Understanding Fear and Stranger-Directed Aggression in Companion Dogs

by

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ABSTRACT

UNDERSTANDING CANINE FEAR AND STRANGER-DIRECTED AGGRESSION

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Stranger-directed aggression is both a public safety and animal welfare concern. The objectives of this thesis were to identify risk factors for stranger-directed aggression in dogs, to assess the effect of targeted owner training on the accuracy of ratings of fear in dogs, and to identify behaviours associated with fear in puppies. Risk factors for stranger-directed aggression were first analyzed using an existing dataset of responses to the Canine Behaviour Assessment and Research Questionnaire (C-BARQ). Fear of strangers, non-social fear, sex and neuter status, age at evaluation, age acquired, where acquired, and breed group were significantly associated with stranger-directed aggression. There was also correlation in this behaviour among dogs from the same participant and country (n=14,310 dogs; 10,951 participants; 67 countries). To further explore the similarities from dogs with the same owner, a survey including the C-BARQ, as well as additional questions relating to dog characteristics, temperament, training, environment and owner demographics and personality was distributed. Dogs' stranger-directed aggression scores were significantly associated with fear of strangers, impulsivity, sex, reason for neutering, training methods, history of abuse, quantity and quality of socialization as a puppy, where kept when left alone, how exercised, breed group, owner extroversion, and whether owners could accurately identify the absence of aggression from videos (n=2,760 dogs; 2,255 households). As fear was found to be associated with stranger-directed aggression, it is important that owners are able to accurately recognize it in dogs. Using a targeted training tool, based on fear behaviours owners were able to reliably identify, recognition of mild to severe fear in videos of dogs improved, but owner ratings of their own dogs' fearfulness were not consistently altered. Finally, to identify fear behaviours shown by puppies, an approach/avoidance test

was developed and used to categorize puppies' responses to fear-provoking stimuli. Lowered posture, lowered tail, freezing, flinching, retreating, barking, and paw lifting were found to increase with non-social fear in puppies. These results can help with identification of dogs at risk of developing stranger-directed aggression, and can direct owners to appropriate training and prevention strategies.

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My sincerest thanks go to all the volunteers and research assistants who helped me with data collection. I must also thank all the dog owners whose participation was essential for this project. My thanks to them enduring my long surveys, or bringing in their puppies to be exposed to fear-inducing situations. I would like to thank my friends in the OVC companion animal behaviour and welfare lab. Their support, advice, and numerous coffee breaks, have been invaluable in getting me through my PhD. My sanity would not be intact without them. Further, I would like to thank my family. Without their support, and thoughtful debates on dog behaviour and psychology, my thesis would not be what it is today. Most importantly, I would like to thank my dog Ripley for his patience being a pilot dog, and model, for my studies. He has given me great insight and appreciation for the complexities of dog behaviour, and furthered my passion for this field.

STATEMENT OF WORK

Through the advisement of, and collaboration with, Drs. Lee Niel and Jason Coe, and on-going discussion with members of her advisory committee, Drs. James Serpell and David Pearl, Hannah Flint designed the studies and conducted the analyses for the research in this thesis.

Chapter 1: Literature Review

Hannah Flint reviewed multiple databases for literature relevant to the topics of study. The literature review was written by Hannah Flint under the guidance of Drs. Lee Niel and Jason Coe. Additional input and revisions were provided by Drs. James Serpell and David Pearl.

Chapter 2: Risk factors associated with stranger-directed aggression in domestic dogs

Access to an existing C-BARQ database was provided by Dr. James Serpell. Hannah Flint performed all statistical analysis with advisement from Dr. David Pearl. The first draft of the manuscript was written by Hannah Flint. This draft was reviewed by Drs. Lee Niel and Jason Coe. Additional input and revisions were received from Drs. James Serpell and David Pearl.

Chapter 3: Effect of targeted training on dog owners' ratings of fear in familiar and unfamiliar dogs

In collaboration with, and with advisement from, Drs. Lee Niel and Jason Coe, Hannah Flint designed the methodology and wrote all the study material. Hannah Flint assembled a collection of behavioural videos through recruitment of local dog owners, and through videos collected by Jacquelyn Jacobs from local humane societies with assistance from research assistants. In addition, Hannah Flint contacted Sue Sternberg, a dog trainer, for additional videos of severe fear reactions, which she supplied. Hannah Flint sorted and edited these videos and prepared them for distribution via online questionnaires with the assistance of research assistants. Hannah Flint conducted all participant recruitment through e-mails to dog behaviour experts, and social media. Hannah Flint coded responses, cleaned and organized all data, and performed all statistical analyses with advisement from Dr. David Pearl. The first draft of the manuscript was written by Hannah Flint. This draft was reviewed by Drs. Lee Niel and Jason Coe. Additional input and revisions were received from Drs. James Serpell and David Pearl.

Chapter 4: Stranger-directed aggression in pet dogs: Owner, environment, training and dog associated risk factors

In collaboration with, and with advisement from, Drs. Lee Niel, Jason Coe, David Pearl and James Serpell, Hannah Flint designed the methodology and wrote all the study material. Hannah Flint conducted all participant recruitment via social media. Hannah Flint coded responses, cleaned and organized all data, and performed all statistical analysis with advisement from Dr. David Pearl. The first draft of the manuscript was written by Hannah Flint. This draft was reviewed by Drs. Lee Niel and Jason Coe. Additional input and revisions were received from Drs. James Serpell and David Pearl.

Chapter 5: Identification of fear behaviours shown by puppies in response to social and non-social stimuli

In collaboration with, and with advisement from, Drs. Lee Niel and Jason Coe, Hannah Flint designed the methodology and wrote all the study material. Hannah Flint conducted all participant recruitment through local puppy training classes, distribution of recruitment flyers to local pet stores and veterinarians and via social media. Hannah Flint conducted all behavioural testing with the help of volunteers and research assistants. Hannah Flint developed an ethogram, edited and coded all videos, cleaned and organized resulting data, and performed all statistical analyses with advisement from Dr. David Pearl. The first draft of the manuscript was written by Hannah Flint. This draft was reviewed by Drs. Lee Niel and Jason Coe. Additional input and revisions were received from Drs. James Serpell and David Pearl.

Chapter 6: Conclusion and general discussion

The first draft of the chapter was written by Hannah Flint. This draft was reviewed by Dr. Lee Niel. Additional input and revisions were received from Drs. Jason Coe, James Serpell, and David Pearl.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

Introduction, literature review, rationale and objectives

1.1 Introduction

Dogs are an integral part of the lives of many households. One study found that 80% of owners in the U.K. spontaneously described their dogs as family members (Hirschman, 1994). A recent survey found that 34% of households in Canada report owning a dog, for an estimated total of 6.4 million dogs (Canadian Animal Health Institute, 2015). This is similar to reports from other developed countries with 36.5% and 24% of households owning dogs in the U.S. and U.K., respectively (American Veterinary Medical Association, 2012; Pet Food Manufacturers' Association, 2016). Dog ownership has been shown to have numerous benefits, both for physical and psychological health (Cutt et al., 2007; Knight and Edwards, 2008). However, owners have certain expectations of their dogs' behaviour (Meyer and Forkman, 2014), and when dogs fail to meet these expectations it can lead to damage to the human-animal relationship and possibly even relinquishment or euthanasia of the animal (Salman et al., 2000, 1998; Serpell, 1996). One of the major causes identified for dog relinquishment to shelters is aggression (Salman et al., 2000, 1998).

Historically, aggression has been categorized based on the assumed internal motivation of the dog. These categories typically included territorial, possessive, fear-related, and dominance aggression, among others (Blackshaw, 1991; Borchelt, 1983). A desire for more objective classifications has led to more scientific research using target-based classifications, including stranger-directed, owner-directed and dog-directed aggression (e.g., Hsu and Serpell, 2003). Previous research has shown that dogs' aggressive behaviour toward different targets is correlated into distinct factors of stranger-directed, owner-directed, unfamiliar dog-directed and familiar dog-directed aggression (Duffy and Serpell, 2012). It is therefore possible to research dogs with these aggression issues to determine what factors influence their aggressive behaviour toward each target, identify dogs at risk for these behaviours, and implement preventative and rehabilitative strategies.

Stranger-directed aggression is of particular importance, as it is estimated that approximately 1.5% of people in the U.S. are bitten by a dog each year (Gilchrist et al., 2008; Sacks et al., 1996), and over one third of dog bites are directed towards people who have no relationship with the dog (Shuler et al., 2008). There is limited information on the prevalence of non-biting aggression in North America, but one study in the U.K. found that approximately 7% of dog owners report that their dog is aggressive towards strangers entering the house, and 5% of dog owners report that their dog is aggressive towards strangers outside of the house (Casey et al., 2014). Stranger-directed aggression can also reduce animal welfare, as dogs that are aggressive towards strangers are more likely to receive physical punishment (Herron et al., 2009), and are less likely to participate in activities with their owner (Bennett and Rohlf, 2007).

One hypothesis for why dogs act aggressively towards strangers is that the dog may view unfamiliar people as a threat, and therefore any aggression towards these strangers may be motivated by fear. Several studies have found associations between fear and stranger-directed aggression in dogs (Duffy et al., 2008; Goodloe and Borchelt, 1998; Hsu and Serpell, 2003; Matos et al., 2015). In addition, dogs that have a past history of abuse, and might therefore be more likely to view humans as a threat, have been shown to be more likely to be aggressive towards strangers (McMillan et al., 2015). Further, it has been suggested that dogs may learn to act aggressively following forced interactions with strangers who do not recognize or acknowledge the dogs' fear behaviours. It is hypothesized that these dogs may then learn that fear displays are not sufficient and later resort to aggression in order to avoid the situation (Overall, 2013). Therefore, it is vital to fully understand fear behaviour, and its role in aggressive displays in order to prevent and manage stranger-directed aggression.

There are also multiple other factors, relating to dog characteristics and other temperament traits, as well as factors relating to how the dog is trained, housed, and managed that have previously been suggested to cause stranger-directed aggression in dogs. A review of the literature on the identification of canine fear and aggression, as well as risk factors for stranger-directed aggression will provide a foundation for further research into understanding the causes of stranger-directed aggression in dogs.

1.2 What is fear?

Fear, as colloquially defined by the Oxford English Dictionary, is an "apprehensive feeling towards anything regarded as a source of danger, or towards a person regarded as able to inflict injury or punishment" (*Oxford English Dictionary*, 1989). Due to difficulties in measuring feelings in animals, a more objective definition is required for describing this state. A definition proposed by Adolphs (2013) describes fear as a central state "caused by particular patterns of threat-related stimuli, and in turn causing particular patterns of adaptive behaviours to avoid or cope with that threat." This definition separates the emotion of fear from the conscious experience, which can be challenging to measure in non-verbal animals, and allowing fear to instead be measured by the behaviours shown by the animal when threatened. What both of these definitions have in common, is that fear is defined by the presence of a stimulus which is a perceived threat. This is what distinguishes fear from anxiety, which refers to the anticipation of a future danger (Adolphs, 2013). Fear-eliciting stimuli are often described based on one of six different properties: novelty, movement, intensity, duration, suddenness and proximity (Gray, 1987). These stimuli can trigger an innate response based on evolutionary significance, or the fear response could be conditioned or learned based on previous experience. There is some evidence that different stimuli activate different neural pathways. Specifically, different areas of the amygdala are activated for painful stimuli, predatory threats, and conspecific threats (Gross and Canteras, 2012). These differences suggest that animals may have different adaptive responses based on the type of threat presented.

1.2.1 Fear response

The fear response is associated with activation of physiological systems including the sympathetic nervous system (SNS), and the hypothalamic-pituitary-adrenal (HPA) axis. The SNS response involves the release of the catecholamines epinephrine and norepinephrine from the adrenal medulla, which stimulate various bodily systems that prepare the animal for an active response to a threat, including fighting or fleeing (Hydbring-Sandberg et al., 2004). These responses include increased heart rate and increased blood flow to skeletal muscles (Hydbring-Sandberg et al., 2004). The HPA response is activated when the hypothalamus is stimulated to release corticotropin-releasing hormone in response to a stressor. The anterior pituitary gland then releases adrenocorticotropin hormone, which in turn causes the release of cortisol from the cortex of the adrenal gland. Cortisol then has a negative feedback effect, reducing the effects of stress (Mormede et al., 2007). The overall effect of this system is to increase glucose availability, while also narrowing arteries resulting in increased blood pressure (Mormede et al., 2007). These two systems work together to prepare the animal to cope with an imminent threat.

Fear responses also involve activation of behavioural responses, which are often categorized based on the four Fs: fight, flight, freeze, or flirt (Marks, 1987). Fight and flight are the most commonly referenced fear responses, and involve aggressive and avoidance behaviours, respectively. The fight response, while initiated by the same neurobiology and technically a part of the fear response, is generally referred to as its own behavioural response under the term aggression, which is discussed in more detail below. The flight response includes typical avoidance behaviours, such as hiding and fleeing. Freezing refers to the cessation of movement in order to avoid detection or appear dead, while flirt refers to submissive behaviours used in order to appease an aggressor. Behaviours that could be part of the flirt response in dogs include lip licking, paw lifting and avoiding eye contact, as these behaviours have been previously referenced as submissive behaviours (Kuhne et al., 2012), and have also been shown to be associated with fear of social, but not non-social, stimuli (Beerda et al., 1998; Godbout et al., 2007; Stellato et al., 2017). In addition, behaviours such as lowered posture and tail are often reported to be associated with fear (Beerda et al., 1998; Goddard and Beilharz, 1984; Stellato et al., 2017), but it is unclear what behavioural response they are part of, as they could be related to the flirt response if they are performed as submissive behaviours to another animal, or they could be related to the freeze or flight response if they are performed to make the animal less noticeable and aid in avoiding detection in conjunction with the animal either freezing or fleeing. Behavioural indicators of fear are discussed in more detail in Section 1.4.2.

Fear responses can also be classified as active or passive responses. Active responses include fight, flight, and flirt, while freezing is a passive response (Steimer, 2002). Whether or not an animal reacts with an active or a passive response depends on the type and proximity of the stimulus and the availability of an escape route. There are also individual differences that can affect how an animal will react (Steimer, 2002).

1.3 What is aggression?

Aggression is defined by the Oxford English Dictionary as “behaviour intended to injure another person of animal” (*Oxford English Dictionary*, 1989). A similar definition has been proposed by psychologist, Arnold H. Buss, laid out in behavioural terms, rather than motivation or intent. This definition states that aggression is “a response that delivers a noxious stimuli to another organism” (Buss, 1961). Buss further went on to categorize aggression as physical vs. verbal. In physical aggression, the noxious stimuli delivered resulted in pain or injury, whereas in verbal aggression, the noxious stimuli were a rejection or threat (Buss, 1961). Similar categorization can be used in dogs, with aggressive behaviour being grouped into threatening behaviours (i.e., verbal aggression) and severe aggression (i.e., physical aggression). Threatening behaviours in dogs typically include barking, growling and baring teeth, while more severe aggression includes snaps, bites and attempts to bite (Horwitz and Neilson, 2007; Hsu and Serpell, 2003; Landsberg et al., 2013; Overall, 2013).

As mentioned above, aggression shares much of the same neurochemistry as fear, as it is part of the fight or flight response. However, it is not well understood why some animals respond aggressively to a threat, while others attempt to flee in the same situation. In addition, some aggressive responses appear to occur in the absence of fear. Research into aggression in humans has indicated that other neurotransmitters, such as serotonin, dopamine, and GABA, have a role in modulating aggression and impulsivity, but their exact mechanism is unknown (Yanowitch and Coccaro, 2011).

1.4 Importance of recognizing fear and aggression

It is important to recognize both fear and aggression to ensure accurate assessment of the dog’s behaviour and temperament. Dog owners need to correctly identify dog emotional states so that they can interact with their own dog in an appropriate manner. Furthermore, dogs in shelters must undergo assessments for fear and aggression in order to determine their adoptability and to match them to the appropriate adoptive environment. Temperament tests are also used in order to predict the future success of working dogs during training in order to not waste time and resources on puppies that will not continue on to become active working dogs. Additionally, temperament tests are used as part of scientific research, and rely on the accurate assessment of dog fearfulness and aggression in order to obtain valid results.

Canine aggression is most notably important as it is a concern for public health and safety, as mentioned above. In addition, understanding and recognizing fear and aggression in dogs can have significant impacts on animal welfare, both in terms of the immediate effects on the individual, as well as long-term impacts on animal health, welfare, and development of related behaviour problems.

In the short term, fear and aggression can negatively impact animal welfare. This is recognized explicitly by the Farm Animal Welfare Council, as the freedom from fear and distress is one of the five freedoms they outline as important to farm-animal welfare (FAWC, 1992). In addition, behaviour problems such as fear and aggression can be welfare issues as they can lead to the use of aversive training techniques in order to manage a dog's behaviour. For example, the use of positive punishment has been found to be associated with aggression in dogs (Arhant et al., 2010; Blackwell, 2008; Herron et al., 2009; Hiby et al., 2004). However, based on the research to date, it is unclear whether positive punishment is used to manage pre-existing aggression issues, or is the cause of the aggression issues. Finally, aggression can impair the human-animal relationship (Serpell, 1996) and has been associated with an increased risk of relinquishment to shelters (Salman et al., 2000, 1998)

Chronic fear can also indirectly affect animal welfare in the long term through negative impacts on a dog's health and longevity. A retrospective survey-based research project analyzing data for 721 dogs found that dogs identified as fearful towards strangers have shorter lifespans than those that are not fearful after controlling for weight, neuter status and accidental death (Dreschel, 2010). In addition, non-social fear and separation anxiety were found to be correlated with skin disorders in dogs (Dreschel, 2010). Similar effects of fear have also been found in other species. Another study looking at male rats found that rats classified as neophobic died sooner than neophilic rats and were less likely to survive similar disease burdens (Cavigelli and McClintock, 2003).

Chronic fear and aggression issues can also be significant sources of stress for animals. In the human literature, chronic stress has been found to impact health and longevity. One study of 392 caregivers of disabled patients, who experienced high levels of emotional strain, found that they had increased mortality compared to 427 non-caregiving controls (Schulz and Beach, 2014). Chronic stress has also been linked to an increased risk of a number of health issues in humans, including obesity, insulin resistance, cardiovascular disease, immune disturbances, altered endocrine response and nervous system disorders (McEwen, 2004). The exact mechanism for how chronic fear and stress impact health and longevity is not known, but it is often attributed to additional strain on the bodily systems caused by an overactive stress response (McEwen, 2004). One study compared peripheral blood mononuclear cells from 39 women with high levels of stress, based on being caregivers to chronically ill children, to 19 control mothers with lower stress levels. This study found women with higher levels of stress had increased oxidative stress, lower telomerase activity, and shorter telomere length, all of which are indicators of aging and early cell death (Epel et al., 2004).

While these changes are typically associated with chronic stress, there can also be serious negative consequences from a single major stressor (Koolhaas et al., 1997). A traditional review of evidence from animals in natural habitats found that a single major stressor can cause long-term neurochemical changes, and can sensitize the animals to future stressors (Koolhaas et al., 1997). This has also been seen in humans, where a single major life event can lead to depression, cardiovascular disease, anxiety-disorders and immune system-related disorders (Koolhaas et al., 1997).

Finally, if fear issues are not addressed they can worsen and develop into additional behavioural issues. It is normal for dogs to respond fearfully to a given stimulus if they perceive it is a threat. However, if these fears are not recognized and addressed they sometimes become generalized into more severe phobias towards the stimulus itself, or even the environment in which the dog had previously encountered the stimulus (Rogerson, 1997). In addition, it has been hypothesized that dogs may learn to act aggressively if their fear responses are not recognized in order to avoid interacting with a stimulus, such as an unfamiliar dog or person (Horwitz and Neilson, 2007; Landsberg et al., 2013; Overall, 2013). This hypothesis is supported by the fact that previous studies have found associations between fear and stranger-directed aggression (Duffy et al., 2008; Goodloe and Borchelt, 1998; Hsu and Serpell, 2003;

Matos et al., 2015). Further, it is suggested that if a dog's threatening signals, such as growling, are frequently ignored, or punished, they may learn to escalate their aggression to actual bite attempts (Horwitz and Neilson, 2007; Landsberg et al., 2013; Overall, 2013).

1.5 Measuring fear and aggression

Fear and aggression can be measured through physiological measures indicating activation of the SNS or HPA axis, as well as through behavioural measures, including behavioural scoring, temperament tests and owner reports.

1.5.1 Physiological measures

While physiological measures are similar between fear and aggression due to the shared neurobiological mechanism, they are generally used as indicators of fear or stress, with aggression being identified solely by its behavioural response. Physiological measures of fear include indicators of sympathetic activity, such as catecholamines and cardiovascular activity, as well as indicators of activation of the HPA axis, such as high levels of cortisol.

Beerda et al. (1997) reviewed a number of different behavioural and physiological responses shown by dogs in response to acute and chronic stress. They identified catecholamines, such as epinephrine and norepinephrine, and altered cardiovascular responses as indicators of an activated sympathetic response. Elevated catecholamine levels have been reported in necropsies of rats following a fear-potentiated startle response (Shekhar et al., 1994). However, their use in scientific research is generally limited, as the process of drawing blood to measure catecholamines is sufficient to trigger the sympathetic response (Beerda et al., 1997). In addition, Beerda et al. (1996) found that urinary catecholamine measures were not reliable measures of stress in dogs, and therefore may not be a viable non-invasive alternative. It is instead recommended that cardiovascular responses, such as blood pressure or heart rate be used as potential non-invasive measures of sympathetic activity (Beerda et al., 1997).

An increase in heart rate has been found to be associated with fear responses in dogs in several studies (Beerda et al., 1998; Hydbring-Sandberg et al., 2004; King et al., 2003; Ogata et al., 2006;

Schalke et al., 2007). Another cardiovascular measure, heart rate variability, has also started coming into common use. This measure compares the relative contribution of the sympathetic system, which results in a high-frequency component (0.15-0.50 Hz), and the vagal nerve, which results in a low-frequency component (<0.15 Hz) (Berntson et al., 1997). In dogs at rest, the vagal nerve predominates, while dogs exposed to stressors show higher contributions of the sympathetic system (Berntson et al., 1997). This measure has been successfully used to differentiate between dogs experiencing different levels of stress (Bergamasco et al., 2010; Kuhne et al., 2014). Finally, elevated blood pressure has been associated with exposure to cat-scent, a naturally fear-inducing stimulus in rats (Dielenberg et al., 2001). This measure has also been shown to be increased during stress-inducing situations in dogs (Kuhne et al., 2012; Schalke et al., 2007).

Activation of the HPA has also been used as a potential measure of fear. Specific indicators of activation of the HPA axis, such as cortisol, can be measured either through the blood, or through less invasive measures, such as saliva, and have been found to be reliable measures of stress (Beerda et al., 1997, 1996; Vincent and Michell, 1992). Studies measuring fear in dogs have reported successful use of salivary (Bergamasco et al., 2010; Dreschel and Granger, 2005; Schalke et al., 2007), and plasma cortisol (Beerda et al., 1998; Dess et al., 1983; Hennessy et al., 1998) as a stress indicator. However, care needs to be taken with the use of salivary cortisol as the method of collection, volume of saliva sampled, use of salivary stimulants and food contamination can all affect results (Dreschel and Granger, 2009). In addition, indicators of activation of the HPA axis are non-specific to fear, and therefore may have issues with false-positives if dogs are aroused for other reasons, such as excitement.

1.5.2 Behavioural measures

Fear and aggression can be measured directly through scoring of the related behavioural responses, and fear can also be assessed through indirect measures, such as latency to approach a stimulus, and time spent near a stimulus. Fearfulness and aggressiveness have also been measured through canine temperament tests. These tests generally involve either directly observing and assessing the dog during a battery of artificially created scenarios, or assessing dog responses to different scenarios through owner-completed evaluations.

Behavioural observation

While many studies use behaviour scoring to assess fear (as reviewed by Overall, 2014), few studies have validated which behaviours are associated with fear responses in dogs, and in what situations they are performed by dogs in response to fear. Beerda et al. (1998) studied 10 laboratory dogs of both sexes, and varying breeds and ages, in order to determine what behaviours dogs perform in response to different stimuli. Dogs were habituated to an experimental room before being exposed to six different stimuli over two consecutive days. This study found that while extreme lowered posture was associated with stimuli not directly involving the experimenter (i.e., a garbage bag full of paper falling into the run with the dog, a loud sound blast, a series of three electric shocks), stimuli that involved administration by the experimenter (i.e., experimenter forced dog to floor by pressing on neck and shoulder, dog pulled to the floor via a rope around its neck, experimenter opened an umbrella while pointing it at the dog) were associated with moderately lowered posture, restlessness, body shaking, oral behaviours, yawning and open mouth. During these stimuli, the experimenter wore a striking outfit, and the stimuli were paired with a distinctive odour that may have made their occurrence more predictable than the stimuli without the experimenter present. The differences in behaviours shown between these types of stimuli could therefore be related to the relative severity or predictability of the stimuli, or it could be that the social nature of the stimuli elicited responses related to the flirt response directed at the experimenter. Another study looking to validate fear behaviours in response to milder stimuli found similar results. Stellato et al. (2017) analyzed the behavioural responses of 31 owned pet dogs to social and non-social stimuli. Dogs were given time to habituate to an outdoor pen, before being presented with three trials: neutral (i.e., no stimulus), social (i.e., approach of a threatening stranger wearing a cape and mask) and non-social (i.e., sudden appearance of a falling garbage bag full of paper). The dogs' behaviours were scored when the stimulus first appeared, then during an approach period where each dog was given the opportunity to approach and interact with the stimulus. The researchers categorized the dogs' responses to the appearance of the stimuli as freeze, fear (i.e., displayed lowered posture or avoidance behaviours), or no fear. The study found that dogs whose behavioural responses were categorized as fear were not significantly more likely to freeze than those whose behavioural responses were not categorized as fear. This suggests that freezing and "fear" are two separate responses to fear-eliciting stimuli. In addition, the occurrence of subtle fear behaviours (i.e. lip licking, yawning, body shaking, whining, panting, paw lifting) were only associated with fear during the approach towards the social stimulus. The occurrence of subtle fear behaviours was not associated with the non-social stimulus, or the appearance of the social stimulus. This could suggest that these subtle behaviours fall into a different category of the fear response, such as flirting.

Recognition of fear is especially crucial in puppies, as it is important that owners recognize and avoid fear in order to facilitate positive experiences and promote normal behavioural development (Overall, 2013). In addition, many service dog organizations use various temperament tests in order to assess the suitability of puppies to continue training as service dogs (e.g., Goddard and Beilharz, 1986, 1984). Despite this, there is little research into when specific fear behaviours develop in puppies, and whether young puppies show the same range of behavioural responses as adult dogs. One study has looked at behaviours shown by puppies during a mock veterinary appointment (Godbout et al., 2007). This study recorded the behaviours shown by 102 puppies, aged eight to sixteen weeks, while free to explore the room on the floor, while being physically examined on the table, and while being physically examined on the floor. This study reported that puppies yawned, lip licked and panted more while being examined, when compared to the floor exploration period, but this difference was not analyzed statistically. The study also reported that older puppies spent significantly more time exploring the environment rather than interacting with the examiner, but there was no statistically significant difference in the other behaviours measured. These results indicate that while yawning, lip licking and panting behaviours do occur in puppies aged eight to sixteen weeks, their relationship to fear, as well as at what age they develop is still unclear. Further research is needed in order to determine when different fear behaviours develop in dogs.

Fear can also be measured through indirect measures of avoidance behaviours, such as latencies to approach, and time spent near a stimulus. A number of paradigms have been developed to assess fear in laboratory species, and some have been adapted for dogs. One of these paradigms is the elevated plus-maze, which has been validated for use in measuring fear in mice (Lister, 1987). This maze consists of two open arms and two closed arms and is based on the premise that animals are fearful of height and open spaces. Animals can be assessed on their level of fear based on the latency to enter, number of entries, and time spent in each of the arms. This paradigm has been used by King et al. (2003) for measuring fear in dogs, and while they found that dogs spent significantly less time in the open arms, they noted that the most useful measure for identifying fearful dogs was the latency to move from the centre of the maze, based on its correlations with other fear measures. However, when King et al. used another paradigm developed for use in mice, the light/dark box (Hascoët and Bourin, 2009), they found this set-up was not successful in eliciting fear in dogs, likely due to differences in behavioural biology. This paradigm is based on rodents' innate aversion to brightly lit areas, most likely due to their nature as a prey species. This paradigm may not have been successful in dogs, as they are a predatory species, and fear of bright lights may not be biologically relevant. Finally, King et al. (2003) also measured latency to approach, and time spent in proximity to novel and startling stimuli in order to assess fearfulness in dogs. They found that an increased latency to approach the object was associated with an increase in cortisol. However, the researchers noted that some dogs showed playful or predatory responses to the stimuli which may have confounded the assessment of fear.

Aggression is typically measured through direct behavioural observation. Indicators of aggression in the scientific literature vary between studies, but generally include growling, exposing teeth, lunging, snapping, biting, or attempting to bite (Bennett et al., 2012; Christensen et al., 2007; Mornement et al., 2014, 2010; Weiss, 2007). Some studies also include other behaviours that might be associated with aggression including freezing, stiff body, tail up, ears forward, eyes hard, mouth closed with lips pursed and barking (Christensen et al., 2007; Weiss, 2007).

Temperament

Temperament can be defined as a set of personality traits that appear in infancy and remain relatively stable throughout an animal's life (Buss and Plomin, 2014). A number of different tests have been developed to assess temperament in dogs, both in person (e.g., Asher et al, 2013; Mornement et al., 2014; Netto and Planta, 1997; Sinn et al., 2010; Svartberg and Forkman, 2002; Valsecchi et al., 2011; van der Borg et al., 2010; Weiss, 2007; Wilsson and Sinn, 2012), and through owner-completed surveys (e.g., Goodloe and Borchelt, 1998; Hsu and Serpell, 2003; Ley et al., 2009). One example, the Dog Mentality Assessment (DMA), was developed for the assessment of working dog temperament and requires a trained observer to rate the severity of a dog's reaction based on 33 different behavioural variables (e.g., aggressive behaviour, startle reaction, avoidance behaviour) relating to 10 different scenarios (e.g., sudden appearance of a stranger, gunshot, small rapidly moving object). Factor analysis of DMA behavioural data collected from 15,329 dogs found five distinct canine personality traits: "Playfulness", "Curiosity/Fearfulness", "Chase-proneness", "Sociability" and "Aggressiveness" (Svartberg and Forkman, 2002). However, other factor analyses using owner evaluations of canine temperament have identified larger numbers of canine temperament traits. Goodloe and Borchelt (1998) used a questionnaire asking about responses to 127 different scenarios and reported 22 different factors, including four different aggression factors (i.e., aggression towards family members, strangers, unfamiliar dogs and biting) and three factors relating to social fear (i.e., fear or avoidance of strangers, friendliness, submission). Similarly, Hsu and Serpell (2003) used a questionnaire asking about responses to 152 different scenarios and identified 11 different factors, including two aggression factors (i.e., stranger-directed and owner-directed aggression), three fear factors (i.e., stranger-directed fear, non-social fear and pain sensitivity), and one factor combining fear and aggression (i.e., dog-directed fear or aggression). These differing number of temperament traits are likely due to a larger number of scenarios being analyzed in owner-completed surveys. Owner reports allow for a more nuanced view of dog temperament, as owners are able to provide a more comprehensive report covering specific scenarios that cannot be easily measured during an in-person behavioural test.

Temperament tests

Temperament tests are often used in scientific research, to assess fear and aggression in canines as well as overall temperament. In addition, temperament tests are often used by shelters and service dog organizations in order to predict a dog's future behaviour. Taylor and Mills (2006) reviewed current literature of temperament tests and emphasized the need for standardization, as well as accurate measurements of test reliability and validity. In particular, validity, or whether or not behavioural tests provide a true measure of a dog's temperament, is often overlooked, as a dog's reaction in an artificial situation at a single time point may not be reflective of its overall temperament (Taylor and Mills, 2006).

In-person behavioural tests

In person behavioural tests are commonly used by shelters and service dog organizations in order to predict a dog's future behaviour. For example, one of these tests, the DMA, has been used in a variety of different studies and has been shown to have good test re-test reliability with two separate test sessions separated by a month, although severity of reactions for fearfulness and aggressiveness were lower at time two suggesting novelty is an important aspect of these measures (Svartberg et al., 2005). Use of the DMA in working dogs has indicated that a certain threshold of boldness on the continuum is predictive of success, with few dogs scoring under the threshold being successful at high levels of performance (Svartberg and Forkman, 2002). A study comparing the results of the DMA to a survey completed by owners about their dogs' behaviours one to two years later found that "Playfulness", "Curiosity/Fearfulness" and "Sociability" had good construct validity as they were associated with corresponding measures on the owner-completed survey. "Chase-proneness" was found to be correlated with the survey measures of human-directed play and non-social fear, but not predatory behaviour. "Aggressiveness" had low associations with all the factors from the survey, but this could be due to the DMA combining aggressive behaviours in a variety of contexts, while the survey separated aggression into owner-directed, stranger-directed and dog-directed aggression. These results indicate that the DMA is successful at measuring stable personality traits relating to play interest with humans, attitude towards strangers, and non-social fearfulness (Svartberg, 2005). They also further indicate the importance of separating aggression into different forms based on the target.

Another example of a common temperament test is the Safety Assessment For Evaluating Rehoming (SAFER™). This test is specifically designed to evaluate a dog's suitability to be rehomed, and measures aggressiveness towards people in different situations, including handling, over-arousal, food or toy possession and introduction to dogs, but does not measure aggression towards strangers. Dogs are given a score based on detailed behavioural descriptions for each subtest ranging from loose body language to attempts to bite. The dogs are then categorized based on the level of aggressive behaviour displayed, and the categories include no issue, some concerning behaviours, recommend behavioural modification, or test terminated due to safety concerns (Weiss, 2007). One study assessing the SAFER™, and another shelter evaluation, the Assess-A-Pet™, indicated that these tests have poor to moderate levels of sensitivity and specificity, and are especially inaccurate at assessing dogs with borderline levels of aggression (Bennett et al., 2012). However, other research in Australia has indicated that a majority of shelters do not use standardized evaluations, but instead use in-house developed behavioural tests with unknown levels of accuracy (Mornement et al., 2010). Christensen et al. (2007) reported that 40.9% of dogs that had passed a modified version of the Assess-A-Pet™ temperament test in the shelter exhibited aggressive behaviour, including lunging, growling, snapping or biting, in the adoptive home, indicating that certain types of aggression (i.e., territorial, predatory and intra-specific aggression) may not be accurately assessed in the shelter. Another behavioural test, the Socially Acceptable Behaviour (SAB)-test, used by the Dutch Kennel Club for selecting non-aggressive dogs for breeding purposes was found to have varying levels of sensitivity and specificity depending on the criteria used to classify dogs as aggressive (i.e., threatening behaviours, single bite attempt, multiple bite attempts), and the types of aggression they displayed (van der Borg et al., 2010). For example, using a criteria of multiple bite attempts raised the specificity, but decreased sensitivity compared to single bite attempts, or only threatening behaviours. In addition, there was a high rate of false negatives in dogs that showed territorial aggression at home, suggesting the test does not adequately assess all types of aggression. Another study using a similar behavioural test for breeding programs, with the inclusion of a subtest where the test-person feigns breaking into a dog's car, found significant correlations between a dog's score on the test and its aggression history (Netto and Planta, 1997). These results highlight the target- and situation-specific nature of aggression, and emphasize the importance of using tests and assessments that differentiate between these forms of aggression.

Other behavioural tests have also been assessed for reliability and validity, as well as their ability to predict future behaviour. While some studies report behavioural tests were successful in predicting future success as a working dog (Asher et al., 2013; Wilsson and Sinn, 2012), another study reported high inter-rater reliability, but that test-retest reliability decreased with increasing time interval and predictive value was poor (Sinn et al., 2010). When looking at a temperament test for shelter dogs, Valsecchi et al. (2011) found adequate levels of intra- and inter-observer reliability, and also found that results obtained while the dog was in the shelter were correlated with results from the same test performed in the dog's new adoptive environment. It is not clear whether these results can be generalized to the dog's everyday behaviour. Mornement et al. (2014) found high levels of inter-rater reliability, with a different in-shelter test used in Australia known as the B.A.R.K. (behavioural assessment for re-homing K9s), but test-retest reliability was relatively weak. In addition, amongst dogs who passed the tests and were subsequently returned, the predictive validity for all the measures except for 'fear' and 'friendliness' were poor. These studies highlight the importance of assessing the reliability and validity of temperament tests before using the results to predict future behaviour, especially when using responses to artificial situations to predict behaviour in a home environment.

Owner reports

Recently, researchers have been using indirect owner reports in order to study dog temperament and behavioural issues. These surveys may offer greater validity, as they are based on multiple observations made by the owner over an extended period of time. In addition, owner completed reports are more convenient, able to reach a broader population, and are time and cost efficient when compared to animal-present behavioural evaluations (Hecht and Spicer Rice, 2015). This method has been criticized as the ratings are more subjective and prone to bias based on the experience and other characteristics of the owners (Meagher, 2009). It has been shown that subjective ratings can be as effective as behavioural tests for predicting success in working dogs when performed by an experienced dog trainer (Wilsson and Sinn, 2012). Other studies have found that dog owners with varying levels of experience are able to accurately rate aggressiveness in videos of dogs (Jacobs et al., 2017b; Mirkó et al., 2013). However, other results suggest that dog owners may under-report aggressiveness in their own dog when compared to ratings of naïve observers (Mirkó et al., 2013). Some researchers have examined the ability of dog owners to categorize different dog emotions, or behavioural responses, based on photos and videos of dogs, and report 60-72% accuracy for identifying fear (Bloom and Friedman, 2013; Tami and Gallagher, 2009; Wan et al., 2012). However, these studies did not ask owners to rate the severity of the fear response, and also did not assess their ability to identify fear when it was not deemed the 'primary' emotion, and was displayed in combination with other behavioural responses. Further research is needed to determine the accuracy of owner-reports of fearfulness and aggression in both their own dog, as well as in unfamiliar dogs.

Several studies have been conducted in order to assess the reliability and validity of different questionnaire-based measures of dog temperament attained through owner reports (e.g., Hsu and Serpell, 2003; Ley et al., 2009). One of the most commonly used questionnaires for this purpose is the Canine Behavioural Assessment and Research Questionnaire (C-BARQ). The C-BARQ asks the owner to rate their dog on a scale of 0 to 4 based on the severity (i.e., 0 = no signs of the behaviour; 1 to 3 = mild to moderate signs of the behaviour; 4 = severe signs of the behaviour) or frequency (0 = never; 1 = seldom; 2 = sometimes; 3 = usually; 4 = always) of their dog's behavioural reactions in a variety of different situations. These questions are divided into eight different categories, three rated based on severity (i.e., aggression, fear and anxiety, excitability) and five rated based on frequency (i.e., sociability, trainability, separation-related behaviour, attachment and attention seeking behaviour, miscellaneous). These questions were originally found to load on to 11 different factors: stranger-directed aggression, owner-directed aggression, stranger-directed fear, non-social fear, dog-directed fear or aggression, separation-related behaviour, attachment or attention-seeking behaviour, trainability, chasing, excitability, and pain sensitivity (Hsu and Serpell, 2003). A few additional questions were later added relating to energy levels, and relationships between dogs in the same household resulting in two new factors, energy level and dog rivalry. In later studies, the factor that was originally identified as ‘dog fear or aggression’ was separated into two distinct factors, dog-directed fear and dog-directed aggression for a total of 14 different factors (Duffy and Serpell, 2012).

The C-BARQ questionnaire has been assessed for different measures of reliability and validity across a number of different studies. Hsu and Serpell (2003) demonstrated internal reliability for the original 11 factors identified in the earlier version of the C-BARQ based on high internal consistency for all of the factors except for pain sensitivity. Inter-rater reliability has also been established by comparing responses from pairs of owners for 75 dogs (Duffy and Serpell, 2008). In addition, Duffy and Serpell (2008) established test-retest reliability by comparing scores of guide dog puppies completed when they were 6 months of age and 12 months of age.

Hsu and Serpell (2003) have established the content validity of the questionnaire through consultation with dog behaviour professionals, and construct validity of 7 of the 11 factors (i.e., owner-directed aggression, stranger-directed aggression, stranger-directed fear, dog-directed fear and aggression, non-social fear, separation-related behaviour, attachment or attention-seeking behaviour) by comparing scores of dogs diagnosed by a canine behaviour practitioner with behavioural issues that match these factors. Construct validity of the remaining four factors (i.e., trainability, chasing, excitability, pain sensitivity) could not be determined as they did not correspond to cases presented for behavioural consultation, and is an area in need of future research. Furthermore, since dogs presented to clinics for behavioural problems generally have more severe behavioural responses than the average dog, it is also important to assess the validity for measures of mild to moderate behavioural responses.

The C-BARQ has also been used successfully to predict future outcomes for dogs. The aggression factors, and most specifically the stranger-directed aggression factor, of a shortened C-BARQ completed by owners relinquishing their dogs to the shelter were found to be associated with the eventual outcomes of successful adoption or euthanasia (Duffy et al., 2014). In addition, three of the measures (i.e., chews on inappropriate objects, urination when left alone, stranger-directed aggression) were found to be consistent between questionnaires completed by surrendering and adoptive owners (Duffy et al., 2014). Another study using the C-BARQ found that a majority of the measures used, including all of the aggression factors, were predictive of future success in guide dogs in training (Duffy and Serpell, 2012). While several studies support the reliability and validity of the C-BARQ, for use in measuring temperament traits in dogs, some further research into various aspects, such as the validity of ratings for dogs with mild to moderate behavioural responses, is still required.

1.6 Risk factors for stranger-directed aggression

Risk factors for stranger-directed aggression can be grouped into two different categories: characteristics related directly to the dog, and characteristics relating to the management and environment, or as referred to in human literature, nature versus nurture.

1.6.1 Dog characteristics

Dog characteristics that have been found to be associated with stranger-directed aggression include breed and genetics, size, reproductive status, and temperament traits.

Breed

Many studies have looked at the effect of breed on temperament and behavioural problems, including aggression. These studies differ in their results, likely due to differences in their source population as well as how they define and categorize aggression.

Three different studies have used dogs referred to a specialist for behavioural problems, and compared the demographics back to the general population of dogs. These dogs would therefore be likely to have relatively severe levels of aggression that motivated their owner to make the time and financial commitment to seek professional advice. Two breeds of dogs were found to have increased risk of aggression across all three studies. These were the German Shepherd Dog and the Cocker Spaniel.

Blackshaw (1991) found that Bull Terriers, German Shepherd Dogs, Cattle Dogs, Labrador Retrievers, Poodles and Cocker Spaniels were over-represented in aggression cases referred to a specialist for behavioural problems in comparison to the general population. Borchelt (1983) conducted a similar study of cases presented to a behavioural specialist, and reported that working dogs, especially German Shepherd Dogs, had the highest proportion of cases with protective aggression, and German Shepherd Dogs, Cocker Spaniels and Miniature Poodles had the highest proportion of cases with fear-elicited aggression. Protective aggression in this study was defined as aggression in the context of protecting the home, yard or owner, while fear-elicited aggression was defined as aggression accompanied by postures of defensiveness, fear or submission. Finally, Lund et al. (1996) reported that German Shepherd Dogs, Cocker Spaniels and Collies had increased risk of stranger-directed aggression, compared to the reference breed of Labrador Retrievers, when studying dogs whose owners consulted with dog behaviour professionals in Denmark.

Other studies have used a cross-sectional design surveying the general population of dog owners to determine levels of aggression, and have also separated out types of aggression based on their intended target. While no one breed is identified as being at increased risk across all studies, two breeds are frequently mentioned when looking at aggression directed towards strangers: Chihuahuas and Dachshunds. In addition, Golden Retrievers and Labrador Retrievers scored low on stranger-directed aggression across all studies. Duffy et al. (2008) reported that when compared to the population average, Australian Cattle Dogs, Australian Shepherds, Chihuahuas, Dachshunds, Doberman Pinschers and German Shepherd Dogs were rated significantly higher for stranger-directed aggression using the C-BARQ. In contrast, Bernese Mountain Dogs, Brittany Spaniels, Collies, Golden Retrievers, Greyhounds, Labrador Retrievers, Portuguese Water Dogs, Siberian Huskies, Wheaten Terriers and Whippets were rated significantly lower than the population average for stranger-directed aggression. They also separated out dogs that were rated as having severe aggression towards strangers, defined as snaps, bites, or attempts to bite, and found that the breeds with the highest percentage of biting dogs were Dachshunds, Chihuahuas, Australian Cattle Dogs, Border Collies and Beagles. The breeds with the lowest percentages of severe aggression were Brittany Spaniels, Siberian Huskies, Whippets, Golden Retrievers and Poodles. Hsu and Sun (2010) conducted a similar study using the C-BARQ in Taiwan, and found that Dachshunds, Chihuahuas, Miniature Schnauzers, mixed breeds and Pomeranians were at the highest risk of scoring greater than the median for stranger-directed aggression, while Golden Retrievers, Shiba Inus, Siberian Huskies, Labrador Retrievers and Beagles were least likely to score greater than the median.

Another study by Casey et al. (2014), using a different dog behaviour survey, found that mixed breeds were more likely to display aggression towards strangers both entering and outside the house when compared to breeds from the United Kingdom Kennel Club's Gundog group (including Golden Retrievers and Labrador Retrievers). When looking only at aggression towards strangers outside the house, Pastoral breeds had higher odds of aggression than mixed breeds, and more specifically German Shepherd Dogs and Belgian Shepherds were the most likely to be aggressive.

While a majority of studies to date have categorized dogs based on their intended role using Kennel Club breed groups, it is potentially more appropriate to group breeds based on genetics. Tonoike et al. (2015) looked at groups of dog breeds that were genetically clustered in Japan. These breed groups were ancient and spitz breeds (i.e., Basenji, Shiba Inu, Akita, Siberian Husky, Samoyed), toy dogs (i.e., Shih Tzu, Chihuahua, Pug, Papillon, Pomeranian, Miniature Pinscher, Brussels Griffon, Pekingese), spaniels, scent hounds and poodles (i.e., American Cocker Spaniel, English Cocker Spaniel, English Springer Spaniel, Cavalier King Charles Spaniel, Brittany, Beagle, Bichon Frise, Maltese, Toy Poodle, Miniature Poodle, Standard Poodle), working dogs (i.e., Doberman Pinscher, German Shepherd), small terriers (i.e., Cairn Terrier, Jack Russell Terrier, West Highland White Terrier, Yorkshire Terrier), sight hounds and herding dogs (i.e., Italian Greyhound, Whippet, Borzoi, Pembroke Welsh Corgi, Australian Shepherd, Border Collie, Shetland Sheepdog), retrievers (i.e., Labrador Retriever, Flat-Coated Retriever, Golden Retriever, Great Dane, Bernese Mountain Dog), and mastiff-like dogs (i.e., Boston Terrier, Boxer, Bulldog, French Bulldog). It is interesting to note that these groups of genetically clustered dogs cover breeds from many different American Kennel Club breed groups. When the C-BARQ stranger-directed aggression scores for dogs from these genetically clustered breed groups were analyzed, all of the groups scored significantly higher than the retrievers, with the exception of the working breeds. However, when the stranger-directed fear scores were analyzed, all of the groups scored significantly higher than the working breeds. While the low scores for retrievers are in line with the results from other studies, the low scores for working dogs, including the German Shepherd Dog is notably surprising.

Genetics

Some of the breed effects seen in dogs suggest that there is a genetic component to aggression. Physical aggression in humans has been shown to have a high degree of heritability (Lacourse et al., 2014; Provencal et al., 2015). In canines, a number of temperament traits including shyness and aggressiveness have been shown to have a genetic basis (Hall and Wynne, 2012; Mackenzie et al., 1985; Saetre et al., 2006; Strandberg et al., 2005; Van Der Waaij et al., 2008). Various studies on certain lines of particular breeds have also shown heritability of particular traits. One line of pointing dogs has been shown to have increased levels of nervousness (Murphree et al., 1969). In addition, English Cocker Spaniels with solid coat colours have been shown to have higher levels of aggression compared to their multi-coloured counter-parts (Amat et al., 2009; Pérez-Guisado et al., 2006; Podberscek and Serpell, 1997).

Size

Size could also play a role in some of the breed effects noted above. Chihuahuas and Dachshunds are both small breeds and were noted in several studies to have high levels of aggression (Duffy et al., 2008; Hsu and Sun, 2010). Size has been shown to be inversely correlated with aggression towards strangers in several studies (Arhant et al., 2010; Duffy et al., 2008; Gonzalez Martinez et al., 2011). However, one study measuring both height and weight of dogs found that stranger-directed aggression increased with increasing body weight, but decreased with increasing height, suggesting that stockier breeds may be at increased risk of stranger-directed aggression (McGreevy et al., 2013). These effects of body size could be due to differences in how smaller dogs are managed (Arhant et al., 2010), or because smaller dogs may be more likely to find a given stimulus threatening due to the proportionally larger size of the stimulus, and therefore act aggressively in order to protect themselves. Finally, it could be that particular small breeds may be predisposed to fear and aggression issues, for reasons other than their size.

Reproductive status

Numerous studies on aggression in both human and non-human animals have found associations between circulating testosterone and increased intra-specific aggression (Book et al., 2001; Kouri et al., 1995; Rose et al., 1971). Testosterone has also been shown to decrease fearfulness and anxiety in many species (Aikey et al., 2002; Boissy and Bouissou, 1994; Bouissou and Vandenheede, 1996; Frye and Seliga, 2001; Van Honk et al., 2005; Vandenheede and Bouissou, 1996), suggesting that testosterone may be indirectly associated with fear-related aggression in dogs. Many studies have reported male dogs show higher rates of aggression than females (Amat et al., 2009; Borchelt, 1983; Casey et al., 2014; Fatjo et al., 2007; Gershman et al., 1994; Lund et al., 1996). One study looked at the interaction between neutering and sex, and found that neutering was associated with stranger-directed aggression in females, but the relationship disappeared when dogs that were neutered due to aggression issues were removed from analysis (Podberscek and Serpell, 1996). However, another study found that stranger-directed aggression was significantly lower in neutered females compared to neutered males, but was not significantly different from intact dogs of either sex (Casey et al., 2014). Cross-sectional studies analyzing the effect of neutering, independent of sex, have found mixed results with some studies reporting aggression being positively associated with neutering (Podberscek and Serpell, 1997), while others report a negative association between aggression and neutering (Gershman et al., 1994; Goodloe and Borchelt, 1998), or no significant association (Amat et al., 2009; Matos et al., 2015; van den Berg et al., 2006). The cause of these differences in results could be due to the different effect of neutering on males and females, insufficient power, the different effect of neutering on different types of aggression (e.g., owner directed, intra-species, stranger-directed), and whether the study controlled for the reason the dog was neutered. There were also differences in how the data were analyzed, with some studies using multivariable regression to control for the effect of sex (Gershman et al., 1994; Goodloe and Borchelt, 1998; van den Berg et al., 2006), while others performed univariable analyses (Amat et al., 2009; Podberscek and

Serpell, 1997). Two studies looking at aggression before and after neutering reported improvements in intra-specific and territorial aggression, but found no effect of neutering on aggression towards unfamiliar people (Hart and Eckstein, 1997; Neilson et al., 1997).

