Angry
83	Standard Poodle	Female	Yes	5.09	Voice	Happy	Angry
84	Hungarian Vizsla	Male	Yes	3.47	Voice	Happy	Angry
85	Staffy cross	Male	Yes	3.99	Voice	Happy	Angry
86	Husky Golden retriever cross	Female	Yes	3.08	Voice	Happy	Angry
87	Labrador	Female	Yes	4.82	Voice	Happy	Angry
88	Terrier / lab cross	Female	Yes	16.00	Voice	Happy	Angry

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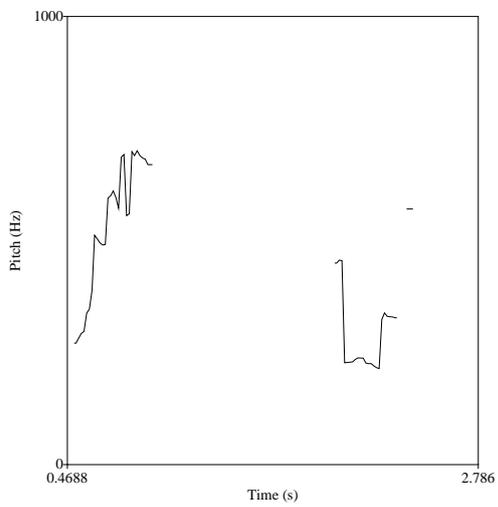
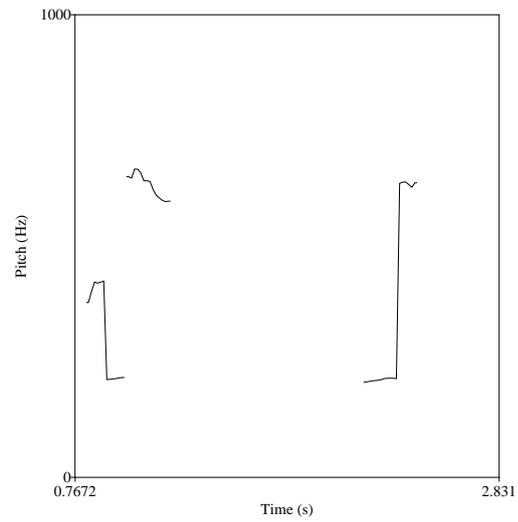
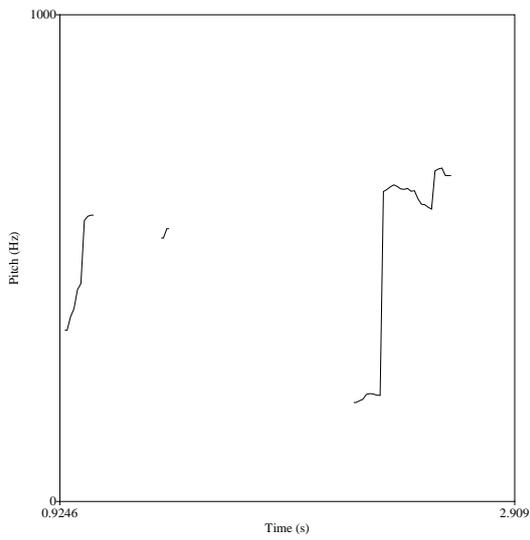
## Appendix C.

*Experiment room set-up for Study 1.*

The barrier was different for each cue; a wooden plank (0.5m x 0.5 m x 0.05m) and plain steel pole (5cm diameter, 1.6m tall) for bodily gestures, 1.0m by 0.6m plain cardboard for facial expression, and both wooden plank and pole and plain cardboard for vocal command.

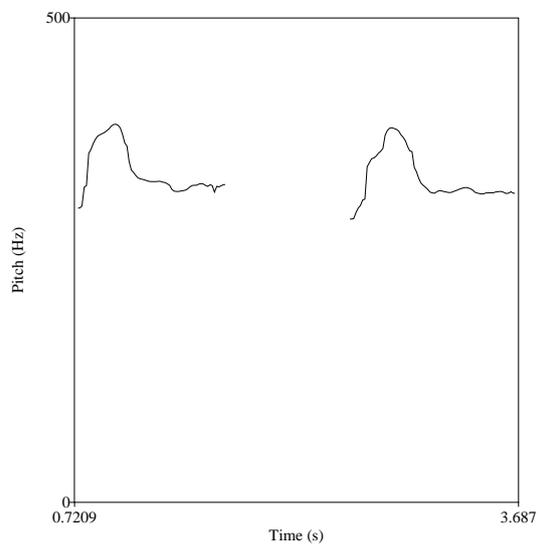
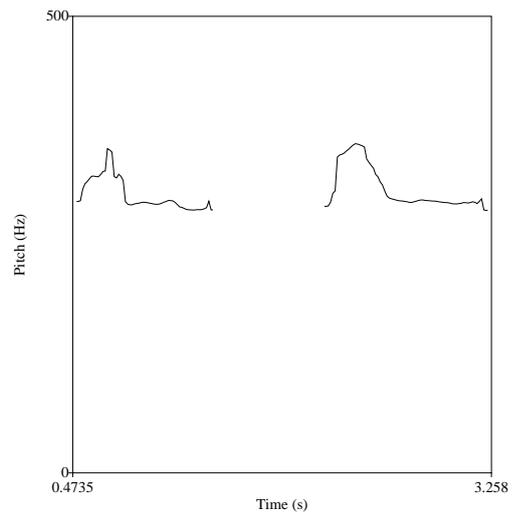
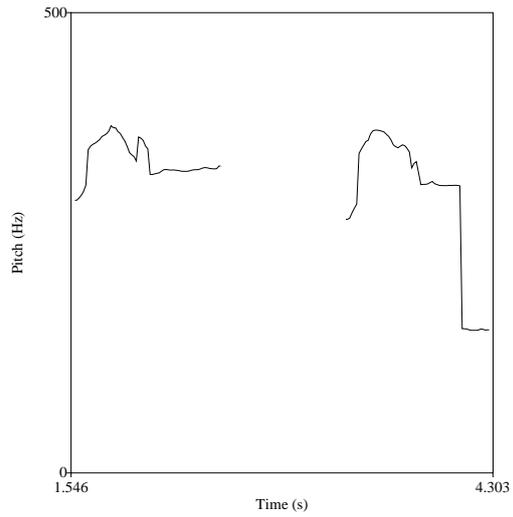
## Appendix D.