Temperament

Several studies exploring dog temperament traits have reported associations between stranger-directed aggression and other traits including other forms of aggressiveness and fearfulness. Goodloe and Borchelt (1998) developed a dog personality questionnaire that identified 22 different factors including stranger-directed aggression. They reported that stranger-directed aggression was positively associated with aggression towards other dogs, biting, barking, separation vocalizations, fear or avoidance of strangers, and one of the play-related factors. In addition, a number of studies using C-BARQ have found associations between stranger-directed aggression and various temperament traits (Duffy et al., 2008; Hsu and Serpell, 2003; Matos et al., 2015). Hsu and Serpell (2003) found that being classified as aggressive towards strangers on the C-BARQ was associated with clinical diagnosis of stranger-directed aggression, owner-directed aggression, and fear of strangers. Other studies using the C-BARQ have also identified significant associations between fear of strangers and stranger-directed aggression, but did not assess other temperament traits (Duffy et al., 2008; Matos et al., 2015).

Impulsivity is also hypothesized to be associated with aggression, as a lack of inhibitory control may influence whether dogs react with a freeze, fight, flight or flirt response when in the presence of a threat. Fatjo et al. (2005) suggest that impulsivity may be a key difference in why dogs attempt to bite, rather than showing threatening behaviours, such as growling, in response to a perceived threat. However, Jacobs et al. (2017a) reported that while impulsivity was associated with resource-guarding in dogs, it was not a factor in comparing dogs that bite to those that show only threatening behaviours. The relationship between aggression and impulsivity has also been studied in other species. Studies have shown significant relationships between poor behavioural regulation and aggression in children (Calkins and Dedmon, 2000; Caspi and Silva, 1995; Davidson et al., 2000; Pulkkinen, 1996). In addition, delay aversion (i.e., choosing a small immediate reward over a large delayed reward), an indicator of poor impulse control, has been found to be associated with aggression in rats (Van den Bergh et al., 2006). While these relationships have not been directly examined in the dog, there are indications that the neurobiology of impulse control is similar between dogs and humans (Cook et al., 2016). In addition, reduced serotonergic activity has been linked to both aggression and poor impulse control in dogs (Reisner et al., 1996).

1.6.2 Environmental and management characteristics

Environment and management characteristics that have been found to be associated with fear or stranger-directed aggression include previous experiences in different contexts, and during different life stages, as well as training methods, home environment, exercise and nutrition.

Previous experiences

The behaviour of dogs can be affected by events throughout their lives, and can even be influenced by perinatal circumstances. Prenatal stress has been shown in numerous species to be associated with changes in adulthood, including impaired stress-coping ability, as well as behavioural inhibition and anxiety in response to novelty (Braastad, 1998). Specifically, prenatal stress has also been show to impair the negative feedback mechanism of the HPA axis resulting in prolonged activation, and poor recovery from stressful experiences (as reviewed by Braastad, 1998).

Adult behaviour can also be influenced by earlier life experiences. Dog behaviour experts often state that the most important period of time for exposing puppies to new people, dogs, and environments is during the critical socialization period (Horwitz and Neilson, 2007; Landsberg et al., 2013; Overall, 2013). If dogs are not adequately socialized with a wide variety of social partners and environmental stimuli during this period from approximately 3-13 weeks, they are at increased risk of suffering severe social limitations in the future, such as fear or aggression when interacting with humans or other dogs (Freedman et al., 1961). However, the onset of different behavioural responses important to socialization, such as fear-related avoidance behaviours, have been shown to vary between breeds (Morrow et al., 2015). It is therefore reasonable to predict that the socialization window may vary between puppies, so the window of 3-13 weeks should only be used as a guideline. A lack of socialization around this time has been shown to result in future behavioural problems. Puppies isolated from specific stimuli (e.g., novel environments, conspecifics, humans) during this period show increased avoidance of those stimuli in the future, and in the case of social stimuli, increased aggression and inability to from social attachments (reviewed by Fox, 1971). Puppies removed from their mother prematurely, and that experienced a period of a lack of stimulation while being housed in a shelter before adoption, were found to be at increased risk of a variety of behavioural issues including fearfulness on walks, fear of noises, aversion towards people of unfamiliar appearance, and aggression towards unfamiliar people (Pierantoni and Verga, 2007). In addition, being fearful has been found to be associated with less socialization opportunities as a puppy (Tiira and Lohi, 2015). Finally, attending socialization classes (Casey et al., 2014) and exposure to urban environments early in life (Appleby et al., 2002) have previously been shown to be associated with a decreased risk of stranger-directed aggression. Negative experiences during this time can also affect future behaviour, as puppies that have been frightened by a stranger are more likely to develop stranger-directed fear, and puppies that have been threatened by another dog are more likely to develop stranger-directed aggression (Serpell and Duffy, 2016).

Negative experiences that occur outside of the socialization window can also have a large effect on fear and aggression in dogs. In human children, a history of abuse has been found to be associated with increased aggression into adolescence and adulthood (Anda et al., 2006; Kaplan et al., 1999). Similarly, a study using the C-BARQ found that dogs whose owners report either confirmed or suspected histories of abuse were at higher risk of stranger-directed aggression (McMillan et al., 2015). Alternatively, due to the lack of causal evidence in these studies, there has been some suggestion that individuals with aggression issues may be at increased risk of being abused (Black et al., 2001; Kaplan et al., 1999). However, further research is needed to address these different hypotheses.

Training methods

The use of positive punishment, specifically physical punishment, while commonly used in the dog training world, has fallen out of favour when raising children. This is due to research indicating that the use of physical punishment on children is associated with behavioural problems including aggression (as reviewed by Gershoff, 2002). Similar associations have also been found in the canine literature, showing that the use of positive punishment increases behavioural and physiological signs of stress (Deldalle and Gaunet, 2014; Horváth et al., 2008), reduces ability to learn (Hiby et al., 2004; Rooney and Cowan, 2011), reduces willingness to interact with a stranger (Rooney and Cowan, 2011), and is associated with behaviour problems, including aggression (Arhant et al., 2010; Blackwell et al., 2008; Casey et al., 2014; Herron et al., 2009; Hiby et al., 2004). However, it is unclear whether the physical punishment causes these behavioural problems, or is more likely to be used on dogs with pre-existing behavioural issues. In addition, many common tools used during dog training, including remote training collars (i.e., shock collars), prong collars and choke chains, operate based on the principals of either positive punishment or negative reinforcement. Few studies have explored the effects of these tools on stress and aggression, and studies to date have mostly focused on the use of remote training collars. Two studies looking at the use of remote training collars during training found that they were associated with stress-related behaviours, but they did not analyze their efficacy (Cooper et al., 2014; Schilder and Van Der Borg, 2004). Based on the results of these studies many researchers have suggested that owners avoid using aversive training methods. However, further research is needed to determine how the use of these training methods, and different training tools, affect the welfare and behaviour of dogs.

Home environment

A few studies have looked at the relationship between the home environment and stranger-directed aggression in dogs (Hsu and Sun, 2010; Matos et al., 2015; Serpell and Duffy, 2016). Matos et al. (2015) evaluated 177 dogs in the Slovak Republic using a translated version of the C-BARQ and found that there were no significant associations between stranger-directed aggression and any of the measured environmental variables (i.e., having access to a yard, living in a town or village, living primarily indoors vs. outdoors). Conversely, a study of 872 dogs in Taiwan, also using a translated version of the C-BARQ, identified several environmental risk factors for stranger-directed aggression, including living in a house with a yard (compared to apartment), living in a rural area (compared to a city), and larger household sizes (Hsu and Sun, 2010). Finally, a study of 978 prospective guide dogs in the USA using the C-BARQ, did not find significant associations between variables related to the home environment and stranger-directed aggression, except that dogs from households with more experienced owners were less likely to display stranger-directed aggression (Serpell and Duffy, 2016). The differences in these studies could be due to differences in the dog populations studied, or due to differences in the sample size, and therefore available power for finding statistically significant differences. Another study by Bennett and Rohlf (2007) evaluating 413 dogs in Australia also reported that being unfriendly/aggressive was associated with larger household sizes. It is possible that larger families are more likely to identify aggression issues since their dogs have more interactions with people on a day to day basis. Alternatively, owners with larger families may have less time for training and exercising their dogs, leading to aggression issues. Further studies are needed to fully explore environmental risk factors for aggression while controlling for potential confounders.

Exercise

While no studies have established a relationship between the amount and type of exercise dogs receive and stranger-directed aggression, there is some evidence of an association between a lack of exercise and non-specific aggression in Cocker Spaniels (Podberscek and Serpell, 1997). In addition, less daily exercise has also been linked with noise sensitivity and separation anxiety (Tiira and Lohi, 2015) and overall nervousness (Kobelt et al., 2003). It is unclear whether reduced exercise causes behavioural issues, or whether these dogs are walked less often due to their behavioural issues. In humans, the role of exercise in reducing anxiety and depression has been well established (as reviewed by Guszkowska, 2004). Additionally, rats given the opportunity to perform voluntary exercise showed less spontaneous aggression towards other rats in the post-exercise period compared to sedentary controls. However, when the opportunity to exercise was removed, the active rats' aggression rose above the level shown by the controls (Harman et al., 1989). Finally, a study looking at housing conditions in laboratory Beagles found that social contact with conspecifics was more important for improving the well-being of the dogs (based on increased time spent sleeping and reduced stereotypic behaviours and vocalizations) than 30 minutes of exercise on a treadmill (Hetts et al., 1992). However, the conditions in this study were confounded since the dogs given access to treadmills were housed singly in small cages, whereas the dogs given social contact were housed in pairs in larger runs. In addition, caution should be taken in comparing these conditions to those of an average pet dog. The results from these studies suggest that exercise may be beneficial in regulating mood, and therefore further exploration into the role of exercise on dog behavioural issues is needed.

Nutrition

The effect of nutrition on aggression is an area of ongoing debate (Haug, 2008), but there is little scientific evidence available to inform this discussion. Most of the differences in aggressive behaviour in relation to diet appear to be due to a deficiency of tryptophan leading to lower concentrations of serotonin, a neurotransmitter that plays an important role in regulating mood and temperament (Gibbons et al., 1979; Kantak et al., 1980a). Low levels of serotonin have been linked to impulsivity (Wright et al., 2012) and aggression (Reisner et al., 1996) in dogs. One study found that dogs fed a low protein diet displayed less territorial aggression than dogs fed a high protein diet (Dodman et al., 1994). The authors hypothesized that this result was due to the low protein diet facilitating transport of tryptophan across the blood-brain barrier. Another study of dogs with territorial aggression issues found that feeding a low protein diet with a tryptophan supplement decreased aggressive behaviours when compared to a low protein diet without tryptophan supplements, or a high protein diet either with or without tryptophan supplementation (DeNapoli et al., 2000). In addition, one study examining the effects of a diet supplemented with alpha-casozepine and L-tryptophan found that owner reports of stranger-directed aggression, stranger-directed fear, non-social fear and touch sensitivity decreased after 7-weeks on the diet (Kato et al., 2012). In addition, dogs fed the supplemented diet had a significantly smaller increase in urinary cortisol in response to a stressful event (i.e., having toenails trimmed at a veterinary clinic) indicating the diet may aid dogs in dealing with anxiety-inducing situations. Finally, tryptophan-free diets have been found to be associated with increased aggression in rats (Gibbons et al., 1979; Kantak et al., 1980b), monkeys (Chamberlain et al., 1987) and human males (Bjork et al., 1999). These results suggest that dietary supplementation with tryptophan may aid in reducing stress and aggression in dogs, although further research into the relationship between tryptophan and protein levels is needed to provide specific dietary recommendations.

1.7 Thesis rationale and objectives

Stranger-directed aggression is a serious concern for public safety, animal welfare and the dog-owner relationship (Salman et al., 2000, 1998; Serpell, 1996). Previous research has indicated a variety of potential risk factors for aggression in dogs, including dog characteristics such as sex (Amat et al., 2009; Borchelt, 1983; Casey et al., 2014; Fatjo et al., 2007; Gershman et al., 1994; Lund et al., 1996), neuter status (Gershman et al., 1994; Goodloe and Borchelt, 1998; Podberscek and Serpell, 1997), breed (Beaver, 1983; Blackshaw, 1991; Borchelt, 1983; Duffy et al., 2008; Hsu and Sun, 2010; Lund et al., 1996), and fearfulness (Duffy et al., 2008; Goodloe and Borchelt, 1998; Hsu and Serpell, 2003; Matos et al., 2015), as well as training methods (Arhant et al., 2010; Blackwell et al., 2008; Herron et al., 2009; Hiby et al., 2004; Hsu and Sun, 2010) and previous experiences (Appleby et al., 2002; Casey et al., 2014; McMillan et al., 2015; Tiira and Lohi, 2015). However, these studies either do not separate aggression based on target, or do not provide a comprehensive analysis controlling for multiple potential risk factors and confounders. In addition, there is limited information available that distinguishes between dogs that only show threatening behaviour, compared to dogs that bite or attempt to bite. In order to direct future research toward identifying effective preventative and treatment strategies, more comprehensive analysis of risk factors for stranger-directed aggression of different severities is required.

The C-BARQ is a previously validated tool, that can be used to collect information on dog temperament traits and characteristics, including specific information about the severity of stranger-directed aggression as well as stranger-directed fear (Hsu and Serpell, 2003). However, the original C-BARQ does not measure a dog’s exposure to different environmental, management, or owner characteristics. In order to gain a full view of the factors associated with stranger-directed aggression, additional data relating to these areas need to be collected. This will allow for a more detailed analysis of a wide range of risk factors while controlling for potential confounders.

In addition, owner reports are often criticized as being subjective, and potentially inaccurate (Meagher, 2009). Therefore, it is important to determine how well owners can recognize the different behavioural responses presented in the C-BARQ, and whether this accuracy can be improved with targeted training. While the C-BARQ has been found to be valid for the identification of clinically diagnosed behavioural problems in dogs (Hsu and Serpell, 2003), further validation is needed in order to determine if owners can recognize milder behavioural responses, that while not clinically significant, may alter a dog's risk of developing behavioural problems such as stranger-directed aggression. Previous research has found that owners are able to identify threatening and aggressive behaviour related to resource-guarding in dogs with a high degree of accuracy (Jacobs et al., 2017b), yet it is unclear how well owners are able to identify fear and fear-related aggression, and whether this influences their ratings of their own dogs.

Finally, numerous studies have identified an association between fear and stranger-directed aggression (Duffy et al., 2008; Goodloe and Borchelt, 1998; Hsu and Serpell, 2003; Matos et al., 2015), and the importance of positive experiences during the socialization window (Appleby et al., 2002; Casey et al., 2014; Freedman et al., 1961; Tiira and Lohi, 2015). Therefore, a critical step towards identifying dogs at risk, and preventing the development of stranger-directed aggression is ensuring correct identification of fear in puppies, so that appropriate interventions can be made. Previous studies have validated behaviours associated with fear in adult dogs (Beerda et al., 1998; Stellato et al., 2017), but more research is needed to determine what behaviours are shown by puppies in response to social and non-social fear-eliciting stimuli.

The objectives for the series of studies presented in this thesis are as follows:

1) To identify risk factors associated with stranger-directed aggression in pet dogs using a pre-existing database of responses to the C-BARQ (Chapter 2);

2) To determine which behavioural measures of fear owners can accurately identify, and to assess the effect of targeted training on the accuracy and consistency of owner ratings of fearfulness in dogs (Chapter 3);
3) To conduct a comprehensive analysis of potential risk factors for stranger-directed aggression in pet dogs, including factors relating to dog characteristics, temperament, training, environment, and owner demographics and personality not measured in previous studies (Chapter 4); and
4) To identify which fear behaviours are shown by puppies in response to fear of social and non-social stimuli, and to determine at what age these behaviours develop (Chapter 5).

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CHAPTER TWO

Risk factors associated with stranger-directed aggression in domestic dogs

Accepted by *Applied Animal Behaviour Science*

2.1 Abstract

Aggression in dogs is a safety concern both for humans and animals, and can lead to decreased animal welfare in affected dogs due to potential abuse, neglect, relinquishment or euthanasia. We examined risk factors associated with stranger-directed aggression in dogs using the previously validated, Canine Behavioural Assessment and Research Questionnaire (C-BARQ). Results are based on participant reports of dog behaviour. Data were analyzed using mixed logistic regression, with participant ID and country as random effects. Dogs (n=14,310) were more likely to demonstrate stranger-directed aggression if the participant rated them as mildly or severely fearful of strangers, or mildly, but not severely, fearful in non-social situations, when compared to dogs with no fear. There was an interaction between sex and neuter status, with neutered males being more likely to be aggressive than any other group. Furthermore, adult dogs were more likely to be aggressive compared to adolescents or seniors, and dogs were less likely to be aggressive if acquired as an adult when compared to being acquired as a puppy or adolescent. The random effects for country and participant were significant ($p<0.001$) with ICCs of 0.01 (CI: 0.00-0.08) and 0.40 (CI: 0.35-0.46), respectively, indicating that there was some correlation in behaviour among dogs within the same country and owned by the same person. The moderate effect of participant suggests that household effects need to be examined further. When looking only at dogs categorized as aggressive towards strangers (n=11,240), dogs were significantly more likely to be categorized as having severe aggression if they were male, and if the owner rated them as mildly or severely fearful of strangers, or mildly, but not severely, fearful in non-social situations, when compared to dogs with no fear. Breed group and where the dog was acquired also had an association with severe aggression. The random effects for country and participant were significant ($p<0.001$) with ICCs of 0.06 (CI: 0.02-0.15) and 0.34 (CI: 0.22-0.48), respectively, indicating once again that there was some correlation in behaviour among dogs within the same country and owned by the same person. These results suggest that variables related to the environment, owner experience and the dog's level of fearfulness are associated with aggressive behaviour towards strangers in dogs. Therefore, it might be possible to identify dogs at risk of developing stranger-directed aggression and implement plans to prevent behavioural issues from developing.

2.2 Introduction

Dog aggression is a serious concern, both for public safety and for the welfare of dogs. According to a 2012 survey of pet ownership in the U.S., 36.5% of households report owning a dog, with a total of almost 70 million owned dogs living in the U.S. alone (American Veterinary Medical Association, 2012). Similarly, 34% of households in Canada, and 24% of households in the U.K. report owning dogs (Canadian Animal Health Institute, 2015; Pet Food Manufacturers' Association, 2016). While there are few data available for the overall prevalence of aggression in dogs, there have been several studies looking into the incidence of dog bites (Gilchrist et al., 2008; Parrish et al., 1959; Sacks et al., 1996; Weiss et al., 1998). It is estimated that in the U.S. approximately 1.5% of people will be bitten by a dog each year, with 0.3% of people requiring medical attention (Gilchrist et al., 2008; Sacks et al., 1996). Additionally, it is reported that 36.2% of dog bites are directed towards people who have no relationship with the dog (Shuler et al., 2008). One study in the U.K. found that approximately 7% of dog owners report that their dogs are aggressive towards strangers entering the house, and 5% of dog owners report that their dog is aggressive towards strangers outside of the house (Casey et al., 2014). These estimates include threats and attempted bites as well as actual bites. Considering the large number of dogs in the world, and the number of interactions between dogs and people every day, these numbers indicate a serious public safety concern.

Aggression can also reduce a dog's welfare by impairing the human-animal relationship (Serpell, 1996), which can eventually lead to relinquishment or euthanasia (Salman et al., 2000, 1998). Dog welfare can also be reduced if the dog remains in the home, as behavioural problems, such as aggression, can cause owners to resort to inhumane training methods, including physical punishment (Ben-Michael et al., 2000). Further, owners are less likely to engage in activities with their dogs if they are aggressive towards strangers (Bennett and Rohlf, 2007). This can result in these dogs leading less enriched lives.

Previous research has categorized aggressive dogs based on assumed motivating factors, such as fear, territoriality or dominance (Beaver, 1983; Blackshaw, 1991; Borchelt, 1983). However, the true motivation for these aggressive behaviours is not always known. Recent research has started categorizing aggression based on the target of the aggressive behaviours, such as strangers, owners or other dogs (Duffy et al., 2008; Gonzalez Martinez et al., 2011; Hsu and Sun, 2010; Liinamo et al., 2007). This categorization has been aided by the development of the Canine Behavioural Assessment and Research Questionnaire (C-BARQ), which asks owners to rate the severity of aggressive behaviours dogs display in a variety of different situations (Hsu and Serpell, 2003). This questionnaire consists of 100 items describing different scenarios on which the owners are asked to rate their dogs' responses. Using factor analysis, these items have been divided into 14 different factors overall, including aggression-related categories of stranger-directed aggression, owner-directed aggression, and dog-directed aggression (Duffy and Serpell, 2012).

The objective of this study was to determine risk factors associated with dogs displaying aggression towards strangers, and further risk factors associated with dogs that display severe aggression towards strangers, defined as biting or attempting to bite, compared to only showing threatening behaviours.

2.3 Materials and methods

2.3.1 Data collection

Data were accessed from the C-BARQ database stored at the School of Veterinary Medicine, University of Pennsylvania. Responses analyzed were collected between April 2006 and February 2013. The database was developed through online administration of the survey (http://vetapps.vet.upenn.edu/cbarq/), which was advertised online, through notification of local veterinary clinics, veterinary magazine articles and word of mouth (Duffy et al., 2008). Participants were each given a unique participant ID, and were able to complete the survey for multiple dogs. The intended participants for this particular dataset were dog owners completing the survey for their own dog. Separate accounts are available for professional dog trainers that are not included in the current data, but it is possible that some amateur dog trainers may have used the general accounts in order to avoid paying applicable fees, so it cannot be conclusively determined that dogs with the same participant ID are actually from the same household. The C-BARQ consisted of 100 different questions that asked participants to rate each of their dogs on a scale of 0 to 4 based on the severity (i.e., 0 = no signs of the behaviour; 1 to 3 = mild to moderate signs of the behaviour; 4 = severe signs of the behaviour) or frequency (0 = never; 1 = seldom; 2 = sometimes; 3 = usually; 4 = always) of each dog's behavioural reactions in a variety of different situations (e.g., when approached directly by an unfamiliar adult while being walked/exercised on a leash). These questions were divided into eight different categories, three rated based on severity (i.e., aggression, fear and anxiety, excitability) and five rated based on frequency (i.e., sociability, trainability, separation-related behaviour, attachment and attention seeking behaviour, miscellaneous). Mild to moderate aggression was defined as barking, growling and baring teeth, while serious aggression was defined as snapping, lunging, biting, or attempting to bite.

For the purpose of analysis, dogs were categorized as showing no fear/aggression, mild to moderate fear/aggression, or severe fear/aggression for each of the following factors: stranger-directed aggression, stranger fear and non-social fear. No fear/aggression was defined as scoring a 0 on all the questions within the given factor. Mild to moderate fear/aggression was defined as scoring a 1 or greater, but without scoring a 4 in any of the questions within the given factor. Severe fear/aggression was defined as scoring a 4 in any of the questions within the given factor, which is described in the questionnaire as the dog snapping, biting or attempting to bite. Due to the large number of breeds represented in the present survey, breeds were categorized into AKC breed groups (American Kennel Club, 2016).

2.3.2 Statistical analysis

Factor analysis and mixed logistic regression models were used to analyze the data using Stata Statistical Software v.13 (StataCorp., College Station, TX, USA).

Factor analysis

A factor analysis was conducted on observations with complete data for all items in order to confirm the stability of the factor structure previously reported (Duffy and Serpell, 2012), using a larger sample size. Both the Kaiser-Meyer-Olkin measure of sampling adequacy (KMO) and the Bartlett's test of sphericity were considered to assess the suitability of conducting factor analysis. Factor analysis was deemed appropriate because the KMO was greater than 0.50 and the Bartlett's test of sphericity was significant (Ferguson and Cox, 1993). Varimax rotation was applied to the factor analysis for orthogonal transformation in order to obtain distinct groupings of items that measured different temperament and behavioural traits (Hatcher and O'Rourke, 2013), and to match the analyses performed previously (Duffy and Serpell, 2012; Hsu and Serpell, 2003). The number of factors was selected using a Kaiser eigenvalue cut-off of 1, with a scree plot used to visually assess whether factors close to the eigenvalue cut-off should be included (Hatcher and O'Rourke, 2013; Streiner, 1994). The questions were determined to load on a given factor if they had a loading value of >0.40 after rotation (Hatcher and O'Rourke, 2013). Questions that did not load on any of the factors were removed, and the factor analysis was repeated. In the case of double loading, the question was assigned to the factor on which it loaded the highest, or when the difference between the factor loadings is small (≤0.20) the question was removed from the analysis (Ferguson and Cox, 1993). Cronbach α was used to assess internal consistency of the identified subscales resulting from the factor analysis, with a level of 0.70 or greater being deemed acceptable (Hatcher and O'Rourke, 2013).

Risk factor analysis

Mixed logistic regression models were used to analyze the data. For the first model, mild to moderate aggression and severe aggression were combined to compare dogs with any stranger-directed aggression, to dogs with no stranger-directed aggression. For the second model, dogs that scored as having severe stranger-directed aggression, defined as biting or attempting to bite, were compared to those that had mild to moderate stranger-directed aggression (excluding dogs with no stranger-directed aggression). The same modelling process was used for both models. Two fear-related factors (stranger fear and non-social fear), ten dog-related variables and four owner-related variables were tested for associations with the dependent variables (Table 2.1), and participant ID, nested within country, was included as a random effect. Collinearity of variables was assessed using various correlation coefficients with a cut-off point of greater than |0.70|. In cases where collinearity was identified, the most biologically meaningful variable was selected for further analysis (Dohoo et al., 2003). Continuous variables were graphically assessed for linearity by examining the relationship between the independent variable and the log odds of the outcome variables using locally weighted regression curves (lowess) and by testing the inclusion of a quadratic term in the model. If the relationship was non-linear and could not be appropriately modeled with the addition of a quadratic term, the continuous variable was categorized.

The possible explanatory variables were first tested univariably against the outcome in a mixed logistic regression model, with participant ID and country as random effects. Variables were retained for further testing if they met a liberal cut-off of $p \leq 0.20$ (Dohoo et al., 2003). All variables retained following the univariable analyses were tested in a main effects model and were removed in a manual backward step-wise fashion (Dohoo et al., 2003). Variables were retained in the main effects model if they were statistically significant ($\alpha = 0.05$) or were identified to be a confounding variable. Confounding variables were identified if they caused a greater than 20% change in the coefficient of other statistically significant variables in the model when removed, and based on their potential causal relationship with the explanatory variable and the outcome (Dohoo et al., 2003). Based on a-priori assumptions, biologically plausible two-way interactions between main effects retained in the model were tested ($\alpha = 0.05$). The model fit was tested by graphically assessing the normality and homoscedasticity of the best linear unbiased predictors (BLUPs). Pearson residuals were also assessed to determine if there were any outliers. Outlying observations were inspected for potential recording errors and their impact on the model. Finally, the intra-class correlation coefficient (ICC) was estimated to measure the degree of correlation among dogs within the same country, and owned by the same person.

2.4 Results

The questionnaire was completed for 17,301 dogs from 13,159 different owners and 70 different countries. Participants completed the survey for a mean of 1.4 dogs, ranging from one to nine. Dogs ranged in age from 6 months to 23 years, with a mean age of 4.3 years. Dogs ranged in weight from 1 to 220 pounds, with a mean weight of 52.1 pounds. A total of 218 different pure breeds were represented, accounting for 79.2% of the dogs, with the remaining 21.8% being mixed breeds. A total of 13,504 dogs

(78.1 %) were categorized as having some level of aggression towards strangers, with 1,125 dogs being categorized as having severe aggression (6.5 %). For a full summary of descriptive statistics please see Table 2.1.

2.4.1 Factor analysis

The factor analysis was conducted based on 7,656 dogs with complete data for every item. When factor analysis was performed, the KMO value was 0.92, indicating a “marvelous” degree of common variance among the variables (Dziuban and Shirkey, 1974), and the Bartlett’s test was significant ($p < 0.001$), indicating that there are significant differences in variance across groups (Ferguson and Cox, 1993). These results support the use of factor analysis on the data. Seventy-two of the 100 items were grouped into thirteen factors defined as stranger-directed aggression, owner-directed aggression, stranger fear, separation-related behaviour, dog fear, trainability, excitability, chasing, dog rivalry, attachment and attention-seeking, elimination problems, non-social fear, and activity/energy (Table 2.2). Five items had moderate loadings on two or more different factors. The item “aggression towards unfamiliar dogs visiting your home” had similar moderate loadings for the factors labeled stranger-directed aggression and dog rivalry, as well as an unnamed factor relating to dog-directed aggression that was no longer present after the removal of cross-loading items (0.41 vs. 0.41 vs. 0.44). Similarly, the items “aggression when approached directly by an unfamiliar male dog while being walked/exercised on a leash” and “aggression when approached directly by an unfamiliar female dog while being walked/exercised on a leash” had similar moderate loadings for the stranger-directed aggression, and dog-directed aggression factors (0.56 vs. 0.49 and 0.53 vs. 0.52, respectively). The item “fear when first exposed to unfamiliar situations (e.g. first car trip, first time in elevator, first visit to veterinarian, etc.)” loaded on both the stranger fear and non-social fear factors with similar moderate loading values (0.44 vs 0.45). Finally, the item “excitable when playing with you or other members of your household” loaded on both the excitability and activity/energy factor with similar moderate loading values (0.47 vs. 0.40). All of the cross-loading items, and the remaining 23 items that did not load on any factor, were removed and the factor analysis was repeated. Cronbach’s α values ranged from 0.76 to 0.93 for the 13 extracted factors

(Table 2.2), indicating these factors have good internal consistency. This factor structure is similar to that reported by Duffy and Serpell (2012) with the exception of the lack of a dog-directed aggression factor, and confirms the stability of the C-BARQ as a measure of these temperament traits.

2.4.2 Risk factor analysis

Due to a non-linear association with the outcome variable, age evaluated, age acquired, and neuter age were categorized using the following cut points: puppies (≤6 months), adolescents (>6 months to 2 years), adults (>2 to 10 years) and seniors (>10 years). Dogs were only evaluated if they were at least 6 months of age, so only the categories of adolescent, adult and senior were used for this variable. The senior category was combined with the adult category for age acquired and neuter age due to a small sample size (<20) in the senior category for these variables.

Model 1: Risk factors associated with stranger-directed aggression

Due to missing data for some of the variables 14,310 of the original 17,301 responses were used for this analysis. The odds of being aggressive towards strangers significantly increased with mild and severe fear of strangers (vs. none), mild non-social fear (vs. none), being acquired from a pet store (vs. breeder, bred by owner, shelter or "other"), from a friend or relative (vs. breeder, bred by owner, shelter or "other"), found stray (vs. "other"), or from a breeder (vs. "other"), and being a neutered male (vs. all other categories; Table 2.3). Adult dogs had significantly increased odds of being aggressive towards strangers when compared to adolescents or seniors (Table 2.3). Being acquired as an adult was found to have significantly decreased odds of stranger-directed aggression in comparison to dogs acquired as puppies or adolescents (Table 2.3). Breed group was also significantly associated with stranger-directed aggression, with hounds having significantly lower odds of stranger-directed aggression than all other breed groups, and mixed breeds having significantly higher odds of stranger-directed aggression than all other breed groups except herding groups (Table 2.3). Based on the ICCs of the model, dogs within in the same country have a correlation of 0.01, while dogs with the same participant ID have a correlation of 0.40. For this model the assumptions for homoscedasticity were met, but the BLUPs were not normal and showed some evidence of bimodality. However, the model, based on Akaike Information Criteria and

Bayesian Information Criteria, was better fitting compared to models without the inclusion of either, or both, of the random effects.

Model 2: Risk-factors associated with stranger aggressive dogs displaying severe stranger-directed aggression

Due to missing data for some of the variables 11,240 of the 13,504 dogs categorized as aggressive towards strangers were included in this analysis. Mild (vs. none) and severe (vs. mild or none) fear of strangers, being male (vs. female), and being acquired from a shelter (vs. breeder), friend or relative (vs. breeder or bred by owner), stray (vs. breeder or bred by owner) or "other" source (vs. breeder or bred by owner) were all associated with significantly increased odds of dogs with stranger-directed aggression displaying severe aggression (Table 2.4). The odds of dogs with stranger-directed aggression displaying severe aggression was lower for dogs with mild non-social fear when compared to dogs with no or severe non-social fear. The breed group was also significantly associated with severe stranger-directed aggression, with sporting breeds having the lowest odds of displaying severe stranger-directed aggression compared to any other breed group (Table 2.4). Based on the ICCs of the model, dogs within the same country have a correlation of 0.06, while dogs with the same participant ID have a correlation of 0.34. For this model the assumptions for homoscedasticity were met, but the BLUPs were not normal and showed some evidence of bimodality. However, the model, based on Akaike Information Criteria and Bayesian Information Criteria, was better fitting compared to models without the inclusion of either, or both, of the random effects.

2.5 Discussion

2.5.1 Factor analysis

The factors identified in the current study are similar to those reported previously with independent datasets (Duffy and Serpell, 2012; Hsu and Serpell, 2003; Hsu and Sun, 2010; Nagasawa et al., 2011; Tamimi et al., 2015; van den Berg et al., 2006), indicating a relatively stable factor structure for CBARQ. Most importantly for the purpose of this study, the stranger-directed aggression factor was consistent across all studies. The stranger fear factor was also present in a majority of the other studies

(Duffy and Serpell, 2012; Hsu and Serpell, 2003; Nagasawa et al., 2011; van den Berg et al., 2006), but combined with other fear factors in some studies (Hsu and Sun, 2010; Tamimi et al., 2015). The two studies that did not find a unique stranger fear factor were conducted in Taiwan and Iran, respectively, and therefore may indicate a difference in the temperaments or circumstances of dogs raised in these countries, or differences in owners' perceptions of dog behaviour. Dogs in these countries may be raised outdoors and have less formal socialization making them more reactive to any novel stimuli, both social and non-social. Non-social fear was also consistent across studies, with the exception of Tamimi et al. (2015), which found that non-social fear combined with the other fear factors. Dog-directed aggression was not identified as a factor in the current study, but has previously been identified as a factor some researchers (Duffy and Serpell, 2012; Hsu and Sun, 2010; Nagasawa et al., 2011), and was found to combine with dog-directed fear by others (Hsu and Serpell, 2003; van den Berg et al., 2006). Similar to the current study, Tamimi et al. (2015) did not identify dog-directed aggression. One reason for dog-directed aggression not being identified in the current study is that three of the four items that loaded into the dog-directed aggression factor in previous studies were removed due to cross-loading in the current study. This could be because these deleted items do not cleanly describe dog-directed aggression, as the unfamiliar dog is likely accompanied by their owner, a stranger, resulting in this cross-loading. In addition, unfamiliar dogs visiting the home may trigger similar behavioural issues as familiar dogs, such as resource guarding, resulting in the cross-loading with dog rivalry. Another possibility is that the use of listwise deletion for observations with missing data in the current study may have resulted in a bias towards dogs from multi-dog households, as some of the items in the questionnaire refer to interactions between the dog and another dog within the same household. This may have biased the sub-sample of the data that were used for factor analysis towards more dog-friendly dogs, resulting in the loss of the dog-directed aggression factor. There was one factor, elimination problems, that was reported in the present study, but was not found in the original C-BARQ factor analysis (Hsu and Serpell, 2003), or the more recent analysis conducted by Duffy and Serpell (2012). This factor was also reported by Tamimi et al. (2015), and they hypothesized that it may be related to urine-marking and therefore is a result of a larger proportion of unneutered dogs being present in their study population. Therefore, the larger sample size of the current study, with a larger number of unneutered dogs compared to previous studies, could explain the presence of this factor. Overall, these results indicate that the factor structure of the C-BARQ is relatively consistent, and is maintained with the large sample size of the current study. Combined with previous studies on the validity of the C-BARQ (Hsu and Serpell, 2003; Svartberg, 2005; van den Berg et al., 2006, 2010) this suggests that the C-BARQ is a reliable evaluation tool of reported canine temperament traits.

2.5.2 Dog characteristics affecting aggressive behaviour

There were few dog characteristics that were significant in both models, with the main similarities being the effect of participants rating their dogs as having stranger fear or non social fear, and the animal's sex. Overall, the lack of similarity between the two stranger-directed aggression models could indicate a difference between what causes dogs to act aggressively, and what causes dogs to escalate from threatening behaviour into actual bite attempts. Threatening behaviours are commonly used in order for an animal to repel a perceived threat while avoiding the costs and risks of an actual physical attack (Archer and Huntingford, 1994). If the threatening behaviours are not successful in removing the perceived threat, then animals will often escalate their behaviour to the point of attacking (Archer and Huntingford, 1994). Dogs that bite or attempt to bite may have either 1) low bite inhibition or impulse control, 2) been pushed beyond their comfort level, or 3) learned that communication through threatening behaviour will either be ignored or punished, and attempting to bite is the only way to protect themselves. As both option 2 and 3 are caused by external factors, it might explain why few of the dog characteristics were significant in the severe aggression model. It would then be predicted that factors relating to a dog's history and environment, including how the owner handles the dog when it is uncomfortable may be the primary risk factors for this behaviour. As these variables were not directly measured in this project, this hypothesis offers an important area for future research.

Fear

The dog characteristic with the largest association with stranger-directed aggression in both models was stranger fear, with higher odds of aggression being seen with greater fear of strangers. Other studies have also found an association between fear of strangers and aggression towards strangers (Duffy et al., 2008; Goodloe and Borchelt, 1998), although in one case the strength of this association differed between different breeds. While these results could indicate that aggression towards strangers is motivated by fear, longitudinal studies are required to determine whether this association is indeed causal. Another possible explanation is that situations that are threatening and provoke aggressive responses may also independently provoke a fear response, without the aggression being motivated by fear. Caution should also be used when interpreting this data as it is based on owner reports, and therefore differences in fearfulness between aggressive and non-aggressive dogs could be due to differences in owner interpretation of their dogs' behaviour, rather than actual differences in their dogs' levels of fearfulness. For example, it is possible that owners may perceive stranger-directed aggression as a form of fear, and rate their dogs as fearful even when they are not displaying typical fear behaviours. Dogs were also more likely to show aggression towards strangers if they had mild non-social fear, but were less likely to show severe aggression. These relationships with stranger-directed aggression are not seen in dogs with extreme non-social fear. This effect might reflect differences in how dogs with extreme non-social fear are managed, or how they respond to fear-provoking stimuli; however, no effect was found for dogs with extreme fear of strangers, which would be expected to show a similar relationship. Given the relatively large number of variables in this analysis, it is also possible that this is a type 1 error, warranting further investigation. Based on these results caution should be taken when handling dogs with fear towards strangers, and these dogs may benefit from targeted training in order to prevent the development of stranger-directed aggression.

Sex and neuter status

Another dog characteristic that was significant in both models was the dog's sex. Neutered male dogs were more likely to exhibit stranger-directed aggression compared to either females, or intact males. Also, male dogs with stranger-directed aggression were more likely to bite or attempt to bite when compared to female dogs. Male dogs have previously been reported to show higher rates of aggression than females (Amat et al., 2009; Borchelt, 1983; Casey et al., 2014; Fatjo et al., 2007; Gershman et al., 1994; Lund et al., 1996). One study looked at the interaction between neutering and sex, and found that neutering was associated with stranger-directed aggression in females, but the relationship disappeared when dogs that were neutered due to aggression issues were removed from the model (Podberscek and Serpell, 1996). However, another study found that stranger-directed aggression was lowest in neutered females when compared to all other categories (Casey et al., 2014). Studies examining the effect of neutering independent of sex have found mixed results (Amat et al., 2009; Gershman et al., 1994; Goodloe and Borchelt, 1998; Matos et al., 2015; Podberscek and Serpell, 1997; van den Berg et al., 2006). The differences could be due to sex-based differences in relation to neutering effect, sample size and statistical variability, or differences in classification of aggressive behaviour. The cross-sectional design of this study makes it impossible to determine causality. However, the reason why the dog was neutered was not significant in either of the models, suggesting that the difference in aggression between neutered and intact dogs in the study population is not likely a result of dogs being neutered in order to fix already existing aggression issues. In addition, the age at which the dog was neutered was not significant in either model. One possible hypothesis is that neutering males makes them more fearful, and consequently more likely to act aggressively. Other studies have found that testosterone reduces fear and anxiety in a range of different species (Aikey et al., 2002; Boissy and Bouissou, 1994; Bouissou and Vandenheede, 1996; Frye and Seliga, 2001; Van Honk et al., 2005; Vandenheede and Bouissou, 1996). However, we did not find an interaction between neuter status and stranger fear, and neuter status was significant even within non-fearful dogs, suggesting that either neutering has an effect on aggressive behaviour independent of fear, or some dog owners are not recognizing fear in their dogs. Interestingly, neuter status did not impact whether aggressive dogs were likely to display severe aggression. These results indicate it may be beneficial to leave male dogs intact, or potentially perform a vasectomy rather than a full gonadectomy, in order to reduce the risk of dogs developing stranger-directed aggression.

However, further research is needed to determine whether the relationship between neutering and stranger-directed aggression is indeed causal.

How the dog was acquired

Where the dog was acquired was significant for both models. When compared to dogs from breeders, dogs from pet stores, or friends or relatives were more likely to be scored as aggressive towards strangers, while dogs from shelters, found stray, from friends or relatives, or from "other" sources were more likely to display severe aggression. Dogs acquired from pet stores have been previously reported to have less favourable temperament traits, including aggression towards strangers, compared to those from non-commercial breeders (McMillan et al., 2013). Commercial breeders that supply pet stores are typically high-volume, and it is possible that puppies in these environments are subject to increased perinatal stress and reduced environmental and social exposure. Prenatal stress has been shown to impact the behaviour of offspring throughout their adult life (Braastad, 1998; Clarke and Schneider, 1993; Tuber et al., 1999), and lack of early socialization has been associated with increased fear and aggression, especially towards strangers (Fox and Stelzner, 1967). There could also be a difference in the type of people who acquire their dogs from these sources. If pets are purchased on impulse from a convenient source, the owner may be unprepared to properly raise, socialize and train a puppy, resulting in higher levels of aggression (Bennett and Rohlf, 2007). Dogs from friends or relatives and from shelters also showed elevated risk levels, possibly because they were relinquished due to pre-existing behaviour problems related to fear and aggression. Further research is needed to explore the reasons for the increased aggression found in dogs acquired from these different sources. In addition, as the C-BARQ relies on owner reports, it is possible that owners who acquire their dogs from different sources perceive their dogs' behaviour differently. Further investigation into the reasons for these behavioural differences is needed before recommendations can be made regarding where to acquire dogs.

Age at acquisition had an effect on the likelihood of displaying stranger-directed aggression, but was not associated with the likelihood of severe aggression. Dogs that were acquired as adults were less likely to be aggressive towards strangers when compared to dogs acquired as puppies or adolescents

(Table 2.3). This effect was also seen in a study by Hsu and Sun (2010), and could be because adult dogs that are aggressive towards strangers are less desirable and at a higher risk for euthanasia.

Breed

Breed group was also significant in both models, but while mixed breeds, and herding breeds were the most likely to be scored as aggressive, these breeds were not more likely to show severe stranger-directed aggression. In addition, hounds were less likely to be scored as aggressive, while sporting breeds were less likely to have both aggression and severe aggression compared to other breed groups. The prevalence of mixed breeds in this study (0.22) was higher than any other individual breed, or breed group, and is similar to numbers reported in previous research ranging from 0.17 to 0.38 (Casey et al. 2014; Hsu and Sun, 2010; Lund et al., 1996). In previous research, results regarding aggression in mixed breeds have been varied (Casey et al., 2014; Hsu and Sun, 2010; Lund et al., 1996; Shuler et al., 2008), possibly due to differences in the severity of aggression being measured. Both Casey et al. (2014) and Hsu and Sun (2010) used methodology similar to the current study, and also found that mixed breeds were more likely to show aggression. In contrast, Lund et al. (1996) used a case-control design and included dogs that were diagnosed as aggressive after seeking consultation with a behaviourist, and found lower levels of aggression in mixed breeds. This sampling method likely resulted in a higher proportion of dogs with severe aggression. Similarly, Shuler et al. (2008) looked at reports of dog bites, and did not include dogs that showed milder levels of aggression, and found lower levels of aggression in mixed breeds. However, over 50% of the dogs studied by Shuler et al. (2008) had no reported breed status, and were therefore listed as “unknown”. The results of both of these studies appear to be consistent with our finding that mixed breeds were not at a higher risk of severe aggression. A higher overall risk of aggression in mixed breeds could be due to differences in early life experiences. Puppies from non-registered breeders are often a result of accidental breeding and are less likely to receive early socialization as planned, purebred puppies (Korbelik et al., 2011), and this could affect a dog’s temperament into adulthood There might also be differences in the type of owner that chooses a mixed breed over a purebred dog, which may cause them to rate mixed breed dogs as more aggressive towards strangers.

Results of studies looking into the risk of stranger-directed aggression in common pure breeds have varied, but German Shepherds are highlighted for increased risks of aggression across all studies (Beaver, 1983; Blackshaw, 1991; Borchelt, 1983; Duffy et al., 2008; Lund et al., 1996). The German Shepherd is a common herding breed, so this is consistent with our results. German Shepherds, and other herding breeds, might be more likely to act aggressively due to differences in how they are raised and trained, as well as the types of people who choose to own this breed. German Shepherds are a popular breed for protection and guarding roles, and therefore owners may encourage aggressive behaviours towards strangers. Three common members of the hound group, Greyhound, Beagles and Dachshunds have been found to differ in the stranger-directed aggression scores, with Greyhounds having scores significantly lower than average, Beagles not differing significantly from average, and Dachshunds having some of the highest levels of stranger-directed aggression (Duffy et al., 2008). Labrador Retrievers and Golden Retrievers, which are common sporting breeds, are commonly found to have reduced risks of stranger-directed aggression compared to the other breeds (Duffy et al., 2008; Hsu and Sun, 2010), which is consistent with our finding that sporting breeds are at a lower risk for severe stranger-directed aggression. Casey et al. (2014) also found reduced risk of stranger-directed aggression in gundogs, the UK Kennel Clubs equivalent to the AKCs sporting dog group. These findings likely have a genetic basis since these breeds have been bred to work cooperatively with people. Also, many of these breeds are bred for retrieval, which requires dogs to be “soft-mouthed” in order to not damage game, and this may be related to improved bite awareness and inhibition. These breed group differences may also be due to differences in how the dogs are raised, and the type of person that acquires them, or how they are perceived by the owner. While the exact reason for the higher risk of stranger-directed aggression in mixed breeds and herding breeds is not known, it can be recommended that owners who are concerned with stranger-directed aggression avoid mixed breeds and herding breeds.

Age

While adolescent and senior dogs were less likely to display aggressive behaviour than adults, age was not related to risk for severe aggression. Some previous studies have suggested that aggressive behaviour increases with age (Bennett and Rohlf, 2007; Pal et al., 1998), while others have not (Matos et al., 2015; Podberscek and Serpell, 1997), so the relationship is unclear. It is possible that owners are more forgiving of mild to moderate levels of aggressive behaviour in young dogs, and therefore do not rate it as severely. The current study did not include dogs under six months of age, so the level of aggression in puppies could not be determined.

2.4.3 Owner characteristics affecting aggressive behaviour

None of the measured variables related to owner experience (number of dogs owned previously, whether they owned dogs as a child) were significant in either of the aggression risk-factor models. This indicates that either an owner's experience does not have an effect on a dog's aggressive behaviour, or that these particular questions are not comprehensive enough to successfully measure an owner's experience level. Demographic data relating to the owner, such as age and sex, were not measured in the current study and, therefore, could not be analyzed.

Both of the current models indicate that dogs owned by the same person are more similar in their aggressive behaviour than can be accounted for by chance. Possible explanations for this finding include: 1) certain owners are more likely to rate their dogs as aggressive; 2) certain owners are more likely to acquire an aggressive dog than other owners; 3) aggression is socially-facilitated, resulting in dogs in a household with an aggressive dog being more likely to display aggression themselves; and 4) unmeasured variables related to how a dog is housed, trained and managed by the owner affect a dog's likelihood of acting aggressively. Based on the manner in which C-BARQ data are collected, it is possible that in some cases the participant variable reflects data from amateur dog trainers that are assessing client dogs using the C-BARQ. While this version of the C-BARQ was intended to be completed by owners and separate accounts were available for professional dog trainers, it is possible that some amateur dog trainers may have used the general accounts in order to avoid paying applicable fees. This may have resulted in unintentional clustering of dogs with behavioural issues within the same participant ID, and may have also biased other results as dog trainers may not see the dogs in a full variety of contexts and situations. However, as no participant rated more than nine dogs, and 99% of participants rated five dogs or less, this should not have made a significant impact on the results in this study. Based on the effect of participant found in the current study, further research is needed exploring owner attitudes and household level variables.

2.4.4 Limitations

The main limitation of this study is that the C-BARQ relies on owners reporting on their dogs' past behaviours. While previous studies have shown high reliability and validity for the C-BARQ (Duffy and Serpell, 2012; Hsu and Serpell, 2003), the exact level of precision of owners' ratings of their dogs' fear and aggression has not been determined. Further research is needed to validate owner ratings of these behaviours using independent observations of their dogs' behaviours. For the current study it is important to note that all risk factors for stranger-directed aggression are based on owner-perceived aggressive behaviours, and may not reflect their dogs' actual aggressive behaviours.

Another limitation of this study is the study population, as it is possible that owners of dogs with behavioural problems may have been more likely to respond to the survey, causing an overestimation of the level of aggression in the broader dog population if extrapolated. Few other studies have reported the prevalence of stranger-directed aggression. Values for severe stranger-directed aggression reported by Duffy et al. (2008) using the C-BARQ are similar to the current study (4.7 %). However, Casey et al. (2014), reported much lower prevalence for stranger-directed aggression (5.1-6.6 %) than found in the current study (78.1 %). These differences could be due to differences in the dog populations, as Casey et al. studied dogs in the U.K, or due to differences in how owners were asked to rate their dog. Casey et al. (2014) asked owners to respond "yes" or "no" if their dogs bark, lunge, growl or bite in a given situation, while the C-BARQ asks owners to rate aggression on a scale of 0 to 4. Owners may be more hesitant to categorize their dog as aggressive using the yes/no questions, than they would be to rate their dog as a 1 or 2 on the C-BARQ, resulting in dogs with mild aggression not being captured in the previous study. The liberal categorization of aggression in the current study may have resulted in smaller effect sizes in comparison to the categorization used by Casey et al. (2014), as milder levels of aggression are being considered.

Finally, the cross-sectional design of this study limits our ability to make causal inferences, and therefore it cannot be determined whether factors associated with stranger-directed aggression actually cause the aggression, alter the owners' perceptions of aggression, or are more likely to occur in dogs that are already aggressive. Instead these identified risk factors can help develop hypotheses for future longitudinal studies.

2.5 Conclusion

A number of dog-related factors are associated with participant-reported aggressive behaviours towards strangers, including breed group, sex, neuter status and where and when the dog was acquired. The largest effect was seen with fear of strangers, supporting the hypothesis that aggression towards strangers is motivated by fear, although these aggressive responses could also have an independent motivation, and are simply expressed in similar situations as fear. There was also a large amount of variation between dogs explained at the participant level, suggesting that further exploration into environment and management factors is needed, as well as into factors which may affect how owners perceive aggression in dogs. While causal inferences cannot be made from the current study, this study is important for generating hypotheses for future longitudinal studies. These results can then be used to aid in the identification of dogs at risk of developing stranger-directed aggression, and may also contribute to the development of strategies for preventing and treating stranger-directed aggression.

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Table 2.1 The number and proportion of dogs in each category of the different categorical variables collected with the C-BARQ questionnaire from April 2006 to February 2013 (n=17,301).

Variable	Category	Number	Proportion
Stranger Aggression	None	3797	0.22
	Mild/Moderate	12379	0.72
	Severe	1125	0.06
Stranger Fear	None	8212	0.50
	Mild/Moderate	7390	0.45
	Severe	903	0.05
Non-Social Fear	None	3307	0.22
	Mild/Moderate	9623	0.64
	Severe	2083	0.14
Breed Group	Hound	1042	0.06
	Toy	1301	0.08
	Sporting	2839	0.16
	Non-sporting	1247	0.07
	Working	2363	0.14
	Terrier	1671	0.10
	Herding	3068	0.18
	Mixed/Other	3770	0.22
Age Evaluated	Adolescent	5993	0.34
	Adult	10275	0.59
	Senior	1033	0.06
Sex	Male	8939	0.52
	Female	8362	0.48
Neutered	Yes	12708	0.74
	No	4593	0.27
Age Neutered	N/A (Intact)	4593	0.27
	Puppy	5751	0.34
	Adolescent	4903	0.29
	Adult	1696	0.10
	Senior	13	0.00
Why Neutered	N/A (Intact)	4593	0.27
	Birth Control	4451	0.26
	Correct behaviour problems	466	0.03
	Prevent behaviour problems	516	0.03
	Correct health problems	238	0.01
	Prevent health problems	1069	0.06
	Recommended by vet	770	0.05
	Required by breeder/shelter	3992	0.23
	Unknown	1206	0.07

Where Acquired	Breeder	7756	0.45
	Bred by owner	877	0.05
	Pet Store	527	0.03
	Shelter	5096	0.30
	Stray	815	0.05
	Friend/Relative	1381	0.08
	Other	849	0.05
Age Acquired	Puppy	11744	0.70
	Adolescent	3673	0.22
	Adult	1454	0.09
	Senior	17	0.00
Health Problems	Yes	2550	0.15
	No	14751	0.85
Owned Amount[1]	0	2757	0.16
	1-2	4748	0.27
	3-5	5155	0.30
	6-10	2550	0.15
	>10	2091	0.12
Owned as Child[2]	Yes	13957	0.81
	No	3344	0.19
Other Dogs[3]	Yes	11579	0.67
	No	5722	0.33

[1] The number of dogs the owner has owned previous to the current dog
[2] Whether or not the owner had dogs as a child
[3] Whether there are other dogs living in the same household

Table 2.2 Factor analysis of the C-BARQ questionnaire including items with a loading of > 0.40 on any given factor using a varimax rotation (C-BARQ accessed Feb, 2013; N = 7,656)

Item	Loading
Factor 1 – Stranger-Directed Aggression (10 items, eigenvalue = 12.82, Cronbach α = 0.93)	
Dog acts aggressively:	
When approached directly by an unfamiliar adult while being walked/exercised on a leash	0.7513
When approached directly by an unfamiliar child while being walked/exercised on a leash	0.6507
Toward unfamiliar persons approaching the dog while s/he is in your car	0.7113
When an unfamiliar person approaches you or another member of your family at home	0.7214
When unfamiliar persons approach you or another member of your family away from your home	0.7388
When mailmen or other delivery workers approach your home	0.7465
When strangers walk past your home while your dog is outside or in the yard	0.7384
When an unfamiliar person tries to touch or pet the dog	0.7078
When joggers, cyclists, rollerbladers or skateboarders pass your home while your dog is outside or in the yard	0.7113
Toward unfamiliar persons visiting your home	0.7306
Factor 2 – Owner-Directed Aggression (8 items, eigenvalue = 4.07, Cronbach α = 0.86)	
Dog acts aggressively:	
When verbally corrected or punished (scolded, shouted at, etc.) by you or a household member	0.5554
When toys, bones or other objects are taken away by a household member	0.7359
When bathed or groomed by a household member	0.4741
When approached directly by a household member while s/he (the dog) is eating	0.7680
When his/her food is taken away by a household member	0.8095
When stared at directly by a member of the household	0.5234
When stepped over by a member of the household	0.5170
When you or a household member retrieves food or objects stolen by the dog	0.7776
Factor 3 – Stranger Fear (4 items, eigenvalue = 3.94, Cronbach α = 0.93)	
Dog acts anxious or fearful:	
When approached directly by an unfamiliar adult while away from your home	0.8100
When approached directly by an unfamiliar child while away from your home	0.7611
When unfamiliar persons visit your home	0.7259
When an unfamiliar person tries to touch or pet the dog	0.7084
Factor 4 – Separation-related behaviour (8 items, eigenvalue = 3.46, Cronbach α = 0.83)	
Dog displays:	
Shaking, shivering or trembling when left, or about to be left, on its own	0.5346
Excessive salivation when left, or about to be left, on its own	0.5269
Restlessness/agitation/pacing when left, or about to be left, on its own	0.6746
Whining when left, or about to be left, on its own	0.6879
Barking when left, or about to be left, on its own	0.6092
Howling when left, or about to be left, on its own	0.5305
Chewing/scratching at door, floor, windows, curtains etc. when left, or about to be left, on its own	0.5335
Loss of appetite when left, or about to be left, on its own	0.4157
Factor 5 – Dog Fear (4 items, eigenvalue = 2.56, Cronbach α = 0.88)	

Dog acts anxious or fearful:	
When approached directly by an unfamiliar dog of the same or larger size	0.8100
When approached directly by an unfamiliar dog of a smaller size	0.7611
When unfamiliar dogs visit your home	0.7259
When barked, growled, or lunged at by an unfamiliar dog	0.7084
Factor 6 – Trainability (8 items, eigenvalue = 2.22, Cronbach α = 0.79)	
Dog:	
Returns immediately when called, while off-leash	0.6402
Obeys the “sit” command immediately	0.5978
Obeys the “stay” command immediately	0.6608
Seems to attend/listen closely to everything you say or do	0.5952
Slow to respond to correction or punishment; ‘thick-skinned’	0.4056
Slow to learn new tricks or tasks	0.4396
Easily distracted by interesting sights, sounds or smells	0.4511
Escapes or would escape from home or yard given the chance	-0.4534
Factor 7 - Excitability (5 items, eigenvalue = 1.52, Cronbach α = 0.81)	
Dog overacts or is excitable:	
When you or other members of the household come home after a brief absence	0.4654
When doorbell rings	0.5632
Just before being taken for a walk	0.7570
Just before being taken on a car trip	0.7559
When visitors arrive at your home	0.5918
Factor 8 – Chasing (4 items, eigenvalue = 1.42, Cronbach α = 0.83)	
Dog:	
Acts aggressively toward cats, squirrels or other small animals entering your yard	0.5424
Chases or would chase cats given the opportunity	0.7395
Chases or would chase birds given the opportunity	0.6987
Chases or would chase squirrels, rabbits and other small animals given the opportunity	0.8112
Factor 9 – Dog Rivalry (4 items, eigenvalue = 1.33, Cronbach α = 0.85)	
Dog acts aggressively:	
Towards another (familiar) dog in your household	0.6486
When approached at a favorite resting/sleeping place by another (familiar) household dog	0.6578
When approached while eating by another (familiar) household dog	0.7274
When approached while playing with/chewing a favorite toy, bone, object, etc., by another (familiar) household dog	0.7422
Factor 10 – Attachment and Attention Seeking (6 item, eigenvalue = 1.31, Cronbach α = 0.76)	
Dog:	
Displays a strong attachment for one particular member of the household	0.5206
Tends to follow you (or other members of household) about the house, from room to room	0.6853
Tends to sit close to, or in contact with, you (or others) when you are sitting down	0.7376
Tends to nudge, nuzzle or paw you (or others) for attention when you are sitting down	0.5843
Becomes agitated (whines, jumps up, tries to intervene) when you (or others) show affection for another person	0.4148
Becomes agitated (whines, jumps up, tries to intervene) when you show affection for another dog or animal	0.4556
Factor 11 – Elimination Problems (3 items, eigenvalue = 1.12, Cronbach α=0.79)	
Dog:	
Urinates against objects/ furnishings in your home	0.5026
Urinates when left alone at night, or during the daytime	0.8242

Defecates when left alone at night, or during the daytime	0.7887
Factor 12 – Non-Social Fear (5 items, eigenvalue = 1.06, Cronbach α = 0.77)	
Dog acts anxious or fearful:	
In response to sudden or loud noises (e.g. vacuum cleaner, car backfire, road drills, objects being dropped, etc.)	0.6346
In heavy traffic	0.4483
In response to strange or unfamiliar objects on or near the sidewalk (e.g. plastic trash bags, leaves, litter, flags flapping, etc.	0.5496
During thunderstorms, firework displays, or similar events	0.5296
In response to wind or wind blown-objects	0.5988
Factor 13 – Activity and Energy (3 items, eigenvalue = 0.91, Cronbach α = 0.77)	
Dog is:	
Hyperactive, restless, has trouble settling down	0.4670
Playful, puppyish, boisterous	0.7098
Active, energetic, always on the go	0.7259

Table 2.3 Multivariable mixed logistic regression model for risk-factors for scoring 1 or greater on any question in the C-BARQ stranger-directed aggression factor with participant ID and country as random effects (N=14,310 dogs; 10,951 participants; 67 countries)

Fixed effects		OR[1]	95% CI[2]	P-value
Stranger Fear	Mild/Moderate vs. None	5.73	4.99-6.59	<0.001
	Severe vs. None	5.24	3.88-7.10	<0.001
	Severe vs. Mild/Moderate	0.92	0.68-1.23	0.560
Non-Social Fear	Mild/Moderate vs None	1.19	1.04-1.35	0.010
	Severe vs. None	1.00	0.82-1.71	0.975
	Severe vs. Mild/Moderate	0.84	0.71-1.00	0.048
Age Evaluated	Adult vs. Adolescent	1.52	1.34-1.72	<0.001
	Senior vs. Adolescent	1.13	0.92-1.38	0.243
	Senior vs. Adult	0.74	0.62-0.90	0.002
Age Acquired	Adolescent vs. Puppy	0.86	0.73-1.01	0.068
	Adult vs. Puppy	0.50	0.40-0.62	<0.001
	Adult vs. Adolescent	0.58	0.46-0.72	<0.001
Where Acquired	Other vs. Breeder	0.75	0.57-0.97	0.030
	Bred by Owner vs. Breeder	0.93	0.72-1.20	0.559
	Shelter vs. Breeder	0.96	0.80-1.15	0.643
	Stray vs. Breeder	1.29	0.94-1.77	0.114
	Pet Store vs. Breeder	1.46	1.03-2.07	0.033
	Friend/Relative vs. Breeder	1.67	1.31-2.12	<0.001
	Bred by Owner vs. Other	1.24	0.87-1.76	0.232
	Shelter vs. Other	1.28	0.98-1.68	0.074
	Stray vs. Other	1.73	1.18-2.51	0.004
	Pet Store vs. Other	1.95	1.28-2.97	0.002
	Friend/Relative vs. Other	2.23	1.61-3.08	<0.001
	Shelter vs. Bred by Owner	1.03	0.76-1.40	0.833
	Stray vs Bred by Owner	1.39	0.94-2.07	0.103
	Pet Store vs. Bred by Owner	1.58	1.04-2.40	0.034
	Friend/Relative vs. Bred by Owner	1.80	1.29-2.52	0.001
	Stray vs. Shelter	1.35	0.99-1.82	0.054
	Pet Store vs. Shelter	1.53	1.05-2.21	0.026
	Friend/Relative vs. Shelter	1.74	1.36-2.23	<0.001
	Pet Store vs. Stray	1.13	0.72-1.78	0.588
	Friend/Relative vs. Stray	1.29	0.90-1.85	0.159
	Friend/Relative vs. Pet Store	1.14	0.76-1.70	0.517
Breed Group	Sporting vs. Hound	1.38	1.08-1.76	0.011
	Toy vs. Hound	1.44	1.07-1.93	0.016
	Working vs. Hound	2.11	1.62-2.73	<0.001
	Non-Sporting vs. Hound	2.20	1.62-2.98	<0.001
	Terrier vs. Hound	2.39	1.80-3.15	<0.001
	Herding vs. Hound	2.90	2.25-3.76	<0.001
	Mixed/Other vs. Hound	3.39	2.61-4.42	<0.001

	Toy vs. Sporting	1.04	0.82-1.33	0.725
	Working vs. Sporting	1.53	1.26-1.86	<0.001
	Non-Sporting vs. Sporting	1.60	1.24-2.05	<0.001
	Terrier vs. Sporting	1.73	1.39-2.16	<0.001
	Herding vs. Sporting	2.11	1.74-2.55	<0.001
	Mixed/Other vs. Sporting	2.46	2.01-3.02	<0.001
	Working vs. Toy	1.46	1.13-1.89	0.003
	Non-Sporting vs. Toy	1.53	1.14-2.06	0.005
	Terrier vs. Toy	1.66	1.26-2.18	<0.001
	Herding vs. Toy	2.02	1.57-2.59	<0.001
	Mixed/Other vs. Toy	2.36	1.82-3.05	<0.001
	Non-Sporting vs. Working	1.04	0.80-1.36	0.745
	Terrier vs. Working	1.13	0.90-1.43	0.295
	Herding vs. Working	1.38	1.13-1.69	0.002
	Mixed/Other vs. Working	1.61	1.30-2.00	<0.001
	Terrier vs. Non-Sporting	1.08	0.82-1.43	0.570
	Herding vs. Non-Sporting	1.32	1.02-1.71	0.033
	Mixed/Other vs. Non-Sporting	1.54	1.18-2.01	0.001
	Herding vs. Terrier	1.22	0.97-1.53	0.087
	Mixed/Other vs. Terrier	1.42	1.13-1.79	0.003
	Mixed/Other vs. Herding	1.17	0.95-1.44	0.142
Sex*Neutered[3]	SF vs IF	0.95	0.79-1.15	0.607
	IM vs IF	1.02	0.84-1.25	0.827
	NM vs IF	1.40	1.15-1.69	0.001
	IM vs SF	1.08	0.90-1.29	0.427
	NM vs SF	1.47	1.29-1.67	<0.001
	NM vs IM	1.37	1.14-1.64	0.001
Random effects				
Participant ID	ICC	0.40	0.35-0.46	<0.001
	Variance	2.16	1.73-2.70	--
Country	ICC	0.01	0.00-0.08	<0.001
	Variance	0.07	0.01-0.48	--

[1] Odds ratio based on output of mixed logistic regression model
[2] 95% confidence interval of the odds ratio
[3] IF represents “Intact Female”; SF represents “Spayed Female”; IM represents “Intact Male”; NM represents “Neutered Male”

Table 2.4 Multivariable mixed logistic regression model for risk-factors for stranger aggressive dogs (scoring 1 or greater in any question in the C-BARQ stranger-directed aggression factor) displaying severe stranger-directed aggression (scoring 4 on at least 1 question in the C-BARQ stranger-directed aggression factor) with participant ID and country as random effects (N=11,240 dogs; 9,070 participants, 64 countries)

Fixed effects		OR[1]	95% CI[2]	P-value
Stranger Fear	Mild/Moderate vs. None	2.27	1.86-2.77	<0.001
	Severe vs. None	9.74	6.93-13.69	<0.001
	Severe vs. Mild/Moderate	4.29	3.21-5.73	<0.001
Non-Social Fear	Mild/Moderate vs. None	0.76	0.61-0.96	0.020
	Severe vs. None	1.20	0.92-1.58	0.182
	Severe vs. Mild/Moderate	1.57	1.27-1.95	<0.001
Sex	Male vs. Female	1.74	1.46-2.06	<0.001
Breed Group	Non-Sporting vs. Sporting	1.62	1.07-2.45	0.022
	Working vs. Sporting	1.66	1.15-2.39	0.007
	Hound vs. Sporting	1.85	1.19-2.88	0.007
	Herding vs. Sporting	1.90	1.36-2.65	<0.001
	Mixed vs. Sporting	1.93	1.38-2.69	<0.001
	Terrier vs. Sporting	2.15	1.48-3.13	<0.001
	Toy vs. Sporting	2.44	1.66-3.59	<0.001
	Working vs. Non-Sporting	1.02	0.69-1.52	0.910
	Hound vs. Non-Sporting	1.14	0.71-1.83	0.582
	Herding vs. Non-Sporting	1.17	0.81-1.69	0.396
	Mixed vs. Non-Sporting	1.19	0.83-1.72	0.339
	Terrier vs. Non-Sporting	1.33	0.89-1.99	0.167
	Toy vs. Non-Sporting	1.51	1.00-2.27	0.050
	Hound vs. Working	1.12	0.73-1.71	0.617
	Herding vs. Working	1.15	0.84-1.56	0.389
	Mixed vs. Working	1.17	0.86-1.59	0.327
	Terrier vs. Working	1.30	0.91-1.85	0.145
	Toy vs. Working	1.47	1.02-2.12	0.038
	Herding vs. Hound	1.03	0.69-1.53	0.896
	Mixed vs. Hound	1.05	0.71-1.55	0.818
	Terrier vs. Hound	1.17	0.76-1.80	0.488
	Toy vs. Hound	1.32	0.85-2.05	0.216
	Mixed vs. Herding	1.02	0.78-1.33	0.888
	Terrier vs. Herding	1.13	0.83-1.56	0.437
	Toy vs. Herding	1.29	0.92-1.79	0.135
	Terrier vs. Mixed	1.11	0.82-1.51	0.494
	Toy vs. Mixed	1.26	0.91-1.74	0.158
	Toy vs. Terrier	1.13	0.78-1.64	0.507
Where Acquired	Bred by Owner vs. Breeder	0.82	0.51-1.30	0.393
	Pet Store vs. Breeder	1.21	0.77-1.90	0.404
	Shelter vs. Breeder	1.29	1.03-1.61	0.028
	Friend/Relative vs. Breeder	1.68	1.25-2.25	0.001

	Stray vs. Breeder	1.74	1.20-2.51	0.003
	Other vs. Breeder	1.79	1.23-2.62	0.002
	Pet Store vs. Bred by Owner	1.48	0.80-2.75	0.221
	Shelter vs. Bred by Owner	1.58	0.97-2.56	0.065
	Friend/Relative vs. Bred by Owner	2.06	1.23-3.44	0.006
	Stray vs. Bred by Owner	2.13	1.21-3.74	0.008
	Other vs Bred by Owner	2.20	1.25-3.87	0.006
	Shelter vs. Pet Store	1.06	0.68-1.67	0.789
	Friend/Relative vs. Pet Store	1.39	0.85-2.26	0.190
	Stray vs. Pet Store	1.44	0.84-2.45	0.184
	Other vs. Pet Store	1.48	0.86-2.56	0.160
	Friend/Relative vs. Shelter	1.30	0.97-1.75	0.077
	Stray vs. Shelter	1.35	0.95-1.92	0.093
	Other vs. Shelter	1.39	0.95-2.03	0.086
	Stray vs. Friend/Relative	1.04	0.69-1.55	0.866
	Other vs. Friend/Relative	1.07	0.70-1.63	0.762
	Other vs. Stray	1.03	0.64-1.65	0.899
Random effects				
Participant ID	ICC	0.34	0.22-0.48	<0.001
	Variance	1.38	0.71-2.68	--
Country	ICC	0.06	0.02-0.15	<0.001
	Variance	0.30	0.10-0.87	--

[1] Odds ratio based on output of mixed logistic regression model
[2] 95% confidence interval of the odds ratio

CHAPTER THREE

Effect of targeted training on dog owners’ ratings of fear in familiar and unfamiliar dogs

In preparation for submission to *Applied Animal Behaviour Science*

3.1 Abstract

Scientific studies often assess aspects of dog temperament, such as fear, via owner reports. However, it is unknown whether owners are able to accurately rate their own dogs' fearfulness. The current study assessed which fear behaviours dog owners are able to reliably recognize and whether training alters participant ratings of fear in familiar and unfamiliar dogs. Dog owners (n=573) were asked to identify which dog behaviours were present/absent in a series of videos. This survey showed that owners were reliably able to recognize (Sn and Sp >0.75) body posture, ear position, tail position, wagging tail, panting, lolling tongue, yawning, lip licking, avoiding eye contact and attempts to hide/escape/retreat. These behaviours were used to make a targeted training tool for recognizing fear in dogs. Next, an intervention study was conducted where dog owners (n=1,413) were surveyed and asked to complete the fear and anxiety portion of the Canine Behavioural Assessment and Research Questionnaire (C-BARQ) for their own dogs, and then either received training on recognizing fear in dogs (i.e., intervention), or did not (i.e., controls). Both groups were then asked to rate the severity of fear in dogs in another series of videos, with three examples each of no fear, mild/moderate fear, and high/severe fear. Finally, owners were asked to complete the C-BARQ survey for their own dogs a second time to determine if training to recognize fear in dogs altered their responses. The effect of training on owner ability to rate dog fear displayed in videos was assessed with a mixed logistic regression model, with owner as a random effect. While training was not associated with owners being more likely to correctly identify 'no fear' (OR: 1.01; 95% CI: 0.86, 1.20; $p = 0.881$), it resulted in owners being more likely to correctly identify 'mild/moderate fear' (OR: 1.60; 95% CI: 1.34, 1.91; $p < 0.001$) and 'high/severe fear' (OR: 1.95; 95% CI: 1.50, 2.54; $p < 0.001$). The effect of training on owner ratings of fear in their own dog was assessed using linear and logistic regression models. Training did not consistently affect the C-BARQ fear factor scores, except to moderate scores for non-social fear. Before recommending the use of training in order to increase the validity of the C-BARQ, further studies are needed to determine why training improves recognition of fear in videos of unfamiliar dogs, but does not alter the owners' rating of their own dogs.

3.2 Introduction

The ability to accurately recognize fear in dogs is important for optimizing animal welfare, preventing behavioural issues and ensuring accurate scientific research. Fear is a negative emotional state that directly impairs animal welfare. If it is not recognized by the owner, then they are not able to take adequate steps to prevent it, such as avoiding related stimuli. Fear has been previously linked to other behavioural problems, such as aggression (Hsu and Serpell, 2003), which can further impair animal welfare and negatively impact the human-animal bond (Serpell, 1996). For example, one study reported that 31% of relinquished dogs were identified as fearful by their owner (Salman et al., 1998). To properly prevent and treat fear, we must first ensure that it is being correctly identified.

Recently, researchers studying dog temperament and behavioural issues have been turning to indirect owner reports on their dogs' behaviour. These surveys allow researchers to gain a larger sample size over a broader geographic area than if they relied on in-person direct behavioural assessments of the dogs. However, these reports rely on a dog owner's ability to correctly identify different dog behaviours, or emotional states. The Canine Behavioural Assessment and Research Questionnaire (C-BARQ), developed by Hsu and Serpell (2003), is a tool that is commonly used to gather indirect owner reports of a dog's behaviour. This questionnaire consists of 100 questions divided into seven sections: 'Trainability', 'Aggression', 'Fear & Anxiety', 'Separation-related behaviour', 'Excitability', 'Attachment and Attention-seeking', and 'Miscellaneous'. Each owner is asked to rate their dog's behavioural response to different scenarios on a 0 (none) to 4 (extreme) scale. Via factor analysis, the researchers have previously identified three different factors relating to fear in dogs: stranger-directed fear, dog-directed fear and non-social fear (Chapter 2). Previous research validating the C-BARQ has found that dogs that were clinically diagnosed with fear of strangers, fear of dogs, or fear of noise and thunderstorms by canine behaviour practitioners also rated higher on the C-BARQ factors of stranger-directed fear, dog-directed fear and non-social fear, respectively (Hsu and Serpell, 2003). No studies have been done to determine if owners correctly rate the severity level of fear in their dogs when completing this type of survey, especially in dogs displaying mild to moderate fear. Some researchers have examined the ability of dog owners to categorize different dog emotions, or behavioural responses, based on photos and videos of dogs, but these studies did not analyze whether owners were able to accurately measure the severity of these responses (Bloom and Friedman, 2013; Tami and Gallagher, 2009; Wan et al., 2012).

The first objective of this study was to determine which behaviours dog owners can reliably identify in order to develop an owner-focused training tool for fear identification. The second objective was to determine whether training with this tool affects the ability of dog owners to recognize fear in videos of unfamiliar dogs. It was hypothesized that training would increase the accuracy of dog owners' ratings of fear in unfamiliar dogs, especially for people with limited previous knowledge of dog behaviour. A third objective was to evaluate whether training changes owner ratings of their own dogs' fear using the 'Fear & Anxiety' portion of C-BARQ. It was further hypothesized that training would result in dog owners having improved recognition of subtle signs of fear in their own dogs, resulting in higher scores for fear, and more dogs being categorized as fearful using the C-BARQ.

3.3 Methods

The study was reviewed and approved by the University of Guelph Research Ethics Board (REB# 15JN021) and Animal Care Committee (AUP# 2566) prior to the start of the study.

This project consisted of four stages. Stage 1 involved distribution of videos of dogs displaying different fear behaviours and a corresponding survey to dog behaviour experts in order to identify which specific fear behaviours were present and/or absent in each video. Stage 2 involved distributing the same videos and a corresponding survey to dog owners to assess their ability to identify different fear behaviours. Findings from Stage 2 were used to inform the development of an owner-focused training tool for the identification of fear in dogs, specific to behaviours that the owners were able to reliably recognize. Stage 3 involved distributing a portion of the previous videos to experts in order to validate the severity of fear demonstrated by the dogs in the videos. Stage 4 involved assessment of an owner-focused training tool for the identification of fear in dogs, which was provided to half of the participants, followed by a survey to assess each participant's ability to identify and rate fearfulness in videos of unfamiliar dogs in order to determine the effect of training. In addition, the 'Fear and Anxiety' portion of the C-BARQ was administered to determine if training altered owner ratings of their fear in their own dogs. All surveys were hosted by FluidSurveys (Fluidsurveys, Ottawa, Ontario, Canada).

3.3.1 Collection of videos

Dogs with no fear to moderate fear when entering new surroundings and interacting with unfamiliar people (based on preliminary owner reports) were recruited to participate in on-campus video collection. Each dog was video recorded while exploring a novel room (at the Primary Healthcare Centre, University of Guelph) and meeting an unfamiliar person (the researcher) using a Sony Handycam HDR-CX220. Dogs were pre-screened with an owner-completed survey, and those that were identified to potentially have severe fear were excluded to protect the welfare of these dogs and the safety of the researcher. In order to obtain additional videos of dogs with moderate to severe fear, existing collections of videos from dog trainers and researchers known to the research team were utilized. Following collection, all videos were edited to display clips focusing on the specific behaviours of interest (Table 3.1). A final pool of 42 videos was selected for inclusion in the study in order to represent the best examples of the full range of dog behaviours and morphotypes (e.g., body size, fur length and colour, breed) available. Videos that were selected for inclusion in Stage 3 and 4, based on being the best examples identified by researchers as representing 'no fear', 'mild to moderate fear' and 'severe fear', were further edited to be close to 10 seconds (7-15 seconds) in length in order to reduce bias due to video clip length.

3.3.2 Stage 1: Expert assessment of video-recorded dogs displaying different fear behaviours

To confirm the presence and/or absence of specific dog fear behaviours in the video series, a pool of experts was recruited from a list of all dog trainers in North America with a minimum qualification of Certification for Professional Dog Trainers – Knowledge Assessed (CPDT-KA). Experts were identified from the Certification Council for Professional Dog Trainers (CCPDT) website, and a recruitment email was sent out to 345 dog trainers, including 212 CPDT-KA and 133 CPDT-KSA (CPDT – Knowledge and Skills Assessed) trainers in Canada and the USA. Each expert independently reviewed three randomly assigned video clips from the 42 clips consisting of dogs displaying different fear behaviours. Each video clip was reviewed by a minimum of five experts. During their review, each expert was asked to independently identify the presence or absence of the fear behaviours listed in Table 3.1. The list of fear behaviours included commonly used terms to describe fear or anxiety taken from the published literature in this area (Handelman, 2008; Landsberg et al., 2013; Overall, 2013). Definitions were available for each term, and appeared when participants hovered their cursor over the term. In addition, to ease identification, behaviours were grouped based on four body areas (posture, body, head, and tail), and each category was presented on a separate page of the questionnaire for identification. Experts had the ability to re-watch each video as many times as they desired.

Responses from the first five experts to score each video were used for analysis. The behaviour was deemed to be present/absent if at least four out of five experts agreed that the behaviour was present/absent in that video. If less than four out of five experts agreed on the presence/absence of the behaviour, then that behaviour was rated as unclear for that video.

3.3.3 Stage 2: Owner identification of specific fear behaviours

Videos from Stage 1 were used for the development of a survey to assess the ability of dog owners to identify fear behaviours. The survey consisted of videos relating to posture (n = 12), full body behaviours (n = 20), head and facial behaviours (n = 18), and tail behaviours (n = 20). We attempted to provide three validated video examples for each behaviour, but were only able to provide two examples each of inguinal exposure and lolling tongue, and one example each of freezing, spatulate tongue, and squinting.

Dog owners were recruited to participate through advertisements on social media, including Facebook and Twitter, and through email bulletins delivered by the University of Guelph to alumni and current faculty, staff and students. Participants had to be at least 18 years of age, and a primary caregiver for a dog (i.e., have daily responsibilities of dog ownership such as feeding and exercising the dog, and financially supporting the dog's care). Each participant was assigned to two randomly selected videos from each of the four body areas, for a total of eight videos per participant. Participants were given a list of behaviours (Table 3.1) and were asked to score whether each behaviour was either present or absent in the video. Definitions were available for all the terms, and appeared when participants hovered the cursor over the term. Participants had the ability to re-watch the video as many times as they desired. In order to control for possible effects of different levels of experience, participants were also asked to provide the following information: age, gender, how many dogs they have owned previously, whether they have advanced knowledge in dog behaviour, what dog-related occupations they have previously held, whether they have attended dog training classes, and whether they have consulted a dog behaviour professional.

Two mixed logistic regression models were run for each behaviour, one to assess the correct identification of the presence of the behaviour (i.e., sensitivity) and one to assess the correct identification of the absence of the behaviour (i.e., specificity). Sensitivity is defined as the probability of the owner correctly identifying the presence of a behaviour, while specificity is defined as the probability of owners correctly identifying the absence of a behaviour (Dohoo et al., 2003). The outcome of the models was whether or not the participant agreed with the experts for the presence or absence of that behaviour, with owner included as a random effect to control autocorrelation in responses from the same observer. In order to control for owner experience with dog behaviour, different variables relating to owner experience (i.e., advanced knowledge of dog behaviour, attended dog training classes, consulted a dog behaviour professional, held a dog-related occupation) were each tested univariably against the outcomes and were retained for further testing if they met a liberal cut-off of $p \leq 0.20$. All variables retained following the univariable analyses were tested in a main effects model and were removed in a manual backward step-wise fashion. Variables were retained in the model if they were statistically significant ($\alpha = 0.05$) or were identified to be a confounding variable. Confounding variables were identified if they caused a greater than 20 % change in the coefficient of other statistically significant variables in the model when removed, and based on their potential causal relationship with the explanatory variable and the outcome (Dohoo et al., 2003). Sensitivity and specificity were calculated for each of the different experience levels based on the output of the logistic regression models (Dohoo et al., 2003). Owner identification was deemed to be acceptable for a given behaviour if both the sensitivity and specificity were above a 75 % cut-off for owners with the lowest level of experience.

Behaviours that were deemed acceptable based on sensitivity and specificity were included in a training tool that was developed to assist owners in the identification and categorization of fear in dogs (Appendix B.11). This training tool included text descriptions accompanied by related pictures and videos of the various included behaviours, and described what behaviours would be expected for mild to moderate fear (lowered tail and posture, ears back, lip licking, yawning, attempts to hide/escape/retreat, avoiding eye contact) as compared to severe fear (crouching/cowering, tail tucked, vigorous attempts to hide/escape/retreat). These descriptions were matched, where possible, to the description of mild to moderate and extreme fear provided in the 'Fear & Anxiety' portion of the C-BARQ.

3.3.4 Stage 3: Expert assessment of fear shown by video-recorded dogs

Stage 3 aimed to refine the pool of videos validated by experts to provide clear examples of dogs displaying no fear, mild to moderate fear, and severe fear. Using the same target population as in Stage 1 (i.e., 345 CPDT-KA dog trainers), the participating experts were shown the fear-identification training tool, followed by 25 videos presented in random order that were selected from the previously described videos. Experts were asked to rate the amount of fear shown by the dog in each video on a five-point scale from 0 (no fear) to 4 (severe fear). Experts had the ability to re-watch each video as many times as they desired.

To further refine the selection of videos, fifteen videos with the highest levels of agreement between CPDT-KA dog trainers were sent out to 70 Diplomates of the American College of Veterinary Medicine (DACVB) using email addresses obtained from the ACVB website. In order to determine which videos to send to the DACVB experts, the percent agreement between CPDT-KA dog trainers was calculated. First the responses were categorized into "no fear" (0), "mild to moderate fear" (1-2) and "high to severe fear" (3-4). To calculate percentage agreement, the total number of experts that rated each video into each fear category was determined and divided by the total number of responses. Five videos with the highest levels of agreement from each category were sent to be assessed by the DACVB experts.

In order to finalize which videos would be included in the survey for dog owners, the percent agreement between DACVB experts was calculated. The same process for categorizing responses, and calculating percent agreement was used as with the CPDT-KA experts. The three videos in each category with the highest agreement between DACVB experts were identified. A minimum of 70% agreement was required across both expert groups for the selected videos.

3.3.5 Stage 4: Assessing the effect of training on owners' rating of fear in dogs

This final stage was developed to determine whether owners who received training had higher levels of agreement with the experts when rating the amount of fear displayed by dogs in videos, compared to those that did not. This stage was also intended to examine whether training in fear behaviours changed the owners' rating of their own dogs on the 'Fear & Anxiety' portion of the C-BARQ. Recruitment for this stage followed the same process as outlined in Stage 2 using snowball sampling after initial recruitment via email and social media. In addition, participants from Stage 2 that expressed interest in further studies were re-contacted directly by email to participate. As all survey responses were anonymous, it was not possible to determine the proportion of participants who responded to both surveys.

A questionnaire consisting of the following four sections was distributed during Stage 4: 1) basic demographic information; 2) the 'Fear & Anxiety' portion of the C-BARQ; 3) categorization of nine expert-validated videos from Stage 3; and, 4) a repetition of the 'Fear & Anxiety' portion of the C-BARQ to examine changes following training. For the C-BARQ portions of the questionnaire, each participant was asked to rate their own dog's level of fear and anxiety on a scale from 0 (no fear) to 4 (severe fear) in a variety of situations (Hsu and Serpell, 2003). After the initial C-BARQ portion, survey participants were randomly assigned to one of two treatment groups: control or training. Participants assigned to the training group received the previously described fear training tool, before proceeding to the video portion of the survey. Participants in the control group proceeded immediately from the initial C-BARQ to the videos. During the video portion of the survey the participants were asked to rate the dog's level of fear in the video on a scale from 0 to 4, with scale labels and descriptions of behaviours provided to match those given in the 'Fear & Anxiety' portion of the C-BARQ. Participants had the ability to re-watch the video as many times as they desired. The C-BARQ was then repeated in order to determine whether training altered participants' ratings of their own dogs. Control participants also completed the C-BARQ a second time in order to control for differences in ratings due to repeating the C-BARQ after a short period of time, and after watching the fear videos.

2.5.1 Statistical analysis

In order to determine the effect of training on the accuracy of participants' rating of videos the participant was scored as either correct (matching the expert rating category) or incorrect (not matching the expert rating category) for each video. These scores were analyzed in a mixed logistic regression model, with participant ID as a random effect, to determine which factors affected the probability of rating a dog's level of fear correctly. Possible explanatory variables tested in this model were treatment (control vs. training), expert rating category (no fear, mild/moderate fear, or high/severe fear), and participant age, gender, number of dogs previously owned, whether they have advanced knowledge in dog behaviour, what dog-related occupations they have previously held, whether they have attended dog training classes, and whether they have consulted a dog behaviour professional.

Collinearity of variables was assessed using various correlation coefficients including Pearson, Spearman and Phi coefficients, depending on the type of variable being compared; with a cut-off of $\geq |0.70|$ to consider two variables collinear. In cases of high collinearity, the most biologically meaningful variable was selected for further analysis. Continuous variables were graphically assessed for linearity by examining the relationship between the independent variable and the log odds of the outcome variable using locally weighted regression curves (lowess) and by testing the inclusion of a quadratic term in the model. If the relationship was non-linear and could not be appropriately modeled with the addition of a quadratic term, the continuous variable was categorized based on biologically appropriate cut-points.

A mixed logistic regression model assessing the association between the explanatory variables and correct scoring by participants with participant modelled using a random intercept was built using the same methodology as described in section 2.3. Treatment group was forced into the final model regardless of significance as it was the main explanatory variable of interest. In addition, biologically plausible two-way interactions were examined among main effects retained in the final main effects model and were retained if they were statistically significant ($\alpha = 0.05$). The model fit was examined graphically by assessing the normality and homoscedasticity of the best linear unbiased predictors (BLUPs). Pearson residuals were also assessed to determine if there were any outliers. Outlying observations were inspected for potential recording errors and impact on the model. Finally, the intra-class correlation coefficient (ICC) was assessed to measure the correlation among ratings from the same participant.

In order to determine the effect of training on a participant's rating of their own dog's fear, the responses from the 'Fear & Anxiety' portion of the C-BARQ at Time 1 and Time 2 were analyzed. Factor scores for stranger-directed fear, dog-directed fear, and non-social fear, were determined by finding the average of the participant's rating for all the questions in each factor.

The scores for each of the C-BARQ factors were analyzed in two different ways. First, in order to determine whether training caused owners to change how they rate fearfulness in their dog, a linear regression model was fitted. For this model the outcome was the factor score for Time 2, with an individual model being run for each of stranger-directed fear, dog-directed fear and non-social fear. The same process as described above for determining the effect of training on the accuracy of participants' rating of videos was used to build the multivariable model, using the possible explanatory variable of treatment group as well as independent variables related to demographics and previous dog-related experience while also controlling for the factor score for Time 1.

Recent studies using C-BARQ have categorized dogs as fearful, or not fearful (McMillan et al., 2013). The standard manner in which this has been accomplished has been to label dogs as fearful if they score greater than 0 on any question in the given factor, and not fearful if they score 0 in all the questions in the factor. In order to determine whether training caused owners to change whether or not they rated their dogs as fearful, a logistic regression model was run. For this model a variable was created for each factor score. A score of 0 was given if the dog was categorized as having no fear (factor score of 0) and a score of 1 was given if the dog was categorized as fearful (factor score > 0). These variables were used as the outcome variables in three logistic regression models, with an individual model being run for each factor. The same process as described above was used to build the multivariable model using the possible explanatory variable of treatment group as well as independent variables related to demographics and previous dog-related experience while controlling for the categorization given for Time 1.

3.4 Results

3.4.1 Stages 1 & 2: Recognition of specific fear behaviours

A total of 102 CPDT dog trainers completed the expert survey, resulting in a response of 30 %. Experts agreed with each other for every video on the presence or absence of inguinal exposure, panting and yawning. Experts did not agree on the presence or absence for at least 25% of the videos for high and neutral head position, neutral body posture, paw lift, trembling, stiff body, furrowed brow, avoiding eye contact, squinting, commissure of lips pulled back, ears back and neutral and stiff tail. For the remaining behaviours (i.e., head lowered, body posture upright or lowered, freezing, attempts to hide/escape/retreat, loose/wiggly body, lolling tongue, spatulate tongue, lip lick, whale eye, ears forward, all tail positions, and tail wagging) experts agreed on 78 to 95% of the videos. Videos where experts did not agree were not used to analyze that behaviour for owner accuracy.

A total of 573 dog owners completed the survey looking at owner recognition of specific fear behaviours in dogs. A summary of the participant demographics and previous experience of respondents is in Table 3.2. On average, dog owners reported having previously owned 4.7 (SD = 11.7) dogs prior to their current dog, ranging from 0 to 200.

The results for the sensitivity and specificity of owner recognition for each behaviour are presented in Table 3.1. Variables relating to previous experience had a significant effect on the sensitivity and specificity for some of the behaviours. Participants who have worked in a shelter had significantly higher sensitivity for head lowered (0.82, 95% CI: 0.69, 0.90 vs. 0.67, 95% CI: 0.63, 0.82; $p = 0.039$), freezing (0.73, 95% CI: 0.41, 0.91 vs. 0.30, 95% CI: 0.20, 0.44; $p = 0.004$), and trembling (0.90, 95% CI:

0.66, 0.97 vs. 0.63, 95% CI: 0.53, 0.72; p = 0.023), higher specificity for spatulate tongue (0.96, 95% CI: 0.86, 0.99 vs. 0.88, 95% CI: 0.79, 0.93; p = 0.042), and lower specificity for freezing (0.72, 95% CI: 0.61, 0.80 vs. 0.80, 95% CI: 0.75, 0.84; p = 0.041), corner of lips drawn back (0.62, 95% CI: 0.45, 0.77 vs. 0.83, 95% CI: 0.76, 0.89; p = 0.007), and ears forward (0.55, 95% CI: 0.37, 0.71 vs. 0.81, 95% CI: 0.77, 0.85; p = 0.001) compared to participants who have not worked in a shelter. Participants who were animal behaviour researchers had significantly lower specificity for head neutral (0.12, 95% CI: 0.01, 0.61 vs. 0.64, 95% CI: 0.55, 0.73; p = 0.047), yawning (0.85, 95% CI: 0.61, 0.95 vs. 0.95, 95% CI: 0.91, 0.98; p = 0.032), corner of lips drawn back (0.49, 95% CI: 0.18, 0.81 vs. 0.83, 95% CI: 0.76, 0.89; p = 0.037), and tail lowered (0.68, 95% CI: 0.36, 0.89 vs. 0.90, 95% CI: 0.81, 0.95; p = 0.032) compared to participants who were not animal behaviour researchers. Participants who have worked as a dog trainer had significantly higher specificity for inguinal exposure (0.86, 95% CI: 0.74, 0.93 vs. 0.62, 95% CI: 0.55, 0.69; p = 0.001), spatulate tongue (0.96, 95% CI: 0.87, 0.99 vs. 0.88, 95% CI: 0.79, 0.93; p = 0.019), and whale eye (0.82, 95% CI: 0.70, 0.90 vs. 0.63, 95% CI: 0.56, 0.69; p = 0.004) compared to participants who have not worked as a dog trainer. Participants who have worked as a veterinary technician had significantly higher sensitivity for ears back (0.93, 95% CI: 0.76, 0.98 vs. 0.76, 95% CI: 0.69, 0.81; p = 0.039), and higher specificity for paw lifting (0.95, 95% CI: 0.80, 0.99 vs. 0.79, 95% CI: 0.71, 0.85; p = 0.027), and lolling tongue (0.97, 95% CI: 089, 0.99 vs. 0.87, 95% CI: 0.82, 0.90; p = 0.019) compared to participants who have not worked as a veterinary technician. Participants who have worked in a kennel had significantly higher sensitivity for head high (0.76, 95% CI: 0.63, 0.86 vs. 0.86, 95% CI: 0.77, 0.92; p = 0.037), and higher specificity for squinting (0.90, 95% CI: 0.79, 0.96 vs. 0.80, 95% CI: 0.72, 0.85; p = 0.029) compared to participants who have not worked at a kennel. Participants who have worked as a dog walker had significantly higher specificity for squinting (0.91, 95% CI: 0.81, 0.96 vs. 0.80, 95% CI: 0.72, 0.85; p = 0.011) compared to participants who have not worked as a dog walker, while having previously held any position relating to dogs increased sensitivity for spatulate tongue (0.48, 95% CI: 0.35, 0.61 vs. 0.23, 95% CI: 0.11, 0.43; p = 0.038) when compared to participants who have not held a dog-related position. Reporting advanced knowledge of dog behaviour significantly increased sensitivity for paw lifting (0.85, 95% CI: 0.68, 0.94 vs. 0.71, 95% CI: 0.58, 0.81; p = 0.032), and whale eye (0.71, 95% CI: 0.51, 0.86 vs. 0.45, 95% CI: 0.33, 0.57; p = 0.044), and decreased specificity for stiff body (0.77, 95% CI: 0.65, 0.86 vs. 0.88, 95% CI: 0.77, 0.94; p = 0.013) when compared to reporting no advanced knowledge of dog behaviour. Finally, previously attending dog training classes significantly increased sensitivity for lolling tongue (0.95, 95% CI: 0.87, 0.98 vs. 0.80, 95% CI: 0.66, 0.90; p = 0.022), increased specificity for loose/wiggly body (0.78, 95% CI: 0.72, 0.82 vs. 0.66, 95% CI: 0.58, 0.72; p = 0.002), and decreased specificity for freezing (0.74, 95% CI: 0.71, 0.77 vs. 0.80, 95% CI: 0.75, 0.84; p = 0.046) when compared to not attending dog training classes. The following behaviours exceeded the 75 % cut-off for both sensitivity and specificity after controlling for experience, and therefore were included in the training tool: body posture, ear position, tail position, wagging tail, panting, lolling tongue, yawning, lip licking, avoiding eye contact and attempts to hide/escape/retreat.

3.4.2 Stage 3: Expert recognition of fear in videos

Out of 345 CPDT-KA dog trainers contacted, a total of 77 trainers completed the survey, for a response of 21 %. Out of 70 DACVBs contacted, a total of 22 veterinary behaviourists completed the survey, for a response of 31 %. Looking only at the nine videos selected for the final owner survey, levels of agreement between experts on video rating category ranged from 0.71 to 1.00, with an average agreement of 0.86 for CPDT-KA trainers, and 0.89 for DACVBs. The proportion of respondents who agreed with the video rating category for the CPDT-KA dog trainers and DACVB veterinary behaviourists for each video are presented in Table 3.3.

3.4.3 Stage 4: Owner recognition of fear in videos

A total of 1,413 dog owners completed the survey, 707 that received training, and 706 that did not. The survey took on average 22.2 minutes to complete with the training, and 14.3 minutes to complete without. A summary of demographic information for participants is presented in Table 3.2. On average, dog owners reported having previously owned 4.0 (SD = 11.9) dogs prior to their current dog, ranging from 0 to 300. The proportion of dog owners who agreed with the video rating category both with and without training are presented in Table 3.3.

Results for the mixed logistic regression model assessing what factors are associated with the owner correctly identifying fear in videos are presented in Table 3.4. A significant interaction effect was noted between treatment group and video rating category. Training was found to significantly increase the odds of rating the video correctly when the video showed mild/moderate fear or severe fear, but not when the video showed no fear. Further, within respondents who received fear training, the odds of rating the video correctly was higher when mild/moderate or severe fear was shown, compared to videos showing no fear. Within the control respondents, the odds of rating the video correctly was higher when severe fear was shown compared to no fear, but there was no significant difference between videos showing mild/moderate and no fear. In addition, advanced knowledge of dog behaviour, and attending dog training classes were found to significantly increase the odds of correctly identifying fear in dogs, while increasing participant age and working as a groomer were found to decrease the odds of correctly identifying fear in dogs. The random effect of participant ID was significant with an ICC of 0.027, indicating that there were significant correlations among ratings made by the same participant.

3.4.4 Stage 4: Rating of fear using C-BARQ

The mean scores for each of the C-BARQ fear factors at Time 1 and Time 2 for both training and control groups are presented in Table 3.5, along with the number of dogs that were categorized as fearful. Overall, owners rated dogs highest in the dog-directed fear factor with a mean score of 1.56 out of 4 at Time 1 compared to 1.39 for stranger-directed fear and 1.33 for non-social fear. However, when looking at whether dogs were categorized as fearful (> 0), the largest proportion of dogs were categorized as having non-social fear (0.95) at Time 1, compared to stranger-directed fear (0.81) or dog-directed fear (0.89). Dog-directed fear also had the greatest change from Time 1 to Time 2, with a mean increase in the factor score of 0.11 compared to an increase in factor score of 0.05 for stranger-directed fear, and 0.00 for non-social fear. However, when looking at whether or not dogs changed category from Time 1 to Time 2, stranger-directed fear had the greatest proportion of dogs changing category (0.064), compared to dog-directed fear (0.038) and non-social fear (0.032).

Based on the results of the linear regression model (Table 3.6), training did not have an effect on the C-BARQ scores at Time 2, except for the non-social fear factor, where there was a significant interaction between treatment and the factor score at Time 1 (Figure 3.1). A strong positive association between the C-BARQ factor score at Time 1 and Time 2, was seen for all three fear factors. There were also several variables related to owner experience that were significant in the models. Owners that reported advanced knowledge of dog behaviour had lower C-BARQ scores at Time 2 for dog-directed fear. Working at a kennel resulted in a lower score at Time 2 for stranger-directed fear. Finally, having never held a dog-related position resulted in a higher C-BARQ score at Time 2 for all three fear factors.