*Pitch increasing rapidly in one angry “Leave” command. Pitch contours taken from 3 dogs (a) Annie (female Border Collie), (b) Aidee (female Border Collie), and (c) Boston (male Labrador).*



## Appendix E.

*Pitch decreasing gently in one happy “Leave” command. Pitch contours taken from 3 dogs (a) Annie (female Border Collie), (b) Aidee (female Border Collie), and (c) Boston (male Labrador).*



## Appendix F.

*Demographic data of participating dogs in Study 2.*

No	Dog breed	Sex	Neutered	Age	Condition
1	Labrador	Female	Yes	8.62	Happy
2	Labrador Retriever	Female	Yes	12.95	Happy
3	Golden Retriever	Female	Yes	11.84	Happy
4	Labrador	Female	Yes	4.32	Happy
5	Huntaway Collie cross	Female	No	1.75	Happy
6	Golden Retriever	Female	Yes	2.18	Happy
7	Staffordshire bull terrier	Female	Yes	7.37	Happy
8	English Setter	Female	Yes	4.28	Happy
9	Lab cross	Female	Yes	1.25	Happy
10	Shetland Sheepdog	Female	Yes	10.19	Happy
11	Collie / Husky / Heading	Female	No	7.16	Happy
12	Labrador Retriever	Female	No	0.93	Happy
13	French mastiff	Female	Yes	2.71	Happy
14	Staffy	Female	No	2.55	Happy
15	Boxer	Female	Yes	9.22	Happy
16	Schnauzer	Female	Yes	2.59	Happy
17	Labrador / Huntaway / Beagle cross	Female	Yes	1.33	Happy
18	Bearded collie / Huntaway cross	Female	Yes	6.67	Happy
19	Labrador	Female	No	1.08	Happy
20	Border Collie	Female	Yes	5.75	Happy
21	Maltese cross	Female	Yes	6.67	Happy

22	Whippet	Female	Yes	2.67	Happy
23	Labrador	Female	Yes	4.25	Happy
24	Labrador / Huntaway	Male	Yes	5.72	Happy
25	Bearded collie / border collie x	Male	Yes	2.22	Happy
26	Labrador	Male	No	1.78	Happy
27	Golden Retriever	Male	Yes	7.76	Happy
28	English Setter	Male	Yes	10.12	Happy
29	Miniature poodle / Tibetan terrier	Male	Yes	1.97	Happy
30	Collie / Husky / Heading	Male	No	2.60	Happy
31	Collie / Husky / Heading	Male	Yes	5.70	Happy
32	Labrador	Male	Yes	9.02	Happy
33	Springer spaniel	Male	Yes	8.01	Happy
34	Jack Russell/fox terrier	Male	Yes	9.42	Happy
35	Chinese Crested	Male	Yes	2.58	Happy
36	Beardie/Huntaway	Male	Yes	6.42	Happy
37	Cairn Yorkshire Maltese terrier cross	Male	Yes	2.75	Happy
38	American Red-nose pitbull	Female	Yes	5.56	Fear
39	Labrador / Border collie	Female	No	2.37	Fear
40	Mini fox terrier	Female	Yes	4.35	Fear
41	Labrador	Female	Yes	4.32	Fear
42	Lab / collie	Female	Yes	1.64	Fear
43	Border Collie	Female	Yes	5.95	Fear
44	Border collie	Female	Yes	3.72	Fear
45	Beardie collie cross	Female	Yes	4.88	Fear
46	Schnauzer	Female	Yes	9.54	Fear
47	Labrador	Female	Yes	5.01	Fear

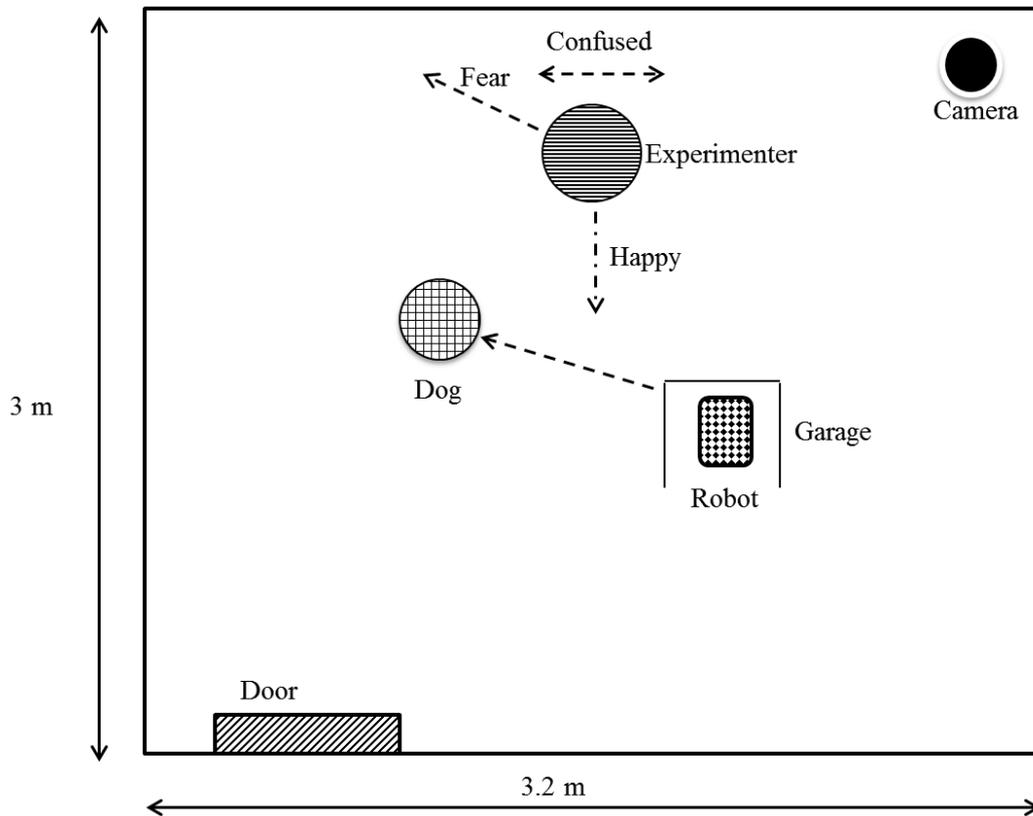
48	Staffy cross	Female	Yes	3.34	Fear
49	German Shepherd	Female	Yes	4.17	Fear
50	Black lab	Female	Yes	3.40	Fear
51	Labrador/Greyhound/collie/bully	Female	Yes	1.85	Fear
52	Border Collie	Female	No	9.77	Fear
53	Border Collie	Female	Yes	1.73	Fear
54	Golden Retriever	Female	Yes	5.42	Fear
55	Belgian Shepherd	Female	Yes	5.01	Fear
56	Boxer	Female	Yes	7.35	Fear
57	American Dingo	Female	Yes	9.92	Fear
58	Boxer / collie cross	Female	Yes	4	Fear
59	Labrador	Female	Yes	1.75	Fear
60	Staffordshire Bull Terrier Collie cross	Female	Yes	6.17	Fear
61	Labrador / Staffordshire Terrier	Male	Yes	5.38	Fear
62	Bichon Frise	Male	No	2.04	Fear
63	Lab huntaway cross	Male	Yes	7.00	Fear
64	German wire-haired pointer	Male	Yes	3.56	Fear
65	Lab cross	Male	Yes	8.65	Fear
66	Hungarian Vizsla	Male	Yes	3.47	Fear
67	Labrador	Male	No	10.68	Fear
68	Golden Retriever	Male	Yes	5.42	Fear
69	Bearded collie	Male	No	1.55	Fear
70	Border collie/ Siberian Husky	Male	Yes	5.38	Fear
71	Staffy cross	Male	Yes	4.41	Fear
72	Weimaraner	Male	Yes	3.42	Fear
73	Irish wolfhound	Male	Yes	9.42	Fear