Based on the results of the logistic regression model (Table 3.7), training had a significant effect on category for dog-directed fear, as part of an interaction with owners reporting advanced knowledge of dog behaviour. Within owners that reported advanced knowledge there was no effect of training. However, within owners who did not report advanced knowledge, training resulted in increased odds of categorizing the dog as having dog-directed fear at Time 2 (Figure 3.2). Training also had a significant effect on category for non-social fear, as part of an interaction with category at Time 1. When dogs were rated as fearful at Time 1, training did not have a significant effect on rating at Time 2. However, when dogs were rated as not fearful at Time 1, owners who received training were more likely to categorize their dog as fearful at Time 2, than those who did not receive training (Figure 3.3). For all of the fear-related factors there were strong positive associations between category at Time 1 and category at Time 2, indicating consistency in fear category across time. Reporting advanced knowledge of dog behaviour, and working as a dog trainer were associated with decreased odds of categorizing their dog as having non-social fear at Time 2, while working as an animal behaviour researcher was associated with increased odds of categorizing their dog as having non-social fear at Time 2. Having worked in a kennel was associated with increased odds of categorizing their dog as having non-social fear, but decreased odds of categorizing their dog as having stranger-directed fear at Time 2. Finally, having previously attended dog training classes was associated with decreased odds of categorizing their dog as having stranger-directed fear at Time 2.

3.5 Discussion

3.5.1 Recognition of specific fear behaviours

Experts did not agree on the presence or absence of the behaviours of neutral head position or body posture, paw lift, trembling, stiff body, furrowed brow, avoiding eye contact, squinting, commissure of lips pulled back, ears back and neutral, and stiff tail for a large proportion of the videos. Some of these behaviours are subtle and may not have been visible in the videos due to inadequate video quality. However, head, body and tail position and stiffness should have been visible in the videos. While specific definitions were provided, it is possible that experts were using their own definitions and that these definitions varied for these behaviours Also, within one video clip a dog may have had both a lowered and a neutral posture at different stages. Some experts may have only rated the more extreme posture, resulting in them not selecting neutral, even when it was present for a portion of the video. These results highlight the need for consistency of definitions for behaviours within the dog behaviour profession.

The fear behaviours that were most consistently identified by owners were lowered posture, ears back, tail down or tucked, attempting to hide, escape or retreat, panting, yawning, lip licking, and avoiding eye contact. While no previous studies have looked at the ability of dog owners to recognize specific fear behaviours, some studies have asked owners what behaviours they use to identify fear in dogs. Tami and Gallagher (2009) found that owners reported using backwards movement, tucked tail and avoiding eye contact as signs of fear in a video clip of a fearful dog. The researcher reported this video clip also contained furrowed brow, hiding, ears back, tense body and stiff tail behaviours, which were not commonly identified by the owners. It is unclear whether owners in the current study were unable to recognize these behaviours, or if they were able to recognize them, but simply did not identify them as signs of fear. However, it is interesting to note that all of the behaviours owners identified as signs of fear in Tami and Gallagher’s study were also found to be reliably recognized in our study. Conversely, many of the behaviours not identified by owners as signs of fear, were found to be unreliably recognized in the current study. Konok et al. (2015) also asked owners to identify which behaviours they believed to be indicative of fear in dogs. They found that owners reported “stay close to me”, tucked tail, “look at me”, hangs head and contracts itself (body low). These behaviours are also similar to those found to be reliable in the current study; though variables related to interactions with the owner were not assessed due to the nature of the videos used.

The behaviours that owners were not able to reliably recognize in the current study included lowered head, freezing, tap out/inguinal exposure, paw lift, trembling, stiff body, spatulate tongue, furrowed brow, whale eye, squinting, corner of lips drawn back, and stiff tail. Some of these behaviours, involve fine details of a dog’s face or body and may not have been recognized due to the quality of the videos. However, it should be noted that experts were able to identify the presence or absence of these behaviours in the videos used. Behaviours, such as tap out/inguinal exposure, whale eye and spatulate tongue, may not have been reliably identified due to owners not understanding the terminology used. Definitions were available for all of the terms, but participants may not have used this feature, and instead guessed at meanings for unknown terms. This is supported by the finding that both sensitivity and specificity were higher for spatulate tongue and whale eye when owners had more experience with dog behaviour. The remaining behaviours, including lowered head, freezing, paw lift, stiff body and stiff tail, should all have been visible in the videos provided, and did not contain complicated terminology. It could then be suggested that these behaviours are not well recognized by dog owners, and may not be useful for describing fear in dogs with this population.

3.5.2 Recognition of fear in videos

Overall, owners showed relatively high levels of agreement with the experts when rating mild to severe fear in dogs, ranging from 63 to 97% for the different videos. These results are similar to those found in other studies asking owners to identify the emotional state of dogs in videos, which report 60 to 72% accuracy for identifying fear (Bloom and Friedman, 2013; Tami and Gallagher, 2009; Wan et al., 2012). Another study asking owners to identify emotions based only on still photographs of the face, found that fear was correctly identified as the primary emotion only 45% of the time (Bloom and Friedman, 2013). The lower accuracy found in that study could be due to the fact that owners most commonly report using posture and avoidance behaviours to identify fear (Konok et al., 2015; Tami and Gallagher, 2009), which could not be viewed in a photograph of a dog's face.

We found that training improved the performance of dog owners for the mild to severe fear videos, but not the no fear videos. Owners were also less likely to rate the no fear videos correctly, regardless of training, when compared to the mild to severe fear videos. However, it should be noted that levels of agreement for experts were also lower for the no fear videos, suggesting these videos might be imperfect examples of no fear. Alternatively, the way the questions were presented (asking the respondent to rate the amount of fear shown) might have biased the respondents towards identifying dogs as fearful, even when no fear was present. Few other studies have looked into the effect of training on the ability of observers to recognize fear. One study found that training was able to improve recognition of pain in rats in both experienced and inexperienced observers (Roughan and Flecknell, 2006). Another study found that inexperienced observers were able to achieve similar ratings to experts after only minimal training when conducting behavioural assessments on working dogs (Fratkin et al., 2015). The results found in the current study suggest that training is beneficial in helping dog owners recognize the presence, if not the absence, of fear when observing unfamiliar dogs.

As expected, previous experience with dog behaviour, in the form of owners reporting advanced knowledge of dog behaviour, and previously having attended dog training classes, resulted in owners being more likely to identify the videos correctly. However, having worked as a groomer, and increasing age, resulted in owners being less likely to identify the videos correctly. Groomers could be less likely to recognize fear in dogs due to becoming desensitized to fear behaviours, as a majority of the dogs they work with are likely to be experiencing some degree of fear or stress during grooming. Tami and Gallagher (2009) did not find a difference between owners, vets, trainers and non-owners, when looking at their ability to categorize different emotional states in dogs, nor did they find an effect of age on their ability to correctly categorize the videos. However, a study by Wan et al. (2012) found the probability of correctly identifying fear in dogs increased with increasing experience. The reason for these contradictory results could be due to differences in methodology. Tami and Gallagher (2009) asked owners to rate the behaviour of the dogs on a 6-point scale and included a wide range of behavioural states (fearful, submissive, indifferent, playful, friendly, confident, aggressive, and defensive), with only one video example per category. The video of a fearful dog included behaviours such as tucked tail, and backing away, which are fairly obvious indicators of fear that may be readily recognized by owners even without training. The study by Wan et al. (2012) included fewer behaviour categories (angry, fearful, happy, neutral, sad) and participants were asked to select one as the primary emotion, but were not required to quantify the degree of fear that the animal was experiencing. They were provided with several different videos of fearful dogs, with a variety of behavioural responses. While some of these responses included lowered posture, tucked tail and attempts to escape, some of them included more subtle behaviours, such as body tension and furrowed brow, which owners with limited experience may not be familiar with. Also, based on the results of early stages of the current study, these behaviours are not well recognized by dog owners when assessing videos. Neither Wan et al. (2012) nor Tami and Gallagher (2009) analyzed whether participants were able to further differentiate the amount of fear the dog was experiencing into mild or severe fear categories.

3.5.3 Rating of fear using C-BARQ

4.3.1 Training

While the training tool developed during this project did have an impact on how well owners could recognize fear in videos of unfamiliar dogs, it did not consistently change how owners rated the fearfulness of their own dog using a survey tool. This indicates that C-BARQ has high reliability, but does not add to the existing validation of the tool. There are at least three possible explanations for these results: 1) dog owners are accurate even without training, even if they are not able to recognize fear in unfamiliar dogs; 2) dog owners may not be accurate, but have an already established idea about whether or not their dog is fearful which is not altered by training; 3) dog owners do not remember their dog showing the subtle signs of fear discussed in the training tool, and need time to go home and reassess their dog with this new knowledge before changes in C-BARQ scores can be observed; and/or 4) the training tool does not transfer well to assessing fear in natural contexts. To determine if this result is due to one of the first two options, an independent assessment of each dog's fearfulness in different situations could be measured and compared to their owner's rating. In order to determine if it is the third option, dog owners could be provided with training and then asked to rate their dogs' fearfulness after a period of time has elapsed and the owners have had an opportunity to observe their dogs in different situations. These are important areas of assessment for future research.

Despite inconsistent results for training, it had a significant effect on C-BARQ ratings for three of the six models that were assessed. The first of these models indicated that training altered the score owners gave their dogs for the non-social fear factor, but this was dependent on how these dogs were rated at Time 1. If dogs had low non-social fear scores at Time 1, training caused these scores to increase at Time 2. However, if dogs had higher non-social fear scores at Time 1, training caused these scores to decrease (Figure 3.1). This interaction suggests that training results in a moderation of non-social fear scores away from the extremes of no fear and severe fear. This result may therefore be due to training calibrating owners to the scale we are using, rather than altering their ability to recognize fear. It could also be a result of the training tool having a greater impact in helping owners recognize subtle behaviours associated with mild fear than those associated with moderate to severe fear.

Similarly, training increased the odds of owners rating their dogs as having non-social fear at Time 2, if they previously rated their dog as not being fearful at Time 1. This result could be due to owners being better able to recognize subtle signs of fear in their dogs, and therefore changing their ratings from non-fearful to fearful after receiving training. However, when combined with the results from the linear regression, this result can instead be explained by training moderated scores away from the extremes. Due to the nature of the categorization, this effect would result in dogs previously rated as not fearful being categorized as fearful, while not affecting dogs previously rated as fearful.

The third model, looking at whether dogs were categorized as fearful or not fearful for dog-directed fear, found that training was associated with owners being more likely to categorize their dog as fearful of other dogs at Time 2 if they did not report having advanced knowledge of dog behaviour. However, it had no effect if owners did report having advanced knowledge of dog behaviour. This is in support of our hypothesis that the training tool will be more effective on owners that have limited experience with dog behaviour.

It is unclear why these effects of training were seen in non-social fear and dog-directed fear, but not in stranger-directed fear. One possible explanation is that strangers may not recognize signs of mild fear in dogs and will continue to approach and try to interact with the dog causing the dog to show more exaggerated signs of fear, which are more readily recognized by an owner. It is also possible that owners may witness more interactions between their dog and strangers, and therefore have a stronger impression about their level of fear. It is important that further studies explore how training affects dog owners' perceptions of their own dogs' fear before recommending using this training in conjunction with the C-BARQ.

4.3.2 Time

Not surprisingly, the main variable that was predictive of C-BARQ score at Time 2, was the score at Time 1. These relationships were very strong across factors and models, suggesting a high degree of repeatability for the C-BARQ factor scores. While a majority of dog owners did change their score from Time 1 to Time 2, these differences were small, and would not cause a meaningful difference in a dog's overall factor score. When looking specifically at whether or not these dogs would be categorized as fearful, a very small percentage of dogs changed categories from Time 1 to Time 2, suggesting that the changes in C-BARQ score are due to variations in the rating of the severity of fear, but generally do not cause a previously non-fearful dog to be rated as fearful, or vice versa. These results provide further evidence that C-BARQ has high test-retest reliability as a tool for measuring fear in owned dogs.

4.3.3 Experience

Different variables related to previous experience with dogs came out significant in each of the models relating to owner's identification of fear in their own dog using the C-BARQ. The effect of a dog owner reporting advanced knowledge of dog behaviour was significant in the linear regression model for dog-directed fear, and the logistic regression model for non-social fear, indicating that owners reporting advanced knowledge are less likely to score their dogs as fearful at Time 2 than those that do not.

Similarly, different dog-related professions came out significant in the different models, but the effect of these professions varied. As we controlled for the owners' ratings at Time 1, this effect of experience should be independent of the original rating. One possible reason for this effect could be that owners with different experience levels may have be affected in different ways in response to completing the C-BARQ at Time 1 and watching the fear videos during this survey, causing them to rate their dogs higher or lower at Time 2. Some owners may have been less susceptible to sensitization caused by the earlier parts of the survey, which resulted in their scores at Time 2 being lower than other owners.

3.5.4 Limitations

One of the major limitations of this study was that owners were asked to assess fear of unfamiliar dogs from short video clips. This means that owners may not be able to see some details that would be visible if observing a dog in a real-life situation. In addition, the owners were not able to observe the dog for an extended period of time to assess changes in behaviour, nor were they able to take cues from the external environment that may help them interpret each dog's behaviour. However, there is also an advantage in watching videos of dogs as the owner is able to replay the video multiple times to observe different parts of the body, and they may be able to pick up on subtle behaviours through repeated observation with more ease. In addition, as only clear examples of different behaviours and levels of fear were used for owner recognition, this may have resulted in over-estimation of their abilities.

Another limitation is the potential bias of the length of the survey. As the training group had the added length of completing the training this may have resulted in increased fatigue or drop out in these respondents biasing the results. While the total sample size was similar between the training and control groups, there was more incomplete data for the training group resulting in smaller numbers for some analyses.

One major limitation to our ability to assess the effect of training on participants' ratings of their own dogs was that we are not aware of the participants' dogs' actual level of fearfulness. Therefore, we can only assess the effect of training on the participants' ratings over time, but cannot determine whether or not these ratings were valid.

Finally, as this is a voluntary online survey, the participant pool may not be representative of the dog owning population as a whole. Owners may be more likely to participate if they have a special interest in dog behaviour. We controlled for this effect with the addition of variables relating to experience with dogs and dog behaviour; however, we might be missing representation from some aspects of the dog owning population that are less interested in dog behaviour. If this is the case, we would expect the observed effect of training to be reduced relative to the general population, as a higher proportion of the participants would already be familiar with signs of fear in dogs before receiving the training. However, it is also possible that these participants have developed their own methods of recognizing fear in dogs, that are inconsistent with our training tool. If they used these preconceived methods for identifying fear in our study, despite instructions to the contrary, it would also be expected to reduce effect sizes. In addition, there is a potential for non-response bias in this study as the vast majority of participants in all stages were female. This is a common issue with survey based research (Sax et al., 2008, 2003; Underwood et al., 2000), and restricts the conclusions that we can draw for male dog owners. Finally, there was also a very high proportion of dogs being rated as fearful in C-BARQ in this study. This may have resulted from owners of fearful dogs being more interested in completing the survey. Alternately, the liberal fear definition that was used, with any dog scoring at least a one in any item relating to that type of fear being deemed fearful, may have resulted in the high proportion of fearful dogs. While numerous other studies using the C-BARQ have also utilized this same definition for fear (e.g., Duffy et al., 2014; McMillan et al., 2015, 2013; Serpell and Duffy, 2016), these studies used this cut-off for the purpose of statistical analyses comparing groups, and did not report overall prevalence. Therefore, it is not possible to determine how the prevalence of the current study compares to that of other populations. It is possible that training may have had a greater effect if a higher cut-off for fear was used.

3.6 Conclusions

Dog owners were able to reliably identify body posture, ears position, tail position, wagging tail, panting, lolling tongue, yawning, lip licking, avoiding eye contact and attempts to hide/escape/retreat. These behaviours were then used to create a targeted training tool on fear behaviours in dogs. While training resulted in dog owners being able to more accurately rate fear in videos of unfamiliar dogs, it did not significantly change an owner's rating of their own dog's behaviour, except for non-social fear. It is therefore unclear whether training would be a beneficial addition to surveys asking owners to report on the behaviour of their own dog. Even if not beneficial for scientific research, this training tool may benefit the general public by improving identification of fear in unfamiliar dogs. Further studies are needed to determine whether owner reports of the level of fearfulness in their dogs are accurate, even without provision of training.

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Table 3.1 The sensitivity (Sn) and specificity (Sp) of dog owner identification of different fear and non-fear related dog behaviours from a survey of expert-validated videos. Sn and Sp were calculated based on the results of mixed logistic regression models for correct identification of either the presence or absence of each behaviour with owner included as a random effect and controlling for variables relating to owner experience. Behaviours in bold fall above the 0.75 cut-off for both Sn and Sp, resulting in its consideration for inclusion in a targeted training tool for recognizing fear in dogs.

Group	**Behaviour**	**Present**		**Absent**	
		Sn (95% CI)	**n**	**Sp (95% CI)**	**n**
Posture	Head Position – High	0.86 (0.77, 0.92)[1]	549	0.61 (0.54, 0.67)	432
	Head Position – Neutral	0.58 (0.54, 0.62)	511	0.64 (0.55, 0.73)[2]	294
	Head Position – Low	0.67 (0.63, 0.82)[3]	486	0.92 (0.90, 0.94)	539
	Body Posture – Upright/Neutral	**0.95 (0.90, 0.98)**	**856**	**0.85 (0.63, 0.95)**	**290**
	Body Posture - Low	**0.75 (0.71, 0.79)**	**489**	**0.93 (0.91, 0.95)**	**547**
Body	Freezing	0.30 (0.20, 0.44)[3]	67	0.80 (0.75, 0.84)[3,4]	1072
	Inguinal Exposure	0.66 (0.44, 0.82)	120	0.62 (0.55, 0.69)[5]	1137
	Paw Lift	0.71 (0.58, 0.81)[6]	257	0.79 (0.71, 0.85)[7]	581
	Trembling	0.63 (0.53, 0.72)[3]	303	0.86 (0.82, 0.88)	526
	Attempt to Hide/Escape/Retreat	**0.79 (0.75, 0.82)**	**434**	**0.93 (0.85, 0.97)**	**632**
	Body Loose/Wiggly	0.72 (0.67, 0.78)	254	0.66 (0.58, 0.72)[4]	252
	Body Stiff	0.41 (0.38, 0.44)	921	0.88 (0.77, 0.94)[6]	456
Head	**Panting**	**0.98 (0.83, 1.00)**	**403**	**0.98 (0.92, 0.99)**	**849**
	Lolling Tongue	**0.80 (066, 0.90)[4]**	**119**	**0.87 (0.82, 0.90)[7]**	**1054**
	Spatulate Tongue	0.23 (0.11, 0.43)[8]	78	0.88 (0.79, 0.93)[3,5]	905
	Yawn	**0.99 (0.03, 1.00)**	**192**	**0.95 (0.91, 0.98)[2]**	**1055**
	Lip Lick	**0.77 (0.70, 0.83)**	**505**	**0.92 (0.79, 0.98)**	**551**
	Furrowed Brow	0.63 (0.57, 0.69)	406	0.85 (0.58, 0.96)	202
	Avoiding Eye Contact	**0.86 (0.83, 0.89)**	**452**	**0.92 (0.88, 0.95)**	**217**
	Whale Eye	0.45 (0.33, 0.57)[6]	220	0.63 (0.56, 0.69)[5]	740
	Squinting	0.24 (0.16, 0.33)	89	0.80 (0.72, 0.85)[1,9]	746
	Corner of Lips Drawn Back	0.33 (0.28, 0.40)	221	0.83 (0.76, 0.89)[2,3]	637
	Ears Back	**0.76 (0.69, 0.81)[7]**	**690**	**0.88 (0.51, 0.98)**	**206**
	Ears Neutral/Forward	**0.83 (0.79, 0.86)**	**525**	**0.81 (0.77, 0.85)[3]**	**344**
Tail	**Tail High/Neutral**	**0.95 (0.88, 0.98)**	**817**	**0.91 (0.87, 0.93)**	**297**
	Tail Down/Tucked	**0.80 (0.73, 0.86)**	**537**	**0.90 (0.81, 0.95)[2]**	**591**
	Tail Stiff	0.69 (0.60, 0.77)	374	0.94 (0.83, 0.98)	603
	Tail Wagging	**0.90 (0.84, 0.94)**	**843**	**0.94 (0.90, 0.97)**	**241**

Superscript numbers indicate that a variable relating to owner experience (see below) was significant in the model, and therefore the sensitivity or specificity reported is calculated based on owners without that experience

1: Kennel worker; 2: Animal-behaviour researcher; 3: Shelter worker; 4: Attended dog training classes; 5: Dog trainer; 6: Reported advanced knowledge of dog behaviour; 7: Veterinary technician; 8: Any job relating to dogs; 9: Dog walker

Table 3.2 Percentage of dog owners in each demographic category, and previous dog experience who responded to Survey 2 assessing dog owner ability to recognize specific fear-behaviours in dogs, and Survey 4 assessing dog owner ability to accurately identify fear in dogs. Respondents to Survey 4 were randomly assigned to control (no training) or training (received targeted training tool for the recognition of fear in dogs).

Variable	**Category**	**Survey 2**		**Survey 4**			
		Total (n)	**%**	**Control (N)**	**Training (n)**	**Total**	**%**
Treatment	--	--	--	706	707	1413	100
Gender	Male	37	6.5	44	44	88	6.3
	Female	529	92.8	650	653	1303	92.9
	Unspecified	4	0.7	5	6	11	0.8
Advanced Knowledge	Yes	187	32.9	220	218	438	31.3
	No	382	67.1	478	482	960	68.7
Attended Classes	Yes	389	68.4	497	496	993	71.0
	No	180	31.6	200	206	406	29.0
Consult Expert	Yes	276	51.8	381	373	754	53.9
	No	296	48.3	318	328	646	46.1
Occupation	Veterinarian	3	0.5	9	7	16	1.1
	Shelter Worker	61	10.7	100	83	183	13.0
	Groomer	61	10.7	48	47	96	6.7
	Researcher	11	1.9	21	17	38	2.7
	Vet Technician	34	5.9	67	50	117	8.3
	Kennel Worker	99	17.3	111	101	212	15.0
	Dog Trainer	96	16.8	134	119	253	17.9
	Dog Walker	125	21.9	168	164	332	23.5
	Other	123	21.5	156	147	303	21.4
	None	241	42.1	281	284	565	40.0

Table 3.3 Proportion of respondents that rated videos in a given category for each of the following groups: CPDT-KA certified dog trainers (n=77), DACVB veterinary behaviourists (n=22) and dog owners who either did (n=707) or did not (n=706) receive targeted training for recognizing fear in dogs.

Rating[1]	**Video**	**CPDT-KA**	**DACVB**	**Owner**	
				Training	**No Training**
No fear	1	0.81	0.54	-	-
	2	0.74	0.73	0.77	0.84
	3	0.71	0.73	0.69	0.68
	4	0.66	-	-	-
	5	0.76	0.64	-	-
	6	0.88	0.82	0.76	0.74
Mild/Moderate	7	0.55	-	-	-
	8	0.65	-	-	-
	9	0.70	0.82	-	-
	10	0.87	0.91	0.79	0.63
	11	0.61	-	-	-
	12	0.77	0.91	0.83	0.82
	13	0.76	0.77	-	-
	14	0.84	0.95	0.86	0.82
				-	-
Severe	15	0.66	-	-	-
	16	0.71	-	-	-
	17	0.93	-	-	-
	18	0.97	0.95	-	-
	19	1.00	1.00	0.94	0.91
	20	1.00	1.00	0.97	0.91
	21	0.97	0.95	0.90	0.85
	22	0.96	0.91	-	-
	23	0.72	-	-	-
	24	0.64	-	-	-
	25	0.75	-	-	-

[1]Rating given to the video by a majority of the experts (CPDT-KA and DACVB). No fear indicates a rating of 0, mild/moderate a rating of 1 or 2, and severe a rating of 3 or 4.

- indicates that the video was not rated by that group of respondents

Table 3.4 Results of mixed effects logistic regression model to determine factors influencing owners' ability to correctly identify the level of fear in nine different videos of dogs (n=9,636 video observations, 1,095 respondents).

Variable	**Category**		**OR (95% CI)**	**P-value**
Video category (stratified by treatment)	No Fear	No Training	Referent	
		Training	1.01 (0.86, 1.20)	0.881
	Mild Fear	No Training	Referent	
		Training	1.60 (1.34, 1.91)	<0.001
	Severe Fear	No Training	Referent	
		Training	1.95 (1.50, 2.54)	<0.001
Treatment (stratified by video category)	No Training	No Fear	Referent	
		Mild Fear	1.02 (0.87, 1.20)	0.814
		Severe Fear	2.64 (2.18, 3.19)	<0.001
	Training	No Fear	Referent	
		Mild Fear	1.61 (1.34, 1.92)	<0.001
		Severe Fear	5.09 (4.00, 6.46)	<0.001
Previously attended training classes		No	Referent	
		Yes	1.15 (1.01, 1.30)	0.033
Advanced knowledge of dog behaviour		No	Referent	
		Yes	1.20 (1.06, 1.36)	0.005
Have worked as a groomer		No	Referent	
		Yes	0.79 (0.63, 0.99)	0.043
Age[1]			0.91 (0.88, 0.95)	<0.001
Participant ID	Variance		0.092 (0.039, 0.220)	0.007
	ICC		0.027 (0.011, 0.063)	--

[1]Age in 10 year units

Table 3.5 Descriptive statistics of how dog owners rated the fear and anxiety of their dog in response to strangers, other dogs, and non-social situations based on their response to the C-BARQ at Time 1 and Time 2. Included are the mean C-BARQ factor score, the number and proportion of dogs categorized as fearful (>0), the mean difference in scores from Time 1 to Time 2 and the number and proportion of dogs that increased or decreased in category from Time 1 to Time 2.

Factor	**Training**	**n**	**Time 1**			**Time 2**			**Difference**				
			Mean (SD)	**Freq**	**Prop**	**Mean (SD)**	**Freq**	**Prop**	**Mean (SD)**	**Increase**		**Decrease**	
										Freq	**Prop**	**Freq**	**Prop**
Stranger-directed fear	Yes	521	1.41 (1.22)	418	0.80	1.47 (1.20)	429	0.82	0.06 (0.40)	24	0.046	13	0.025
	No	571	1.41 (1.18)	463	0.81	1.45 (1.17)	482	0.84	0.04 (0.39)	26	0.046	7	0.012
Dog-directed fear	Yes	437	1.55 (1.22)	389	0.89	1.68 (1.21)	399	0.91	0.13 (0.45)	14	0.032	4	0.009
	No	476	1.57 (1.19)	422	0.89	1.66 (1.21)	421	0.88	0.09 (0.46)	8	0.019	9	0.019
Non-social fear	Yes	476	1.37 (0.90)	455	0.96	1.36 (0.92)	445	0.93	0.00 (0.39)	5	0.011	15	0.032
	No	525	1.33 (0.88)	498	0.95	1.33 (0.96)	490	0.93	0.00 (0.37)	2	0.004	10	0.019

Table 3.6 Results of linear regression models to determine the effect of training on C-BARQ factor scores at Time 2 for stranger-directed fear (n=1,092 respondents), dog-directed fear (n=910 respondents) and non-social fear (n=1,001 respondents) while controlling for the effect of factor scores at Time 1.

Variable	**Category**	**Stranger-directed fear**		**Dog-directed fear**		**Non-social Fear**	
		Coef (95% CI)	P-value	Coef (95% CI)	P-value	Coef (95% CI)	P-value
Received training	No	Referent		Referent		Referent	
	Yes	0.016 (-0.029, 0.062)	0.484	0.033 (-0.025, 0.090)	0.265	0.107 (0.023, 0.191)	0.012
Factor score (Time 1)		0.936 (0.917, 0.955)	<0.001	0.928 (0.904, 0.952)	<0.001	1.00 (0.968, 1.04)	<0.001
Factor score x Training interaction		--	NS	--	NS	-0.083 (-0.134, -0.031)	0.002
Advanced knowledge of dog behaviour	No	Referent		Referent		Referent	
	Yes	--	NS	-0.118 (-0.188, -0.048)	0.001	--	NS
Worked in a kennel	No	Referent		Referent		Referent	
	Yes	-0.087 (-0.158, -0.016)	0.016	--	NS	--	NS
Held any dog-related job	Yes	Referent		Referent		Referent	
	No	-0.057 (-0.108, -0.006)	0.030	-0.091 (-0.156, -0.025)	0.007	-0.065 (-0.112, -0.019)	0.006

NS indicates variable not significant in final multi-variable model (p>0.05)

Table 3.7 Results of logistic regression models to determine the effect of training on whether owners categorize their dog as fearful (scoring >0 on the given factor in C-BARQ) at Time 2 for stranger-directed fear (n=1,088 respondents), dog-directed fear (n=910 respondents) and non-social fear (n=997 respondents) while controlling for the effect of whether the dog was categorized as fearful at Time 1.

Variable	**Category**	**Stranger-directed fear**		**Dog-directed fear**		**Non-social Fear**	
		OR (95% CI)	P-value	OR (95% CI)	P-value	OR (95% CI)	P-value
Received training	No	Referent		Referent		Referent	
	Yes	0.780 (0.459, 1.33)	0.359	5.25 (1.86, 14.79)	0.002	15.22 (1.44, 160.4)	0.023
Advanced knowledge	No	Referent		Referent		Referent	
	Yes	--	NS	1.09 (0.384, 3.09)	0.873	0.262 (0.102, 0.674)	0.005
Knowledge x Training interaction		--	NS	0.149 (0.031, 0.721)	0.018	--	NS
Fearful (Time 1)	No	Referent		Referent		Referent	
	Yes	213.5 (111.6, 408.4)	<0.001	273.0 (122.8, 607.0)	<0.001	2775 (277.8, 27724)	<0.001
Fearful x Training interaction		--	NS	--	NS	0.040 (0.003, 0.482)	0.011
Worked as a trainer	No	Referent		Referent		Referent	
	Yes	--	NS	--	NS	0.321 (0.127, 0.812)	0.016
Worked in a kennel	No	Referent		Referent		Referent	
	Yes	0.251 (0.115, 0.550)	0.001	--	NS	8.57 (2.00, 36.78)	0.004
Worked as a animal behaviour researcher	No	Referent		Referent		Referent	
	Yes	--	NS	--	NS	30.83 (1.36, 700.8)	0.031
Attended dog training classes	No	Referent		Referent		Referent	
	Yes	0.400 (0.219, 0.731)	0.003	--	NS	--	NS

NS indicates variable not significant in final multi-variable model (p>0.05)

Figure 3.1 Effect of targeted fear training on owners' ratings of their own dogs on the C-BARQ non-social fear factor at Time 2 in comparison to their rating before training at Time 1, based on the output of a linear regression model (n=1,001).

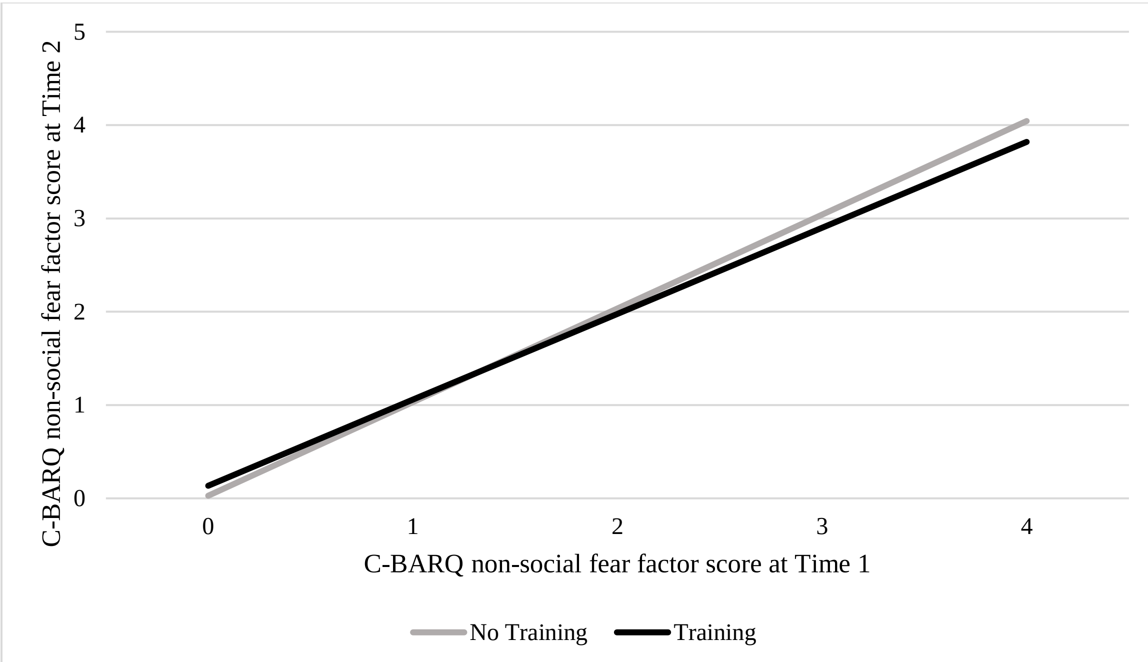


Figure 3.2 Effect of targeted fear training on the predicted probability (95% CI) of owners' rating their dog as fearful on the C-BARQ dog-directed fear factor at Time 2, when the owner reports having advanced knowledge of dog behaviour, or no advanced knowledge, based on the output of a logistic regression model (n=910) while controlling for rating at Time 1.

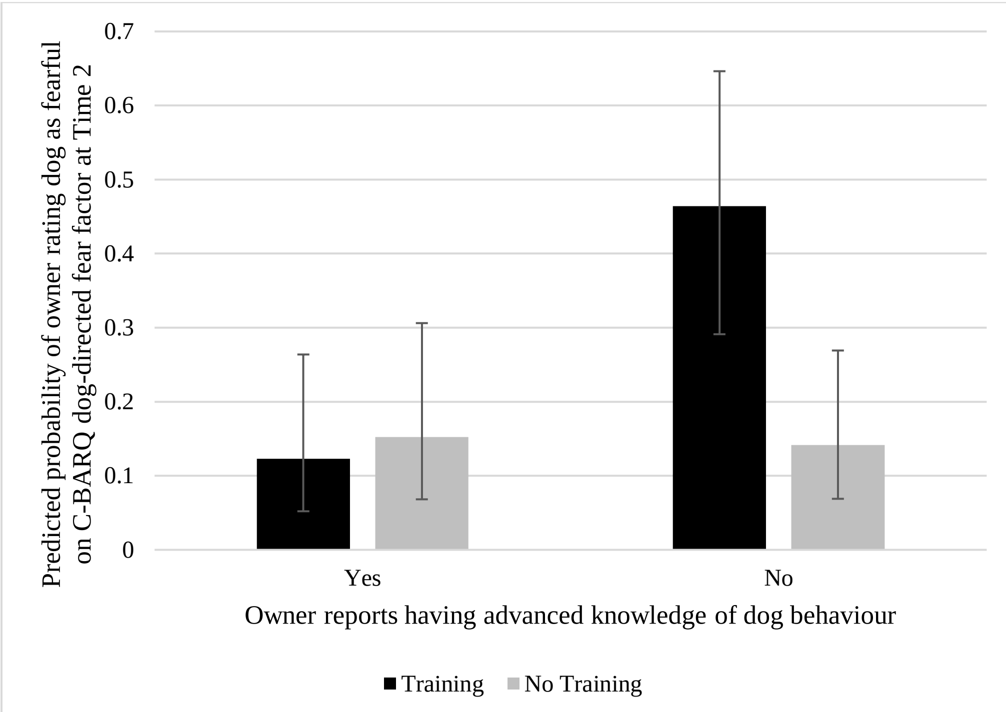
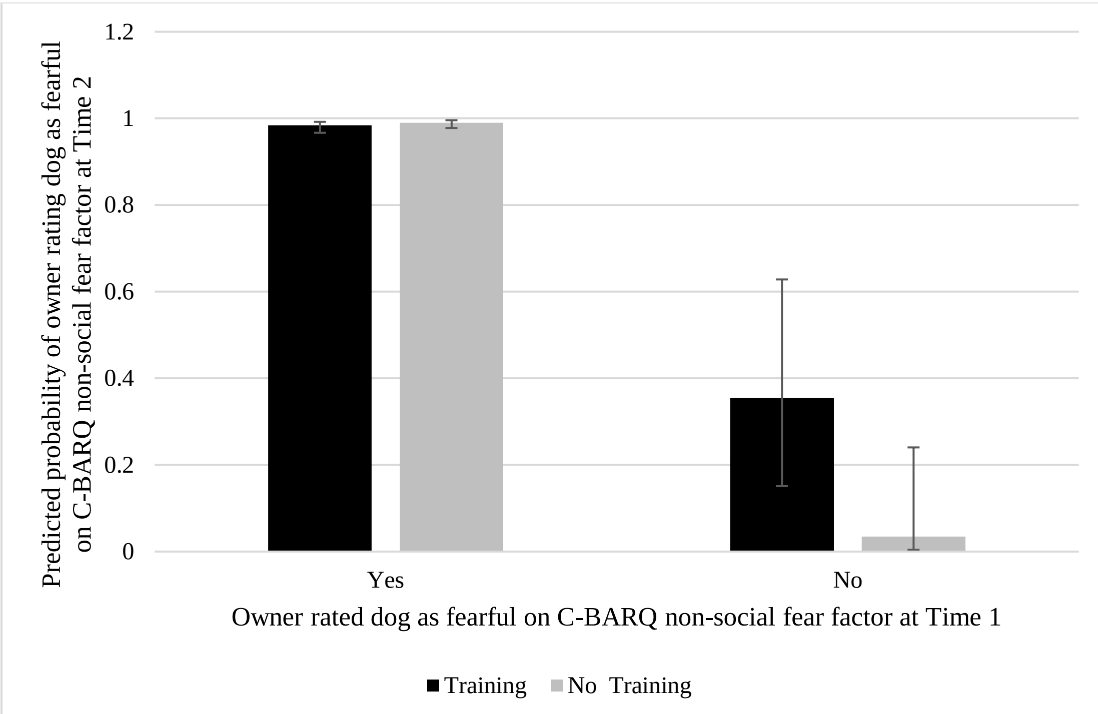


Figure 3.3 Effect of targeted fear training on the probability of owners' rating their dog as fearful on the C-BARQ non-social fear factor at Time 2, when the owner rated their dog as fearful, or not fearful at Time 1, based on the output of a logistic regression model (n=997).



CHAPTER FOUR

Stranger-directed aggression in pet dogs: Owner, environment, training and dog associated risk factors

In preparation for submission to *Preventive Veterinary Medicine*

4.1 Abstract

Stranger-directed aggression in dogs is both a public-safety and animal welfare concern. Aggression can result in human injuries, and can impair the human-animal relationship and lead to an increased risk of physical punishment, relinquishment or euthanasia. Our objective was to determine risk factors for dogs that display stranger-directed aggression using the previously validated, owner-completed Canine-Behavioural Assessment and Research Questionnaire (C-BARQ) with additional questions added relating to dog characteristics, temperament, training, environment, and owner demographics and personality. Stranger-directed aggression scores were analyzed using a mixed linear regression model with household as a random effect. In addition, a mixed logistic regression model comparing dogs with severe stranger-directed aggression (bites or attempts to bite) to dogs showing only threatening behaviours, with household as a random effect. Data on 3,264 dogs and 2,713 owners were collected. Variables significantly associated with higher stranger-directed aggression scores were dog fear of strangers, impulsivity, male dogs, being neutered for behavioural reasons, use of various training tools and physical punishment by owner, exposure to strangers less than once a month as a puppy, history of abuse, feeding on a schedule, and the owner being extroverted. In addition, dogs that were indifferent towards strangers as a puppy were at increased risk of stranger-directed aggression compared to dogs that were excited. Finally, breed group was also associated with reported stranger-directed aggression, with hounds scoring lower than herding breeds. Variables associated with increased risk of severe stranger-directed aggression were severe fear of strangers, impulsivity, male dogs, use of head halters, use of physical punishment, exposure to strangers less than once a month as a puppy, and indifference towards strangers as a puppy. In addition, the use of toys or praise as a reward, exercising off-leash and asking for a different behaviour when the dog performed an unwanted behaviour were both associated with lower risk of severe stranger-directed aggression. These results indicate that the primary risk factors for stranger-directed aggression relate to dog and training variables. Identification of these factors may be used to identify dogs at risk, and implement appropriate training plans to help prevent the development of stranger-directed aggression.

4.2 Introduction

Aggression towards strangers is a considerable public safety concern, as well as an issue for animal welfare. It is estimated that approximately 1.5% of people in the U.S. are bitten by a dog each year (Gilchrist et al., 2008; Sacks et al., 1996), and one report suggests approximately one third of dog bites are directed towards unfamiliar people (Shuler et al., 2008). Dogs that are aggressive towards strangers are more likely to receive physical punishment (Herron et al., 2009), which can in turn further increase the risk of aggression (Blackwell et al., 2008; Herron et al., 2009; Hiby et al., 2004). In addition, dogs that are aggressive towards strangers are less likely to participate in activities with their owner, which may reduce animal welfare (Bennett and Rohlf, 2007). Finally, aggression can impair the human-animal relationship (Serpell, 1996), and lead to an increased risk of relinquishment or euthanasia (Salman et al., 2000, 1998).

Previous research has indicated a number of risk factors for dogs acting aggressively, including factors relating to the dog, owner, training methods and environment. One of the dog characteristics most commonly reported to be associated with aggression is sex. Several studies have reported that male dogs are more likely to be aggressive than female dogs (Amat et al., 2009; Borchelt, 1983; Casey et al., 2014; Fatjo et al., 2007; Gershman et al., 1994; Lund et al., 1996; Chapter 2). In addition, a number of studies have reported associations between neuter status and aggression, but they vary in their results. Some studies report a positive association between neutering and aggression (Podberscek and Serpell, 1997; Chapter 2), while others report a negative association (Gershman et al., 1994; Goodloe and Borchelt, 1998), or no association (Amat et al., 2009; Matos et al., 2015; van den Berg et al., 2006). Many studies have also looked at dog breed as a risk factor for aggression. Breeds that are more commonly reported to be aggressive than other breeds include Chihuahuas (Duffy et al., 2008; Hsu and Sun, 2010), Dachshunds (Duffy et al., 2008; Hsu and Sun, 2010), German Shepherds (Blackshaw, 1991; Borchelt, 1983; Duffy et al., 2008; Lund et al., 1996) and Cocker Spaniels (Blackshaw, 1991; Borchelt, 1983; Lund et al., 1996). In addition, sporting breeds, such as the Golden Retriever and Labrador Retriever, are commonly found to be less likely to be aggressive than other breeds (Casey et al., 2014; Duffy et al., 2008; Hsu and Sun, 2010; Tonoike et al., 2015; Chapter 2). Another dog characteristic that has been found to be associated with aggression is size, with small dogs being more likely to be aggressive (Arhant et al., 2010; Duffy et al., 2008; Gonzalez Martinez et al., 2011). Finally, dog temperament, and most notably fear, have been found to be associated with aggression (Duffy et al., 2008; Goodloe and Borchelt, 1998; Hsu and Serpell, 2003; Matos et al., 2015; Chapter 2). It has also been hypothesized that impulsivity is associated with aggression in dogs. This relationship has been established in humans (Calkins and Dedmon, 2000; Caspi and Silva, 1995; Davidson et al., 2000; Pulkkinen, 1996), and rats (Van den Bergh et al., 2006), and has also been found to be associated with resource-guarding in dogs (Jacobs et al., 2017a), but has not been examined in relation to other forms of aggression.

There is little evidence that owner characteristics affect aggression in dogs, but it is anecdotally suggested that owners who are more anxious can pass that anxiety on to their dogs. One study has found that owner personality can affect how owners react in different situations, which can in turn affect their dogs' aggressive behaviours (Cimarelli et al., 2016). Other studies have found that owner experience with dogs is associated with aggression in dogs (Jacobs et al., 2017a). However, it is possible that differences in aggression due to owner experience could be partially due to their ability to recognize aggression, rather than actual differences in the dogs' behaviours. Previous studies have reported that experienced owners are more accurate at rating aggression (Jacobs et al., 2017b) and fear (Chapter 3) in dogs, suggesting this relationship needs to be further explored.

Several studies have reported the effects of training methods on aggression in dogs. Dogs who are trained with positive punishment have a higher risk of aggression (Arhant et al., 2010; Blackwell et al., 2008; Herron et al., 2009; Hiby et al., 2004; Hsu and Sun, 2010). Previous experiences have also been found to affect aggressive responses in dogs, including a lack of socialization (Appleby et al., 2002; Casey et al., 2014), and a prior history of abuse (McMillan et al., 2015). Few management factors, beyond training methods, have been investigated in dogs. There is some suggestion that nutrition can affect aggression in dogs, specifically the levels of dietary protein and tryptophan (DeNapoli et al., 2000; Dodman et al., 1994; Kato et al., 2012). In addition, there are some anecdotal suggestions that raw food diets are associated with aggression in dogs, possibly due to their protein content. Another management characteristic that has been anecdotally suggested to increase aggression is "spoiling" the dog, usually in the form of feeding table scraps, or allowing the dog on furniture. Finally, lack of exercise and mental stimulation have been suggested by dog behaviour professionals to increase aggression (Horwitz and Neilson, 2007; Landsberg et al., 2013; Overall, 2013). Lack of exercise has been shown to be associated with aggression (Podberscek and Serpell, 1997), noise sensitivity, separation anxiety (Tiira and Lohi, 2015), and overall nervousness in dogs (Kobelt et al., 2003).

There is also limited evidence on the effect of the environment on dog aggression. Some studies have reported increased aggression in dogs living in rural areas, and in houses with yards (Hsu and Sun, 2010). In addition, dogs living with more human household members have been found to have increased risk of aggression (Bennett and Rohlf, 2007; Hsu and Sun, 2010). Another environmental characteristic that has not been studied, but has been suggested by dog behaviour professionals to increase aggression, is having access to a vantage point where they can see outside traffic (Horwitz and Neilson, 2007; Landsberg et al., 2013; Overall, 2013). It is suggested that aggression can become a self-rewarding behaviour as dogs barking at strangers outside the house, and then the stranger leaves, reinforces the barking behaviour.

Despite all the different studies examining risk factors for aggression in dogs, no single study has looked specifically at stranger-directed aggression while analyzing the full range of potential risk factors, including dog, owner, training and environmental factors. The current study aimed to examine different risk factors hypothesized to be associated with stranger-directed aggression based on anecdotal reports, professional recommendations, or previous research. The specific objective of this study was to determine which of these factors were associated with dogs displaying aggression towards strangers, as recorded by the C-BARQ, as well as which factors affected the dogs to display severe aggression in the form of biting or attempting to bite.

4.3 Materials and methods

4.3.1 Data collection

The study protocol and all study materials were reviewed and approved by the University of Guelph Research Ethics Board (REB# 16JL030). This was a cross-sectional survey available online between August 15 and September 16, 2016, and was hosted through Qualtrics (Qualtrics, Provo, UT). All responses were anonymous. The questionnaire was initially distributed through social media, emails to students, faculty and alumni of the University of Guelph, and emails to participants from previous research projects conducted by the research group. Snowball sampling was further used to distribute the questionnaire, where participants were encouraged to share the questionnaire with others through email and social media (Atkinson and Flint, 2001; Biernacki and Waldorf, 1981). An incentive of entry into a lottery draw for a chance to win one of six $100 prizes was used to encourage participation.

The questionnaire partially consisted of questions relating to five different areas that were hypothesized to be associated with stranger-directed aggression in dogs: dog temperament, dog characteristics, training, environment, and owner demographics and personality.

Dog temperament

Dog temperament was assessed using two different previously validated scales. Fear and aggression were measured using the ‘Fear and Anxiety’ and ‘Aggression’ portions of the Canine Behavioural Assessment and Research Questionnaire (C-BARQ), respectively (Hsu and Serpell, 2003). The C-BARQ consists of a series of questions asking owners to rate their dogs’ fear and aggression on a scale from 0 (none) to 4 (severe) in a variety of situations. Dogs were then given a score for the factors of stranger-directed aggression, stranger-directed fear, and non-social fear, by calculating the dogs’ average scores across each of the questions in that factor. In order to determine risk factors for severe stranger-directed aggression (i.e., biting or attempting to bite), dogs were also categorized as showing mild to moderate aggression (i.e., threatening behaviours), defined as scoring between 1 and 3 on any question in the stranger-directed aggression factors, or severe aggression, defined as scoring a 4 on any question in the stranger-directed aggression factors. Dogs that scored a 0 on all questions relating to this factor were considered not aggressive towards strangers. Dogs were categorized in the same fashion for stranger-directed fear and non-social fear.

Impulsivity was measured using the Dog Impulsivity Assessment Scale (DIAS; Wright et al., 2012). The DIAS asks owners to rate their agreement (strongly agree, somewhat agree, neutral, somewhat disagree, strongly disagree) with a series of statements about their dog. These ratings are then converted into values of 1-5 for the purposes of analysis. Previous studies have identified three main factors in the DIAS: behavioural regulation, aggression and response to novelty, and responsiveness. For the purposes of this project only the behavioural regulation factor was analyzed, in order to avoid biasing the results by including factors that incorporated questions relating to aggression. Further, the responsiveness factor related mostly to questions regarding trainability and response to novelty, which either did not directly relate to our hypothesis, or were covered by questions in the C-BARQ fear and anxiety section. Dogs were given a score between 0 and 1 for behavioural regulation by totalling the responses for all the questions in that factor, and dividing it by 50 (i.e., the highest possible total score), with higher scores reflecting poor behavioural regulation.

Dog characteristics

Owners were asked to complete basic information about their dogs' characteristics, including their dogs' age, sex, weight and breed, as well as when and where they acquired the dogs, and if, when and why the dogs were spayed/neutered. Dogs under six months of age were excluded from analysis, as the C-BARQ has not been validated for use in puppies. Due to the large number of breeds represented in the present survey, breeds were categorized into Canadian Kennel Club breed groups (Canadian Kennel Club, 2015) for the purposes of analysis. The owners were also asked about any current health problems their dogs may be experiencing and if they were on medications. Finally, the owners were asked if their dogs had experienced any known history of abuse.

Training

Owners were asked to complete information about specific training they have done with their dogs, as well as the type of training methods they typically use, and how they typically react when their dogs perform an unwanted behaviour. A comprehensive list of training methods was provided to owners including, for example, giving treats for correct responses, praising correct responses, ignoring incorrect responses, and giving a leash correction for incorrect responses. These were then categorized as whether or not they used positive punishment when training their dogs as well as what types of rewards they used (treat, praise, toy, other). Similarly, owners were given a list of reactions when their dogs perform an unwanted behaviour, including, for example, ignoring the unwanted behaviour, giving a time out, making a loud noise, or using a shock collar. These responses were then categorized into ignoring the unwanted behaviour, asking for a different behaviour, waiting for a desirable behaviour, avoiding the situation in the future, redirecting, non-physical corrections and physical corrections. Owners were also asked which training tools they have regularly used on their dogs, including no-pull harnesses, head halters, prong collars and shock collars. Owners who had acquired their dogs at less than five months of age were also asked about the socialization they had done with their dogs, including how often they exposed their dogs to different situations, such as interacting with children, teens or unfamiliar adults. Owners were also asked if their puppies acted excited, indifferent or scared when meeting new people during socialization.

Environment

Information about the environment each dog lived in was also collected. This included information about whether the dog lives primarily indoors, where the dog is left when home alone, where the dog sleeps, the amount of time the dog is alone, whether it has access to a vantage point where it can view pedestrian traffic, whether it is allowed on furniture, whether it has a yard, and the type of dwelling, and residential area the dog lives in. This section also included questions about what and how often each dog is fed, the amount and type of exercise it receives, and how often it is provided with mental stimulation in the form of food puzzles or games. Finally, this section also contained information about the composition of each household, including how many people and dogs live in the household, whether the people in the household are all male, female or both, and whether the dog lives with children.

Owner characteristics

This section collected information about each owner's age, gender, household income, education, country of residence, and how many dogs they had owned previously. In order to address the hypothesis that owner personality, or anxiety, can affect dog behaviour, we also included questions from two previously validated scales: the Ten Item Personality Inventory (TIPI; Gosling et al., 2003) and the Generalized Anxiety Disorder 7-Item Scale (GAD-7; Spitzer et al., 2006). The TIPI asks respondents to rate their level of agreement with how well different personality traits apply to them on a seven-point scale ranging from 1 (disagree strongly) to 7 (agree strongly). These items were used to give the participants a score between 1 and 7 for each of the Big-Five personality domains (extroversion, agreeableness, conscientiousness, emotional stability, openness to new things). Owners were then categorized as being either greater than, or less than neutral (4) for each of the five domains. The GAD-7 consists of seven questions asking about how frequently participants experienced different anxiety-related feelings over the past two weeks on a four-point scale ranging from 0 (not at all) to 3 (nearly every day). These responses are then totalled to provide an overall score out of 21. Owners were then categorized as having none (0-4), mild (5-9), moderate (10-14) or severe (15-21) generalized anxiety based on previously established cut-points (Spitzer et al., 2006).

Owner recognition of fear and aggression

In order to assess how well owners can recognize fear and aggression, they were asked to rate a series of videos on the level of fear or aggression a dog was displaying using a 5-point scale, similar to that used for the C-BARQ. The fear videos had been previously validated by experts as showing either no, mild/moderate or severe fear (Chapter 3). The aggression videos showed dogs interacting with food or rawhides that had been previously categorized by experts as showing no resource guarding, threatening behaviour (i.e., growling, freezing, body tension and baring teeth), or aggression (i.e., biting or attempting to bite; Jacobs et al., 2017). These were used to represent the categories of no aggression, mild to moderate aggression (threatening behaviour), and severe aggression (biting or attempting to bite). There were three examples from each category for fear, and one example from each category for aggression. For the purposes of analysis, owners were categorized as whether or not they were successful at identifying each of the categories of fear and aggression videos. For fear, owners had to correctly categorize two out of the three videos to be classified as successful at identifying these behaviours. For aggression, owners had to correctly categorize each of the individual videos to be classified as successful at identifying these behaviours.

In addition, owners were given the opportunity to complete the questionnaire for multiple dogs. Owners were instructed to complete the questionnaire for their dogs in alphabetical order based on their names, for up to a total of five dogs in order to reduce potential selection bias. For each questionnaire completed, owners were provided with an additional entry into the lottery draw.

4.3.2 Statistical analysis

Mixed linear and logistic regression models were fitted to estimate the association between stranger-directed aggression in dogs and possible explanatory variables relating to dog temperament, dog characteristics, environment, training and owner using Stata Statistical Software: Release 14 (StataCorp. 2015, College Station, Texas, USA). Model 1 was a mixed linear regression model where the dependent variable was the overall factor score for the C-BARQ stranger-directed aggression factor. Model 2 was a mixed logistic regression model where the dependent variable was whether the dog displayed severe stranger-directed aggression (scoring a 4 on at least one question in the C-BARQ stranger-directed aggression factor) or mild to moderate stranger-directed aggression (scoring between 1 and 3 on any question in the C-BARQ stranger-directed aggression factor). Both models included household as a random effect in order to control for correlations in behaviour among dogs within the same household. Both multivariable models were fitted using the following procedure. Independent variables relating to dog characteristics (Table 4.1), socialization (Table 4.2), training (Table 4.3), environment (Table 4.4), owner characteristics (Table 4.5), and dog temperament (Table 4.6) were tested for univariable associations with the dependent variables, and were considered for inclusion in the main effects models if they met a liberal cut-off ($\alpha = 0.20$). Variables in the main effects model were removed in a manual backward step-wise fashion, and were retained if they were statistically significant ($\alpha = 0.05$) or were identified to be a confounding variable. Confounding variables were identified if they caused a greater than 20% change in the coefficient of other statistically significant variables in the model when removed, and based on their potential causal relationship with the explanatory variable and the outcome (Dohoo et al., 2003). Biologically plausible two-way interactions were tested in the multivariable model and were included if they were statistically significant ($\alpha = 0.05$). Pairwise comparisons between categories of significant variables were performed, with a Bonferroni adjustment for multiple testing. The intra-class correlation coefficient (ICC) was estimated to assess the amount of correlation between dogs within the same household, both for the final model, and in an intercept-only model without the inclusion of the fixed effects. If the random-intercept did not have a significant effect on the model, Akaike and Bayesian Information Criteria were compared between models with and without the inclusion of the random effect, and the model with the lowest values was used for further analysis. For mixed models, best linear unbiased predictors (BLUPs) were assessed for normality and homoscedasticity to assess model fit. In addition, standardized residuals and Pearson residuals were graphically assessed for outliers for linear and logistic mixed models, respectively. If the regular linear regression model fit the data the best, standardized residuals, Cook's distance, and DFBETA values were used to assess outliers, leverage and influence, respectively. If the regular logistic regression model fit the data the best, Pearson residuals, leverage and delta-beta values were used. In addition, the Hosmer-Lemeshow goodness-of-fit test was used, and the model was determined to fit the data if the test was not significant ($\alpha = 0.05$; Dohoo et al., 2003). Outlying observations were inspected for potential recording errors and their impact on the model.

4.4 Results

A total of 2,748 dog owners responded to the questionnaire and completed information for a total of 3,308 dogs. As dogs under six months were excluded from analysis, only data relating to 2,713 owners and 3,264 adult dogs are presented. A majority of owners (83.8%) completed the questionnaire for one dog, with 13.1%, 2.2%, 0.8% and 0.1% of owners completing the questionnaire for two, three, four, and five dogs, respectively. Most commonly, dogs were mixed breeds (36.2%), followed by herding (15.2%), sporting (12.1%), working (11.1%), toy (6.0%), hound (5.7%), non-sporting (5.7%), terrier (5.2%) and other pure-breeds (2.9%). The most common breeds in each breed group respectively, were Border Collie, Labrador Retriever, Rottweiler, Chihuahua, Greyhound, Shih Tzu, and American Staffordshire Terrier (Table 4.7).

A total of 2,650 (81.2%) dogs were classified as having some level of aggression towards strangers according to C-BARQ, with 405 (15.3%) of those dogs displaying severe aggression. The mean (SD) score for the C-BARQ stranger-directed aggression factor was 0.82 (0.86) and ranged from 0 to 4. A full summary of descriptive statistics for the data collected from this survey relating to dog characteristics, socialization, training, environment, owner demographics, and dog temperament can be found in Tables 4.1 to 4.6.

4.4.1 Model 1: Factors associated with C-BARQ stranger-directed aggression factor score

The C-BARQ stranger-directed aggression score had a significant positive association with fear of strangers, impulsivity, being male, being spayed/neutered for behavioural reasons, having a confirmed or suspected history of abuse, reacting fearful or indifferent to strangers during socialization (vs. excited), being exposed to strangers less than once a month, being physically punished by the owner, the owner avoiding situations where the dog performs unwanted behaviours, use of head halters, shock collars, choke chains and no-pull harnesses, feeding on a schedule, and the owner being extroverted (Table 4.8). Stranger-directed aggression scores were significantly lower in dogs that were crated when left alone, exercised on leash, off-leash, or at the dog park, dogs trained with toys or verbal praise as a reward, when the owner asks for a different behaviour when the dog performs an unwanted behaviour, and when the owner was able to correctly identify the absence of aggression in videos (Table 4.8). Breed group was significantly associated with stranger-directed aggression (p=0.003), with hounds scoring lower than herding breeds, and with no significant differences between the other breed groups after adjusting for multiple pairwise comparisons (Table 4.8). Based on the ICC of the full model, dogs within the same household had a correlation in stranger-directed aggression score of 0.12. When modelled without the fixed effects, the effect of household was not significant. For this model the assumptions for homoscedasticity and normality were met.

4.4.2 Model 2: Factors associated with dogs displaying severe stranger-directed aggression

The odds of aggressive dogs displaying severe stranger-directed aggression were significantly higher with increasing impulsivity, dogs being mildly or severely fearful of strangers (vs. no fear), or male dogs (vs. female; Table 4.9). Greater odds of severe stranger-directed aggression were also significantly associated with dogs that were indifferent towards strangers during socialization as a puppy (vs. excited), dogs that were exposed to strangers less than once a month as a puppy, the use of head halters, and the use of physical corrections when the dog performed an unwanted behaviour (Table 4.9). Lower odds of severe stranger-directed aggression were associated with the use of toys or praise as a reward, owners asking for a different behaviour when dogs performed an unwanted behaviour, and exercising off leash (Table 4.9). The random effect of household was not significant in this model, and the exclusion of this variable resulted in a model with lower Akaike and Bayesian Information Criteria. When modelled as a random effect only model, without the fixed effects (in order to determine the baseline correlation between dogs within the same household), the effect of household remained insignificant. Therefore, the random effect of household was excluded from the final model. There was no evidence of lack of fit based on a non-significant Hosmer-Lemeshow goodness-of-fit test ($\chi^2 = 9.02$; df = 8; p = 0.341), and no outliers or highly influential observation were noted when assessing Pearson residuals, leverage and delta-beta values.

4.5 Discussion

The results of both models of risk factors for stranger-directed aggression and severe stranger-directed aggression highlight similar findings. A number of factors that were significant in both models may aid in the identification of dogs at risk of developing stranger-directed aggression, including dog temperament traits, such as fear and impulsivity, dog characteristics, such as sex and breed, and factors relating to a dog's prior history, such as a history of abuse, or inadequate socialization. In addition, the results indicate a few training and management factors that may aid in preventing stranger directed aggression, including avoiding the use of aversive training methods, and providing adequate socialization to puppies. It is also notable that the effect of household was small, only accounting for 9.1 % of variation in the model of stranger-directed aggression, and was insignificant in the model of severe stranger-directed aggression. The effect of household was also insignificant in both models when modelled without the fixed effects. It was previously reported there were significant correlations in aggressive behaviour in dogs within the same household, when measuring primarily dog temperament and demographic factors (Chapter 2). However, household was not a significant factor in the current population of dogs. This may have been due to few households rating more than one or two dogs in the current study, resulting in insufficient power to detect correlations between dogs within the same household. Alternatively, there could truly be no correlation in the behaviour of dogs within the same household, which could indicate a difference in the population of owners and dogs surveyed in the two studies. In the future, studies can target multi-dog households to determine if there is, indeed, similarities in the behaviour of these dogs beyond the identified owner, management, and environmental effects.

4.5.1 Dog temperament

Fear

Fear of strangers was associated with increased aggression in both models. This is consistent with findings of other studies looking at dog temperament (Duffy et al., 2014; Goodloe and Borchelt, 1998; Hsu and Serpell, 2003; Matos et al., 2015; Chapter 2), and could indicate that aggression towards strangers could be motivated by fear. Alternatively, it is possible that stimuli that provoke aggressive responses also independently provoke a fear response, as both aggression and fear are typical responses to a threat. When looking specifically at severe aggression, only severe fear of strangers significantly increased the odds of severe aggression when compared to no fear. This suggests that while mild to moderate fear of strangers is associated with stranger-directed aggression, it may not be sufficient to cause dogs to bite. Non-social fear was not significantly associated with stranger-directed aggression in either model, suggesting that target-specific fear is a more important factor in determining dogs at risk of stranger-directed aggression.

Impulsivity

Another temperament trait that was associated with stranger-directed aggression in both models was impulsivity. This is consistent with the hypothesis that dogs that act aggressively do so because they are less able to inhibit their responses; this link between aggression and poor behavioural regulation has been well studied in children (Calkins and Dedmon, 2000; Caspi and Silva, 1995; Davidson et al., 2000; Pulkkinen, 1996), but not in dogs. However, there are indications that the neurobiology of impulse control is similar between dogs and humans (Cook et al., 2016), and reduced serotonergic activity has been linked to both aggression and poor impulse control in dogs (Reisner et al., 1996). In addition, aggression in rats has been found to be associated with delay aversion, an indicator of poor impulse control (Van den Bergh et al., 2006). Previous research into resource guarding in dogs, also using the behavioural regulation portion of the DIAS, found that impulsivity was associated with aggressive behaviours, but was not significant when only biting aggression was analyzed (Jacobs et al., 2017). This difference could indicate a difference in the effect of impulsivity on dogs with stranger-directed aggression and resource-guarding aggression, or could be due to insufficient power to detect an effect of impulsivity in the resource-guarding study, as only 3% of dogs were identified as having biting aggression. With these results, it may be possible to identify dogs at risk of developing stranger-directed aggression using existing measures of impulsivity. In addition, exercises for improving impulse control may benefit dogs with, or at risk of developing, stranger-directed aggression.

4.5.2 Dog characteristics

Sex and neuter status

Male dogs have been shown to be more aggressive than female dogs in several studies (Amat et al., 2009; Borchelt, 1983; Casey et al., 2014; Fatjo et al., 2007; Gershman et al., 1994; Lund et al., 1996; Chapter 2). In the present study, male dogs had higher scores on the stranger-directed aggression factor of the C-BARQ, and also were more likely to show severe aggression defined as biting or attempting to bite.

Neuter status has been reported in some studies to be associated with aggression (Gershman et al., 1994; Goodloe and Borchelt, 1998; Podberscek and Serpell, 1997; Chapter 2), while others report no relationship between neutering and aggression (Amat et al., 2009; Matos et al., 2015; van den Berg et al., 2006). The current study found no relationship between stranger-directed aggression and neutering in either model, with the exception of dogs that were neutered for behavioural reasons. While it is not unexpected that dogs neutered for behavioural reasons would score higher on the stranger-directed aggression factor of the C-BARQ, as the aggression is highly likely the behavioural problem the dog was neutered for, it does suggest that neutering may not mitigate stranger-directed aggression issues.

Weight

Previous studies have identified size or weight as risk factors for stranger-directed aggression (Arhant et al., 2010; Duffy et al., 2008; Gonzalez Martinez et al., 2011; McGreavy et al, 2013), however weight was not significant in the current study. Duffy et al. (2008) noted that stranger-directed aggression was highest in small to medium breeds. However, they did not conduct statistical analysis to analyze the effect of this variable. McGreavy et al. (2013) found that stranger-directed aggression increases with bodyweight. However, this was modeled in combination with height, which showed an inverse relationship with aggression. They hypothesize that this may have been caused by a clustering of terriers with short legs, and comparatively larger bodyweights. In addition, Gonzalez Martinez et al. (2011) reported an increased risk of aggression towards people as size decreased. As height was not measured in the current study, it is unclear how this would have affected the results. Finally, one study looking at differences between small and large dogs found that while reported aggression was higher in small dogs (Arhant et al., 2010), there were also significant differences in how these dogs were trained and managed that could lead to increased aggression. As we controlled for some of the differences in how dogs were trained and managed in the current study, this may account for why weight was not significant. Based on the results of the current study, it does not appear as if weight affects stranger-directed aggression beyond differences in how larger and small dogs are trained and managed.

Breed

Overall, the effects of breed group on stranger-directed aggression should be interpreted with caution. There is a large amount of variation in stranger-directed aggression scores between individual breeds within the same breed group, with breeds with the highest prevalence being overly representative of the behaviour of the group as a whole. For example, the working group contains both Siberian Huskies and Rottweilers. Siberian Huskies have been found to have low levels of stranger-directed aggression, both in the current study, and in previous research (Duffy et al., 2008). Meanwhile Rottweilers have been found to have relatively high levels of stranger-directed aggression (Blackshaw, 1991; Duffy et al., 2008; Lund et al., 1996). Certain breed groups may have more variation than others, as they represent a more diverse group of dogs. For example, the non-sporting and working groups include breeds bred for a wide variety of purposes, whereas the herding group includes dogs primarily bred for working with livestock, and has more consistent scores across breeds for stranger-directed aggression. This variation within group may have resulted in underestimation of the effect of breed on stranger-aggression in the current study.

Previous studies have shown that German Shepherd Dogs, a member of the herding group, have some of the highest rates of stranger-directed aggression (Beaver, 1983; Blackshaw, 1991; Borchelt, 1983; Duffy et al., 2008; Lund et al., 1996). This is consistent with our findings that herding breeds were scored higher for stranger-directed aggression, when compared to hounds. Similarly, herding breeds were found to be at risk of stranger-directed aggression in Chapter 2. Conversely, hounds were found to have low levels of stranger-directed aggression, both in the current study and in Chapter 2, but the three primary breeds in this group vary greatly in their aggressiveness. Previous research has found that greyhounds, the most prevalent hound in the current study, had stranger-directed aggressions scores that were significantly lower than average, Beagles did not differ significantly from average, and Dachshunds had some of the highest levels of stranger-directed aggression (Duffy et al., 2008). Finally, both the current study and Chapter 2 found that sporting breeds scored low on stranger-directed aggression in both models. This is supported by previous research that has found that the United Kingdom Kennel Club's gundog group (equivalent to the CKC sporting group) has been previously reported to be at lower risk of stranger-directed aggression (Casey et al., 2014). In addition, Labrador Retrievers and Golden Retrievers, the most common members of the sporting group have been previously reported to have low levels of stranger-directed aggression (Duffy et al., 2008; Hsu and Sun, 2010).

History of abuse

Owners reporting both confirmed and unknown histories of abuse were associated with increased stranger-directed aggression scores, but were not associated with severe aggression. Another study using the C-BARQ has reported increased stranger-directed aggression in dogs whose owners report confirmed or suspected histories of abuse (McMillan et al., 2015). In support of these findings, abuse in children has been linked with increased aggression in adolescence and adulthood (Anda et al., 2006; Kaplan et al., 1999). However, there has been some suggestion that aggressive behaviour can also be a risk factor that increases the likelihood of abuse occurring (Black et al., 2001; Kaplan et al., 1999), so a causal relationship cannot be definitively determined. Based on these results, extra caution should be taken while handling dogs with known or suspected histories of abuse, especially when interacting with strangers.

4.5.3 Environment

Exercise

While the amount of exercise that was provided was not significant in either model, the type of exercise was. Dogs that were exercised by walking on-leash, off-leash or going to the dog park scored lower on the stranger-directed aggression factor when compared to dogs that were not exercised in these manners. Additionally, dogs that were exercised off-leash were at decreased risk of severe stranger-directed aggression in the form of biting, or attempting to bite. These results suggest that dogs that are exercised outdoors are less aggressive. This is most likely because people with dogs that are aggressive towards strangers are less likely to take their dog out in public due to safety concerns. Further, owners of dogs that show severe stranger-directed aggression would be less likely to let their dog off-leash and risk having their dog bite. However, it could also reflect a protective effect of increased social interaction in public spaces, and requires further investigation.

Feeding

While stranger-directed aggression was not significantly associated with the type of food that was fed or the frequency at which meals were provided, there was a significant relationship with whether dogs were fed on a fixed schedule. This question was provided in order to test the hypothesis that providing a predictable routine for your dog reduces anxiety and in turn aggression. However, the current results do not support this hypothesis, as dogs fed on a schedule showed increased stranger-directed aggression scores. One possible explanation for this finding is that there are other unmeasured confounders, relating to the owner or dog that make them more likely to feed on a routine, that are associated with an increase in stranger-directed aggression. Alternatively, owners of stranger-directed aggressive dogs may be more likely to feed their dog on a schedule, in order to provide stability for their dog. Finally, it could be that feeding on a fixed schedule actually increases anxiety in the dog as they start anticipating their next meal. This is supported by a study by Jagoe and Serpell (1996), which found that dogs fed after owners ate their own meals were more likely to show territorial aggression when compared to those fed before their owners. They hypothesized that this finding was due to increased arousal, or increased value placed on the food, caused by having to wait for their meal. Further exploration of the effect of fixed routines on stranger-directed aggression is needed in order to provide recommendations for owners.

Housing

Most of the variables relating to housing were not significant in either model, including the type of dwelling they lived in, whether they had a yard, and whether they lived in an urban or rural area. However, dogs that were crated when left alone during the day had lower stranger-directed aggression scores. Crating dogs was not associated with severe stranger-directed aggression, suggesting that while this practice may be associated with lower levels of aggression, it does not affect whether dogs bite or attempt to bite. It is possible that crating restricts views outside of the home; some have recommended that dogs not be allowed access to areas of the house where they can see people or animals outside, as territorial aggression may be reinforced when these stimuli leave after the dog reacts (Horwitz and Neilson, 2007; Landsberg et al., 2013; Overall, 2013). It could also be that owners that crate train their dogs are more likely to work on other training that helps to prevent aggression issues. While further research is needed to determine whether this relationship is causal, dogs with stranger-directed aggression may benefit from crate training.

4.5.4 Training

Training methods

The methods owners reported using when training their dogs were not significantly associated with stranger-directed aggression in the current study, with the exception of training using toys or praise as a reward which were associated with lower stranger-directed aggression scores and reduced risk of severe stranger-directed aggression. When owners were asked specifically about how they react when their dogs perform an unwanted behaviour some significant effects were found. Asking for a different behaviour was found to be associated with lower stranger-directed aggression scores and decreased risk of severe aggression. Conversely, physically correcting the dog was associated with increased stranger-directed aggression scores and increased risk of severe aggression. These results support our hypothesis that the use of positive punishment, in the form of physically correcting the dog, can increase stranger-directed aggression, while using positive reinforcement by rewarding alternate behaviours can help reduce or prevent aggression issues. These findings are supported by other literature that found that the use of positive punishment increases stress (Horváth et al., 2008), reduces ability to learn (Hiby et al., 2004; Rooney and Cowan, 2011) and is associated with behaviour problems, including aggression (Arhant et al., 2010; Blackwell et al., 2008; Herron et al., 2009; Hiby et al., 2004). Due to the cross-sectional nature of this study, we must be cautious in making causal inferences, since it is unclear whether the use of positive punishment increases aggression, or whether owners of aggressive dogs are more likely to resort to positive punishment in an attempt to manage their dog. Based on these results, aversive training methods should be avoided, both for the welfare of the dog as well as the risk of future behavioural issues.

Tools used

The current study found using a no-pull harness, head halter, shock collar and choke chain were all associated with increased stranger-directed aggression. Additionally, head halters were associated with increased risk of severe stranger-directed aggression in the form of biting, or attempting to bite. All of these tools work to stop behaviours, most notably pulling on leash, through the process of positive punishment or negative reinforcement. With the exception of shock collars, all of the devices work by applying pressure when the dog pulls, and releasing pressure when the dog walks on a loose leash. It is anecdotally suggested that dogs that react aggressively on leash may do so because they have learned to associate the presence of strangers with the discomfort caused by pulling, and react aggressively in order to avoid the strangers and further discomfort. These findings provide some support for this hypothesis, but due to the cross-sectional design of this survey a causal relationship cannot be inferred. Similar to the result that the use of physical punishment increases the probability of aggression, as described above, it cannot be determined whether these tools cause the aggressive behaviour, or whether owners with aggressive dogs are more likely to use these tools in order to gain more control on leash. Few studies have specifically looked at the effects of these tools on aggressive behaviour in dogs. One study looking at dogs relinquished to shelters found that owners who used prong collars and choke chains on their dogs reported lower satisfaction with their dogs' behaviours, including leash pulling (Kwan and Bain, 2013). However, once again it is unclear whether owners were unsatisfied because of pre-existing behaviour problems or due to problems caused by the prong collars and choke chains. Another study looking at relinquishment found that the use of head halters when the dog was a puppy reduced the risk of the dog being relinquished later in life (Duxbury et al., 2003). The authors suggested that this may be because the tool provides more control for owners giving them more confidence. In addition, they suggested that this improved control may aid in the learning of desirable behaviours, and reducing the chance of puppies learning undesirable behaviours. Another study looking at the behaviour of dogs wearing harnesses, compared to collars found no difference in stress-related behaviours, suggesting this tool is not aversive to the dog (Grainger et al., 2016). In addition, a study looking at the use of shock collars has found they cause an increase in stress-related behaviours, but did not go into their efficacy as a training tool (Schilder and Van Der Borg, 2004). Using a no-pull harness or head halter is commonly recommended for preventing and managing stranger-directed aggression (Horwitz and Neilson, 2007; Landsberg et al., 2013; Overall, 2013), supporting the idea that these devices are believed to control aggression, rather than causing it. Given the results of the current study, these tools should be considered with caution, with more research being conducted to further determine their efficacy as training tools, and their effect on dog welfare.

Socialization

Socializing puppies is often recommended as the most important method of preventing stranger-directed aggression (Horwitz and Neilson, 2007; Landsberg et al., 2013; Overall, 2013). The period from approximately 3-13 weeks has been identified as a critical socialization window, where if dogs are not exposed to people they suffer severe social limitations in the future (Freedman et al., 1961), although recent research has indicated that this window may differ between different breeds (Morrow et al., 2015).

Attending socialization classes (Casey et al., 2014), and exposure to urban environments early in life (Appleby et al., 2002), have previously been shown to decrease the risk of stranger-directed aggression. In the current study, dogs that were exposed to unfamiliar people less than once a month had higher stranger-directed aggression scores than dogs exposed more than once a month. There were no significant differences between any of the other socialization categories. This could indicate that exposing puppies to new people at least once a month is sufficient to prevent aggression towards strangers. However, it is also possible that puppies socialized less than once a month were not exposed to strangers more frequently because they were already showing aggressive responses. In addition, as some of the dogs in this study were over ten years of age at the time of the survey, it is possible that there is recall bias relating to the ability of owners to correctly recall how frequently they exposed their puppy to strangers. Owners who invested more time and effort into socializing their puppy may be more likely to correctly recall the amount of socialization their puppy received. These owners may also be more likely to spend more time and effort into other aspects of caring for their dog, which may result in lower stranger-directed aggression scores. However, the extent to which this may have biased the results is unknown.

In both models, dogs had higher stranger-directed aggression ratings when they were indifferent towards meeting new people as a puppy, in comparison to dogs that were excited in this context as puppies. However, while a similar effect was observed for the overall stranger-directed aggression score for dogs that were scored as fearful as puppies, this effect was not statistically significant for severe aggression. One hypothesis to explain this discrepancy is that some of the puppies may not have actually been indifferent towards the new people, but may have been experiencing fear that was not recognized by their owners. If the owners did not recognize the fear their puppy was experiencing they may not have known to end the interaction, therefore increasing the number of negative interactions with new people that a puppy would experience during their socialization period. This could then result in the puppy learning to act aggressively in order to avoid interactions with strangers in the future. This effect may have been especially important in puppies that go on to bite or attempt to bite strangers. These results indicate the importance of socialization in preventing stranger-directed aggression. However, further research examining the relationship between the quantity and quality of exposure to strangers during puppyhood and aggression towards strangers is needed to provide accurate socialization recommendations.

4.5.5 Owner

Personality and anxiety

We hypothesized that factors relating to owner personality would influence aggression as they may affect how the owner responds in different situations. Cimarelli et al. (2016) found that owners who scored high on the personality trait of openness showed more warmth and enthusiasm, and gave less commands when their dogs were put in a variety of situations. Similarly, owners who scored lower on the personality trait of conscientiousness were less likely to pet and praise their dog during stressful situations. The same study also found that dogs that acted aggressively during a threatening stranger test were more likely to have owners who gave a lot of commands. However, neither openness nor conscientiousness were significant in the current study, possibly due to the inclusion of questions relating to how the owner responds when the dog performs an unwanted behaviour, which may be an intervening variable for the effects of these personality traits. The only variables relating to the owner's personality associated with stranger-directed aggression in the current study was whether the owner was categorized as being extroverted. It is possible that more extroverted owners are more likely to approach strangers with their dog, and therefore put their dog in more situations in which they have the opportunity to act aggressively. Similarly, extroverted owners may be more sensitive to any stranger-directed aggression shown by their dog during these interactions. Finally, extroverted owners may differ from introverted owners in other aspects of how they train and manage their dog, which affect stranger-directed aggression and were not measured in the current study.

Rating of fear and aggression videos

A majority of participants were able to correctly identify fear in the videos, although performance was less accurate for the mild to moderate fear videos, suggesting that some participants were not able to recognize subtle indicators of fear. Conversely, participants were not very accurate at identifying aggression in videos in the current study. These low levels of accuracy could be due to participants using their own definitions of aggression, rather than using the instructions given with the videos defining mild to moderate aggression as threatening behaviours and severe aggression as biting or attempting to bite. As some people only consider aggression to include actual bite attempts this could have resulted in them rating these videos lower. This hypothesis is supported by the fact that a previous study using the same videos, but asking owners to categorize them as threats versus aggression found much higher levels of accuracy (Jacobs et al., 2017b). However, this does not fully explain why the accuracy was considerably lower for the severe aggression video than for mild aggression. Another possible reason for this difference is that the severe aggression video is of a small dog (Chihuahua), and people may be less likely to rate small dogs as aggressive since they appear less threatening. In addition, it is possible that not all participants had their volume turned up to a high enough level to hear vocal behaviours, such as growling. Regardless of the reason for this poor identification, it suggests that caution should be used in interpreting the prevalence of severe aggression in the current study, as it is possible that it is being underestimated.

Whether or not participants were able to correctly identify the presence of fear and aggression did not have a significant effect on the stranger-directed aggression factor score. However, participants who were not able to correctly identify the absence of aggression rated their dogs' aggression higher on the C-BARQ. It is possible that these owners are more likely to rate dog behaviours as more severe, regardless of the reality. Similarly, it is possible that participants who own aggressive dogs may be overly sensitive to subtle behaviours shown by the dogs in the videos causing them to incorrectly rate these dogs as being aggressive. Previous research indicated that while training can improve recognition of fear in videos, it does not consistently alter owner ratings of their own dogs (Chapter 3). This suggests that owner ability to correctly rate videos may not be reflective of their accuracy in rating their own dog. Further studies examining the accuracy of owner ratings of their own dog's behaviour are needed in order to determine what impact this has on the validity of using the C-BARQ for measuring fear and aggression in dogs.

4.5.6 Limitations

As stated above, the main limitation of this study is that the survey relies on owners reporting on their dogs' past behaviours. While previous studies have shown high reliability and validity for the C-BARQ (Duffy and Serpell, 2012; Hsu and Serpell, 2003), the exact level of precision of owners' ratings of their dogs' fear and aggression has not been determined. Based on owner accuracy on video ratings, there is some concern that reports of fear and aggression in their own dogs are inaccurate. However, it could be that while owners are not entirely accurate with short video clips of unfamiliar dogs, their ratings of their own dogs may be more accurate because they have more exposure to them. As the video ratings of severe fear and aggression were the least accurate, it is likely owners were underestimating fear and aggression in their dogs. Therefore, while prevalence estimates from the current study might not be accurate, the identified risk factors should be reliable.

Another limitation of this study is the study population. A vast majority of the respondents were women, which is not representative of the entire dog owning population. While owner gender was considered for inclusion in analysis, it was not significant. However, this may have been due to a lack of power caused by the small sample size of men in the current study. Also, while the advertisement did not specify the study objective, it is possible that owners of dogs with behavioural problems may have been more likely to respond to the survey, causing an overestimation of the level of aggression in the broader dog population if extrapolated. Finally, the research group did not have control over where people shared the survey, which may have resulted in over-representation of certain groups of people based on where the questionnaire was shared. As this study did not aim to measure prevalence, these limitations may have been less likely to bias the measures of association.

Finally, the cross-sectional design of this study limits our ability to make causal inferences, and therefore it cannot be determined whether factors associated with stranger-directed aggression actually cause the aggression, or are more likely to occur in dogs that are already aggressive. Instead these identified risk factors can help develop hypotheses for future longitudinal studies.

4.6 Conclusions

The current study built on the existing knowledge of risk factors that are associated with stranger-directed aggression in dogs, and may be useful for informing future research into methods for prevention and treatment. The results suggest a number of factors that may aid in identifying dogs at risk of developing stranger-directed aggression, including dogs that are fearful, impulsive, male, or belonging to certain breed groups. The results also highlight the importance of previous experiences on stranger-directed aggression, and suggest that good socialization and avoiding the use of aversive training methods would be beneficial for preventing stranger-directed aggression issues. Further studies into the accuracy of owner-reports, as well as longitudinal studies exploring the causal nature of these associations, are needed in order to help identify dogs at risk of developing stranger-directed aggression and to implement appropriate interventions.

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Table 4.1 Dog characteristic data collected for 3,264 dogs (≥6 months old) in a cross-sectional study aiming to identify risk factors for dogs developing stranger-directed aggression. Proportions are displayed for categorical variables, and means (SD) are presented for continuous variables.

Variable	Category	Prop/Mean(SD)	N
Sex	Male	0.51	1581
	Female	0.49	1539
Neutered	Yes	0.85	2658
	No	0.15	457
Neuter Age	Puppy	0.12	266
	Juvenile	0.67	1456
	Adult	0.21	452
Neutered for behavioural reasons		0.02	75
Breed Group	Herding	0.15	473
	Hound	0.06	177
	Non-Sporting	0.06	177
	Sporting	0.12	379
	Terrier	0.05	161
	Toy	0.06	188
	Working	0.11	346
	Non-CKC purebred	0.03	89
	Mixed breed	0.36	1131
Weight (lbs)		51.5 (29.1)	3026
Dog Age	Juvenile	0.14	442
	Adult	0.70	2164
	Senior	0.16	507
Age Acquired	Puppy	0.58	1819
	Juvenile	0.21	661
	Adult	0.21	644
Where Acquired	Breeder	0.34	1076
	Family/Friend	0.09	283
	Stray	0.02	53
	Other	0.14	449
	Pet Store	0.02	58
	Rescue	0.23	719
	Shelter	0.16	503
Chronic health problems		0.24	746
Type of health problem	Gastro	0.04	125
	Musculoskeletal	0.08	263
	Skin	0.07	221
	Metabolic	0.02	72
	Neuro	0.02	50
	Pain	0.03	93
	Vision	0.02	75
	Hearing	0.02	65
On medication		0.26	818
History of abuse	Yes	0.10	294
	Unsure	0.23	679
	No	0.67	2007

Table 4.2 Socialization data that were collected for a subsample of 1,745 dogs (≥6 months old) that were acquired before they were 5 months of age as part of a cross-sectional study aiming to identify risk factors for dogs developing stranger-directed aggression.

Variable	Category	Prop	N
Socialization to heavy traffic	< once a month	0.25	432
	1-2 x a month	0.14	249
	Once a week	0.16	281
	2-3 x a week	0.24	423
	Daily	0.22	392
Socialization to children	< once a month	0.39	679
	1-2 x a month	0.20	352
	Once a week	0.11	186
	2-3 x a week	0.10	167
	Daily	0.21	356
Socialization to teenagers	< once a month	0.43	754
	1-2 x a month	0.17	297
	Once a week	0.10	178
	2-3 x a week	0.09	156
	Daily	0.21	357
Socialization to unfamiliar adults	< once a month	0.07	126
	1-2 x a month	0.18	307
	Once a week	0.22	386
	2-3 x a week	0.32	556
	Daily	0.21	363
Socialization to wheelchairs/canes/walkers	< once a month	0.60	1037
	1-2 x a month	0.17	298
	Once a week	0.10	167
	2-3 x a week	0.08	142
	Daily	0.06	99
Socialization to large crowds	< once a month	0.61	1060
	1-2 x a month	0.24	412
	Once a week	0.09	163
	2-3 x a week	0.05	81
	Daily	0.02	29
Socialization to bikes, skateboards, rollerblades	< once a month	0.33	579
	1-2 x a month	0.21	372
	Once a week	0.17	303
	2-3 x a week	0.16	286
	Daily	0.12	200
Socialization to pet stores	< once a month	0.42	722
	1-2 x a month	0.30	513
	Once a week	0.19	333
	2-3 x a week	0.08	139
	Daily	0.02	26
Socialization to vet office	< once a month	0.61	1054
	1-2 x a month	0.28	479
	Once a week	0.07	123
	2-3 x a week	0.02	42
	Daily	0.03	43
Reaction to meeting people as a puppy	Excited	0.73	1272

	Scared	0.12	200
	Indifferent	0.15	264

Table 4.3 Training provided to 3,264 dogs (≥6 months old) collected in a cross-sectional study aiming to identify risk factors for dogs developing stranger-directed aggression.

Variable	Category	Prop	N
Attended training classes		0.60	1788
Trained in	Socialization	0.45	1343
	Puppy class	0.32	954
	Basic obedience	0.64	1923
	Agility	0.22	670
	Advance obedience	0.20	593
	Protection	0.02	48
Trained to relax		0.55	1651
Train ‘nothing in life is free’		0.58	1736
Hours spent training per week	0	0.18	536
	1	0.26	778
	2	0.18	522
	3-4	0.15	453
	5-7	0.12	368
	8+	0.10	291
Training method	Treat	0.89	2663
	Praise	0.94	2825
	Toy	0.52	1551
	Other reward	0.08	247
	Positive punishment	0.55	1630
Tools used	Head halter	0.25	755
	Front-clip harness	0.34	1029
	Prong collar	0.12	364
	Shock collar	0.06	181
	Vibration collar	0.05	137
	Bark/Spray collar	0.05	141
	Choke chain	0.10	307
Reaction to unwanted behaviour	Physical correction	0.16	486
	Non-physical correction	0.79	2376
	Ask for different behaviour	0.49	1459
	Ignore behaviour	0.27	819
	Avoid situation in the future	0.19	566
	Redirect	0.59	1773
	Wait for desirable behaviour	0.38	1131
Used counter-conditioning	Yes	0.64	1904
	No	0.31	917
	Unsure	0.05	145
Used desensitization	Yes	0.54	1611
	No	0.42	1245
	Unsure	0.04	117

Table 4.4 Environmental data that were collected from 3,264 dogs (≥6 months old) in a cross-sectional study aiming to identify risk factors for dogs developing stranger-directed aggression. Proportions are displayed for categorical variables, and means (SD) are presented for continuous variables.

Variable	Category	Prop/Mean(SD)	N
Housed indoors		0.98	2914
Sleeping location	Owner's bed	0.45	1331
	Bedroom	0.48	1439
	Room	0.25	755
	Crate	0.17	495
	Outside	0.01	30
	Other	0.06	164
Location left when alone	Loose in house	0.69	2053
	Room	0.14	405
	Crate	0.20	582
	Outside	0.05	153
	Other	0.06	168
Time spent alone (hrs/day)		4.64 (2.74)	2884
Access to vantage point		0.59	1750
Allowed on furniture	Yes, all	0.56	1664
	Yes, some	0.32	962
	None	0.12	348
Time spent exercising (min/day)		77.35 (71.39)	2909
Type of exercise	Walking on-leash	0.77	2292
	Running on-leash	0.13	391
	Walking off-leash	0.40	1203
	Running off-leash	0.16	488
	Running beside bike, etc.	0.05	159
	Playing fetch	0.54	1614
	Dog park	0.20	594
	Practicing dog sports	0.15	436
	Loose in yard	0.70	2081
Play mental games	Never	0.26	767
	A few times a year	0.17	490
	Once or twice a month	0.16	479
	Once or twice a week	0.21	619
	Every day	0.20	607
Food	Commercial dry	0.84	2480
	Commercial wet	0.15	459
	Commercial semi-moist	0.01	44
	Commercial raw	0.10	288
	Homemade cooked	0.14	423
	Homemade raw	0.12	343
Give table scraps		0.68	2016
Number of times fed/day	1	0.10	292
	2	0.75	2216
	3+	0.07	193
	Free-fed	0.09	259
Feed on a schedule		0.82	2418
Residential area	Urban	0.30	892
	Suburban	0.43	1274

	Rural	0.27	801
Dwelling type	Single-detached house	0.69	2036
	Semi-detached house	0.07	222
	Row house	0.06	173
	Duplex	0.03	100
	<5 story apartment	0.06	190
	5+ story apartment	0.04	119
	Mobile home	0.01	44
	Other	0.03	84
Yard	Fenced	0.69	2056
	Unfenced	0.29	573
	None	0.11	338
Household size	1	0.19	563
	2	0.49	1434
	3	0.15	450
	4+	0.17	485
Household gender	All females	0.27	793
	All Males	0.02	51
	Both male and female	0.71	2098
Lives with	Baby (0-4)	0.05	159
	Child (5-9)	0.05	166
	Preteen (10-14)	0.06	199
	Teen (15-19)	0.07	240
Number of other dogs in house	1	0.42	1206
	2	0.35	999
	3	0.12	357
	4+	0.12	325

Table 4.5 Characteristics of the 2,713 owners surveyed during a cross-sectional study aiming to identify risk factors for dogs developing stranger-directed aggression.

Variable	Category	Prop	N
Gender	Male	0.05	126
	Female	0.94	2263
	Other	0.01	11
Age	<25	0.08	200
	25-29	0.16	370
	30-34	0.14	331
	35-39	0.11	251
	40-44	0.11	251
	45-49	0.10	241
	50-54	0.11	255
	55-59	0.09	220
	≥60	0.11	263
Education	High school or less	0.09	221
	Some college	0.22	512
	Associate degree	0.10	233
	Bachelor degree	0.32	755
	Graduate degree	0.19	445
	Professional degree	0.08	198
Household income	<$35,000	0.17	349
	$35,000-49,999	0.12	242
	$50,000-74,999	0.20	404
	$75,000-99,999	0.17	345
	$100,000-149,999	0.21	418
	$150,000+	0.13	257
Country	Canada	0.69	1596
	United States	0.22	505
	United Kingdom	0.02	56
	Australia	0.02	43
	Other	0.05	123
Owned dogs as a child		0.78	1887
Number of dogs owned previously	0	0.38	906
	1-2	0.29	693
	3-4	0.16	381
	5+	0.17	414
Correctly rated videos	No fear	0.92	2490
	Mild fear	0.72	1951
	Severe fear	0.88	2383
	No aggression	0.91	2471
	Mild aggression	0.66	1779
	Severe aggression	0.24	646
TIPI (>4)[1]	Extroverted	0.40	945
	Agreeable	0.82	1902
	Conscientious	0.83	1952
	Emotionally stable	0.63	1492
	Open to new experiences	0.80	1876
GAD-7[2]	None (0-4)	0.66	1527
	Mild (5-9)	0.23	522

	Moderate (10-14)	0.08	175
	Severe (15-21)	0.04	81

[1] Ten item personality inventory
[2] Generalized anxiety disorder 7-item scale

Table 4.6 Temperament traits for 3,264 dogs (≥6 months old) collected through a cross-sectional study aiming to identify risk factors for dogs developing stranger-directed aggression. Proportions are displayed for categorical variables, and means (SD) are presented for continuous variables.

Variable	Category	Prop/Mean(SD)	N
DIAS behavioural regulation score		0.56 (0.08)	3264
C-BARQ stranger aggression score		0.82 (0.86)	3264
C-BARQ stranger fear score		0.83 (1.01)	3214
C-BARQ non-social fear score		1.00 (0.83)	3215
C-BARQ stranger aggression category	None	0.19	614
	Mild/Moderate	0.69	2245
	Severe	0.12	405
C-BARQ stranger fear category	None	0.38	1223
	Mild/Moderate	0.54	1744
	Severe	0.08	247
C-BARQ non-social fear category	None	0.13	417
	Mild/Moderate	0.65	2104
	Severe	0.22	694

Table 4.7 Stranger-directed aggression statistics for the top three most common dog breeds from each breed group (n=3,121). Items in boldface represent the total values for all members of the given breed group.

Breed group	Breed (% of breed group)	N	Mean score (SD)	Mild/moderate aggression[1]		Severe aggression[2]	
				N	% (95% CI)	N	% (95% CI)
Herding	Border Collie (26.0%)	123	0.718 (0.753)	85	69.1 (60.3, 76.7)	14	11.4 (6.8, 18.4)
	German Shepherd Dog (24.1%)	114	0.911 (0.785)	89	78.1 (69.4, 84.8)	13	11.4 (6.7, 18.8)
	Australian Shepherd (15.4%)	73	1.02 (1.02)	52	71.2 (59.6, 80.6)	15	20.6 (12.6, 31.6)
	All	**473**	**0.851 (0.833)**	**345**	**72.9 (68.7, 76.8)**	**62**	**13.1 (10.3, 16.5)**
Hound	Greyhound (24.9%)	44	0.287 (0.452)	23	52.3 (37.2, 67.0)	1	2.3 (0.3, 15.5)
	Beagle (22.6%)	40	0.483 (0.762)	21	52.5 (36.6, 67.9)	4	10.0 (3.6, 24.6)
	Dachshund (18.6%)	33	0.988 (1.06)	19	57.6 (39.6, 73.8)	6	18.2 (8.0, 36.1)
	All	**177**	**0.624 (0.842)**	**107**	**60.5 (53.0, 67.4)**	**18**	**10.2 (6.5, 15.6)**
Non-sporting	Shih Tzu (17.0%)	30	0.941 (1.04)	16	53.3 (34.8, 71.0)	7	23.3 (11.0, 42.8)
	Standard Poodle (14.1%)	25	0.680 (0.905)	16	64.0 (42.5, 81.0)	3	12.0 (3.6, 33.3)
	Bulldog (13.0%)	23	0.427 (0.564)	14	60.9 (38.6, 79.4)	1	4.35 (0.5, 28.4)
	All	**177**	**0.702 (0.786)**	**118**	**66.7 (59.3, 73.3)**	**18**	**10.2 (6.5, 15.6)**
Sporting	Labrador Retriever (36.9%)	140	0.602 (0.809)	88	62.9 (54.5, 70.5)	14	10.0 (6.0, 16.3)
	Golden Retriever (28.5%)	108	0.445 (0.479)	77	71.3 (61.9, 79.1)	3	2.78 (0.9, 8.4)
	American Cocker Spaniel (5.0%)	19	1.18 (1.02)	11	57.9 (33.5, 78.9)	3	15.8 (4.6, 42.2)
	All	**379**	**0.630 (0.785)**	**250**	**66.0 (61.0, 70.6)**	**30**	**7.92 (5.6, 11.1)**
Terrier	American Staffordshire Terrier (0.211)	34	0.368 (0.449)	22	64.7 (46.6, 79.4)	1	2.9 (0.4, 19.8)
	Parson Russell Terrier (0.193)	31	0.866 (0.888)	24	77.4 (58.4, 89.3)	4	12.9 (4.6, 31.1)
	Staffordshire Bull Terrier (0.124)	20	0.351 (0.699)	7	35.0 (16.4, 59.6)	2	10.0 (2.2, 35.5)
	All	**161**	**0.688 (0.813)**	**103**	**64.0 (56.2, 71.1)**	**19**	**11.8 (7.6, 17.8)**
Toy	Chihuahua (0.277)	52	1.35 (1.06)	33	63.5 (49.2, 75.7)	15	28.9 (17.9, 43.0)
	Pomeranian (0.133)	25	0.902 (0.936)	15	60.0 (38.8, 78.0)	5	20.0 (8.0, 41.7)
	Pug (0.106)	20	0.588 (0.626)	13	65.0 (40.4, 83.6)	0	0
	All	**188**	**1.01 (0.925)**	**126**	**67.0 (59.9, 73.4)**	**33**	**17.6 (12.7, 23.7)**
Working	Rottweiler (0.159)	55	0.961 (0.827)	34	61.8 (48.0, 74.0)	12	21.8 (12.6, 35.1)
	Siberian Husky (0.150)	52	0.296 (0.54)	24	47.1 (33.5, 61.1)	2	3.9 (0.9, 15.0)
	Boxer (0.147)	51	0.889 (0.792)	38	73.1 (59.0, 83.6)	8	15.4 (7.7, 28.4)
	All	**346**	**0.816 (0.836)**	**224**	**64.7 (59.5, 69.6)**	**50**	**14.5 (11.1, 18.6)**
Other		**89**	**0.808 (0.834)**	**63**	**70.8 (60.3, 79.4)**	**11**	**12.4 (6.9. 21.2)**
Mixed breed		**1131**	**0.888 (0.890)**	**806**	**71.3 (68.6, 73.8)**	**143**	**12.6 (10.8, 14.7)**
All		**3121**	**0.813 (0.858)**	**2142**	**68.6 (67.2, 70.3)**	**384**	**12.3 (11.3, 13.6)**

[1]Number and percentage of dogs that scored a 1 or greater on any question in the C-BARQ stranger-directed aggression factor without scoring a 4
[2]Number and percentage of dogs that scored a 4 on any question in the C-BARQ stranger-directed aggression factor

Table 4.8 Mixed linear regression of variables associated with C-BARQ stranger-directed aggression factor score with household as a random effect (Model 1; n=2,760 dogs; 2,255 households).