74	Collie blue heeler cross	Male	Yes	3.5	Fear
75	Staffordshire Terrier / Rottweiler cross	Male	Yes	2	Fear
76	Labrador / Poodle	Female	Yes	2.48	Confused
77	Belgian Shepherd	Female	No	1.61	Confused
78	Golden Retriever	Female	Yes	1.78	Confused
79	Labrador	Female	Yes	10.97	Confused
80	Border Collie	Female	No	7.14	Confused
81	Border Collie	Female	Yes	10.82	Confused
82	Griffon Bruxellois	Female	Yes	3.15	Confused
83	Miniature poodle	Female	No	1.01	Confused
84	Border collie	Female	Yes	9.41	Confused
85	Labrador	Female	Yes	8.39	Confused
86	Labrador cross	Female	Yes	7.89	Confused
87	Standard Poodle	Female	Yes	5.09	Confused
88	Collie / Husky / Heading	Female	Yes	2.60	Confused
89	Scottish terrier	Female	Yes	2.19	Confused
90	Border collie / German Shepard cross	Female	Yes	9.73	Confused
91	Spaniel cross	Female	Yes	6.75	Confused
92	Border Collie	Female	Yes	4.5	Confused
93	Cocker Spaniel / Labrador	Female	Yes	4.67	Confused
94	French bulldog	Female	No	4.42	Confused
95	English Pointer	Female	No	1.17	Confused
96	French bulldog	Female	Yes	6.5	Confused
97	Spoodle	Female	Yes	2.17	Confused
98	German Shepherd	Female	Yes	5.08	Confused
99	American Red-nose pitbull	Male	No	5.56	Confused

100	Huntaway cross	Male	Yes	1.74	Confused
101	Beardie collie cross	Male	Yes	2.88	Confused
102	German Shepherd	Male	Yes	2.75	Confused
103	Cocker spaniel	Male	No	1.04	Confused
104	Australian Shepherd	Male	Yes	3.49	Confused
105	Huntaway cross	Male	Yes	7.60	Confused
106	Belgian Shepherd	Male	Yes	4.21	Confused
107	Huntaway / Staffordshire Terrier	Male	Yes	6.67	Confused
108	Lab cross	Male	Yes	11.52	Confused
109	Huntaway cross	Male	Yes	2.68	Confused
110	Collie cross	Male	Yes	11.86	Confused
111	Spoodle	Male	Yes	4.79	Confused
112	Fox Terrier	Male	Yes	7.17	Confused
113	Staffy / Boxer / bull terrier / whippet cross	Male	Yes	10.33	Confused
114	Chihuahua / fox terrier cross	Male	Yes	12.33	Confused

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## Appendix G.

*Experiment room set-up for Study 2.*

The dashed arrows indicate the experimenter's movement in each emotion.

Experimenter always exit from the room using the same door.

Appendix H.

*Toy robots used in the Study 2.*



Each robot was 30cm tall and 18cm wide, and had moving arms and legs, and a helmet.

The 'garage' (behind the robots) was a box with the cut-out in the middle and two A4 sheets of paper as doors.

## Appendix I.

*Demographic data of participating dogs in Study 3.*

No	Name	Breed	Include	Sex	Neutered	Age	Task	Obtained From	Other People In Household
1	Amber	Greyhound	Yes	Female	No	1.17	Emotion	Adopted	Yes
2	Becca	German Shepherd X Greyhound	Yes	Female	No	1.17	Emotion	Own	Yes
3	Tannah	Golden Retriever	Yes	Female	Yes	1.20	Emotion	Breeder	No
4	Evie	Lab / collie	Yes	Female	Yes	1.64	Emotion	Adopted	Yes
5	Carly	Border Collie	Yes	Female	Yes	1.73	Emotion	Own	Yes
6	Brie	Golden Retriever	Yes	Female	Yes	1.78	Emotion	Breeder	Yes
7	Daisy	Labrador/Greyhound/collie/bully	Yes	Female	Yes	1.85	Emotion	Breeder	Yes
8	Georgia	Husky golden retriever cross	Yes	Female	Yes	2.08	Emotion	Breeder	Yes
9	Gin	Border retriever cross	Yes	Female	No	2.18	Emotion	Breeder	Yes
10	Zeta	Labrador / Border collie	Yes	Female	Yes	2.37	Emotion	Breeder	Yes
11	Rua	German Short-haired Pointer	Yes	Female	Yes	2.48	Emotion	Breeder	Yes
12	Tui	Labrador / Poodle	Yes	Female	Yes	2.48	Emotion	Breeder	Yes
13	Ruby	Staffy	Yes	Female	No	2.55	Emotion	Breeder	Yes
14	Jazz	Shihtzu / Lhasa apso	Yes	Female	Yes	2.78	Emotion	Breeder	Yes
15	Tya	Miniature poodle	Yes	Female	Yes	3.19	Emotion	Breeder	Yes
16	Meg	Labrador	Yes	Female	No	3.32	Emotion	Breeder	Yes
17	Diva	French mastiff	Yes	Female	Yes	3.71	Emotion	Breeder	Yes
18	Trix	Foxy Jack Russell cross	Yes	Female	Yes	3.90	Emotion	Adopted	No
19	Paki	Lab cross	Yes	Female	Yes	4.27	Emotion	Breeder	No
20	Kiri	Cocker Spaniel / Labrador / Hungarian Visla	Yes	Female	Yes	5.35	Emotion	Adopted	No