Fixed effects	Category	Coef	95% CI	P-value
Stranger Fear	None	Referent		
	Mild/Moderate	0.41	0.35, 0.47	<0.001
	Severe	1.29	1.18, 1.40	<0.001
DIAS behavioural regulation score[1]		0.21	0.17, 0.24	<0.001
Sex	Female	Referent		
	Male	0.12	0.07, 0.17	<0.001
Neutered for behavioural reasons	No	Referent		
	Yes	0.32	0.15, 0.50	<0.001
	Not Neutered	0.02	-0.06, 0.10	0.595
History of abuse	No	Referent		
	Unsure	0.10	0.02, 0.17	0.010
	Yes	0.14	0.04, 0.24	0.005
Breed group	Hound	Referent		
	Non-Sporting	0.09	-0.07, 0.25	0.256
	Sporting	0.14	0.01, 0.27	0.040
	Other Purebreds	0.14	-0.04, 0.33	0.136
	Terrier	0.14	-0.01, 0.30	0.073
	Mixed	0.20	0.08, 0.32	0.001
	Working	0.22	0.09, 0.35	0.001
	Toy	0.23	0.08, 0.38	0.003
	Herding	0.27	0.14, 0.40	<0.001
Training methods*	Toy reward	-0.08	-0.13, -0.02	0.008
	Praise	-0.12	-0.24, -0.00	0.049
Tools used*	No-pull harness	0.09	0.03, 0.15	0.002
	Head halter	0.12	0.05, 0.18	<0.001
	Shock collar	0.19	0.07, 0.30	0.001
	Choke chain	0.11	0.01, 0.15	0.017
Response to unwanted behaviour*	Ask for different behaviour	-0.09	-0.15, -0.04	0.001
	Physical correction	0.13	0.06, 0.21	<0.001
	Avoid situation in the future	0.08	0.01, 0.15	0.024
Reaction to meeting people as a puppy	Excited	Referent		
	Indifferent	0.14	0.04, 0.24	0.006
	Scared	0.27	0.16, 0.39	<0.001
	NA	0.32	0.02, 0.62	0.038
Socialized with adults	< once a month	0.31	0.15, 0.46	<0.001
	1-2 x a month	0.09	-0.02, 0.21	0.114
	Once a week	0.04	-0.07, 0.14	0.518

	2-3 x a week	0.05	-0.05, 0.15	0.296
	Daily	Referent		
	NA	-0.24	-0.55, 0.07	0.130
Location when left alone*	Crate	-0.14	-0.21, -0.08	<0.001
Feed on a schedule*		0.08	0.00, 0.15	0.036
Exercised*	On leash	-0.10	-0.16, -0.03	0.004
	Off leash	-0.11	-0.16, -0.05	<0.001
	Dog park	-0.09	-0.16, -0.02	0.010
TIPI (>4)*	Extroverted	0.08	0.03, 0.14	0.002
Correctly rated videos*	No aggression	-0.13	-0.23, -0.04	0.007
Random Effect				
Household	Variance	0.06	0.03, 0.12	0.003
	ICC	0.12	0.06, 0.23	--
Dog	Variance	0.42	0.38, 0.47	--

[1]Coef and CI for a 10% increase in DIAS score
* Multiple responses possible, so each category analyzed as "yes" vs. "no"

Table 4.9 Logistic regression model of risk factors for stranger aggressive dogs (C-BARQ stranger-directed aggression score > 0) displaying severe stranger-directed aggression (scoring 4 on at least 1 question in the C-BARQ stranger-directed aggression factor) (Model 2; n=2,383).

Fixed effects	Category	OR	95% CI	P-value
Stranger Fear	None	Referent		
	Mild/Moderate	1.67	1.20, 2.32	0.003
	Severe	13.30	8.65, 20.44	<0.001
DIAS behavioural regulation score[1]		1.81	1.53, 2.13	<0.001
Sex	Female	Referent		
	Male	1.80	1.38, 2.34	<0.001
Training methods*	Toy reward	0.68	0.51, 0.89	0.005
	Praise	0.53	0.33, 0.85	0.009
Response to unwanted behaviour*	Ask for different behaviour	0.69	0.52, 0.91	0.008
	Physical correction	1.51	1.11, 2.07	0.009
Tools used*	Head halter	1.63	1.23, 2.17	0.001
Reaction to meeting new people as a puppy	Excited	Referent		
	Indifferent	1.97	1.22, 3.18	0.005
	Scared	1.27	0.75, 2.14	0.374
	NA	4.87	1.36, 17.43	0.015
Socialized with adults	< once a month	2.73	1.41, 5.27	0.003
	1-2 x a month	0.64	0.34, 1.21	0.169
	Once a week	0.58	0.32, 1.08	0.086
	2-3 x a week	0.82	0.47, 1.44	0.493
	Daily	Referent		
	NA	0.29	0.08, 1.12	0.073
Exercised*	Off leash	0.68	0.52, 0.91	0.008

[1]OR and CI for a 10% increase in DIAS score
* Multiple responses possible, so each category analyzed as “yes” vs. “no

CHAPTER FIVE

Identification of fear behaviours shown by puppies in response to non-social stimuli

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5.1 Abstract

Understanding fear behaviour in puppies is important for dog welfare, prevention of behavioural issues and validity of scientific research. To date, it is unknown which specific behaviours puppies show when they are fearful, and whether these behaviours are similar to those seen in older dogs. We assessed which puppy behaviours are associated with fear in the presence of social and non-social stimuli. Puppies (<6 months; n=25) were introduced into a 3.7m long run and trained to approach the far end to obtain a food reward. After training, each puppy completed four trials with noisy or unpredictable novel objects (non-social stimuli), two trials with strangers (social stimuli), and six control trials with no stimuli. All sessions were video-recorded, and frequency and duration of behaviours performed during each trial (n=193) was recorded. Trials were categorized as 'fearful' if the latency to approach was greater than the mean+2 SD of the control trials. As no puppies were categorized as 'fearful' for social stimuli these trials were excluded from analysis. Linear, logistic and Poisson mixed models, with puppy as a random effect, were used to model behaviour durations, presence of behaviour (yes/no) and counts of how many times the puppy performed the behaviour in a given trial, respectively. The following behaviours occurred more in 'fearful' trials in comparison to control trials: lowered posture ($p<0.001$), lowered tail ($p=0.001$), freezing ($p<0.001$), retreating ($p<0.001$), flinching ($p<0.001$), paw lift ($p=0.006$) and barking ($p=0.002$). Sniffing ($p<0.001$), locomotion ($p<0.001$) and panting ($p<0.001$) occurred less in 'fearful' trials. No significant difference was found for ear position, lip licking and tail wagging. Yawning, shaking, elimination, whining and growling occurred too infrequently for analysis. These results indicate that postural, retreating and barking behaviours are the most reliable indicators of fear in puppies in situations where they are able to control their approach to non-social stimuli intended to elicit fear.

5.2 Introduction

Correct identification of fear is important for promoting positive welfare in dogs. Fear is a negative emotional state, and if not correctly identified owners may repeatedly put their dog in fear-provoking situations where their welfare is impaired. Fearfulness has also been linked to the development of behavioural issues, such as aggression (Hsu and Serpell, 2003), which can impair the human-animal bond (Serpell, 1996) and increase the risk of relinquishment (Salman et al., 1998, 2000). Recognition of fear is especially important in puppies. Owners are recommended to expose their puppies to a variety of new people and situations in the first few months of life in order to prevent future behavioural issues (Horwitz and Neilson, 2007; Landsberg et al., 2013; Overall, 2013). However, if owners do not correctly identify and alleviate their puppies' fear, puppies can develop negative associations with strangers and new environmental stimuli. Poor socialization has been linked to a variety of behavioural issues, most predominantly aggression towards strangers (Appleby et al., 2002; Casey et al., 2014).

Previous research has looked at identifying fear behaviours in adult dogs, but there is limited research into when these behaviours develop and what behaviours are shown by puppies. Only one study has looked specifically at fear behaviours in puppies. Godbout et al. (2007) looked at the behavioural responses of puppies (2 to 4 months) at the vet clinic during free exploration of the room followed by a physical exam on the table, and on the floor. The researchers found that puppies panted, yawned and lip licked more during the exams than during free exploration, although this association was not analyzed statistically. There was also a statistically significant difference in the behaviours shown depending on age, sex and predicted adult weight. However, it is unclear whether these differences are based on the different expressions of fear in these puppies, or due to the differences in the overall level of fearfulness across these factors.

Several studies have looked at acute fear behaviour in adult dogs. For example, Beerda et al. (1998) used a series of six different aversive stimuli (sound blasts, electric shock, opening umbrella, falling bag and two different forms of restraint) to identify behaviours associated with acute stress in dogs. They found that very low posture was associated with sudden, unpredictable stimuli (sound blasts, electric shock and falling bag), while stimuli that could be predicted by the presence of the researcher (opening umbrella and restraint) were associated with lowered posture, body shaking, oral behaviours, yawning and open mouth. These results suggest a difference in fear behaviours based either on the predictability, or social nature of the stimulus. Another study looking at fear responses to milder stimuli found similar results. Stellato et al. (2017) looked at the responses of adult dogs to a bag falling at a distance and the appearance of an intimidating stranger. They found that both stimuli caused an increase in lowered posture and avoidance behaviours in a proportion of the dogs. When looking specifically at dogs that showed these fear responses they saw an overall increase in other subtle fear behaviours (i.e., lip licking, yawning, body shaking, whining, panting, paw lifting) when the dog approached the intimidating stranger. However, these subtle behaviours did not increase after the falling bag stimuli. Together, these studies suggest that fear behaviours may differ with different types and intensities of stimuli and further exploration is needed to validate these behaviours as indicators of fear in adult dogs and puppies.

The primary objective of this study was to identify which behaviours are associated with fear of social and non-social stimuli in puppies aged two to six months. To accomplish this we developed a behavioural test for objectively categorizing the response of puppies as fearful or non-fearful in relation to social and non-social stimuli. We hypothesized that lowered posture and avoidance behaviours would be associated with fear of both social and non-social stimuli, although some of the subtle behaviours may only be seen during social stimuli trials. The second objective was to determine if puppy sex and age are associated with differences in the expression of these behaviours. We predicted that older puppies would be more likely to express subtle fear behaviours (e.g., lip licking, yawning, paw lifting) during their fear response, since these may be learned social signals.

5.3 Methods

This study received approval from the University of Guelph Animal Care Committee (AUP #3404) and complies with all institutional, provincial, and national regulations pertaining to the use of animals in research. Puppy owners were recruited using social media, and via advertisements sent out through local puppy classes and veterinary clinics.

5.3.1 Behavioural test

All behaviour testing was conducted at the Hill's Pet Nutrition Primary Healthcare Centre on the University of Guelph campus (Guelph, ON, Canada) in a room with a separate entrance from the veterinary clinic. Puppies were handled by their owners during all aspects of testing and were given approximately two minutes to acclimate to the room before the procedure began. During testing, puppies were placed in, or encouraged to enter, a run created by attaching two 61x61 cm exercise pens (Life Stages Exercise Pen, MidwestPetProducts Inc., Irvine, California, USA) together. These pens formed a run 1.2 m wide by 3.7 m long. After being placed inside, puppies were encouraged to travel to the far end of the run where a food reward was placed on a plastic plate. Puppies were free to exit the run at any point during the trial. If they were still inside after 30 seconds the owner encouraged them to exit by crouching down and calling their name. This procedure was repeated until the puppy proceeded immediately to the end of the run without hesitation, and without requiring encouragement from the owner or researcher. Training sessions were separated only by a brief period while the puppy went behind a screen and another treat was placed at the end of the run. Each puppy was required to perform a minimum of three training sessions before continuing with the experiment.

Immediately following completion of training, puppies were exposed to six different stimuli, split into two categories: social (stranger facing towards the puppy, stranger facing away from the puppy), and non-social (fan with streamers, remote-controlled toy car, bubble blowing machine, stuffed plastic bag being raised and lowered on a string). It was predicted that these stimuli would elicit a mild fear response based on novelty, unpredictable movement and noisiness. Stimuli were introduced, one at a time, in a randomly assigned order and were alternated with blank control trials. Blank control trials served to minimize carry-over effects, and to provide a baseline response for each puppy as a "no fear" control for comparison during analysis. The stimuli were presented outside the end of the run adjacent to the site of the food reward. Between trials the researcher set up the run for the next stimulus and the puppy was taken behind a screen so that they could not observe what was happening. If at any time the puppy showed hesitation to approach the end of the run during a blank trial, the blank trial was repeated until the puppy once again readily approached the end. Only the blank trials where the puppy showed no hesitation were included in analysis. If at any point during the procedure the puppy showed extreme fear or any aggressive behaviour the experiment was terminated. If puppies showed any hesitation to approach the stimuli, or showed signs of fear, the puppy was encouraged to interact with that stimulus outside of the run after the trial using praise and food rewards in order to create a positive association with that stimulus. All trials were video recorded for later analysis (Handycam HDR-CX220, Sony Electronics, San Diego, California, USA).

For the purposes of analysis, trials were categorized as blank (control), approached stimulus, and avoided stimulus. Approaching the stimulus was defined as the puppy reaching the end of the run and lowering its head towards the plate containing the food reward. Avoiding the stimulus was defined as the puppy failing to approach the stimulus within 30 seconds, or having a latency to approach the stimulus greater than the mean + 2 standard deviations of that particular puppy's blank trials. While approach trials were analyzed and included in the models, the results for these trials are not presented or discussed as it could not be determined whether or not puppies were fearful during these trials.

5.3.2 Video analysis

Videos of the stimulus trials, and the immediately preceding blank control trials, were coded for behaviours predicted to be related to fear using The Observer XT 12 software (Noldus Information Technology, Netherlands). An ethogram (Table 5.1) was developed based on a previously established dog behaviour ethogram (Overall, 2014), with a focus on specific behaviours that have been recorded in previous research into canine fear (Beerda et al., 1997; Godbout et al. 2007; Stellato et al. 2016). State behaviours were recorded as durations of time spent performing that behaviour, while point behaviours were scored as frequency or "yes/no" for occurrence. In addition, the time spent in the run was determined for each puppy so that it could be controlled for during analysis. For analyses of oral behaviours, the amount of time a puppy's face was visible was used as the denominator.

5.3.3 Statistical analysis

Data were analyzed using Stata Statistical Software: Release 14 (StataCorp. 2015, College Station, Texas, USA). The occurrence of different behaviours predicted to be associated with fear were analyzed using mixed linear, logistic and Poisson regression models with puppy as a random effect. Collinearity of the possible explanatory variables of trial categorization, age, sex, stimulus and time spent in run, was assessed with various correlation coefficients with a cut-off point of ≥ |0.70|. If two variables were highly correlated the most biologically meaningful variable was selected for further analysis. The assumption of linearity between the dependent variables (log odds of the outcome for logistic models and log of the rate for Poisson models) and continuous explanatory variables was graphically assessed using locally weighted regression curves (lowess), and by testing the inclusion of a quadratic term in the model. If the relationship was non-linear and could not be appropriately modeled with the addition of a quadratic term, the continuous variable was categorized.

State behaviours were analyzed using mixed linear regression models with duration of time spent performing the behaviour as the outcome and with puppy as a random effect. Point behaviours were analyzed using mixed Poisson regressions, if they occurred in at least 20% of the trials, with puppy as a random effect. The number of times the puppy performed the behaviour was the outcome, and the natural log of the amount of time the puppy spent in the run was included in the model as the offset. If point behaviours occurred infrequently (<20% of trials) they were scored on a yes/no basis of whether they occurred at all during the observation period. These behaviours were analyzed using mixed logistic regressions, with occurrence as the outcome, and with puppy as a random effect.

For all models the possible explanatory variables were first tested univariably against the outcome and were considered for inclusion in the multivariable if they met a liberal cut-off using a p-value of ≤0.20 (Dohoo et al., 2003). All variables significant in the univariable analyses were included in a main effects model and were removed in a manual backward step-wise fashion. As trial categorization was the variable of interest, this variable was forced into each of the final models even if it was not significant. Otherwise, variables were retained in the model if they were statistically significant (α=0.05) or were a confounding variable. Confounding variables were identified if they caused a greater than 20% change in the coefficient of other statistically significant variables in the model when removed, and based on their potential causal relationship with the explanatory variable and the outcome (Dohoo et al., 2003). Biologically plausible two-way interactions were examined among the main effects retained in the model and were retained if they were significant ($\alpha = 0.05$). The model fit was assessed by graphically assessing the normality and homoscedasticity of the best linear unbiased predictors (BLUPs). Pearson (logistic and Poisson regression models) and standardized (linear regression models) residuals were also assessed to determine if there were any outliers. Outlying observations were inspected for potential recording errors and impact on the model. In order to test for overdispersion, Poisson models were re-run as mixed negative binomial models. If overdispersion was present, based on a significant likelihood ratio test comparing Poisson and negative binomial models ($\alpha = 0.05$), the negative binomial model was used (Dohoo et al., 2003).

5.4 Results

Behavioural testing was completed for 25 puppies, including 17 males and 8 females. Initial training to criteria took a mean of 5.6 trials per puppy, and ranged from a minimum of three to a maximum of twelve. One puppy failed to reach the initial training criteria; this puppy did not readily approach the end of the run without encouragement, and testing was terminated when the puppy showed no improvement after fifteen minutes. Puppies that were included in final analyses ranged in age from 8 to 24 weeks old, with a mean age of 17 weeks, and represented 14 different pure breeds and 7 mixed breeds. Descriptive statistics for the puppies included in the study are provided in Table 5.2. All puppies approached the stranger during the trials with social stimuli, therefore the social trials, and their preceding blank trial were removed from further analysis.

A total of 193 trials were coded and included in the analysis, including 96 blank trials. Out of the 97 non-social stimuli trials completed, 57 trials were scored as avoiding the stimulus, and 40 trials were scored as approaching the stimulus. One puppy showed a severe fear reaction to one of the stimuli used and testing was terminated after only two stimuli trials. Puppies spent a large proportion of time panting, locomoting and tail wagging in both control trials, and trials where puppies avoided the stimuli. In addition, during trials where puppies avoided the stimuli they spent a high proportion of time with lowered posture and lowered tail (Table 5.3; Figure 5.1). The most frequent behaviours puppies performed during trials where they avoided the stimuli were barking, retreating and flinching (Table 5.4;

Figures 5.2 and 5.3) and these behaviours occurred infrequently during control trials. Whine, growl, shake, scratch self, interact with the environment, yawn, and elimination were not analyzed due to infrequent occurrence.

5.4.1 Multivariable regression models

Associations with avoiding non-social stimuli

The duration of time (seconds) that puppies spent with lowered posture (β = 5.33; 95% CI: 3.51, 7.15; $p < 0.001$), lowered tail (β = 3.40; 95% CI:1.35, 5.44; $p = 0.001$) and freezing (β = 4.22; 95% CI: 2.67, 5.76; $p < 0.001$), were significantly higher when the puppy avoided the stimulus, compared to blank trials (N = 193). In contrast, the duration of time that puppies spent panting (β = -1.50; 95% CI: -2.64, -0.35; $p = 0.010$), sniffing (β = -3.23; 95% CI: -4.87, -1.60; $p < 0.001$) and locomoting (β = -3.10; 95% CI: -4.75, -1.45; $p < 0.001$) decreased significantly when the puppy avoided the stimulus compared to a blank trial. The duration of time the puppies spent with ears back (β = -0.17; 95% CI: -0.93, 0.60; $p = 0.669$), and tail wagging (β = 0.95; 95% CI: -0.80, 2.70; $p = 0.288$) was not significantly associated with avoiding the stimulus. The predicted time spent performing these behaviours in control and avoidance trials calculated from the output of the multivariable mixed linear regression models with time spent in the run standardized to 30 seconds and all other variables set to the referent category are presented in Figure 5.1.

Significantly greater odds of the occurrence of barking (OR: 14.7; 95% CI: 2.75, 78.3; $p = 0.002$), and paw lifting (OR: 41.5; 95% CI: 2.92, 588.6; $p = 0.006$) were found when the puppy avoided the stimulus, compared to blank runs (N = 193). There was no significant association found between the occurrence of lip licking (OR: 3.08; 95% CI: 0.95, 9.99; $p = 0.061$) and avoiding the stimulus. The predicted probability of performing these behaviours during control and avoidance trial calculated from the output of the multivariable mixed logistic regression models with time spent in the run standardized to 30 seconds and all other variables set to the referent category are presented in Figure 5.2.

The rates of flinching (IRR: 60.2; 95% CI: 7.93, 457.2; $p < 0.001$) and retreating (IRR: 82.2; 95% CI: 11.3, 595.4; $p < 0.001$) were significantly higher when puppies avoided the stimulus compared to blank trials (N = 193). The predicted rate of performing these behaviours per 30 second period in control and avoidance trials calculated from the output of the multivariable mixed Poisson regression models with all other variables set to the referent category are presented in Figure 5.3.

Associations with other explanatory variables

The possible explanatory variables of stimulus, trial number, time spent in run, sex and age were significantly associated with some of the measured behaviours in the final multivariable models. The type of non-social stimulus was associated with sniffing, freezing, locomoting and flinching. Puppies spent significantly more time sniffing the bubble machine ($\beta = 2.11$; 95% CI: 0.34, 3.88; $p = 0.019$) compared to the bag on a string and there were no significant differences among the other non-social stimuli. Puppies spent significantly less time freezing when exposed to the bubble machine ($\beta = -2.54$; 95% CI: -0.42, -0.85; $p = 0.003$) or fan with streamers ($\beta = -1.93$; 95% CI: -3.58, -0.27; $p = 0.023$) when compared to the bag on a string and there was no significant difference in freezing with the toy car ($\beta = -0.96$; 95% CI: -2.69, 0.76; $p = 0.274$) compared to the bag on a string. Puppies spent significantly more time locomoting when exposed to the bubble machine ($\beta = 2.60$; 95% CI: 0.68, 4.52; $p = 0.008$) when compared to the toy car, and there were no significant differences among the other non-social stimuli. Finally, puppies flinched significantly more when exposed to the bag on a string (IRR: 2.32; 95% CI: 1.08, 4.97; $p = 0.031$), bubble machine (IRR: 2.32; 95% CI: 1.08, 4.98; $p = 0.031$), or toy car (IRR: 2.46; 95% CI: 1.16, 5.23; $p = 0.19$) when compared to the fan with streamers.

The trial number was significantly associated with tail wagging ($\beta = -0.35$; 95% CI: -0.38, -0.13); $p = 0.002$) and retreating (IRR: 0.90; 95% CI: 0.84, 0.97; $p = 0.003$), with both behaviours decreasing in later trials. The amount of time spent in the run was positively associated with lowered posture ($\beta = 0.13$; 95% CI: 0.06, 0.20; $p < 0.001$), lowered tail ($\beta = 0.21$; 95% CI: 0.13, 0.30; $p < 0.001$), freezing ($\beta = 0.06$; 95% CI: 0.02, 0.11; $p = 0.003$), panting ($\beta = 0.17$; 95% CI: 0.12, 0.22; $p < 0.001$), sniffing ($\beta = 0.23$; 95% CI: 0.18, 0.28; $p < 0.001$), locomoting ($\beta = 0.19$; 95% CI: 0.14, 0.24; $p < 0.001$), ears back ($\beta = 0.05$; 95% CI: 0.02, 0.09; $p = 0.001$), tail wagging ($\beta = 0.13$; 95% CI: 0.05, 0.20; $p = 0.001$), barking (OR: 1.08; 95% CI: 1.02, 1.14; $p = 0.014$), and lip licking (OR: 1.08; 95% CI: 1.03, 1.14; $p = 0.003$). The amount of the time spent in the run was not significantly associated with paw lifting ($p = 0.296$) and was included as part of the offset for the Poisson models estimating rates for flinching and retreating. Sex was only significantly associated with panting behaviour, with females spending more time panting ($\beta = 4.05$; 95% CI: 1.25, 6.85; $p = 0.005$). Finally, age was not significantly associated with any of the studied behaviours.

The random effect of puppy was significant for lowered tail (σ^2=12.38; 95% CI: 5.60, 27.37; $p<0.001$), freezing (σ^2=1.14; 95% CI: 0.36, 3.59; $p=0.007$), panting (σ^2=9.68; 95% CI: 5.14, 18.22; $p<0.001$), sniffing (σ^2=2.79; 95% CI: 1.23, 6.32; $p<0.001$), locomoting (σ^2=0.91; 95% CI: 0.21, 3.97; $p=0.043$), ears back (σ^2=0.97; 95% CI: 0.39, 2.41; $p=0.002$), tail wagging (σ^2=11.83; 95% CI: 5.89, 23.74; $p<0.001$), barking (σ^2=2.81; 95% CI: 0.74, 10.70; $p<0.001$), lip licking (σ^2=1.59; 95% CI: 0.37, 6.85; $p=0.006$), paw lifting (σ^2=3.56; 95% CI: 0.70, 18.25; $p=0.001$), flinching (σ^2=0.23; 95% CI: 0.05, 0.99; $p=0.022$), and retreating (σ^2=0.21; 95% CI: 0.05, 0.80; $p=0.012$), but not for lowered posture (σ^2=0.41; 95% CI: 0.00, 108.63; $p=0.355$).

There were no concerning outliers based on residuals. Visual analysis of the BLUPs indicated constant variance, but lacked normality for some of the models. However, the models, based on Akaike Information Criteria and Bayesian Information Criteria, were better fitting compared to models without the inclusion of the random effects. There was no significant overdispersion present in the Poisson models for flinching ($p = 0.723$), and retreating ($p = 0.579$), based on non-significant likelihood ratio tests comparing Poisson to negative binomial models, indicating that the assumption of equal mean and variance was met.

5.5 Discussion

The non-social stimuli used in this study were successful in eliciting an objectively measurable response, as 58.8% of trials were classified as avoiding the stimulus. In addition, all but three of the puppies avoided at least one of the non-social stimuli. This avoidance was interpreted as a fear response since the puppies demonstrated, during training and control trials, that they were motivated to approach the end of the run to retrieve the food reward. Therefore, the non-social stimuli and categorization method used in this study appears to be useful for studies aiming to measure fear in puppies. However, the social stimuli used in the present study were not successful at eliciting a fear response in this sample of puppies. Anecdotally, many of the owners reported that they chose to participate in the study because it was a good socialization opportunity. Therefore, these owners may have been actively seeking out socialization opportunities, leading to higher levels of socialization in the test puppies. In the future, it may be beneficial to utilize more intimidating social stimuli, as merely the presence of a stranger may not be sufficient to elicit a fear response in puppies. Alternatively, use of pre-screening surveys may be used in order to pre-select puppies with fear of strangers. However, this needs to be balanced with protecting the welfare of puppies that are involved in these types of studies.

The current study found that lowered posture, lowered tail, freezing, flinching, retreating, barking and paw lifting were associated with avoiding non-social stimuli, and therefore are likely to be indicative of fear. While significant differences were found for all of these behaviours, it is worth noting that puppies still spent a proportion of time in control trials with a lowered tail, lowered posture and freezing, and therefore these behaviours may not be as specific to fear as flinching, retreating, barking and paw lifting, which rarely occurred during control trials. Previous research has also found strong evidence for the use of lowered posture and retreating or avoidance behaviours to assess fear in adult dogs (Beerda et al., 1998; Goddard and Beilharz, 1984; King et al., 2003; Stellato et al., 2017). The other fear behaviours that were related to puppy fear in the current study, including freezing, flinching, barking and paw lifting have not been as extensively studied. One study examined these behaviours in adult dogs and found that dogs categorized as fearful (i.e., displayed lowered body posture or avoidance behaviours) were more likely to show other behaviours indicative of fear including body shaking, hiding, yawning, vocalizing, tail wagging, lip licking, paw lifting, and displacement activities (Stellato et al., 2017). In the study, these behaviours were analyzed grouped together; therefore, it cannot be determined whether these behaviours are individually associated with fear. In addition, these behaviours were only associated with fear when approaching an intimidating stranger, not when the stranger appeared, or in the presence of a non-social stimulus. This could indicate that some of these behaviours are only displayed in social situations in adult dogs. This is supported by findings of another study that found that when adult dogs were able to predict the occurrence of aversive stimuli based on the presence of the researcher they showed an increase in restlessness, lowered posture, oral behaviours, body shaking, yawning and open mouth (Beerda et al., 1998). When a sudden or unexpected non-social stimulus was presented there was only an increase in lowered posture, not the other behaviours.

Previous research examining behaviours shown by puppies when being handled by a veterinarian found that there was an increase in lip licking, yawning and panting compared to when the puppy was free to explore the room (Godbout et al., 2007). In contrast, we did not find a similar association between fear and these oral behaviours. If some of these behaviours are social communication related to fear rather than explicit signs of fear it could explain these different findings; while the researcher and owner were present in the current study, they were not directly linked to the non-social stimuli. Lip licking may also have been elevated in control trials in the current study due to the presence of food. While lip licks immediately surrounding the consumption of the treat were excluded from analysis, there were still a number of dogs that lip licked during blank control trials. Similarly, yawning was only performed by one puppy in the current study, while it was observed in multiple puppies in another study examining responses during a veterinary examination (Godbout et al., 2007). This suggests that yawning is part of puppies' behavioural repertoire, and is possibly a social cue rather than specifically a fear response. Other studies that have reported an increase in yawning behaviour also involved adult dogs exposed to social stimuli (Beerda et al., 1998, 2000). It is also possible that puppies were experiencing mild levels of fear throughout the study, including the control trials resulting in oral behaviours not being found to be positively associated with fear. Finally, it is possible the puppies did not experience sufficient fear to induce yawning, and other oral behaviours, in the current study. Further research is needed to determine the context in which these oral behaviours are performed, both in adult dogs and puppies, in order to understand whether these behaviours are indicative of fear or another emotional response.

Another behaviour that was not significantly associated with avoiding non-social stimuli in the current study was tail wagging. While not typically considered an indicator of fear, this behaviour is anecdotally described as an indicator of positive affect and therefore might be expected to be reduced in situations involving fear. The lack of association in the current study indicates that tail wagging neither increases, nor decreases in the presence of fear and therefore is not a reliable indicator of either positive affect or fear. Finally, ear position was not found to be significantly associated with fear. It is possible that video quality in the current study influenced the accuracy of scoring for this behaviour, particularly for dark-coloured dogs. Periods when ear position was clear during video review was controlled for in the analysis. However, increased variability may have impaired detection of any differences.

In the current study, panting, sniffing and locomotion were found to decrease in fearful puppies. This is possibly due to the increase in freezing behaviours seen in these puppies; when puppies freeze they close their mouths and stop panting, while also stopping sniffing and locomotion. Panting has been previously suggested to be associated with fear and anxiety in adult dogs (Voith et al., 1987). Similarly, sniffing, and other displacement activities are also suggested to be signs of stress in adult dogs (Beerda et al., 2000). Finally, locomotion, in the form of pacing (Dreschel and Granger, 2005) or restlessness (Beerda et al., 1998) has been previously found to be associated with fear and stress in adult dogs. The results of the current study indicate that panting, sniffing and locomotion may not be reliable indicators of fear in puppies, at least in non-social situations. Other behaviours used by dog behaviour professionals to describe fear (Horwitz and Neilson, 2007; Landsberg et al., 2013; Overall, 2013) were not measured in the current study due to limitations of video quality. These behaviours include trembling, salivating, facial tension, whale eye, and retraction of the commissure of lips.

Significant differences in freezing and flinching behaviours between the different objects may suggest that these behaviours are more likely to occur for certain types of stimuli. For example, puppies were more likely to flinch towards stimuli that moved unpredictably (i.e., bag on a string, bubble machine, toy car) compared to more predictable stimuli (i.e., fan with streamers). Puppies also froze more with a large, looming stimuli (i.e., bag on a string), when compared to smaller stimuli that were placed at the same level as the puppy (i.e., bubble machine, fan with streamers). Tail wagging and retreating behaviours decreased in later trials, suggesting these behaviours may have been affected by habituation to the experimental procedure, or the presentation of non-social stimuli, resulting in a decrease in these behaviours. However, trial number was not significant for a majority of the behaviours analyzed indicating minimal order effects. The random effect of puppy was significant for all behaviours, except for lowered posture, indicating that while there was variation in the performance of these behaviours between puppies, trials within the same puppy were significantly correlated. This may suggest that unmeasured variables relating to the puppies' characteristics or previous experiences may affect their expression of the behaviours studied in response to fear.

There were very few significant associations between the different behaviours shown by puppies during the tests and the age or sex of the puppies. Each of the main behaviours discussed in this study were performed by puppies in each of the age categories, suggesting that these behaviours are part of the behavioural repertoire of puppies from at least eight weeks of age onward. The sample size for the current study was relatively small, and we had limited representation of very young puppies, so it is possible that while minor age and sex differences exist, we did not have sufficient power to detect them. Overall, our results suggest that puppies are capable of displaying similar fear behaviours to adult dogs.

5.5.1 Limitations

While the experimental procedure was standardized across puppies, there was some variation in handling due to the involvement of each puppy's owner. The owner was present in order to minimize baseline levels of fear that may have been elevated by separation and handling by a stranger. While owners were given instructions on how to handle their puppies, minor differences in owner behaviour may have affected puppy responses.

The population of puppies used in the current study may not have been representative of the general puppy population. Many of the puppies were recruited through puppy training schools, therefore they may have received more training and socialization than the average puppy. In addition, there may be a selection bias in the owners who enrolled their puppy in the study having been more interested in animal behaviour, and engaged in socializing and training their puppy than the average owner. Anecdotally, many of the owners that brought in their puppy said they did so because they thought it was a good socialization opportunity. This indicates that these owners were actively seeking out socialization opportunities for their puppy, possibly more so than the average owner. The test was successful in eliciting fear responses from these puppies indicating that the methodology was effective with this population. However, it is possible that less socialized puppies might have displayed more exaggerated fear responses, and that this might have influenced the behaviours that were identified.

In the current study, none of the puppies reacted fearfully to the stranger stimuli. This may have been due to a higher level of socialization in the test puppies. This resulted in only non-social stimuli being included in analysis. Therefore, the resulting behaviours associated with fear in puppies are only related to non-social stimuli, as puppies may display a different set of behaviours when fearful of a stranger, or another dog, and further research is needed to examine these stimuli. In addition, as discussed above, it may be beneficial to utilize more intimidating social stimuli in future studies, as merely the presence of a stranger may not be sufficient to elicit a fear response in puppies. Alternatively, use of pre-screening surveys may be used in order to pre-select puppies with fear of strangers.

Due to the video angle, it was not possible to blind the observer to whether trials were blank controls, or object trials. While the observer was blind to the trial categorisation of “avoid” or “approach”, this difference would have been obvious from casually observing a majority of the trials. This lack of blinding may have led to observer bias in the current study. This may have biased results away from the null, but the effect should be minimal due to limited room for interpretation in identifying behaviours provided by the ethogram.

Finally, there were limitations due to video quality, which may have resulted in an underrepresentation of some behaviours, specifically facial behaviours (e.g., ear position and lip licking). Due to the nature of the experimental set up, each dog’s face was not always visible. Even when the dog was facing the camera facial details were not always discernible, especially in dark faced dogs. In order to control for this issue during analysis, the amount of time when the face was not clearly visible was subtracted from the amount of time the puppy spent in the run. It is possible that some information bias remained and resulted in these behaviours not being significant in the final models.

5.6 Conclusions

These results indicate that the current approach/avoidance test using various novel objects as non-social stimuli was effective at eliciting a fear response in puppies between two and six months of age. However, the presence of a stranger was not sufficient to elicit a fear response in this group of puppies and different social stimuli, or targeted selection of fearful puppies, should be used in the future. Lowered posture and tail position, and increased freezing, flinching, retreating, barking, and paw lifting behaviours, were all associated with avoidance of a non-social stimulus, and therefore are potential indicators of fear in puppies. Oral behaviours, such as lip licking, yawning and panting, as well as displacement behaviours such as sniffing and locomotion, were not found to be reliable indicators of fear in puppies in the current study, so while their presence cannot be used to identify the presence of fear, neither should their absence be interpreted as an absence of fear in puppies.

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Table 5.1 Ethogram of puppy behaviours scored during approach/avoidance test for fear of social and non-social stimuli

Behaviour	Description	Type
Posture		
Neutral	Normal posture under neutral conditions (first blank run)	Default
Lowered	Back rounded and/or legs bent with body lowered to the ground, head lowered	State
Sitting	Front legs straight, rear end and resting on hocks or floor	State
Lying	Body in contact with ground, not supported by legs	State
Ear position		
Neutral/Erect	Ears relaxed and held to the side of the head, or pointed forward	Default
Back	Ears pulled back against head	State
Tail position		
Neutral	Tail held in normal position under neutral conditions (compare to average tail position during first blank run)	Default
Lowered	Tail hanging down below neutral position, or tucked up between the dog's hind legs towards the belly	State
Vocalizations		
Bark	Sharp vocalization, often loud and repetitive	Point
Whine	High-pitched vocalization	State
Growl	Low-pitched grumble, with or without exposed teeth	State
Howl	Low-pitched, long-duration vocalization	State
Locomotion		
Walk	4 beat gait, three feet on the ground at all times	State
Trot	2 beat gait, diagonally opposite legs moving together	State
Run/Canter	3 or 4 beat gait with a moment of suspension	State
Back up	Dog moves backwards at any pace	State
Behaviours		
Jump	All four feet leave the ground, no backwards movement	Point
Rear	Front 2 feet leave the ground	Point
Lunge	Sudden forward movement with stiff legs	Point
Jump back	Sudden backwards movement with stiff legs	Point
Flinch	Sudden tensing and relaxing of muscles over entire body	Point
Micro-freeze	Sudden cessation of movement for less than 1s	Point
Freeze	Stops moving and remains motionless for at least 1s	State
Stretch	Extend either fore legs or hind legs and hold for at least 1s	Point
Bow	Lower front end with elbows to the ground	Point
Paw lift	Dog raises one paw from the ground and holds it stationary in the air (pause at top of lift)	Point
Shake	Rotation of the body starting at the head and moving caudally	Point
Hackles	Hair along neck and/or back is raised	State
Wagging tail	Tail moving from side to side	State
Eliminate	Expels urine or feces from the body	Point
Scratch (self)	Scratching body or head with hind paw, or head with fore paw	State
Interact w/ environment	Digging/scratching/mouthing at the ground or cage bars	State
Grooming	Oral contact with own body	State
Head Behaviours		
Sniffing	Nose to ground/stimulus, mouth closed with sharp inhale and breathing rapidly	State

Eating	Head lowered to plate and jaw moving and/or tongue contacting plate	State
Pant	Mouth open and breathing rapidly, often with tongue protruding	State
Lip lick	Tongue flicking forwards out of mouth, or over nose. Excluding lip licks within 1 second before or 3 seconds after an eating bout.	Point
Yawning	Dog opens mouth wide without barking	Point
Sneeze	Sudden explosive expulsion of air through nose	Point
Cough	Sudden explosive expulsion of air through open mouth without vocalization	Point
Latencies		
Time spent in run - Begin	When first paw touches the ground inside the run OR when the owner lets go of the leash	State
Time spent in run – End	When the first paw leaves the run OR when the owner makes physical contact with the dog or leash	State
Latency to approach – Begin	When first paw touches the ground inside the run OR when the owner lets go of the leash	State
Latency to approach – End	When the dog lowers its nose to within 1” of the plate at the end of the run	State
Face not visible	Any time when the face of the dog is turned away from the camera to a degree where accurate recording of facial behaviours is not possible	State

Table 5.2 Descriptive statistics for puppies (n=25) used during approach/avoidance behavioural test for assessing fear behaviours in puppies in response to four different novel, non-social stimuli (n=97 trials; 40 approach, 57 avoid)

Puppy	Sex	Age (weeks)	Breed	Number of Trials	
				Approach	Avoid
1	Male	12	Catahoula Leopard Dog	0	4
2	Male	20	Belgian Tervuren	1	3
3	Male	24	Catahoula Leopard Dog	2	2
4	Female	22	Shepherd Mix	1	2
5	Male	22	Lab/Shar-Pei	0	4
6	Female	24	Golden Retriever	4	0
7	Male	11	Golden Retriever	2	3
8	Male	24	Labrador Retriever	1	3
9	Female	20	Springer Spaniel	2	2
10	Female	18	Newfoundland	1	3
11	Male	19	Labrador Retriever	3	1
12	Male	17	Golden Doodle	0	4
13	Male	16	Wheaton Terrier	3	1
14	Female	20	Airedale Terrier	4	0
15	Female	20	Shepherd Mix	3	1
16	Male	9	Australian Koolie	3	0
17	Male	21	Smooth Collie	3	1
18	Male	21	Nova Scotia Duck Tolling Retriever	1	3
19	Male	8	Mastiff Mix	0	4
20	Male	16	Yorkshire Terrier Mix	1	3
21	Male	13	Maltese Mix	2	2
22	Female	16	Collie Mix	0	2
23	Male	10	Miniature Bull Terrier	0	4
24	Male	11	Portuguese Water Dog	0	4
25	Female	11	Nova Scotia Duck Tolling Retriever	3	1

Table 5.3 Mean duration (seconds) and proportion of time spent performing different state behaviours during trials when the puppy avoided the stimulus (n=57) and during blank control trials (n=96).

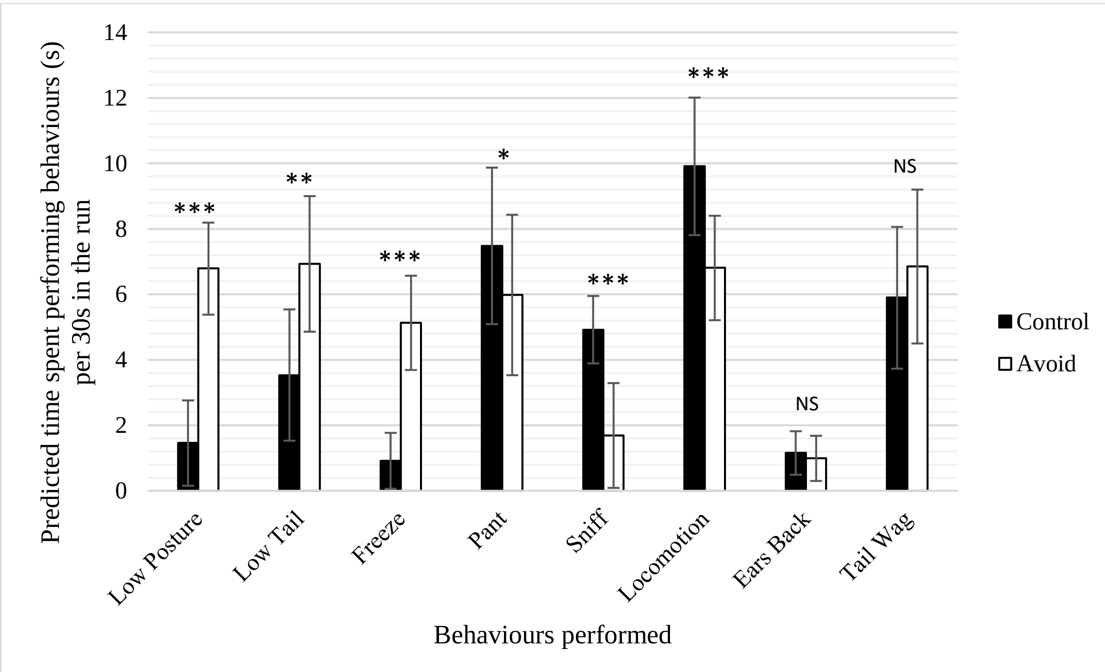
Behaviour	Avoided Stimulus		Control (Blank)	
	Mean (SD)	Proportion	Mean (SD)	Proportion
Lowered posture	6.5 (8.3)	0.23	0.1 (0.7)	0.01
Sitting	1.6 (4.7)	0.06	1.2 (3.5)	0.04
Lying down	0.4 (1.6)	0.01	1.0 (4.0)	0.03
Ears back	0.9 (2.9)	0.03	0.6 (2.3)	0.04
Tail lowered	6.1 (8.4)	0.26	1.2 (3.8)	0.06
Whine	0.1 (0.4)	0.00	0.1 (0.5)	0.00
Howl	0	0	0	0
Walk	4.3 (3.6)	0.17	6.8 (4.4)	0.38
Trot	1.1 (1.3)	0.05	1.5 (1.7)	0.11
Run	0.6 (1.1)	0.02	0.4 (0.7)	0.03
Locomotion	6.0 (3.9)	0.24	8.7 (4.1)	0.52
Back up	0.9 (1.2)	0.04	0	0
Freeze	3.6 (5.2)	0.13	0.2 (0.9)	0.01
Hackles	0	0	0	0
Wagging tail	3.7 (7.8)	0.13	2.6 (5.4)	0.15
Scratch (self)	0.4 (1.3)	0.01	0.3 (1.4)	0.01
Interact w/ environment	0.4 (1.7)	0.01	0.6 (2.3)	0.02
Grooming	0	0	0	0
Sniffing	2.0 (2.8)	0.07	2.6 (4.6)	0.09
Eating	2.0 (2.1)	0.08	3.2 (2.1)	0.19
Panting	1.9 (3.9)	0.08	3.0 (5.2)	0.19
Time spent in run	27.7 (10.6)	NA	19.7 (11.4)	NA

NA indicates not applicable

Table 5.4 Counts of behaviours and number of trials in which the behaviour occurred during trials when the puppy avoided the stimulus (n=57) and during blank control trials (n=96).

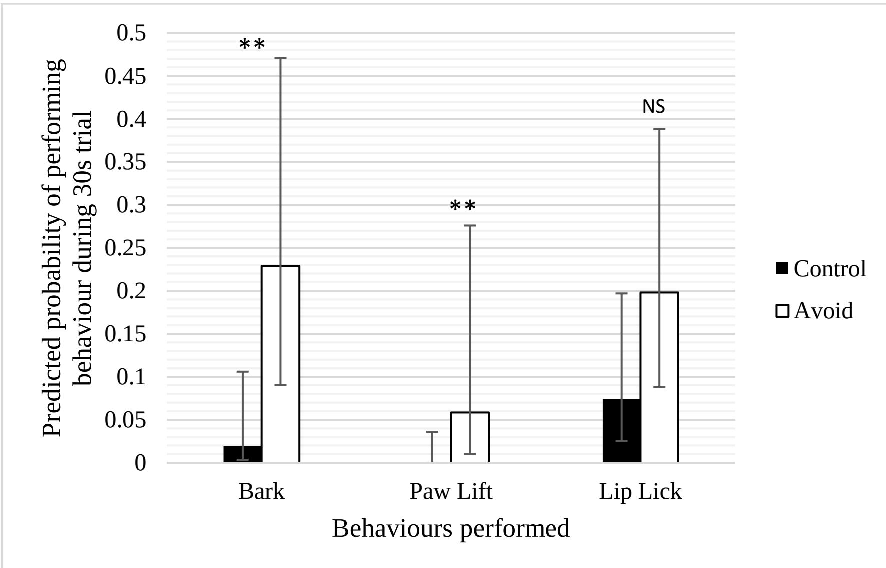
Behaviour	Avoided Stimulus			Control (blank)		
	Count	# of Trials	#/Trial	Count	# of Trials	#/Trial
Bark	83	16	1.46	4	4	0.04
Growl	4	2	0.07	0	0	0
Back Up	33	25	0.58	1	1	0.01
Jump Back	31	17	0.54	0	0	0
Retreat	64	32	1.12	1	1	0.01
Flinch	44	25	0.77	1	1	0.01
Paw lift	15	10	0.26	1	1	0.01
Shake	0	0	0	7	6	0.07
Eliminate	1	1	0.02	0	0	0
Lip lick	20	13	0.35	9	7	0.09
Yawn	0	0	0	1	1	0.01

Figure 5.1 Predicted mean time (95% CI) spent performing behaviours during a trial calculated from the output of eight multivariable mixed linear regression models with puppy as a random effect for the outcomes of duration of time spent performing different behaviours (i.e., lowered posture, lowered tail, freezing, panting, locomotion, sniffing, ears back and tail wagging) during an approach/avoidance behavioural test on puppies (2-6 months; n=25). Responses were assessed during "control" trials (n=96) with no stimulus and trials where the puppies were determined to "avoid" (fail or show significant hesitation to approach; n=57) a non-social stimulus placed at the end of the run, time spent in the run was standardized to 30 seconds, and all other variables were set to their referent category



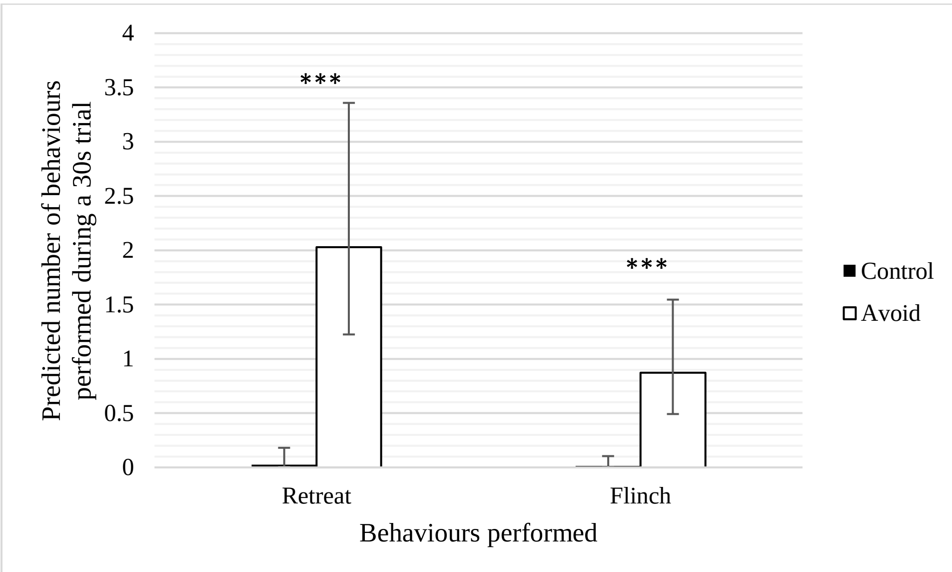
***: p<0.001, **: p<0.01, *: p≤0.05, NS: p>0.05

Figure 5.2 Predicted probability (95% CI) of performing behaviours during a trial calculated from the output of three multivariable mixed logistic regression models with puppy as a random effect for the outcomes of whether or not different behaviours (i.e., barking, paw lifting, lip licking) occurred during an approach/avoidance behavioural test on puppies (2-6 months; n=25). Responses were assessed during "control" trials (n=96) with no stimulus and trials where the puppies were determined to "avoid" (fail or show significant hesitation to approach; n=57) a non-social stimulus placed at the end of the run, time spent in the run was standardized to 30 seconds, and all other variables were set to their referent category



***: p<0.001, **: p<0.01, *: p≤0.05, NS: p>0.05

Figure 5.3 Predicted rate (95% CI) of performing behaviours per 30s calculated from the output of two multivariable mixed Poisson regression models with puppy as a random effect, and time spent in the run as exposure for the outcome of number of times different behaviours (i.e., retreating, flinching) were performed during an approach/avoidance behavioural test on puppies (2-6 months; n=25). Responses were assessed during "control" trials (n=96) with no stimulus and trials where the puppies were determined to avoid (fail or show significant hesitation to approach; n=57) a non-social stimulus placed at the end of the run, and all other variables set to their referent category



***: p<0.001, **: p<0.01, *: p≤0.05, NS: p>0.05

CHAPTER SIX

Conclusion and general discussion

6.1 Introduction

It is estimated that approximately 4.5 million people are bitten by dogs every year in the United States (Centers for Disease Control and Prevention, 2015), and this does not include the number of times dogs act aggressively by threatening, or attempting to bite. Aggression is a huge public safety concern, but is also one of the leading causes for dogs being relinquished to shelters (Salman et al., 2000, 1998). In addition, dogs that are aggressive may have reduced welfare; specifically, dogs that are aggressive towards strangers may be limited in the number of activities they can participate in outside of the house (Bennett and Rohlf, 2007). This may lead to dogs not receiving sufficient mental stimulation and physical exercise, leading to reduced welfare, and potentially further behavioural problems. Stranger-directed aggression is thought to be caused in part by fear of strangers, and these two behavioural responses have been found to be associated in previous studies (Duffy et al., 2008; Goodloe and Borchelt, 1998; Hsu and Serpell, 2003; Matos et al., 2015). Previous research has not taken a comprehensive look at multiple risk factors for stranger-directed aggression while also controlling for potential confounders. In addition, no research has statistically analyzed what factors are associated with dogs biting or attempting to bite, when compared to dogs that only show threatening behaviours. The overarching goal of this thesis was to inform prevention and treatment strategies for stranger-directed fear and aggression in dogs. The three main objectives of the current thesis were to: 1) to identify risk factors for stranger-directed aggression in dogs; 2) to assess the effect of targeted training on the accuracy of owner reports of fearfulness in dogs; and 3) to identify behaviours associated with fear of social and non-social stimuli in puppies.