21	Gem	Heading	Yes	Female	Yes	5.77	Emotion	Breeder	Yes
22	Delta	Collie / Husky / Heading	Yes	Female	No	5.88	Emotion	Breeder	Yes
23	Pepper	Schnauzer	Yes	Female	Yes	8.56	Emotion	Breeder	Yes
24	Jessie	Shetland Sheepdog	Yes	Female	Yes	8.93	Emotion	Breeder	Yes
25	Georgia	Labrador Retriever	Yes	Female	Yes	9.92	Emotion	Breeder	Yes
26	Cassie	Border Collie	Yes	Female	Yes	11.79	Emotion	Breeder	Yes
27	Aidee	Border Collie	Yes	Female	Yes	11.82	Emotion	Breeder	Yes
28	Bella	Golden Retriever	Yes	Female	Yes	12.84	Emotion	Breeder	Yes
29	Jet	Labrador Retriever	Yes	Female	Yes	12.95	Emotion	Breeder	Yes
30	Polly	Bichon / poodle / chihuahua / terrier	Yes	Female	Yes	14.77	Emotion	Breeder	Yes
31	Angel	Terrier cross	Yes	Female	Yes	15.21	Emotion	Adopted	No
32	Dweezil	German Shepherd X Greyhound	Yes	Male	No	1.17	Emotion	Own	Yes
33	Bruno	Great Dane cross	Yes	Male	Yes	1.42	Emotion	Adopted	Yes
34	Jack	Huntaway cross	Yes	Male	Yes	2.74	Emotion	Adopted	Yes
35	Wolf	Belgian Shepherd	Yes	Male	No	2.95	Emotion	Breeder	Yes
36	Lukas	Standard Poodle	Yes	Male	Yes	3.93	Emotion	Breeder	Yes
37	Yoda	Schnauzer, Staffy and Labrador	Yes	Male	No	4.12	Emotion	Adopted	Yes
38	Colin	Spoodle	Yes	Male	Yes	4.79	Emotion	Breeder	Yes
39	Austin	Weimaraner	Yes	Male	Yes	5.17	Emotion	Breeder	Yes
40	Horse	German Short-haired Pointer	Yes	Male	No	5.18	Emotion	Adopted	Yes
41	Gaius	Labrador / Staffordshire Terrier	Yes	Male	Yes	5.38	Emotion	Adopted	Yes
42	Tera	American Red-nose pitbull	Yes	Male	No	5.56	Emotion	Breeder	Yes
43	Buddy	Blue Heeler/Beardie	Yes	Male	Yes	6.08	Emotion	Adopted	Yes
44	Ash	Labrador / Huntaway	Yes	Male	Yes	6.72	Emotion	Breeder	Yes
45	Benson	Black lab	Yes	Male	Yes	6.76	Emotion	Adopted	Yes
46	Zappa	German Shepherd X Greyhound	Yes	Male	No	7.59	Emotion	Own	Yes

47	Bailey	Border Collie	Yes	Male	Yes	8.14	Emotion	Breeder	No
48	Freddy	Golden Retriever	Yes	Male	No	8.14	Emotion	Breeder	Yes
49	Ned	English Setter	Yes	Male	Yes	9.16	Emotion	Breeder	Yes
50	Buddy	Boxer Maltese/Cavalier King Charles Spaniel	Yes	Male	Yes	10.17	Emotion	Breeder	Yes
51	Coco	cross	No	Female	Yes	2.92	Emotion	Breeder	Yes
52	Mako	Whippet	No	Male	Yes	6.84	Emotion	Adopted	No
53	Lilley	Labrador cross	Yes	Female	Yes	0.98	Gender	Adopted	Yes
54	Maggie	Scottish terrier	Yes	Female	Yes	1.56	Gender	Breeder	No
55	Molly	Belgian Shepherd	Yes	Female	No	1.61	Gender	Breeder	Yes
56	April	Maltese Chi Tzu cross	Yes	Female	Yes	1.73	Gender	Breeder	Yes
57	Lorri	Huntaway Collie cross	Yes	Female	No	1.75	Gender	Adopted	Yes
58	Pup	Border Collie / Greyhound / Whippet	Yes	Female	Yes	1.80	Gender	Adopted	Yes
59	Tinkerbelle	Griffon	Yes	Female	Yes	1.83	Gender	Breeder	Yes
60	Penny	Labrador / Huntaway / Beagle cross	Yes	Female	Yes	2.74	Gender	Adopted	Yes
61	Lexi	Border collie	Yes	Female	Yes	3.39	Gender	Breeder	No
62	Georgie	Labrador	Yes	Female	Yes	4.32	Gender	Breeder	Yes
63	Violet	Mini fox terrier	Yes	Female	Yes	4.35	Gender	Breeder	Yes
64	Ashire	Border collie	Yes	Female	Yes	4.68	Gender	Breeder	Yes
65	Baby Jean	American Red-nose pitbull	Yes	Female	Yes	5.56	Gender	Breeder	Yes
66	Chewy	Beardie collie cross	Yes	Female	Yes	5.56	Gender	Adopted	Yes
67	Jay	German Short-haired Pointer	Yes	Female	Yes	5.64	Gender	Breeder	Yes
68	Jess	Staffordshire bull terrier	Yes	Female	No	6.04	Gender	Breeder	Yes
69	Ruby	German Shepherd	Yes	Female	Yes	6.42	Gender	Breeder	Yes
70	Fizz	Border Collie	Yes	Female	No	7.14	Gender	Own	Yes
71	Mia	Staffordshire Bull Terrier Collie cross	Yes	Female	Yes	7.48	Gender	Breeder	Yes
72	Star	Labrador cross	Yes	Female	Yes	7.56	Gender	Adopted	Yes

73	Kip	Labrador	Yes	Female	Yes	8.07	Gender	Breeder	Yes
74	Mitzi	Border collie / German Shepard cross	Yes	Female	Yes	8.39	Gender	Adopted	Yes
75	Denver	Labrador	Yes	Female	Yes	8.62	Gender	Breeder	Yes
76	Bonnie	Red heeler cross	Yes	Female	Yes	8.89	Gender	Adopted	Yes
77	Amethyst	Boxer	Yes	Female	Yes	8.90	Gender	Breeder	Yes
78	Annie	Border Collie	Yes	Female	No	9.77	Gender	Breeder	Yes
79	Éclair	Labrador	Yes	Female	Yes	10.97	Gender	Breeder	Yes
80	Boston	Labrador	Yes	Male	No	1.45	Gender	Own	Yes
81	Winston	Bearded collie / border collie x	Yes	Male	Yes	1.90	Gender	Breeder	Yes
82	Bruno	Bichon Frise	Yes	Male	Yes	2.04	Gender	Breeder	Yes
83	Jake	Huntaway cross	Yes	Male	Yes	2.07	Gender	Adopted	Yes
84	Kaiser	German Shepherd	Yes	Male	Yes	2.43	Gender	Breeder	Yes
85	Colin	Beardie collie cross	Yes	Male	Yes	2.56	Gender	Breeder	No
86	Toby	Border collie/ Siberian Husky	Yes	Male	Yes	3.05	Gender	Breeder	Yes
87	Martin	Australian Shepherd	Yes	Male	Yes	3.15	Gender	Breeder	Yes
88	Tommy	Collie cross	Yes	Male	Yes	3.18	Gender	Adopted	Yes
89	Joey	Staffordshire Terrier / Rottweiler cross	Yes	Male	Yes	3.36	Gender	Adopted	Yes
90	Bailey	Chinese Crested	Yes	Male	Yes	3.95	Gender	Breeder	Yes
91	T-bone	Staffordshire Bull Terrier	Yes	Male	Yes	4.29	Gender	Adopted	Yes
92	Smudge	Boxer / labrador / huntaway	Yes	Male	Yes	4.42	Gender	Breeder	Yes
93	Sammy	Lab huntaway cross	Yes	Male	Yes	7.00	Gender	Breeder	Yes
94	Pippin	Springer spaniel	Yes	Male	Yes	7.41	Gender	Breeder	Yes
95	Bobby	Collie cross	Yes	Male	Yes	8.24	Gender	Adopted	Yes
96	Cody	Samoyed	Yes	Male	No	9.56	Gender	Breeder	Yes
97	Niki	Border Collie	No	Female	No	5.95	Gender	Breeder	Yes

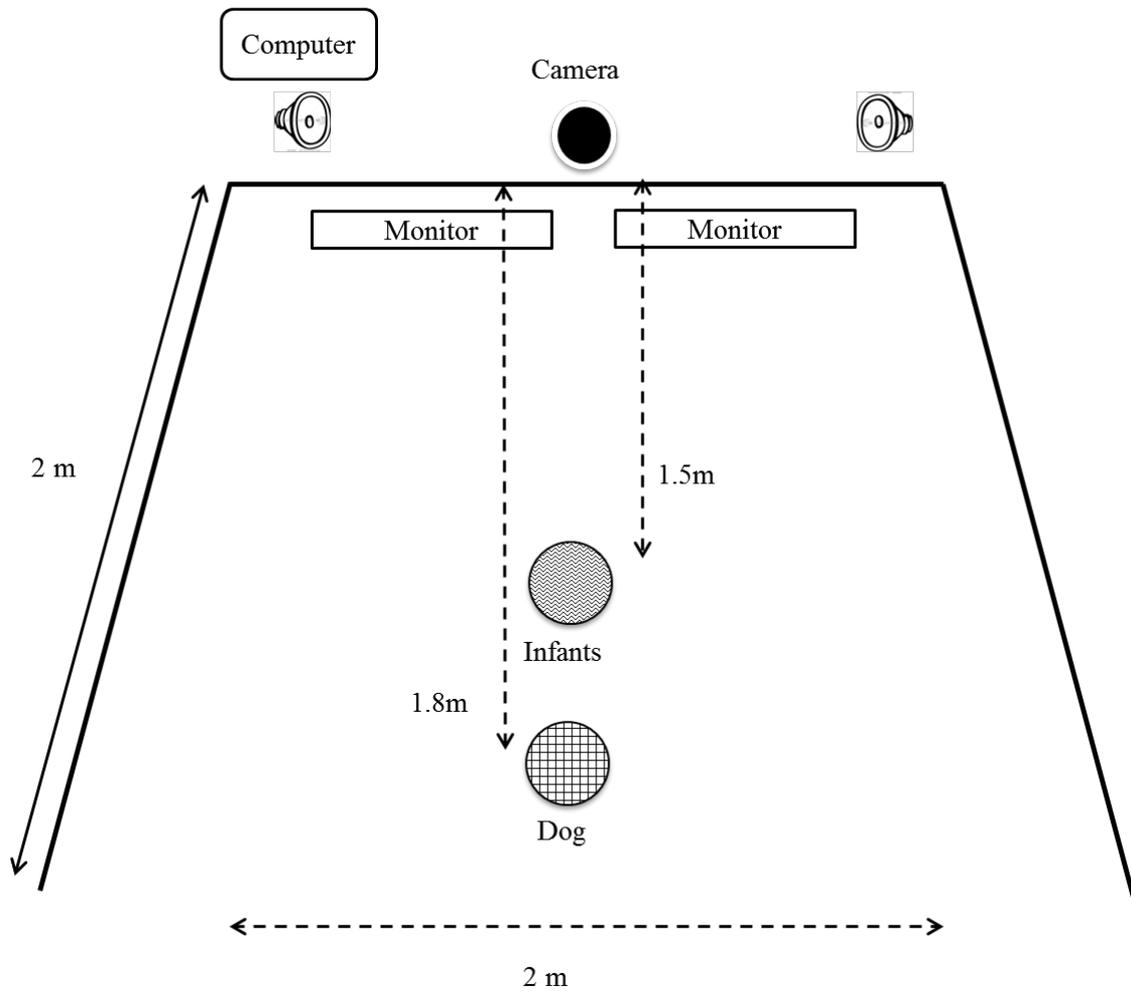
## Appendix J.