6.2 Summary

This thesis consists of four major research studies: the first study examined risk factors for dogs displaying stranger-directed aggression. This study used a pre-existing dataset of responses to the C-BARQ to determine what variables were associated with stranger-directed aggression, while including household and country as random effects to control for similarities in environment and management from dogs in the same household and from the same countries. This study identified several risk factors for stranger-directed aggression, including fear of strangers, mild non-social fear, being acquired from a pet store or from a friend or relative (vs. breeder), being acquired as a puppy or juvenile (vs. adult), and being an adult (vs. adolescent or senior), and being a neutered male. Risk factors for severe stranger-directed aggression included fear of strangers, being acquired from a shelter, friend or relative, or found stray (vs. breeder), and being male. In addition, dogs within the same household had correlations of 0.40 in stranger-directed aggression and 0.34 in severe stranger-directed aggression, suggesting that unmeasured environmental and management factors have a large effect on stranger-directed aggression in dogs. These results are hypothesis-generating for future studies, which can explore the causal relationships between the identified risk factors, as well as explore possible environmental and managements factors that may account for the correlations between dogs within households.

Owner-completed reports on dog behaviour, such as the C-BARQ, have been previously criticized as they rely on owner interpretation of dog behaviour. In order to address this issue, the second study assessed how well owners identified fear in dogs, and whether this identification could be improved with the use of a targeted training tool. The goal was to determine whether a preliminary training tool could improve C-BARQ ratings for future studies using this survey. First, owners were asked to identify the presence or absence of a series of behaviours relating to fear in dogs from expert-validated videos. The results indicate that owners were able to reliably identify (Sn and Sp > 0.70) dog body posture, ear position, tail position, wagging tail, panting, lolling tongue, yawning, lip licking, avoiding eye contact, and attempts to hide/escape/retreat. These behaviours were then included in a training tool for recognizing fear in dogs, and owners were asked to rate the level of fearfulness shown by dogs in short, expert-validated, video clips, as well as the level of fearfulness displayed by their own dog using the C-BARQ. The results from this study indicate that training improves the recognition of mild to severe fear in video clips of unfamiliar dogs, but does not consistently alter owners’ ratings of their own dogs’ fear. This result could be due to owners being able to correctly identify their own dogs’ fearfulness, even if they are not familiar with specific fear behaviours. Alternatively, owners could have set ideas about their own dogs' fearfulness which are not altered by training, even if they are incorrect. In order to determine why training does not alter owner responses to C-BARQ further studies need to be conducted.

The third study aimed to repeat the analysis conducted in Study 1 in order to determine risk factors for stranger-directed aggression in dogs, and severe stranger-directed aggression (biting or attempting to bite), using a different population of dogs, and with the inclusion of a number of additional questions relating to dog characteristics, temperament, training, environment, and owner demographics and personality. Videos of dogs displaying different levels of fear and aggression were also rated by owners in order to control for owner accuracy in identifying and rating these behavioural states. As training was previously found to improve owner ratings of videos of unfamiliar dogs, but not consistently affect C-BARQ scores for their own dog (Chapter 3), the training tool was not included in the current study. This study identified several risk factors and sparing factors for stranger-directed aggression in dogs, primarily relating to the dog, training and environment. Similar to Chapter 2, fear of strangers was found to be a major risk factor for both stranger-directed aggression and severe stranger-directed aggression. Another risk factor that was common between both Chapter 2 and Chapter 4 was sex, with males having higher stranger-directed aggression scores, and being more likely to display severe stranger-directed aggression. Other risk factors identified in this study include impulsivity, history of abuse, use of potentially aversive training tools, including head halters, shock collars, choke chains and no-pull harnesses, and using physical punishment. In addition, dogs that were exposed to strangers less than once a month as a puppy, and dogs that were fearful or indifferent towards strangers as a puppy had stranger-directed aggression scores, and were more likely to show severe stranger-directed aggression. Variables relating to where the dog was acquired were significant in Chapter 2, but not in Chapter 4. This could be because variables relating to dogs' previous experiences, including socialization and a history of abuse were controlled for in Chapter 4, and may have accounted for any differences in dogs from different sources. The only variables relating directly to the owner that were significant were whether they were categorized as extroverted using the TIPI, and their ability to correctly identify the absence of aggression in videos. Extroverted owners scored their dogs higher for stranger-directed aggression, while owners who were able to rate the absence of aggression correctly scored their dogs lower on stranger-directed aggression. These results indicate that risk factors for stranger-directed aggression relate primarily to a dog's temperament, previous experiences, and training methods used. These results highlight areas for future research for determining causal relationships with stranger-directed aggression, which will help identify dogs at risk, and inform preventive strategies.

Previous literature, including Chapter 4 in the current thesis, has identified the importance of socializing puppies to unfamiliar people in order to prevent future behavioural issues, such as aggression towards strangers. It was also found that puppies that were either scared or indifferent towards strangers were more likely to display stranger-directed aggression as adults. In order to further explore this relationship, a better understanding of fear-related behaviours in puppies is needed. Specifically, we need to determine whether puppies show the full repertoire of fear behaviours shown by adult dogs so that the fear state can be accurately identified. The fourth study aimed to identify what behaviours puppies show in response to fear of social and non-social stimuli. No puppies were afraid of the social stimuli, so only responses to non-social stimuli were analyzed. Lowered posture, lowered tail, freezing, retreating, flinching, paw lift and barking were all found to be associated with fear of non-social stimuli, as determined through avoidance of the associated stimuli. Sniffing, locomotion and panting occurred less when puppies were fearful of non-social stimuli, and there were no significant differences in yawning, lip licking and ears back between non-social stimuli and control trials. These results indicate that many of the behaviours displayed by adult dogs in response to fear are also shown by puppies, with no effect of age within puppies. In addition, barking, which has not been previously highlighted as an indicator of fear in adult dogs, was found to be associated with non-social fear in puppies. However, oral behaviours, such as panting, lip licking and yawning may not be related to fear in puppies, or may only be shown in response to fear of social stimuli. Further research into when these behaviours develop, and what behaviours are shown by puppies in response to social fear are needed, especially for use in research focusing on stranger-directed fear and aggression.

6.3 Key findings and recommendations

- Owners were able to reliably identify dog body posture, ear position, tail position, wagging tail, panting, lolling tongue, yawning, lip licking, avoiding eye contact, and attempts to hide/escape/retreat. It would be useful to target the use of these behaviours when describing dog fear to owners, over behaviours that are less reliably recognized.
- Targeted training improved owners' ratings of video clips of unfamiliar dogs displaying mild to severe levels of fear. This training tool may be used for improving recognition of fear in dogs among the general public, or for training staff in positions that require interactions with unfamiliar dogs, such as shelter workers, dog groomers, and veterinary technicians.
- Targeted training did not alter owners' ratings of fearfulness in their own dogs. It is therefore unclear whether this training tool would be a beneficial addition to dog temperament surveys. Further research to explore this finding is needed.
- The use of physical punishment by the owner when their dog performed an unwanted behaviour was associated with increased stranger-directed aggression in dogs. In addition, the use of various training tools that are thought to be aversive, such as shock collars, choke chains and head halters were associated with increased stranger-directed aggression. While further research is needed to establish causal relationships, veterinarians, behaviourists, and trainers should recommend avoiding aversive training methods until further information is available.
- Being exposed to unfamiliar people less than once a month, and being either fearful or indifferent towards unfamiliar people as a puppy were associated with increased stranger-directed aggression scores and increased odds of bite attempts directed towards strangers. Veterinarians, behaviourists, and trainers should emphasize the importance of creating multiple positive experiences with unfamiliar people during a puppy's socialization period.
- Dogs that were male, impulsive, and fearful of strangers all had higher stranger-directed aggression scores, and were more likely to show severe stranger-directed aggression. Further

research is needed to determine whether these relationships are causal, and therefore whether they will aid in identification of dogs at risk of developing stranger-directed aggression and implementation of preventive strategies.

- Puppies showed an increase in freezing, flinching, lowered posture, lowered tail, paw lifting and barking when fearful of a non-social stimulus. Therefore, these behaviours could be useful in assessing fearfulness in puppies in future research.
- Puppies did not show a significant increase in panting, lip licking, or yawning when fearful of a non-social stimulus. Further research is needed to determine if these behaviours are not indicative of fear in puppies, or if they are only displayed in response to social fear or more severe fear.

6.4 Critique of methods

Studies 1 and 3 shared similar methodology as they were both cross-sectional surveys aimed at determining risk factors for stranger-directed aggression in dogs, and therefore shared a number of advantages and limitations. One advantage of the current studies in comparison to previous studies into stranger-directed aggression in dogs is that they had large sample sizes, which provided sufficient power to analyze a large number of risk factors. Another advantage of the current studies was the ability to analyze data from multiple dogs within the same household, so that the correlation between dogs that shared the same owner and environment could be determined. This provides information on how much the home environment affects a dog's likelihood to act aggressively, and also controls for the effect of unmeasured environmental and management variables in the model. In addition, Study 3 collected data covering a large number of variables relating to the dog, and its training, environment, and owner, which allowed for a more comprehensive analysis of potential risk factors, and confounding variables, than has been previously conducted. Finally, for both Study 1 and Study 3 we conducted separate analyses for dogs that showed severe aggression in the form of biting or attempting to bite. This provides additional information on what factors may cause an aggressive dog to escalate to the point of attempting to bite.

The main limitation for these studies is the reliance on indirect owner reports of dog behaviour. While owner reports are often criticized as being subjective and prone to bias (Meagher, 2009), they are also a more convenient and cost efficient method of obtaining a large sample size from a broad population (Hecht and Spicer Rice, 2015). While previous studies have shown high reliability and validity for the C-BARQ (Duffy and Serpell, 2012; Hsu and Serpell, 2003), especially for dogs with clinical behavioural issues, the validity of owner reports for milder levels of fear and aggression have not been determined. The accuracy of owner reports of fear (Chapter 3) and aggression (Jacobs et al., 2017) in videos of dogs has been measured, but it is unclear whether this accuracy correlates with an owner's ability to rate fear and aggression in their own dog. In Study 3, it was found that owners did not achieve high levels of accuracy for rating videos of dogs, especially for mild to severe aggression. However, it could be that while owners are not entirely accurate with short video clips of unfamiliar dogs, their ratings of their own dog, who they have much more exposure to, are more accurate. Study 3 controlled for variables related to owner accuracy in rating fear and aggression videos during analysis, but, as mentioned above, this may not have been successful in controlling for accuracy of rating one's own dog.

Another limitation for Studies 1 and 3 is that due to the cross-sectional design of these studies causal inferences cannot be made, and therefore it cannot be determined whether the identified factors associated with stranger-directed aggression actually cause the aggression, or are instead more likely to occur in dogs that are already aggressive. For example, the use of head halters was significantly associated with stranger-directed aggression in both models in Study 3. However, head halters are often recommended as a way to control aggressive dogs, and therefore these tools may not cause aggression, but may instead be more likely used with aggressive dogs. These studies provide useful hypothesis-generating information, and can inform future longitudinal studies focused on determining the causal nature of the relationships between these factors and stranger-directed aggression.

Study 2 aimed to determine the accuracy of owner reports of fear in dogs, and has strengths in comparison to previous studies that have looked at owner identification of emotions and behavioural responses in dogs. Previous studies have asked owners to categorize dogs based on the primary emotion the owner believes the dog is experiencing. However, owners were not asked to quantify the severity of those emotions (Bloom and Friedman, 2013; Tami and Gallagher, 2009; Wan et al., 2012). The current study provides a more detailed view of how well owners can identify fear of different severities. In addition, the current study used a large number of different video examples for each level of severity, improving external validity.

The major limitation of Study 2 is that while the accuracy of owners' recognition of fear in unfamiliar dogs from short video clips was determined, this cannot necessarily be extrapolated to their ability to recognize fear in real-life. During the survey, owners were able to re-watch videos numerous times, which allowed them to focus on specific parts of the animal and might have improved recognition of subtle behaviours. Conversely, there may be details that would be visible if observing the dog in real-life that were limited in the current study due to some portions of the dog not being visible in the video frame, and video quality. In addition, owners may be better able to assess behaviour when they observe changes over an extended period of time, or when they are able to take cues from the external environment, which are missing from a short video clip. In addition, while we were able to determine that training generally did not change an owner's rating of their own dog's fear, we could not determine whether or not these ratings were accurate.

Studies 1, 2 and 3 were all conducted as voluntary online questionnaires, and therefore share some limitations in the representative nature of the study population. Owners may be more likely to participate in these studies if they have a special interest in dog behaviour, or have dogs with behavioural issues. This may have led to an over-representation of aggressive dogs in Studies 1 and 2, or an over-representation of more experienced owners in each of Studies 1, 2 and 3. However, as the aims of these studies were not to measure prevalence, and variables related to experience were controlled for in analysis, this should have little influence on our observed outcomes. In addition, a vast majority of participants in all three studies were female, suggesting that males were less likely to participate, leading to potential non-response bias.

Study 4 aimed to identify behaviours associated with fear in puppies. This study adds important information about what behaviours puppies show when fearful of non-social stimuli, and provides data for comparison to those shown by adult dogs. This study also provides a useful paradigm for categorizing the responses of puppies as fearful towards non-social stimuli. The major limitation of this study is that puppies did not respond fearfully towards social stimuli, and therefore the behaviours found to be associated with fear in the current study are only related to non-social stimuli. Another limitation of this study is that while the experimental procedure was standardized across puppies, there was some variation in handling due to the involvement of each puppy's owner. In addition, the population of puppies used in the current study may not have been representative of the general puppy population, as owners who volunteered their puppies may be more interested in dog behaviour, and may be actively seeking socialization opportunities for their dogs. The test was successful in eliciting fear responses towards non-social stimuli for these puppies, indicating that the methodology was effective with this population. However, it is possible that less socialized puppies might have displayed more exaggerated fear responses, or may have been fearful of social stimuli, and this might have influenced the behaviours that were identified. In addition, due to the nature of the content of the videos, it was not possible to fully blind the observer to the trial categorisation, which may have led to observer bias away from the null hypothesis. Finally, there were limitations due to video quality, which may have resulted in an underrepresentation of some behaviours, specifically facial behaviours (e.g., ear position and lip licking). While these issues were present across trials, it is possible that some information bias was present and resulted in these behaviours not being significant in the final models.

6.5 Future directions

In the future, longitudinal research is needed to further investigate whether the factors identified in Study 1 and Study 3, which are associated with stranger-directed aggression in dogs, are causal. Ideally these studies should start following puppies from an early age in order to encompass the socialization period that begins at three weeks of age (Fox and Stelzner, 1967). These studies will establish causal relationships, which will aid in the identification of dog characteristics and temperament traits that are indicative of dogs at risk of developing stranger-directed aggression in the future. In addition, by identifying causal relationships we will be able to determine training, environment, and management related factors that increase a dog's risk of developing aggression, and therefore we can implement strategies for preventing stranger-directed aggression in dogs.

Future studies also need to further explore the accuracy of owner reports of fear in their own dogs. The current study on fear identification found that dog owners did not alter their reports of their own dogs' fearfulness following training on fear behaviours in dogs. It is possible that owners did not notice their dogs performing some of the subtle behaviours identified in the training tool and therefore did not immediately alter their perception of their dogs' fearfulness. However, if they were given time to observe their dogs with their new knowledge, they may notice their dogs performing these behaviours and therefore change their rating of their dogs' fearfulness in future reports. Future studies could provide additional time between training and an owner assessing their dog in order to determine if this is the case. Another potential reason that owners did not alter their responses was that they had a fixed idea of their dogs' fearfulness which was not altered by training. This may be because the owners were already correct about their dogs' level of fearfulness, or they may have been incorrect, but unwilling to alter their views. In order to determine which of these scenarios were correct, further studies need to compare owner reports of their dog's fearfulness to their dog's actual reaction to simulations of real-life scenarios, such as the approach of a stranger during an on-leash walk. This will help determine the accuracy of owner-reports of dog fearfulness, and therefore the validity of scientific research that use owner-reports to assess dog fear.

Finally, further research is needed to assess behaviours associated with social fear in puppies. Another experiment of similar design to Study 4 could be conducted using more threatening social stimuli so that responses to these stimuli can be identified. Alternatively, puppies could be pre-screened for their level of socialization, or fear of strangers, in order to select for puppies that are more likely to respond fearfully to a stranger during the test. This would allow for the identification of behaviours associated with fear of social stimuli. Specifically, it would aid in testing whether oral behaviours, such as lip licking, yawning and panting, are shown by puppies in response to social stimuli, or whether they are not a part of a puppy's typical fear response.

6.6 Conclusions

This thesis includes the most comprehensive risk factor analysis for stranger-directed aggression completed to date, as previous studies have analyzed risk factors for dogs in different specific geographical areas (e.g., Hsu and Sun, 2010; Matos et al., 2015), or have had a narrow focus on a small group of potential risk factors (e.g., Casey et al., 2014; Duffy et al., 2008). In addition, this thesis provides information on factors associated with dogs biting or attempting to bite, when compared to dogs that only show threatening behaviours. This thesis is hypothesis-generating, identifying factors for further research into causes of stranger-directed aggression in companion dogs. This thesis also provides valuable information about the identification of fear in dogs. While the current thesis shows that owners can be trained to identify fear in videos of unfamiliar dogs, further research is needed to determine how accurate owners are at identifying their own dogs' fear, and if necessary, how this accuracy can be improved. Lastly, this thesis identifies behaviours shown by puppies in response to non-social stimuli. The paradigm developed during this thesis can also be modified, and used to identify behaviours associated with fear of social-stimuli in puppies. This will aid in future research focusing on fearfulness in puppies, which may help develop targeted socialization strategies for preventing fear and aggression towards strangers.

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APPENDIX A

Risk factors associated with stranger-directed aggression in domestic dogs

A. 1: C-BARQ

A. 1: C-BARQ

ID Code:

Canine Behavioural Assessment & Research Questionnaire (C–BARQ)

The following questions are designed to allow you to describe how your dog has been behaving in the recent past (i.e. during the last few months). Please try to answer all of the questions. If you have never observed the dog in the situation described, please check the "Not observed/not applicable" box on the right.

SECTION 1: Training difficulty

Some dogs are more obedient and trainable than others. By checking the appropriate boxes, please indicate how trainable or obedient your dog has been in each of the following situations in the recent past:

	Never	Seldom	Sometimes	Usually	Always	Not observed/ not applicable
1. When off the leash, returns immediately when called.	☐	☐	☐	☐	☐	☐
2. Obeys the "sit" command **immediately.**	☐	☐	☐	☐	☐	☐
3. Obeys the "stay" command **immediately.**	☐	☐	☐	☐	☐	☐
4. Seems to attend/listen closely to everything you say or do.	☐	☐	☐	☐	☐	☐
5. Slow to respond to correction or punishment; 'thick-skinned'.	☐	☐	☐	☐	☐	☐
6. Slow to learn new tricks or tasks.	☐	☐	☐	☐	☐	☐
7. Easily distracted by interesting sights, sounds or smells.	☐	☐	☐	☐	☐	☐
8. Will 'fetch' or attempt to fetch **sticks, balls, or objects.**	☐	☐	☐	☐	☐	☐

SECTION 2: Aggression

Some dogs display aggressive behaviour from time to time. Typical signs of moderate aggression in dogs include barking, growling and baring teeth. More serious aggression generally includes snapping, lunging, biting, or attempting to bite.

By circling or underlining a number on the following 5-point scales (0= No aggression, 4= Serious aggression), please indicate your own dog's recent tendency to display **aggressive behaviour in each of the following contexts:**

9. When verbally corrected or punished (scolded, shouted at, etc) by you or a household member.

No aggression: No visible signs of aggression	Moderate aggression: growling/barking—baring teeth	Serious aggression: Snaps, bites or attempts to bite.	Not observed
	0..............1..............2..............3..............4		☐

10. When approached directly by an unfamiliar adult while being walked/exercised on a leash.

No aggression: No visible signs of aggression	Moderate aggression: growling/barking—baring teeth	Serious aggression: Snaps, bites or attempts to bite.	Not observed
	0..............1..............2..............3..............4		☐

11. When approached directly by an unfamiliar child while being walked/exercised on a leash.

No aggression: No visible signs of aggression	Moderate aggression: growling/barking—baring teeth	Serious aggression: Snaps, bites or attempts to bite.	Not observed
	0..............1..............2..............3..............4		☐

12. Toward unfamiliar persons approaching the dog while s/he is in your car (at the gas station for example).

No aggression: No visible signs of aggression	Moderate aggression: growling/barking—baring teeth	Serious aggression: Snaps, bites or attempts to bite.	Not observed
	0..............1..............2..............3..............4		☐

13. When toys, bones or other objects are taken away by a household member.

No aggression: No visible signs of aggression	Moderate aggression: growling/barking—baring teeth	Serious aggression: Snaps, bites or attempts to bite.	Not observed
	0..............1..............2..............3..............4		☐

14. When bathed or groomed by a household member.

No aggression: No visible signs of aggression	**Moderate aggression**: growling/barking—baring teeth **0..............1..............2..............3..............4**	**Serious aggression**: Snaps, bites or attempts to bite.	**Not observed** ☐

15. When an unfamiliar person approaches you or another member of your family at home.

No aggression: No visible signs of aggression	**Moderate aggression**: growling/barking—baring teeth **0..............1..............2..............3..............4**	**Serious aggression**: Snaps, bites or attempts to bite.	**Not observed** ☐

16. When unfamiliar persons approach you or another member of your family away from your home.

No aggression: No visible signs of aggression	**Moderate aggression**: growling/barking—baring teeth **0..............1..............2..............3..............4**	**Serious aggression**: Snaps, bites or attempts to bite.	**Not observed** ☐

17. When approached directly by a household member while s/he (the dog) is eating.

No aggression: No visible signs of aggression	**Moderate aggression**: growling/barking—baring teeth **0..............1..............2..............3..............4**	**Serious aggression**: Snaps, bites or attempts to bite.	**Not observed** ☐

18. When mailmen or other delivery workers approach your home.

No aggression: No visible signs of aggression	**Moderate aggression**: growling/barking—baring teeth **0..............1..............2..............3..............4**	**Serious aggression**: Snaps, bites or attempts to bite.	**Not observed** ☐

19. When his/her food is taken away by a household member.

No aggression: No visible signs of aggression	**Moderate aggression**: growling/barking—baring teeth **0..............1..............2..............3..............4**	**Serious aggression**: Snaps, bites or attempts to bite.	**Not observed** ☐

20. When strangers walk past your home while your dog is outside or in the yard.

	Moderate aggression:		**Not observed** ☐

No aggression: No visible signs of aggression	**growling/barking—baring teeth** **0..............1..............2..............3..............4**	**Serious aggression**: Snaps, bites or attempts to bite.	

21. When an unfamiliar person tries to touch or pet the dog.

No aggression: No visible signs of aggression	**Moderate aggression**: growling/barking—baring teeth **0..............1..............2..............3..............4**	**Serious aggression**: Snaps, bites or attempts to bite.	**Not observed** ☐

22. When joggers, cyclists, rollerbladers or skateboarders pass your home while your dog is outside or in the yard.

No aggression: No visible signs of aggression	**Moderate aggression**: growling/barking—baring teeth **0..............1..............2..............3..............4**	**Serious aggression**: Snaps, bites or attempts to bite.	**Not observed** ☐

23. When approached directly by an unfamiliar male dog while being walked/exercised on a leash.

No aggression: No visible signs of aggression	**Moderate aggression**: growling/barking—baring teeth **0..............1..............2..............3..............4**	**Serious aggression**: Snaps, bites or attempts to bite.	**Not observed** ☐

24. When approached directly by an unfamiliar female dog while being walked/exercised on a leash.

No aggression: No visible signs of aggression	**Moderate aggression**: growling/barking—baring teeth **0..............1..............2..............3..............4**	**Serious aggression**: Snaps, bites or attempts to bite.	**Not observed** ☐

25. When stared at directly by a member of the household.

No aggression: No visible signs of aggression	**Moderate aggression**: growling/barking—baring teeth **0..............1..............2..............3..............4**	**Serious aggression**: Snaps, bites or attempts to bite.	**Not observed** ☐

26. Toward unfamiliar dogs visiting your home.

No aggression:	**Moderate aggression**: growling/barking—baring teeth		**Not observed** ☐

No visible signs of aggression	0..............1..............2..............3..............4	**Serious aggression**: Snaps, bites or attempts to bite.	

27. Toward cats, squirrels or other small animals entering your yard.

No aggression: No visible signs of aggression	**Moderate aggression**: growling/barking—baring teeth 0..............1..............2..............3..............4	**Serious aggression**: Snaps, bites or attempts to bite.	Not observed ☐

28. Toward unfamiliar persons visiting your home.

No aggression: No visible signs of aggression	**Moderate aggression**: growling/barking—baring teeth 0..............1..............2..............3..............4	**Serious aggression**: Snaps, bites or attempts to bite.	Not observed ☐

29. When barked, growled, or lunged at by another (unfamiliar) dog.

No aggression: No visible signs of aggression	**Moderate aggression**: growling/barking—baring teeth 0..............1..............2..............3..............4	**Serious aggression**: Snaps, bites or attempts to bite.	Not observed ☐

30. When stepped over by a member of the household.

No aggression: No visible signs of aggression	**Moderate aggression**: growling/barking—baring teeth 0..............1..............2..............3..............4	**Serious aggression**: Snaps, bites or attempts to bite.	Not observed ☐

31. When you or a household member retrieves food or objects stolen by the dog.

No aggression: No visible signs of aggression	**Moderate aggression**: growling/barking—baring teeth 0..............1..............2..............3..............4	**Serious aggression**: Snaps, bites or attempts to bite.	Not observed ☐

32. Towards another (familiar) dog in your household (leave blank if no other dogs).

No aggression: No visible signs of aggression	**Moderate aggression**: growling/barking—baring teeth 0..............1..............2..............3..............4	**Serious aggression**: Snaps, bites or attempts to bite.	Not observed ☐

33. When approached at a favorite resting/sleeping place by another (familiar) household dog (leave blank if no other dogs).

No aggression: No visible signs of aggression	Moderate aggression: growling/barking—baring teeth	Serious aggression: Snaps, bites or attempts to bite.	Not observed
	0..............1..............2..............3..............4		☐

34. When approached while eating by another (familiar) household dog (leave blank if no other dogs).

No aggression: No visible signs of aggression	Moderate aggression: growling/barking—baring teeth	Serious aggression: Snaps, bites or attempts to bite.	Not observed
	0..............1..............2..............3..............4		☐

35. When approached while playing with/chewing a favorite toy, bone, object, etc., by another (familiar) household dog (leave blank if no other dogs).

No aggression: No visible signs of aggression	Moderate aggression: growling/barking—baring teeth	Serious aggression: Snaps, bites or attempts to bite.	Not observed
	0..............1..............2..............3..............4		☐

Are there any other situations in which your dog is sometimes aggressive? If so, please describe briefly:

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SECTION 3: Fear and Anxiety

Dogs sometimes show signs of anxiety or fear when exposed to particular sounds, objects, persons or situations. Typical signs of mild to moderate fear include: avoiding eye contact, avoidance of the feared object; crouching or cringing with tail lowered or tucked between the legs; whimpering or whining, freezing, and shaking or trembling. Extreme fear is characterized by exaggerated cowering, and/or vigorous attempts to escape, retreat or hide from the feared object, person or situation.

Using the following 5-point scales (0=No fear, 4=Extreme fear), please indicate your own dog's recent tendency to display fearful **behaviour in each of the following circumstances:**

36. When approached directly by an unfamiliar adult while away from your home.

No fear/anxiety: No visible signs of fear	Mild—Moderate fear/anxiety	Extreme fear: cowers; retreats or hides, etc.	Not observed
	0..............1..............2..............3..............4		☐

37. When approached directly by an unfamiliar child while away from your home.

No fear/anxiety: No visible signs of fear	Mild—Moderate fear/anxiety	Extreme fear: cowers; retreats or hides, etc.	Not observed
	0..............1..............2..............3..............4		☐

38. In response to sudden or loud noises (e.g. vacuum cleaner, car backfire, road drills, objects being dropped, etc.).

No fear/anxiety: No visible signs of fear	Mild—Moderate fear/anxiety	Extreme fear: cowers; retreats or hides, etc.	Not observed
	0..............1..............2..............3..............4		☐

39. When unfamiliar persons visit your home.

No fear/anxiety: No visible signs of fear	Mild—Moderate fear/anxiety	Extreme fear: cowers; retreats or hides, etc.	Not observed
	0..............1..............2..............3..............4		☐

40. When an unfamiliar person tries to touch or pet the dog.

No fear/anxiety: No visible signs of fear	Mild—Moderate fear/anxiety	Extreme fear: cowers; retreats or hides, etc.	Not observed
	0..............1..............2..............3..............4		☐

41. In heavy traffic

No fear/anxiety: No visible signs of fear	Mild—Moderate fear/anxiety	Extreme fear: cowers; retreats or hides, etc.	Not observed
	0..............1..............2..............3..............4		☐

42. In response to strange or unfamiliar objects on or near the sidewalk (e.g. plastic trash bags, leaves, litter, flags flapping, etc.

No fear/anxiety: No visible signs of fear	Mild—Moderate fear/anxiety	Extreme fear: cowers; retreats or hides, etc.	Not observed
	0..............1..............2..............3..............4		☐

43. When examined/treated by a veterinarian.

No fear/anxiety: No visible signs of fear	Mild—Moderate fear/anxiety	Extreme fear: cowers; retreats or hides, etc.	Not observed
	0..............1..............2..............3..............4		☐

44. During thunderstorms, firework displays, or similar events.

No fear/anxiety: No visible signs of fear	Mild—Moderate fear/anxiety	Extreme fear: cowers; retreats or hides, etc.	Not observed
	0..............1..............2..............3..............4		☐

45. When approached directly by an unfamiliar dog of the same or larger size.

No fear/anxiety: No visible signs of fear	Mild—Moderate fear/anxiety	Extreme fear: cowers; retreats or hides, etc.	Not observed
	0..............1..............2..............3..............4		☐

46. When approached directly by an unfamiliar dog of a smaller size.

No fear/anxiety: No visible signs of fear	Mild—Moderate fear/anxiety	Extreme fear: cowers; retreats or hides, etc.	Not observed
	0..............1..............2..............3..............4		☐

47. When first exposed to unfamiliar situations (e.g. first car trip, first time in elevator, first visit to veterinarian, etc.)

No fear/anxiety: No visible signs of fear	Mild—Moderate fear/anxiety	Extreme fear: cowers; retreats or hides, etc.	Not observed
	0..............1..............2..............3..............4		☐

48. In response to wind or wind-blown objects.

No fear/anxiety: No visible signs of fear	Mild—Moderate fear/anxiety	Extreme fear: cowers; retreats or hides, etc.	Not observed
	0..............1..............2..............3..............4		☐

49. When having nails clipped by a household member.

No fear/anxiety: No visible signs of fear	Mild—Moderate fear/anxiety	Extreme fear: cowers; retreats or hides, etc.	Not observed
	0..............1..............2..............3..............4		☐

50. When groomed or bathed by a household member.

<u>No fear/anxiety</u>: No visible signs of fear	**<u>Mild—Moderate fear/anxiety</u>** **0..............1..............2..............3..............4**	**<u>Extreme fear</u>:** cowers; retreats or hides, etc.	**Not observed** ☐

51. When having his/her feet toweled by a member of the household.

<u>No fear/anxiety</u>: No visible signs of fear	**<u>Mild—Moderate fear/anxiety</u>** **0..............1..............2..............3..............4**	**<u>Extreme fear</u>:** cowers; retreats or hides, etc.	**Not observed** ☐

52. When unfamiliar dogs visit your home.

<u>No fear/anxiety</u>: No visible signs of fear	**<u>Mild—Moderate fear/anxiety</u>** **0..............1..............2..............3..............4**	**<u>Extreme fear</u>:** cowers; retreats or hides, etc.	**Not observed** ☐

53. When barked, growled, or lunged at by an unfamiliar dog.

<u>No fear/anxiety</u>: No visible signs of fear	**<u>Mild—Moderate fear/anxiety</u>** **0..............1..............2..............3..............4**	**<u>Extreme fear</u>:** cowers; retreats or hides, etc.	**Not observed** ☐

SECTION 4: Separation-related behaviour.

Some dogs show signs of anxiety or abnormal behaviour when left alone, even for relatively short periods of time. Thinking back over the recent past, how often has your dog shown each of the following signs of separation-related behaviour when left, or about to be left, on its own (check appropriate boxes):

	Never	Seldom	Sometimes	Usually	Always	Not observed/ not applicable
54. Shaking, shivering or trembling.	☐	☐	☐	☐	☐	☐
55. Excessive salivation.	☐	☐	☐	☐	☐	☐
56. Restlessness/agitation/pacing.	☐	☐	☐	☐	☐	☐
57. Whining.	☐	☐	☐	☐	☐	☐
58. Barking.	☐	☐	☐	☐	☐	☐
59. Howling.	☐	☐	☐	☐	☐	☐
60. Chewing/scratching at doors, floor, windows, curtains, etc.	☐	☐	☐	☐	☐	☐
61. Loss of appetite.	☐	☐	☐	☐	☐	☐

Are there any other situations in which your dog is fearful or anxious? If so, please describe:

____

____

SECTION 5: Excitability

Some dogs show relatively little reaction to sudden or potentially exciting events and disturbances in their environment, while others become highly excited at the slightest novelty. Signs of mild to moderate excitability include increased alertness, movement toward the source of novelty, and brief episodes of barking. Extreme excitability is characterized by a general tendency to over-react. The excitable dog barks or yelps hysterically at the slightest disturbance, rushes towards and around any source of excitement, and is difficult to calm down.

Using the following 5-point scales (0=Calm, 4=Extremely excitable), please indicate your own dog's recent tendency to become excitable in each of the following **circumstances:**

62. When you or other members of the household come home after a brief absence.

Calm: little or no special reaction	Mild—Moderate excitability	Extremely excitable: over-reacts, hard to calm down.	Not observed
	0..............1..............2..............3..............4		☐

63. When playing with you or other members of your household.

Calm: little or no special reaction	Mild—Moderate excitability	Extremely excitable: over-reacts, hard to calm down.	Not observed
	0..............1..............2..............3..............4		☐

64. When doorbell rings.

Calm: little or no special reaction	Mild—Moderate excitability	Extremely excitable: over-reacts, hard to calm down.	Not observed
	0..............1..............2..............3..............4		☐

65. Just before being taken for a walk.

Calm: little or no special reaction	Mild—Moderate excitability	Extremely excitable: over-reacts, hard to calm down.	Not observed
	0..............1..............2..............3..............4		☐

66. Just before being taken on a car trip.

Calm: little or no special reaction	Mild—Moderate excitability	Extremely excitable: over-reacts, hard to calm down.	Not observed
	0..............1..............2..............3..............4		☐

67. When visitors arrive at your home.

<u>Calm</u>: little or no special reaction	**<u>Mild—Moderate excitability</u>**	**<u>Extremely excitable</u>: over-reacts, hard to calm down.**	**Not observed**
	0...............1...............2...............3...............4		☐

Are there any other situations in which your dog sometimes becomes over-excited? If so, please describe briefly:

____

SECTION 6: Attachment and Attention-seeking.

Most dogs are strongly attached to their people, and some demand a great deal of attention and affection from them. Thinking back over the recent past, how often has your dog shown each of the following signs of attachment or attention-seeking.

	Never	Seldom	Sometimes	Usually	Always	Not observed/ not applicable
68. Displays a strong attachment for one particular member of the household.	☐	☐	☐	☐	☐	☐
69. Tends to follow you (or other members of household) about the house, from room to room.	☐	☐	☐	☐	☐	☐
70. Tends to sit close to, or in contact with, you (or others) when you are sitting down.	☐	☐	☐	☐	☐	☐
71.Tends to nudge, nuzzle or paw you (or others) for attention when you are sitting down.	☐	☐	☐	☐	☐	☐
72. Becomes agitated (whines, jumps up, tries to intervene) when you (or others) show affection for another person.	☐	☐	☐	☐	☐	☐
73. Becomes agitated (whines, jumps up, tries to intervene) when you show affection for another dog or animal.	☐	☐	☐	☐	☐	☐

SECTION 7: Miscellaneous

Dogs display a wide range of miscellaneous behaviour problems in addition to those already covered by this questionnaire. Thinking back over the recent past, please indicate how often your dog has shown any of the following behaviours:

	Never	Seldom	Sometimes	Usually	Always	Not observed/ not applicable
74. Chases or would chase cats given the opportunity.	☐	☐	☐	☐	☐	☐
75. Chases or would chase birds given the opportunity.	☐	☐	☐	☐	☐	☐
76. Chases or would chase squirrels, rabbits and other small animals given the opportunity.	☐	☐	☐	☐	☐	☐
77. Escapes or would escape from home or yard given the chance.	☐	☐	☐	☐	☐	☐
78. Rolls in animal droppings or other 'smelly' substances.	☐	☐	☐	☐	☐	☐
79. Eats own or other animals' **droppings or feces.**	☐	☐	☐	☐	☐	☐
80. Chews inappropriate objects.	☐	☐	☐	☐	☐	☐
81. 'Mounts' objects, furniture, or **people.**	☐	☐	☐	☐	☐	☐
82. Begs persistently for food when people are eating.	☐	☐	☐	☐	☐	☐
83. Steals food.	☐	☐	☐	☐	☐	☐
84. Nervous or frightened on stairs.	☐	☐	☐	☐	☐	☐
85. Pulls excessively hard when on the leash.	☐	☐	☐	☐	☐	☐
86. Urinates against objects/ furnishings in your home.	☐	☐	☐	☐	☐	☐

	Never	Seldom	Sometimes	Usually	Always	Not observed/ not applicable
87. Urinates when approached, petted, handled or picked up.	☐ ☐	☐	☐	☐		☐
88. Urinates when left alone at night, or during the daytime.	☐	☐	☐	☐	☐	☐
89. Defecates when left alone at night, or during the daytime.	☐	☐	☐	☐	☐	☐
90. Hyperactive, restless, has trouble settling down.	☐	☐	☐	☐	☐	☐
91. Playful, puppyish, boisterous.	☐	☐	☐	☐	☐	☐
92. Active, energetic, always on the go.	☐	☐	☐	☐	☐	☐
93. Stares intently at nothing visible.	☐	☐	☐	☐	☐	☐
94. Snaps at (invisible) flies.	☐	☐	☐	☐	☐	☐
95. Chases own tail/hind end.	☐	☐	☐	☐	☐	☐
96. Chases/follows shadows, light spots, etc.	☐	☐	☐	☐	☐	☐
97. Barks persistently when alarmed or excited.	☐	☐	☐	☐	☐	☐
98. Licks him/herself excessively.	☐	☐	☐	☐	☐	☐
99. Licks people or objects excessively.	☐	☐	☐	☐	☐	☐
100. Displays other bizarre, strange, or repetitive behaviour(s) *	☐	☐	☐	☐	☐	☐

***Please describe:** ____

____

APPENDIX B

Effect of targeted training on dog owners' ratings of fear in familiar and unfamiliar dogs

B. 1: Stage 1 recruitment email
B. 2: Stage 1 consent form
B. 3: Stage 2 recruitment poster
B. 4: Stage 2 consent form
B. 5: Stage 1 & 2 sample pages from survey
B. 6: Stage 3 recruitment email
B. 7: Stage 3 consent form
B. 8: Stage 4 recruitment poster
B. 9: Stage 4 consent form
B. 10: Stage 3 & 4 sample page from survey
B. 11: Fear training tool

B. 1: Stage 1 Recruitment email

Subject:
Expert assistance with upcoming research project - Ontario Veterinary College

Message body:
I am a PhD student at the University of Guelph. We are currently developing and validating a questionnaire aimed at assessing owner ability to recognize fear behaviours in dogs. This questionnaire will be used as an owner identification tool in future dog temperament surveys. We are recruiting CPDT-KSA dog behaviour professionals to assist with developing and validating this identification tool via an online questionnaire. Your responses will be used as a 'gold standard' with which to compare the responses of our dog owner participants.
Please note the following:

- -We anticipate this questionnaire to take between 15 and 30 minutes to complete
- -We ask that you complete this survey by August 30, 2015
- -In appreciation of your time, you will be entered into a draw for a $100 CAD visa gift card (odds of winning are approximately 1 in 50).
- -All information provided will be kept confidential
- -You will be asked to view videos of fearful dogs, which may be disturbing to some participants
- -We will be recontacting you to complete a second survey expanding on this first survey in the near future

If you would like to participate, please go to the survey link below

http://fluidsurveys.com/s/dogbehaviourexpert/

If you have any questions or concerns, Dr. Lee Niel or Ms. Hannah Flint may be reached at:

Hannah Flint, PhD candidate

Department of Population Medicine
Ontario Veterinary College
University of Guelph
Guelph, ON, N1G 2W1

Email: flinth@uoguelph.ca

Lee Niel, PhD

Assistant Professor
Department of Population Medicine
Ontario Veterinary College
University of Guelph
Guelph, ON, N1G 2W1
Tel: 519-824-4120, Ext. 53030
Fax: 519-763-8621
Email: niell@uoguelph.ca

B. 2: Stage 1 Consent form

UNIVERSITY of GUELPH

Expert and Owner Recognition of Canine Fear

You are asked to participate in a research study conducted by Dr. Lee Niel and Ms. Hannah Flint from the Department of Population Medicine at the Ontario Veterinary College, University of Guelph.

If you have any questions or concerns about this research, please feel free to contact
Dr. Niel at 519-824-4120 x53030 or niell@uoguelph.ca, or Ms. Flint at flinth@uoguelph.ca

Purpose of the study

Many studies looking at fear in dogs and risk factors for developing behavioural issues rely on owner reports of dog behaviour through questionnaires. In order to make sure these reports are accurate we first need to ensure that dog owners are able to correctly identify fear behaviours in their dog. For the present study, we will be comparing dog owner responses to expert responses, which will be considered the 'gold standard'. The Natural Sciences and Engineering Research Council of Canada (NSERC) has provided funding for this project

Who can participate?

For the current expert survey we are recruiting participants that have achieved the CPDT-KA certifications from the Certification Council for Professional Dog Trainers.

Procedures

You will be asked to watch video clips of dog behaviour and then respond to questions about which specific dog behaviours you observed for each video. At a later date we will recontact you with another survey where you will be asked to watch video clips of dog behaviour and respond with how you would rate that dog's level of fearfulness. We anticipate the time commitment to be between 15-30 minutes for this survey and approximately 15 minutes for the second survey for a total of 30-45 minutes. In appreciation for your time, you will be entered into a lottery to receive a $100 CAD visa gift card (estimated odds of winning are 1 in 50) for each survey that you complete.

Important information about potential risks and benefits

This study poses no known physical risks to participants. You will be asked to view videos of dogs displaying fearful behaviours which may be disturbing to some participants.

Every effort will be made to ensure confidentiality of any identifying information that is obtained in connection with this study. Participant's email address will be recorded in order to contact them for lottery results. However, this information will be kept separately from survey responses and will be destroyed after the lottery draw. Survey responses will be anonymous and kept in either a locked file cabinet in a secure room, or on an encrypted and password protected computer. Responses will only be viewed and handled by members of the research team. Data will be kept for 10 years after which they will be destroyed. Please note that confidentiality cannot be guaranteed while data are in transit over the internet. If you are randomly selected as a winner of a gift card, it may be necessary to release participant names to university or granting agency financial auditors.

There are no direct benefits to you from participating in this research. This project will benefit research and society as it will allow for the development of a targeted training tool for identifying fear in dogs, which may help in the identification of fearful dogs and prevent fear-related dog bites.

Participation and withdrawal

Participation in this study is completely voluntary. You may discontinue participation in the study at any time up until submission of your survey without consequence. You may also choose to skip any question in the survey without penalty. After submission your data cannot be removed as responses are anonymous. Contact Lee Niel or Hannah Flint by phone or email (see contact information above) if you have concerns or questions regarding participation or withdrawal from the survey.

Research Results

If you would be interested in receiving the completed results of this study please select that option at the end of the survey with your email address.

Rights of research participants

You are not waiving any legal claims, rights or remedies because of your participation in this research study. If you have questions regarding your rights as a research participant, contact:

Director, Research Ethics
Telephone: (519) 824-4120, ext. 56606
E-mail: sauld@uoguelph.ca

If you have read the above information and agree to participate in this study, please select the "yes" button below to proceed to the survey.

We encourage you to print this form and keep it for your records.

B. 3: Stage 2 Recruitment poster

UNIVERSITY of GUELPH

CHANGING LIVES
IMPROVING LIFE

1 in 300 chance to win $50!

Do you own a dog?

We want to know how well dog owners recognize and interpret different dog behaviours!

Please visit the survey at: http://fluidsurveys.com/s/caninebehaviour/

Participation involves completion of a 15 minute survey showing videos of different dog behaviours.

If you have any questions please contact PhD student, Hannah Flint, at flinth@uoguelph.ca

Must be at least 18 years of age and currently be the primary caregiver for a dog to participate

B. 4: Stage 2 Consent form

Expert and Owner Recognition of Canine Fear

You are asked to participate in a research study conducted by Dr. Lee Niel and Ms. Hannah Flint from the Department of Population Medicine at the Ontario Veterinary College, University of Guelph.

If you have any questions or concerns about this research, please feel free to contact
Dr. Niel at 519-824-4120 x53030 or niell@uoguelph.ca, or
Ms. Flint at flinth@uoguelph.ca

PURPOSE OF THE STUDY

Dogs often exhibit subtle behaviours that can be difficult to identify. In this study, we are trying to determine which behaviours regular dog owners are able to accurately identify from video clips. The Natural Sciences and Engineering Research Council of Canada (NSERC) has provided funding for this project

WHO CAN PARTICIPATE

- Currently a primary dog owner (defined as a senior household member who has a primary role in caring and paying for a dog)
- At least 18 years of age

PROCEDURES

You will be asked to watch a series of video clips of dogs, and then respond to questions about specific dog behaviours that you observed for each video. We anticipate the entire survey to take no more than 15 minutes. In appreciation for your time, you will be entered into a draw to win one of four $50 visa gift cards. Estimated chances of winning are 1 in 300.

POTENTIAL RISKS AND BENEFITS

This study poses no known physical risks to participants. You will be asked to view videos of dogs displaying fearful or aggressive behaviours which may be disturbing to some participants. **Every effort will be made to ensure confidentiality of any identifying information that is obtained in connection with this study.** Participant's email address will be recorded in order to contact them for lottery results. However, this information will be kept separately from survey responses and will be destroyed after the lottery draw. Survey responses will be anonymous and kept in either a locked file cabinet in a secure room, or on an encrypted and password protected computer. Responses will only be viewed and handled by members of the research team. Data will be kept for 10 years after which they will be destroyed. Please note that confidentiality cannot be guaranteed while data are in transit over the internet. If you are randomly selected as a winner of a gift card, it may be necessary to release participant names to university or granting agency financial auditors.

There are no direct benefits to participants from participation in this research. This project will benefit research and society as it will allow for the development of a targeted training tool for identifying fear and aggression in dogs, which may help in the identification of fearful dogs and prevent fear-related dog bites.

PARTICIPATION AND WITHDRAWAL

Participation in this study is completely voluntary. You may discontinue participation in the study at any time up until submission of your survey without consequence. You may also choose to skip any question in the survey without penalty. After submission your data cannot be removed as responses are anonymous. Contact Lee Niel or Hannah Flint by phone or email (see contact information above) if you have concerns or questions regarding participation or withdrawal from the survey.

RESEARCH RESULTS

If you would be interested in receiving the completed results of this study please select that option at the end of the survey with your email address.