*Demographic data of participating infants in Study 3.*

No	Sex	Task	Age (months)
1	Female	Emotion	7.00
2	Female	Emotion	7.43
3	Female	Emotion	7.20
4	Female	Emotion	7.67
5	Female	Emotion	7.67
6	Female	Emotion	6.73
7	Female	Emotion	6.83
8	Female	Emotion	6.53
9	Female	Emotion	7.30
10	Female	Emotion	8.50
11	Male	Emotion	7.13
12	Male	Emotion	7.17
13	Male	Emotion	5.90
14	Male	Emotion	6.93
15	Male	Emotion	7.77
16	Male	Emotion	7.23
17	Male	Emotion	8.20
18	Male	Emotion	9.07
19	Male	Emotion	7.07
20	Male	Emotion	5.73
21	Male	Emotion	7.30
22	Male	Emotion	5.13
23	Male	Emotion	7.77
24	Male	Emotion	6.57

Appendix K.

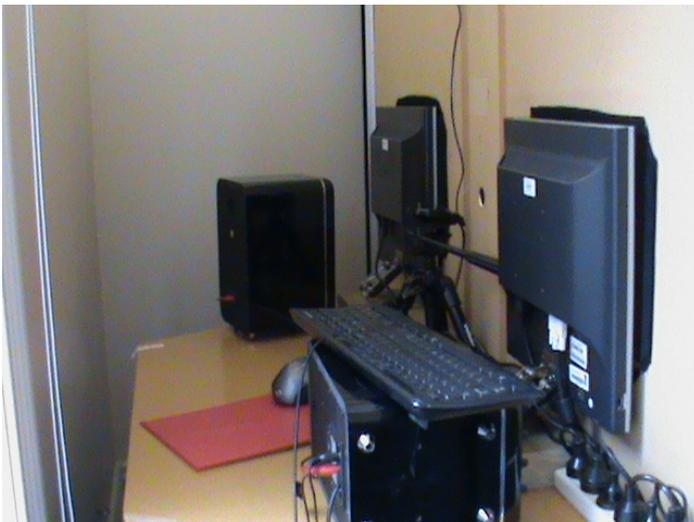
*Experiment room set-up for Study 3.*



Dogs sat at 1.8m from the screen, and young infants at 1.5m.

Appendix L.

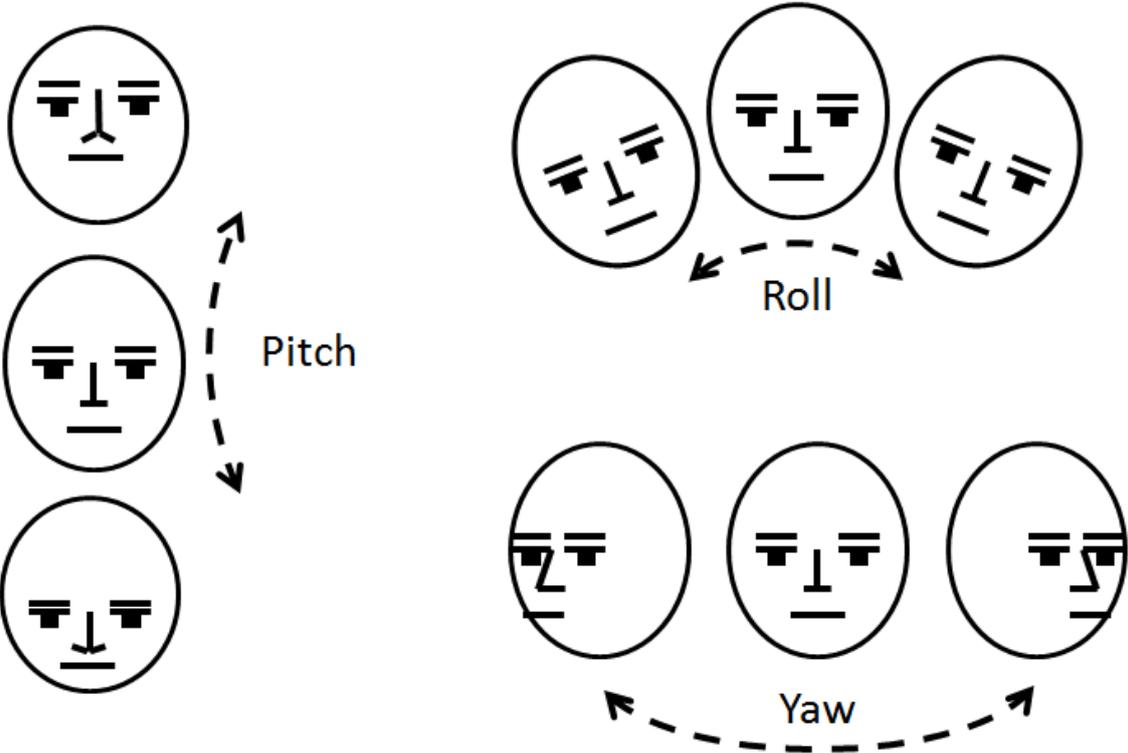
*Experiment set-up for Study 3.*



The experimental area for the participants (top picture), and computer, speakers, and video cameras were located behind the monitor screens (bottom picture).

Appendix M.

Three different head poses identified in CERT used in Study 3.



## Appendix N.

*Demographic data of participating dogs in the Study 4.*

No	Dog breed	Sex	Spayed/ Neutered	Age	Condition	Inclusion	Number of other dogs in home	Other people than owner in home	Children $\leq$ 12 years in home
1	English Setter Staffordshire Terrier /	f	Yes	3.39	Crying	Yes	1	Yes	No
2	Rottweiler cross Long haired	m	Yes	2.79	Crying	Yes	0	No	No
3	Weimaraner	m	Yes	3.43	Crying	Yes	1	Yes	No
4	Labrador	f	Yes	3.52	Crying	Yes	2	Yes	No
5	Lab cross Huntaway /	f	Yes	4.43	Crying	Yes	1	No	No
6	Staffordshire Terrier	m	Yes	4.61	Crying	Yes	0	Yes	Yes
7	Border Collie	f	No	6.62	Crying	Yes	1	Yes	No
8	Stafford bull terrier	f	Yes	5.60	Crying	Yes	0	Yes	Yes
9	Collie- retriever cross American Red-nose	f	No	2.39	Crying	Yes	1	Yes	No
10	pitbull	f	Yes	5.47	Crying	Yes	1	No	No
11	Border Collie	m	Yes	3.16	Crying	Yes	1	No	No
12	Labrador	m	No	2.03	Crying	Yes	0	Yes	No
13	Labrador Retriever	f	Yes	10.14	Crying	Yes	2	Yes	No
14	Spoodle	m	Yes	4.34	Crying	Yes	0	Yes	No
15	Golden Retriever	m	Yes	9.61	Crying	Yes	0	Yes	No
16	Belgian Shepherd	f	No	1.17	Crying	Yes	2	Yes	No
17	Collie / Husky /	m	No	1.60	Crying	Yes	4	No	No

Heading									
18	Labrador	f	Yes	2.75	Crying	Yes	0	No	No
19	Huntaway cross	m	Yes	1.36	Crying	Yes	0	Yes	No
20	Red heeler cross	f	Yes	9.57	Crying	Yes	1	Yes	No
21	Collie foxy cross	m	Yes	3.86	Crying	Yes	1	Yes	No
22	Labrador	m	Yes	8.00	Crying	Yes	0	Yes	No
23	Boxer lab cross	f	Yes	4.10	Crying	Yes	0	No	No
24	Labrador cross	f	Yes	7.25	Crying	Yes	0	Yes	Yes
25	Boxer	f	Yes	6.16	Crying	No	1	Yes	No
26	Black lab / hunteraway	m	Yes	6.36	Crying	No	2	Yes	Yes
27	Golden Retriever	f	Yes	4.25	Crying	No	2	Yes	No
28	Golden Retriever	f	Yes	1.30	Crying	No	1	No	No
29	Golden Retriever	m	Yes	4.27	Crying	No	2	Yes	No
30	Border Collie / Kelpie Cross	f	Yes	9.07	Crying	No	0	Yes	No
31	Labrador / Staffordshire Terrier	m	Yes	4.88	Crying	No	2	Yes	No
32	Collie blue heeler cross	m	Yes	6.92	Crying	No	1	Yes	No
33	Border Collie	f	Yes	8.82	Crying	No	7	Yes	No
34	English Setter	m	Yes	9.28	Babbling	Yes	1	Yes	No
35	Labrador / Huntaway / Beagle cross	f	Yes	2.22	Babbling	Yes	1	Yes	No
36	Labrador	f	Yes	10.45	Babbling	Yes	0	Yes	No
37	Border Collie	f	Yes	1.21	Babbling	Yes	7	Yes	No
38	Border collie / German Shepherd	f	Yes	8.96	Babbling	Yes	0	Yes	No

	cross								
39	Australian Shepherd Border collie/ Siberian	m	Yes	2.72	Babbling	Yes	0	Yes	Yes
40	Husky	m	Yes	3.62	Babbling	Yes	1	Yes	Yes
41	Labrador	f	Yes	2.37	Babbling	Yes	0	Yes	No
42	Labrador	f	Yes	3.19	Babbling	Yes	0	No	No
43	Labrador / Huntaway	m	Yes	5.38	Babbling	Yes	2	Yes	No
44	Corgi American Red-nose	f	Yes	2.63	Babbling	Yes	1	Yes	No
45	pitbull	m	No	5.47	Babbling	Yes	1	No	No
46	Labrador Bearded collie /	f	Yes	3.68	Babbling	Yes	2	Yes	No
47	border collie x	m	Yes	1.47	Babbling	Yes	0	Yes	No
48	Border Collie	m	Yes	8.37	Babbling	Yes	1	No	No
49	Border collie cross German Shepherd X	m	Yes	9.47	Babbling	Yes	1	Yes	No
50	Greyhound	m	No	7.81	Babbling	Yes	7	Yes	No
51	Labrador Retriever German Shepherd X	f	No	3.43	Babbling	Yes	2	Yes	No
52	Greyhound	m	No	1.42	Babbling	Yes	7	Yes	No
53	Border Collie	f	No	5.49	Babbling	Yes	7	Yes	No
54	Hungarian Vizsla	m	No	3.40	Babbling	Yes	2	Yes	No
55	Border collie cross	m	Yes	3.11	Babbling	Yes	0	Yes	No
56	Lab cross German wire-haired	f	Yes	1.29	Babbling	Yes	1	Yes	No
57	pointer	m	Yes	3.54	Babbling	Yes	0	Yes	Yes
58	Labrador	f	Yes	6.97	Babbling	Yes	0	Yes	No
59	Labrador	m	No	10.39	Babbling	Yes	0	Yes	Yes

60	Australian Shepherd	m	Yes	0.88	Babbling	Yes	0	Yes	Yes
61	Border terrier cross Jack Russell / Fox	f	No	2.03	Babbling	No	1	Yes	No
62	terrier	f	No	0.84	Babbling	No	1	Yes	Yes
63	Golden Retriever	m	Yes	6.88	White Noise	Yes	1	No	No
64	Black lab Collie / Husky /	f	Yes	8.44	White Noise	Yes	0	No	No
65	Heading	m	Yes	4.55	White Noise	Yes	4	No	No
66	Scottish deerhound	m	Yes	10.28	White Noise	Yes	3	Yes	No
67	Black lab foxy, bordie collie,	m	Yes	7.86	White Noise	Yes	1	Yes	Yes
68	heading, spaniel	f	Yes	3.13	White Noise	Yes	0	Yes	No
69	Labrador Chesapeake Bay	m	No	5.50	White Noise	Yes	0	Yes	No
70	Retriever Border Collie/Huntaway/Labr	m	No	9.64	White Noise	Yes	1	Yes	No
71	ador	f	Yes	7.31	White Noise	Yes	0	No	No
72	Boxer	m	Yes	10.38	White Noise	Yes	1	Yes	No
73	Border Collie	f	Yes	10.36	White Noise	Yes	7	Yes	No
74	French mastiff	f	Yes	2.21	White Noise	Yes	0	Yes	No
75	Lab / collie German Shepherd X	f	Yes	1.14	White Noise	Yes	0	Yes	Yes
76	Greyhound	f	No	1.38	White Noise	Yes	7	Yes	No
77	English labrador German Shepherd X	f	Yes	5.22	White Noise	Yes	1	Yes	No
78	Greyhound	f	No	5.43	White Noise	Yes	7	Yes	No
79	German Shepherd	f	No	3.42	White Noise	Yes	7	Yes	No

80	Bearded collie	m	No	1.41	White Noise	Yes	1	Yes	No
81	Standard Poodle	f	Yes	7.72	White Noise	Yes	0	Yes	No
82	Beardie collie cross	m	Yes	2.94	White Noise	Yes	1	No	No
83	Lab kelpie cross Border Collie /	m	Yes	8.62	White Noise	Yes	2	Yes	No
84	Huntaway Schnauzer, Staffy and	f	Yes	10.29	White Noise	Yes	1	No	No
85	Labrador	m	Yes	5.08	White Noise	Yes	1	Yes	Yes
86	German Shepherd	f	Yes	4.49	White Noise	Yes	0	Yes	Yes
87	Huntaway X German Short-haired	m	Yes	6.42	White Noise	No	0	Yes	No
88	Pointer American Red-nose	f	Yes	5.12	White Noise	No	1	Yes	No
89	pitbull	f	Yes	8.57	White Noise	No	0	Yes	No
90	Huntaway X Labrador/Greyhound/	f	Yes	6.33	White Noise	No	0	Yes	No
91	collie/bully	f	Yes	2.10	White Noise	No	0	Yes	Yes
92	Border collie	f	Yes	5.01	White Noise	No	0	Yes	No

## Appendix O.

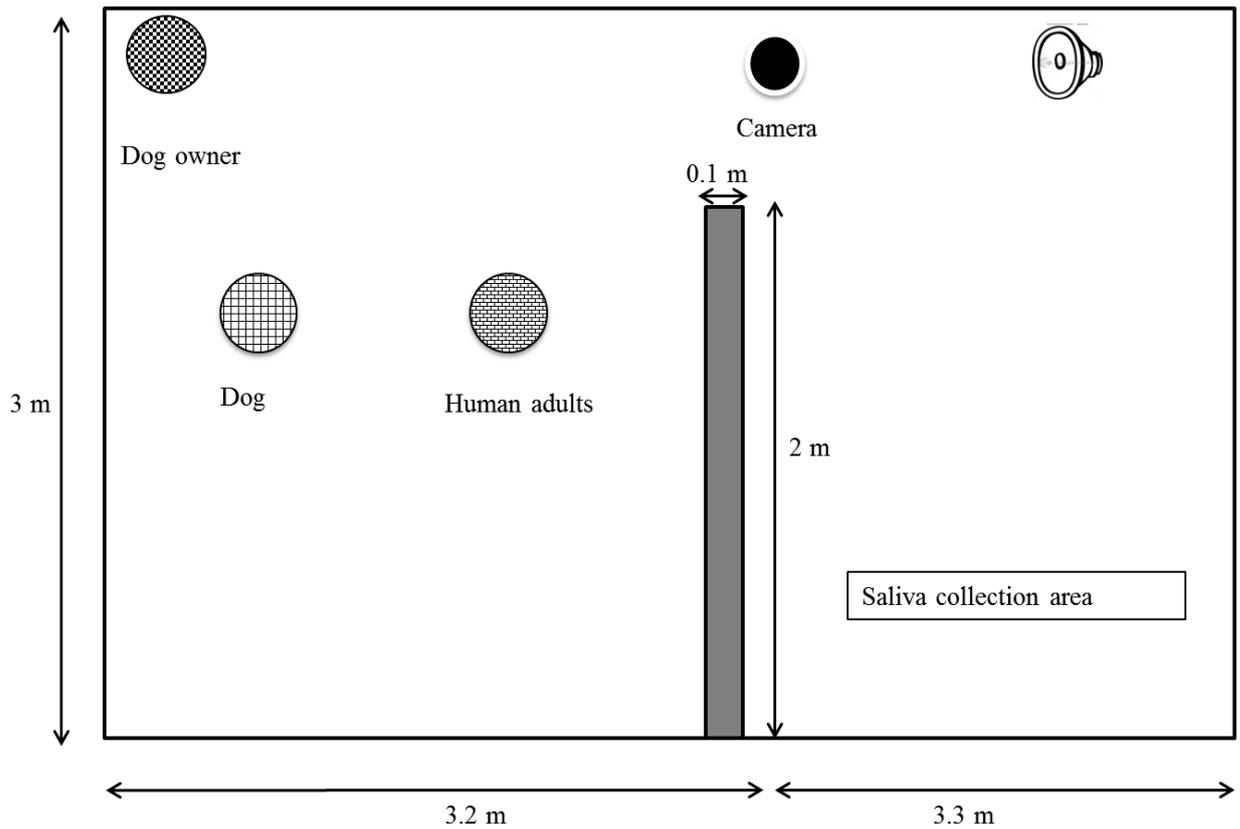
*Demographic data of young adults in Study 4.*

No	Sex	Condition	Age
1	Male	Crying	22
2	Male	Crying	25
3	Male	Crying	19
4	Male	Crying	21
5	Male	Crying	20
6	Male	Crying	22
7	Male	Crying	20
8	Male	Crying	25
9	Male	Crying	25
10	Male	Crying	18
11	Male	Crying	21
12	Male	Crying	20
13	Female	Crying	22
14	Female	Crying	18
15	Female	Crying	21
16	Female	Crying	19
17	Female	Crying	25
18	Female	Crying	22
19	Female	Crying	24
20	Female	Crying	20
21	Female	Crying	24
22	Female	Crying	19
23	Female	Crying	23
24	Male	Babbling	20
25	Male	Babbling	24
26	Male	Babbling	21
27	Male	Babbling	21
28	Male	Babbling	23
29	Male	Babbling	23
30	Male	Babbling	20
31	Male	Babbling	19
32	Male	Babbling	24
33	Male	Babbling	21
34	Female	Babbling	22
35	Female	Babbling	21
36	Female	Babbling	21
37	Female	Babbling	20

38	Female	Babbling	24
39	Female	Babbling	21
40	Female	Babbling	23
41	Female	Babbling	21
42	Female	Babbling	25
43	Female	Babbling	20
44	Male	White noise	24
45	Male	White noise	24
46	Male	White noise	25
47	Male	White noise	25
48	Male	White noise	19
49	Male	White noise	20
50	Male	White noise	20
51	Male	White noise	21
52	Male	White noise	21
53	Male	White noise	22
54	Male	White noise	19
55	Male	White noise	22
56	Male	White noise	19
57	Male	White noise	18
58	Male	White noise	20
59	Female	White noise	20
60	Female	White noise	20
61	Female	White noise	23
62	Female	White noise	21
63	Female	White noise	23
64	Female	White noise	22
65	Female	White noise	22
66	Female	White noise	22
67	Female	White noise	23
68	Female	White noise	24
69	Female	White noise	19
70	Female	White noise	19
71	Female	White noise	19
72	Female	White noise	21
73	Female	White noise	19
74	Female	White noise	19

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## Appendix P.

*Experiment room set-up in Study 4.*

Dogs were able to move freely in a 3m by 3m room and their owners were present throughout the study. Young adults sat in the middle of experimental area. Saliva collection was done in the adjacent area.