RIGHTS OF RESEARCH PARTICIPANTS

You are not waiving any legal claims, rights or remedies because of your participation in this research study. If you have questions regarding your rights as a research participant, contact:

Director, Research Ethics
Telephone: (519) 824-4120, ext. 56606
E-mail: sauld@uoguelph.ca

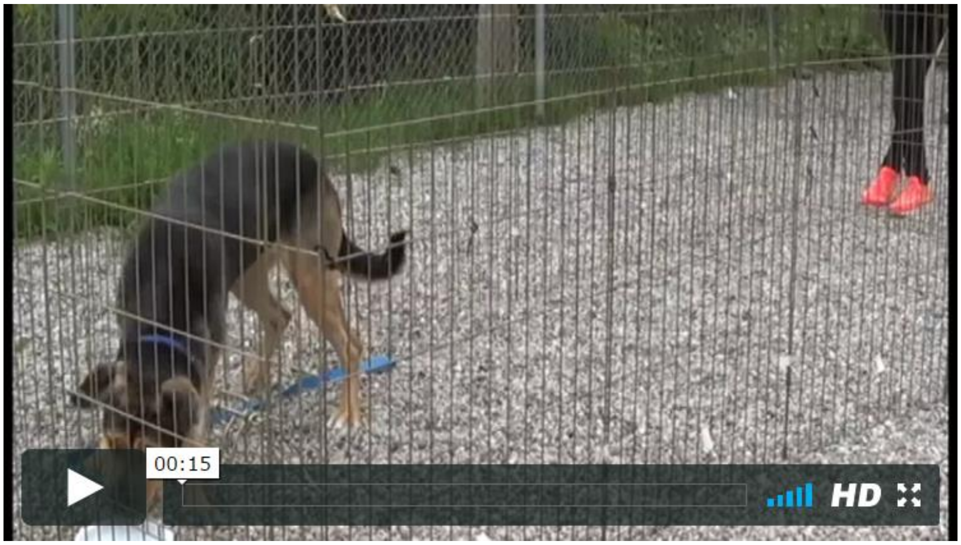
If you have read the above information and agree to participate in this study, please select the "yes" button below to proceed to the survey.

We encourage you to print this form and keep it for your records.

B. 5: Stage 1 & 2 Sample pages from survey

Please watch the video below focusing on overall posture and indicate which of the following behaviours and events occur.

If it is not possible to see whether a behaviour occurred please indicate "Don't know"
Note: There will be multiple pages with the same video asking you to focus on different behaviours.
Hover the cursor over the behaviour to see a definition



1

2 **Head Position**

	Yes	No	Don't Know
High	○	○	○
Neutral	○	○	○
Lowered	○	○	○

3

4

5

6 **Body Posture**

	Yes	No	Don't Know
Upright	○	○	○
Neutral	○	○	○
Lowered	○	○	○

7

Please watch the video below focusing on full body behaviours and indicate which of the following behaviours and events occur.

If it is not possible to see whether a behaviour occurred please indicate "Don't know"
Note: There will be multiple pages with the same video asking you to focus on different behaviours.
Hover the cursor over the behaviour to see a definition

[same video as above]

Body

	Yes	No	Don't Know
Freezing	○	○	○
Tap out, ie. inguinal exposure	○	○	○
Paw lift	○	○	○
Trembling	○	○	○
Attempts to hide, retreat, or escape	○	○	○
Lunging	○	○	○
Raised hackles, ie. piloerection	○	○	○
Body shake	○	○	○
Loose/Wiggly	○	○	○
Stiff	○	○	○

Please watch the video below focusing on the head and face and indicate which of the following behaviours and events occur.

If it is not possible to see whether a behaviour occurred please indicate "Don't know"
Note: There will be multiple pages with the same video asking you to focus on different behaviours.
Hover the cursor over the behaviour to see a definition

[same video as above]

Head

	Yes	No	Don't Know
Panting	○	○	○
Lolling tongue	○	○	○
Spatulate tongue	○	○	○
Yawning	○	○	○
Lip lick	○	○	○
Furrowed brow	○	○	○
Avoiding eye contact	○	○	○
Whale eye	○	○	○
Hard stare	○	○	○
Squinting	○	○	○
Corner of lips drawn back	○	○	○
Corner of lips pushed forward	○	○	○
Teeth bared	○	○	○
Snapping	○	○	○
Biting/Attempting to bite	○	○	○

	Yes	No	Don't Know
Ears back	○	○	○
Ears neutral	○	○	○
Ears pricked/forward	○	○	○

Please watch the video below focusing on the tail and vocalizations and indicate which of the following behaviours and events occur.

If it is not possible to see whether a behaviour occurred please indicate "Don't know"
Note: There will be multiple pages with the same video asking you to focus on different behaviours.
Hover the cursor over the behaviour to see a definition

[same video as above]

1 **Vocalizations**

	Yes	No	Don't Know
Whining/Whimpering	○	○	○
Growling	○	○	○
Snarling	○	○	○
Barking	○	○	○

2

3 **Tail**

	Yes	No	Don't Know
High	○	○	○
Neutral	○	○	○
Lowered	○	○	○
Tucked	○	○	○
Stiff	○	○	○
Wagging	○	○	○

4

B. 6: Stage 3 Recruitment email

Subject:
Expert assistance with upcoming research project - Ontario Veterinary College

Message body:
I am a PhD student at the University of Guelph. We are currently developing and validating a questionnaire aimed at assessing owner ability to recognize fear behaviours in dogs. This questionnaire will be used as a training tool in future dog temperament surveys. We are recruiting DACVB/CPDT-KA certified dog behaviour professionals to assist with developing and validating this identification tool via an online questionnaire. Your responses will be used as a 'gold standard' with which to compare the responses of our dog owner participants.

Please note the following:

-We anticipate this questionnaire to take approximately 15 minutes to complete
-In appreciation of your time, you will be entered into a draw for a $100 CAD visa gift card (odds of winning are approximately 1 in 50).
-All information provided will be kept confidential
-You will be asked to view videos of fearful dogs, which may be disturbing to some participants
-You will be re-contacted in one week with a reminder email if you have not completed the online survey

If you would like to participate, please go to the survey site by clicking on the link below

http://fluidsurveys.com/s/fearbehaviour/

If you have any questions or concerns, Dr. Lee Niel or Ms. Hannah Flint may be reached at:

Hannah Flint, PhD candidate

Department of Population Medicine
Ontario Veterinary College
University of Guelph
Guelph, ON, N1G 2W1

Email: flinth@uoguelph.ca

Lee Niel, PhD

Assistant Professor
Department of Population Medicine
Ontario Veterinary College
University of Guelph
Guelph, ON, N1G 2W1
Tel: 519-824-4120, Ext. 53030
Fax: 519-763-8621
Email: niell@uoguelph.ca

B. 7: Stage 3 Consent form

UNIVERSITY of GUELPH

Expert and Owner Recognition of Canine Fear

You are asked to participate in a research study conducted by Dr. Lee Niel and Ms. Hannah Flint from the Department of Population Medicine at the Ontario Veterinary College, University of Guelph.

If you have any questions or concerns about this research, please feel free to contact Dr. Niel at 519-824-4120 x53030 or niell@uoguelph.ca, or Ms. Flint at flinth@uoguelph.ca

Purpose of the study

Many studies looking at fear in dogs and risk factors for developing behavioural issues rely on owner reports of dog behaviour through questionnaires. In order to make sure these reports are accurate we first need to ensure that dog owners are able to correctly identify fearfulness in their dog. For the present study, we will be comparing dog owner responses to expert responses, which will be considered the 'gold standard'. The Natural Sciences and Engineering Research Council of Canada (NSERC) has provided funding for this project

Who can participate?

For the current expert survey we are recruiting participants that have achieved the CPDT-KA certifications from the Certification Council for Professional Dog Trainers (or DACVB certification from the American College of Veterinary Behaviourists).

Procedures

You will be asked to watch video clips of dog behaviour and respond with how you would rate that dog's level of fearfulness. We anticipate the time commitment to be about 10-15 minutes. In appreciation for your time, you will be entered into a lottery to receive a $100 CAD visa gift card (estimated odds of winning are 1 in 50).

Important information about potential risks and benefits

This study poses no known physical risks to participants. You will be asked to view videos of dogs displaying fearful behaviours which may be disturbing to some participants.

Every effort will be made to ensure confidentiality of any identifying information that is obtained in connection with this study. Participant's email address will be recorded in order to contact them for lottery results. However, this information will be kept separately from survey responses and will be destroyed after the lottery draw. Survey responses will be anonymous and kept in either a locked file cabinet in a secure room, or on an encrypted and password protected computer. Responses will only be viewed and handled by members of the research team. Data will be kept for 10 years after which they will be destroyed. Please note that confidentiality cannot be guaranteed while data are in transit over the internet. If you are randomly selected as a winner of a gift card, it may be necessary to release participant names to university or granting agency financial auditors.

There are no direct benefits to you from participating in this research. This project will benefit research and society as it will allow for the development of a targeted training tool for identifying fear in dogs, which may help in the identification of fearful dogs and prevent fear-related dog bites.

Participation and withdrawal

Participation in this study is completely voluntary. You may discontinue participation in the study at any time up until submission of your survey without consequence. You may also choose to skip any question in the survey without penalty. After submission your data cannot be removed as responses are anonymous. Contact Lee Niel or Hannah Flint by phone or email (see contact information above) if you have concerns or questions regarding participation or withdrawal from the survey.

Research Results

If you would be interested in receiving the completed results of this study please select that option at the end of the survey with your email address.

Rights of research participants

You are not waiving any legal claims, rights or remedies because of your participation in this research study. If you have questions regarding your rights as a research participant, contact:

Director, Research Ethics
Telephone: (519) 824-4120, ext. 56606
E-mail: sauld@uoguelph.ca

If you have read the above information and agree to participate in this study, please select the "yes" button below to proceed to the survey.

We encourage you to print this form and keep it for your records.

B. 8: Stage 4 Recruitment poster

UNIVERSITY of GUELPH

CHANGING LIVES IMPROVING LIFE

1 in 300 chance to win $50!

Do you own a dog?

We want to know how well dog owners recognize and report fearfulness in dogs!

Please visit the survey at: http://fluidsurveys.com/s/OwnerFearRecognition/

Participation involves completion of a 20 minute survey with questions about your dog and videos of fearful dogs.

If you have any questions please contact PhD student, Hannah Flint, at flinth@uoguelph.ca

Must be at least 18 years of age and currently be the primary caregiver for a dog to participate

B. 9: Stage 4 Consent form

UNIVERSITY of GUELPH

Expert and Owner Recognition of Canine Fear

You are asked to participate in a research study conducted by Dr. Lee Niel and Ms. Hannah Flint from the Department of Population Medicine at the Ontario Veterinary College, University of Guelph.

If you have any questions or concerns about this research, please feel free to contact
Dr. Niel at 519-824-4120 x53030 or niell@uoguelph.ca, or Ms. Flint at flinth@uoguelph.ca

Purpose of the study

Dogs often exhibit subtle behaviours that can be difficult to identify. In this study, we are trying to determine whether dog owners can correctly categorize the level of fear that dogs are displaying in video clips. The Natural Sciences and Engineering Research Council of Canada (NSERC) has provided funding for this project

Who can participate?

- Currently a primary dog owner (defined as a senior household member who has a primary role in caring and paying for a dog)
- At least 18 years of age

Procedures

You will be asked to watch a series of video clips of dogs, and to rate the fear level of each dog. We anticipate the entire survey to take no more than 20 minutes. In appreciation for your time, you will be entered into a draw to win one of four $50 CAD visa gift cards. Estimated chances of winning are 1 in 300.

Important information about potential risks and benefits

This study poses no known physical risks to participants. You will be asked to view videos of dogs displaying fearful behaviours which may be disturbing to some participants. **Every effort will be made to ensure confidentiality of any identifying information that is obtained in connection with this study.** Participant's email address will be recorded in order to contact them for lottery results. However, this information will be kept separately from survey responses and will be destroyed after the lottery draw. Survey responses will be anonymous and kept in either a locked file cabinet in a secure room, or on an encrypted and password protected computer. Responses will only be viewed and handled by members of the research team. Data will be kept for 10 years after which they will be destroyed. Please note that confidentiality cannot be guaranteed while data are in transit over the internet. If you are randomly selected as a winner of a gift card, it may be necessary to release participant names to university or granting agency financial auditors.

Possible benefits of this study include the provision of training on fear behaviours in dogs, which will help the participant better understand the emotional state of their own dog. This project will benefit research and society as it will allow for the development of a targeted training tool for identifying fear in dogs, which may help in the identification of fearful dogs and prevent fear-related dog bites.

Participation and withdrawal

Participation in this study is completely voluntary. You may discontinue participation in the study at any time up until submission of your survey without consequence. You may also choose to skip any question in the survey without penalty. After submission your data cannot be removed as responses are anonymous. Contact Lee Niel or Hannah Flint by phone or email (see contact information above) if you have concerns or questions regarding participation or withdrawal from the survey.

Research Results

If you would be interested in receiving the completed results of this study please select that option at the end of the survey with your email address.

Rights of research participants

You are not waiving any legal claims, rights or remedies because of your participation in this research study. If you have questions regarding your rights as a research participant, contact:

Director, Research Ethics
Telephone: (519) 824-4120, ext. 56606
E-mail: sauld@uoguelph.ca

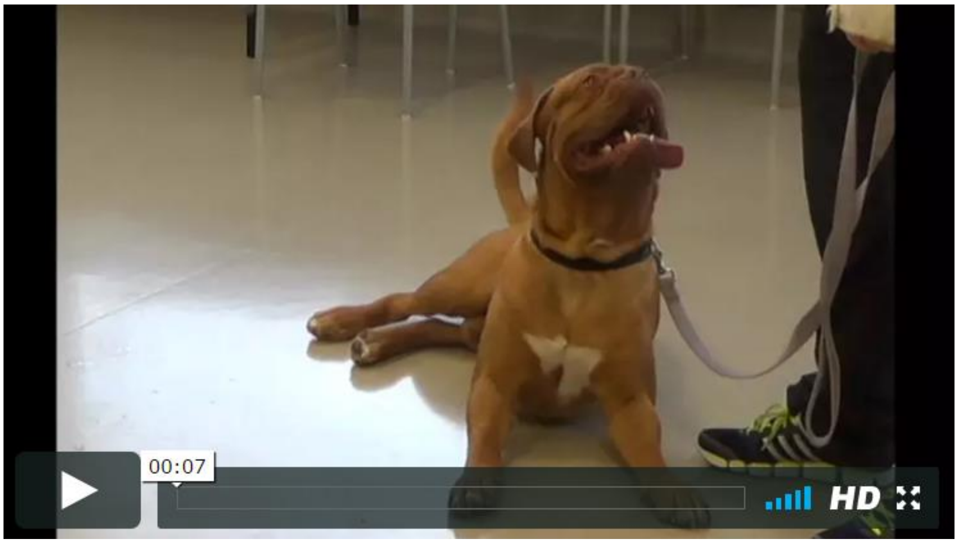
If you have read the above information and agree to participate in this study, please select the "yes" button below to proceed to the survey.

We encourage you to print this form and keep it for your records.

B. 10: Stage 3 & 4 Sample page from survey

Please watch the video below and indicate how much fear the dog is experiencing.

Typical signs of mild to moderate fear include: lowered posture with tail lowered and ears back, lip licking, panting, yawning, avoiding eye contact, avoidance of the feared object. Extreme fear is characterized by crouching or cowering, and/or vigorous attempts to escape, retreat or hide from the feared object, person or situation.



How much fear do you feel this dog is experiencing?

0=No fear, 1-2=Mild to Moderate fear, 3-4=High to Extreme fear

◉ **0** ○ **1** ○ **2** ○ **3** ○ **4**

B. 11: Fear training tool

How to identify fear in dogs:

Dogs have many ways in which they give information about their emotional state. We will go over some of the most important and easily recognized signs of fear. When trying to determine if a dog is fearful just remember PET-B:

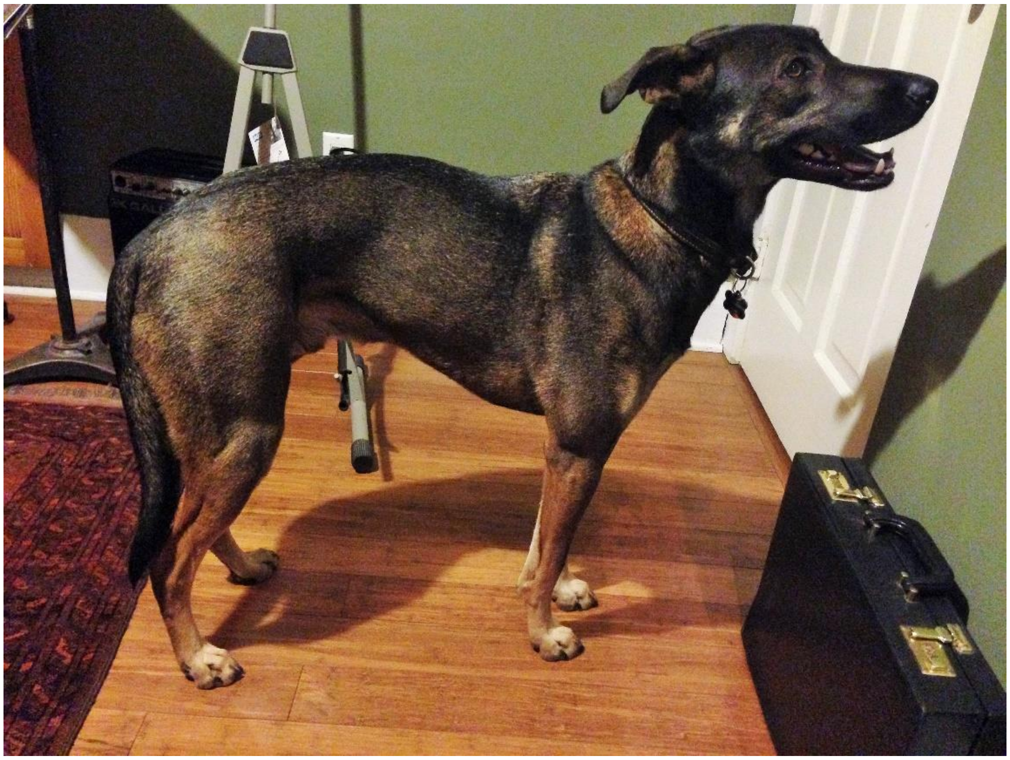
P- Posture
E- Ear position
T- Tail position
B- Behavioural signs

Posture

Dogs convey a lot of information through their posture. When dogs are relaxed they will stand with weight evenly distributed over their legs and without muscle tension. This is called a neutral posture and is shown in the picture below:

When a dog is alert, aroused or aggressive they may try to make themselves appear larger. They stand tall and upright as if on their tiptoes. You can often recognize this posture as the back seems to slope upwards towards the head and the front legs angle forwards as if the dog if leaning against an invisible leash. An example of a dog in this upright posture is shown below:

Lastly when a dog is fearful, or submissive they will try to make themselves appear smaller. This lowered posture is characterized by an arched back. A dog experiencing extreme fear may also bend the legs into a crouched or cowering posture. An example of a dog with a slightly lowered posture is shown below:

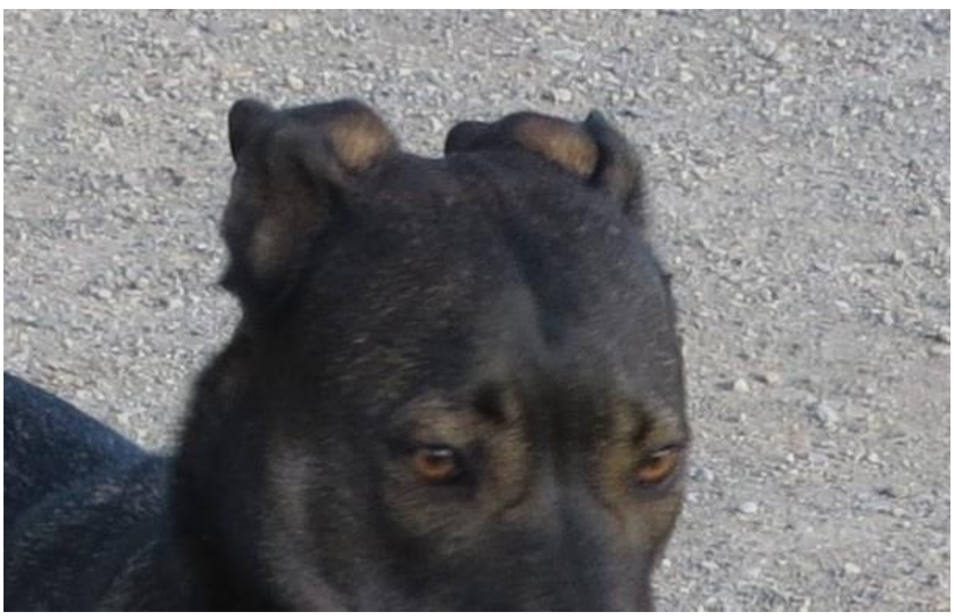


Ear Position

The ears can also convey information about the dog's emotional state. If the ears are pulled back the dog is stressed or fearful. If the dog is experiencing extreme fear the ears may by pinned back against the head. A dog not experiencing fear will have ears in a neutral to forward position.

A dog with neutral ear position is shown below:

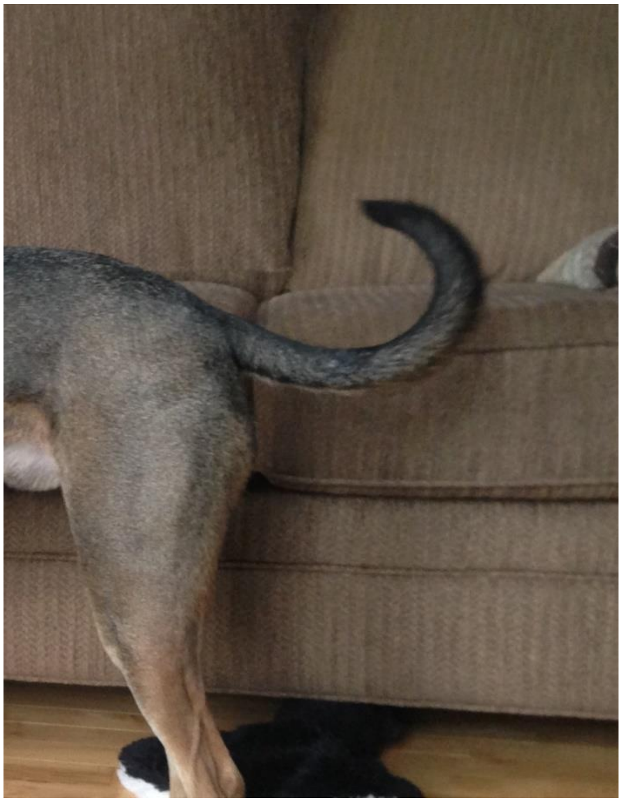
A dog with their ears back is shown below:



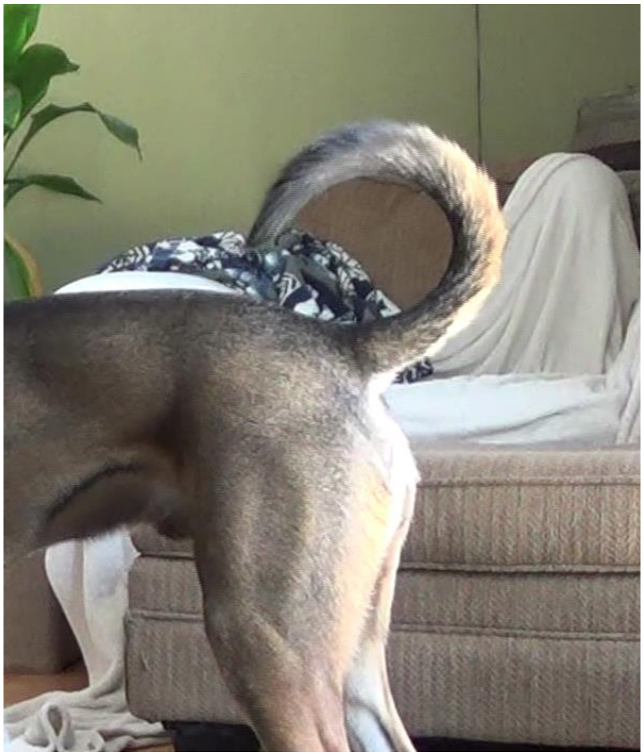
Tail Position

Dogs also communicate through their tail. Tail carriage can vary significantly between dog breeds and individuals, so it is important to compare to the dog's normal tail carriage. Some dogs have tails that naturally curl, so make sure you pay attention to the position of the base of the tail.

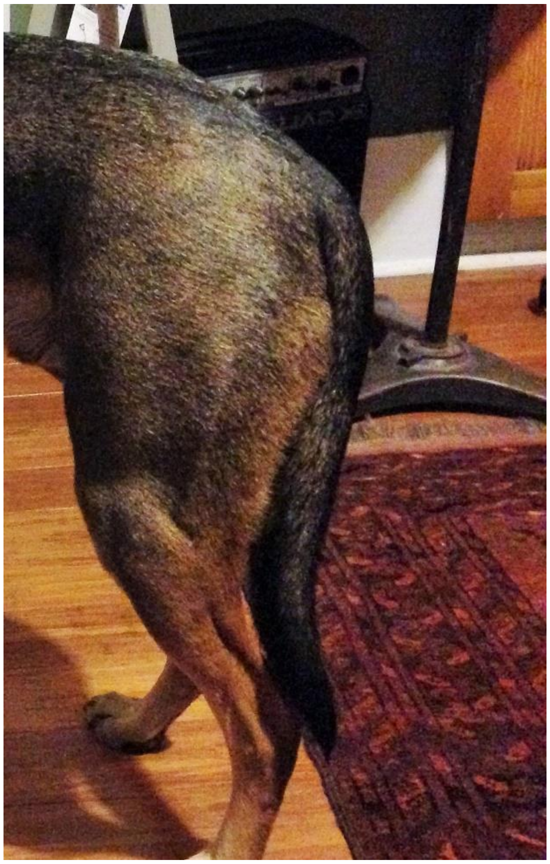
A dog that is relaxed will have the base of the tail in a range anywhere from level with the dog's back to almost straight down towards the ground. A dog with a relaxed, neutral tail position can be seen below:



An aroused, alert or aggressive dog will have their tail raised above the line of the dog's back, as shown in the picture below:



Lastly, a fearful dog will have the tail lowered to hang straight down between the back legs, or if experiencing more extreme fear the tail may be tucked up towards the dog's belly. Below is a picture of a tail in a lowered position:



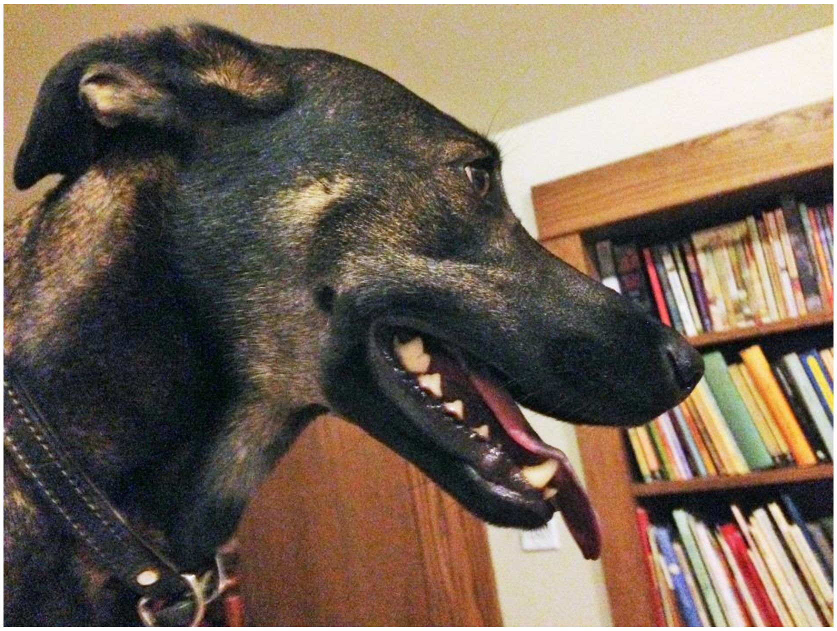
While a wagging tail is often thought to indicate a happy dog this is not always the case. A dog may wag his tail for a variety of reasons including in excitement, aggression and fear. A wagging tail should not be used to judge a dog's mood.

Behavioural Signs

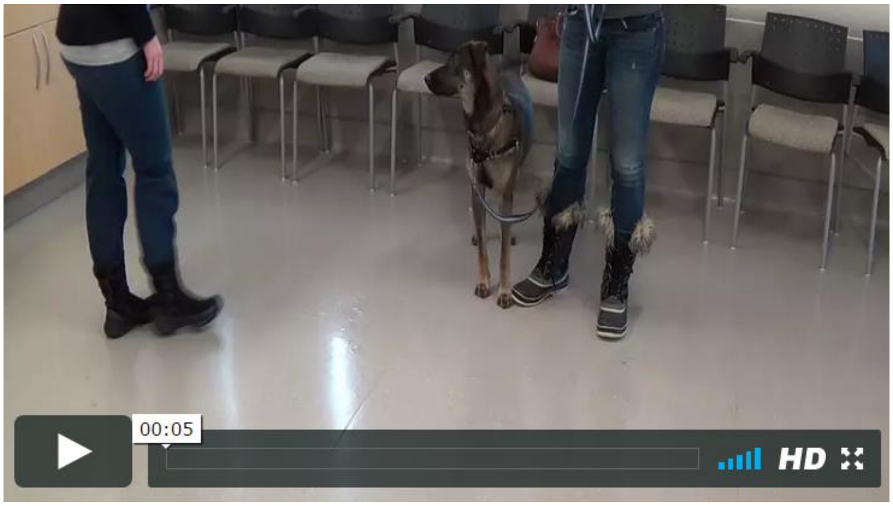
There are a number of behavioural signs of fear in dogs other than posture.

If the dog is panting when not over-heated or exercised they are likely stressed. A relaxed dog's tongue may "loll" out the side of the mouth without any muscle tension, while a stressed dog's tongue will be tense and may stick straight out of the mouth, or even curl upwards.

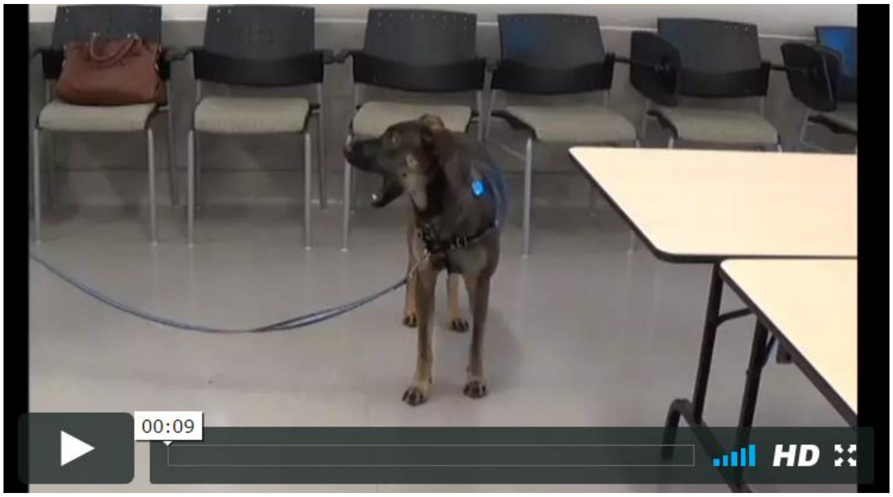
Below is a picture of a dog panting with a lolling tongue, followed by a picture of a stressed dog with tension in the tongue while panting.



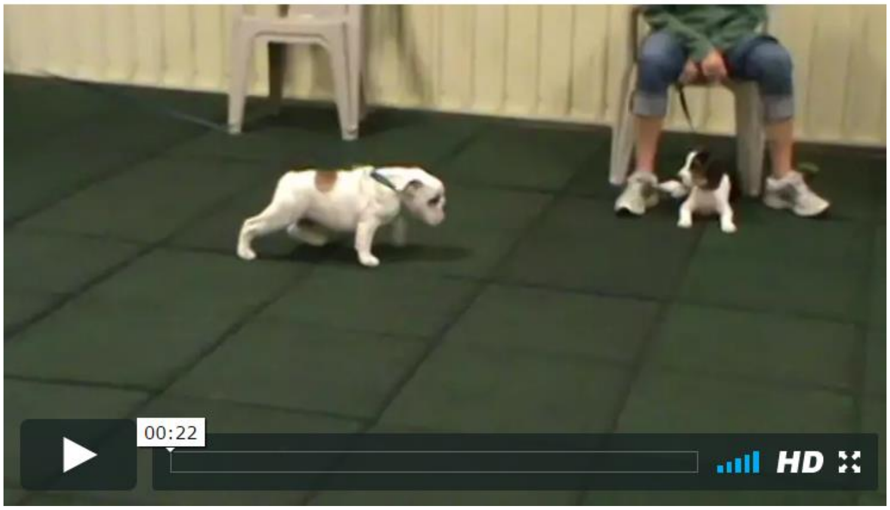
Another sign of fear in dogs is lip licking. This is a rapid movement of the tongue to lick the dog's lips, often towards the nose. This is notable when performed when not in the presence of food. See the video below for an example of a dog lip licking:



Dogs will often give an exaggerated yawn when stressed or fearful. See below for a video example of a dog giving a stress yawn:



One of the most obvious signs that a dog is fearful is if they are trying to avoid the situation. This may be obvious, such as trying to hide, escape or retreat. An example of a dog trying to escape from an object that frightened him is shown in the video below:



Dog's may also show avoidance in subtle ways, such as avoiding eye contact. When this is happening the dog may glance quickly at the individual they are afraid of, but will not hold their gaze. A video example of a dog showing this behaviour is shown below:

Putting it all together:

No Fear (shown below):

- P: Posture neutral to upright
- E: Ears neutral to forward
- T: Tail neutral to high
- B: Lack of behavioural sign of fear

Mild to moderate fear (shown below):

- P: Posture lowered
- E: Ears back
- T: Tail lowered
- B: Lip licking, panting, yawning, attempts to hide, escape or retreat and/or avoiding eye contact.

High to extreme fear:

- P: Crouching/cowering
- E: Ears back or pinned
- T: Tail tucked
- B: Vigorous attempts to hide, escape or retreat and/or any of the signs of mild to moderate fear


Ears Back
Cowering
Lip Lick
Hiding/Retreating
Tail Tucked
*Also look for other signs of mild/moderate fear

APPENDIX C

Stranger-directed aggression in pet dogs: Owner, environment, training and dog associated risk factors

C. 1: Recruitment poster
C. 2: Consent form
C. 3: Survey

C. 1: Recruitment poster

UNIVERSITY of GUELPH

CHANGING LIVES
IMPROVING LIFE

1 in 500 chance to win $100!

Do you own a dog?

We want to know what factors may influence your dog's response in different situations!

Please visit the survey at:

http://bit.ly/dogbehavioursurvey

Participation involves completion of a 30-40 minute survey with questions about you and your dog

If you have any questions please contact PhD student, Hannah Flint, at flinth@uoguelph.ca

Must be at least 18 years of age and currently be the primary caregiver for a dog to participate

C. 2: Consent form

Risk Factors for Developing Fear and Aggression in Dogs

You are asked to participate in a research study conducted by Dr. Lee Niel and Ms. Hannah Flint from the Department of Population Medicine at the Ontario Veterinary College, University of Guelph.

If you have any questions or concerns about this research, please feel free to contact
Dr. Niel at 519-824-4120 x53030 or niell@uoguelph.ca, or
Ms. Flint at flinth@uoguelph.ca

PURPOSE OF THE STUDY

Dog fear and aggression is a safety concern both for humans and animals, and can lead to decreased animal welfare in affected dogs. In this study, we are trying to determine which factors are associated with fearfulness and related aggression in dogs. Ultimately we are looking to develop strategies to prevent dog fear and aggression. The Natural Sciences and Engineering Research Council of Canada (NSERC) has provided funding for this project

WHO CAN PARTICIPATE

- Currently a primary dog owner (defined as a senior household member who has a primary role in caring and paying for a dog)
- At least 18 years of age

PROCEDURES

You will be asked to answer a series of questions relating to yourself, your household, and your dog. We anticipate the entire survey to take approximately 30-40 minutes. In appreciation for your time, you will be entered into a draw to win one of six $100 visa gift cards. Estimated chances of winning are 1 in 500.

POTENTIAL RISKS AND BENEFITS

This study poses no known physical risks to participants. **Every effort will be made to ensure confidentiality of any identifying information that is obtained in connection with this study.** Identifying information will be obtained and kept separately from questionnaire responses – at no time will identifying information be linked to the data. All data will be stored on a password-protected computer in a locked room. Only the researchers will have access to this information. Email addresses will be collected to be able to contact the winner of the lottery draw and information will be destroyed after a winner is selected. Data will be kept for 10 years after which they will be destroyed. Please note that confidentiality cannot be guaranteed while data are in transit over the internet. If you are randomly selected as a winner of a gift card, it may be necessary to release participant names to university or granting agency financial auditors.

Some questions will ask about your personality, anxiety levels, relationship with your dog, and how you train and interact with your dog, which may cause you embarrassment or anxiety. However, all questions are optional, and your results will be anonymous.
There are no direct benefits to participants from participation in this research. This project will benefit society as it will provide a greater understanding of risk factors for fear and aggression, which can lead to the identification of dogs at risk of developing behavioural issues. This will aid the implementation of preventative strategies and may lead to a reduction in dog bites.

PARTICIPATION AND WITHDRAWAL

Participation in this study is completely voluntary. You may discontinue participation in the study at any time up until submission of your survey without consequence. You may also choose to skip any question in the survey without penalty. After submission your data cannot be removed as responses are anonymous. Contact Lee Niel or Hannah Flint by phone or email (see contact information above) if you have concerns or questions regarding participation or withdrawal from the survey.

RESEARCH RESULTS

If you would be interested in receiving the completed results of this study please select that option at the end of the survey with your email address.

RIGHTS OF RESEARCH PARTICIPANTS

You are not waiving any legal claims, rights or remedies because of your participation in this research study. If you have questions regarding your rights as a research participant, contact:

Director, Research Ethics
Telephone: (519) 824-4120, ext. 56606
E-mail: sauld@uoguelph.ca

This project has been reviewed by the University of Guelph Research Ethics Board for compliance with federal guidelines for research involving human participants (REB #).

If you have read the above information and agree to participate in this study, please select the "yes" button below to proceed to the survey.

We encourage you to print this form and keep it for your records.

C. 3: Survey

Thank you for your interest in our survey!

Are you over 18 years old?
- Yes
- No

Do you currently own a dog?
- Yes
- No

Please fill out this survey for a dog you currently own. If you have multiple dogs please complete the survey for the dog with a name closest to the beginning of the alphabet. At the end of this survey you will have the opportunity to answer questions about your other dogs. Each survey completed will give you an additional entry into the bonus draw.

For each of the statements below, please mark the box that most accurately describes your level of agreement. The answer should reflect the general personality of your dog. For example, if a statement applies to your dog in some situations but not others, please make a judgement as to how much you agree.

	Strongly Agree	Mostly Agree	Partly agree, partly disagree	Mostly Disagree	Strongly Disagree	Don't Know
My dog shows extreme physical signs when excited (e.g. drooling, panting, raising hackles, urination, licking lips, widening of eyes).	❍	❍	❍	❍	❍	❍
When my dog gets very excited it can lead to fixed repetitive behaviour (i.e. an action that is repeated in the same way over and over again) such as tail chasing or spinning around in circles.	❍	❍	❍	❍	❍	❍
I would consider my dog to be very impulsive (i.e. has sudden, strong urges to act; acts without forethought, acts without considering effects of actions).	❍	❍	❍	❍	❍	❍
My dog becomes aggressive (e.g. growl, snarl, snap, bite) when excited.	❍	❍	❍	❍	❍	❍
My dog does not think before it acts (e.g. would steal food without first looking to see if someone is watching).	❍	❍	❍	❍	❍	❍
My dog can be very persistent (e.g. will continue to do something even if it knows it will get punished or told off).	❍	❍	❍	❍	❍	❍
My dog may become aggressive (e.g. growl, snarl, snap, bite) if frustrated with something.	❍	❍	❍	❍	❍	❍
My dog calms down very quickly after being excited.	❍	❍	❍	❍	❍	❍
My dog appears to have a lot of control over how it responds.	❍	❍	❍	❍	❍	❍
My dog is not very patient (e.g. gets agitated waiting for its food, or waiting to go out for a walk).	❍	❍	❍	❍	❍	❍
My dog seems to get excited for no reason.	❍	❍	❍	❍	❍	❍
My dog doesn't like to be approached or hugged.	❍	❍	❍	❍	❍	❍
My dog appears to be 'sorry' after it has done something wrong.	❍	❍	❍	❍	❍	❍
My dog is easy to train.	❍	❍	❍	❍	❍	❍
My dog takes a long time to lose interest in new things.	❍	❍	❍	❍	❍	❍
My dog reacts very quickly.	❍	❍	❍	❍	❍	❍
My dog is very interested in new things and new places.	❍	❍	❍	❍	❍	❍
My dog is not keen to go into new situations.	❍	❍	❍	❍	❍	❍

In the following sections we are going to ask you to watch videos and rate the level of aggression or fear you feel the dog is displaying. There are 12 videos in total. You may watch each video multiple times.

Please watch the videos below and indicate how much aggression the dog is expressing. Typical signs of mild to moderate aggression in dogs include threatening behaviours, such as barking, growling and baring teeth. More serious aggression generally includes snapping, lunging, biting or attempting to bite.

[Videos of dogs displaying varying levels of aggression displayed here x3]

How much aggression do you feel this dog is expressing? 0=No aggression, 1-3=Mild to Moderate aggression, 4=Serious aggression

- ❍ 0
- ❍ 1
- ❍ 2
- ❍ 3
- ❍ 4

Please watch the videos below and indicate how much fear the dog is experiencing.   Typical signs of mild to moderate fear include: lowered posture with tail lowered and ears back, lip licking, panting, yawning, avoiding eye contact, avoidance of the feared object. Extreme fear is characterized by crouching or cowering, and/or vigorous attempts to escape, retreat or hide from the feared object, person or situation.

[Videos of dogs displaying varying levels of fear displayed here x9]

How much fear do you feel this dog is experiencing?0=No fear, 1-2=Mild to Moderate fear, 3-4=High to Extreme fear

- ❍ 0
- ❍ 1
- ❍ 2
- ❍ 3
- ❍ 4

For the following questions please rate your dog's AVERAGE response during the past three months in each of the given situations. For example, if your dog's reaction varies within a given situation, please make a judgement as to the severity of your dog's most typical reaction.

Aggression

Some dogs display aggressive behaviour from time to time. Typical signs of moderate aggression in dogs include barking, growling and baring teeth. More serious aggression generally includes snapping, lunging, biting, or attempting to bite. Using the following 5-point scale (0 = No aggression, 4 = Serious aggression), please indicate your dog's recent tendency to display aggressive behaviours in each of the following contexts:

	0	1	2	3	4	Not Observed
When verbally corrected or punished (scolded, shouted at, etc) by you or a household member	❍	❍	❍	❍	❍	❍
When approached directly by an unfamiliar adult while being walked/exercised on a leash	❍	❍	❍	❍	❍	❍
When approached directly by an unfamiliar child while being walked/exercised on a leash	❍	❍	❍	❍	❍	❍
Toward unfamiliar persons approaching the dog while s/he is in your car (at the gas station for example)	❍	❍	❍	❍	❍	❍
When toys, bones or other objects are taken away by a household member	❍	❍	❍	❍	❍	❍
When bathed or groomed by a household member	❍	❍	❍	❍	❍	❍
When an unfamiliar person approaches you or another member of your family at home	❍	❍	❍	❍	❍	❍
When unfamiliar persons approach you or another member of your family away from your home	❍	❍	❍	❍	❍	❍
When approached directly by a household member while s/he (the dog) is eating	❍	❍	❍	❍	❍	❍
When mailmen or other delivery workers approach your home	❍	❍	❍	❍	❍	❍
When his/her food is taken away by a household member	❍	❍	❍	❍	❍	❍
When strangers walk past your home while your dog is outside or in the yard	❍	❍	❍	❍	❍	❍
When an unfamiliar person tries to touch or pet the dog	❍	❍	❍	❍	❍	❍
When joggers, cyclists, rollerbladers or skateboarders pass your home while your dog is outside or in the yard	❍	❍	❍	❍	❍	❍
When approached directly by an unfamiliar male dog while being walked/exercised on a leash	❍	❍	❍	❍	❍	❍
When approached directly by an unfamiliar female dog while being walked/exercised on a leash	❍	❍	❍	❍	❍	❍
When stared at directly by a member of the household	❍	❍	❍	❍	❍	❍
Toward unfamiliar dogs visiting your home	❍	❍	❍	❍	❍	❍
Toward cats, squirrels or other small animals entering your yard	❍	❍	❍	❍	❍	❍
Toward unfamiliar persons visiting your home	❍	❍	❍	❍	❍	❍
When barked, growled, or lunged at by another (unfamiliar) dog	❍	❍	❍	❍	❍	❍
When stepped over by a member of the household	❍	❍	❍	❍	❍	❍
When you or a household member retrieves food or objects stolen by the dog	❍	❍	❍	❍	❍	❍

Towards another (familiar) dog in your household (select not observed if no other dogs)	❍	❍	❍	❍	❍	❍
When approached at a favorite resting/sleeping place by another (familiar) household dog (select not observed if no other dogs)	❍	❍	❍	❍	❍	❍
When approached while eating by another (familiar) household dog (select not observed if no other dogs)	❍	❍	❍	❍	❍	❍
When approached while playing with/chewing a favorite toy, bone, object, etc., by another (familiar) household dog (select not observed if no other dogs)	❍	❍	❍	❍	❍	❍

Fear & Anxiety

Dogs sometimes show signs of anxiety or fear when exposed to particular sounds, objects, persons or situations. Typical signs of mild to moderate fear include: lowered posture with tail lowered and ears back, lip licking, panting, yawning, avoiding eye contact, and avoidance of the feared object. Extreme fear is characterized by crouching or cowering, and/or vigorous attempts to escape, retreat or hide from the feared object, person or situation. Using the following 5-point scale (0 = No fear, 4 = Extreme fear), please indicate your dog's recent tendency to display fearful behaviours in each of the following contexts:

	0	1	2	3	4	Not Observed
When approached directly by an unfamiliar adult while away from your home	❍	❍	❍	❍	❍	❍
When approached directly by an unfamiliar child while away from your home	❍	❍	❍	❍	❍	❍
In response to sudden or loud noises (e.g. vacuum cleaner, car backfire, road drills, objects being dropped, etc.)	❍	❍	❍	❍	❍	❍
When unfamiliar persons visit your home	❍	❍	❍	❍	❍	❍
When an unfamiliar person tries to touch or pet the dog	❍	❍	❍	❍	❍	❍
In heavy traffic	❍	❍	❍	❍	❍	❍
In response to strange or unfamiliar objects on or near the sidewalk (e.g. plastic trash bags, leaves, litter, flags flapping, etc.	❍	❍	❍	❍	❍	❍
When examined/treated by a veterinarian	❍	❍	❍	❍	❍	❍
During thunderstorms, firework displays, or similar events	❍	❍	❍	❍	❍	❍
When approached directly by an unfamiliar dog of the same or larger size	❍	❍	❍	❍	❍	❍
When approached directly by an unfamiliar dog of a smaller size	❍	❍	❍	❍	❍	❍
When first exposed to unfamiliar situations (e.g. first car trip, first time in elevator, first visit to veterinarian, etc.)	❍	❍	❍	❍	❍	❍
In response to wind or wind-blown objects	❍	❍	❍	❍	❍	❍
When having nails clipped by a household member	❍	❍	❍	❍	❍	❍
When groomed or bathed by a household member	❍	❍	❍	❍	❍	❍
When having his/her feet toweled by a member of the household	❍	❍	❍	❍	❍	❍
When unfamiliar dogs visit your home	❍	❍	❍	❍	❍	❍
When barked, growled, or lunged at by an unfamiliar dog	❍	❍	❍	❍	❍	❍

Do you feel your dog's behaviour is currently better or worse than it was last year? (A score of 0 indicates no change)

______ Fear/Anxiety

______ Aggression

Dog characteristics

What is your dog's sex?
- ❍ Male
- ❍ Female

Is your dog spayed/neutered?
- ❍ Yes
- ❍ No

At what age was your dog spayed/neutered? (leave blank if not known)

___ Years

___ Months

___ Weeks

Why did you choose to spay/neuter your dog?
- ❍ Birth control
- ❍ Correct behaviour problems
- ❍ Prevent behaviour problems
- ❍ Correct health problems
- ❍ Prevent health problems
- ❍ Recommended by vet
- ❍ Required by breeder/shelter
- ❍ Unknown

Did your dog experience a heat before being spayed?
- ❍ Yes
- ❍ No
- ❍ Don't Know

Has your dog ever had a litter?
- ❍ Yes
- ❍ No
- ❍ Don't Know

Has your dog ever bred a female?
- ❍ Yes
- ❍ No
- ❍ Don't Know

Dog breed: [drop down list of dog breeds]

What is your dog's weight (in pounds)?

Dog's current age (approximate, if unknown):
Years _______
Months _______

What age was your dog when you acquired him/her (approximate, if unknown):
Years _______
Months _______
Weeks _______

Where did you acquire your dog from?
❍ Breeder
❍ Pet store
❍ Rescue (e.g. breed-specific or foster group rescue)
❍ Shelter
❍ Free-roaming stray
❍ Family or friend
❍ Other, please specify ____________________

Does your dog currently have any acute (temporary) medical issues?
❍ Yes
❍ No

Does your dog currently have any chronic (long-term) medical issues?
❍ Yes
❍ No

Do these issues affect any of the following systems/organs
❑ Gastrointestinal issues (e.g. diarrhea, vomiting)
❑ Musculoskeletal issues (e.g. hip displasia, ruptured cruciate ligament, lameness)
❑ Skin condition (e.g. allergies, dermatitis)
❑ Metabolic/Endocrine issues (e.g. diabetes, hypothyroidism)
❑ Neurological issues (e.g. epilepsy, wobblers)
❑ Condition causing chronic pain
❑ Poor vision
❑ Poor hearing
❑ Other (please specify): ____________________

Is your dog currently on any medications (excluding preventatives such as flea/tick medications)?
❍ Yes
❍ No

What are these medications?

Socialization

Please answer these questions about the time between when you got your puppy and when they turned 6 months (24 weeks) of age.

Please indicate how frequently you exposed your puppy to the following situations:

	Never	Less than once a month	1-2 times a month	Once a week	2-3 times a week	Daily
Walked on leash	❍	❍	❍	❍	❍	❍
Walked off-leash	❍	❍	❍	❍	❍	❍
Exposed to heavy traffic	❍	❍	❍	❍	❍	❍
Went to off-leash dog parks	❍	❍	❍	❍	❍	❍
Interacted with unfamiliar dogs on-leash	❍	❍	❍	❍	❍	❍
Had play dates with familiar dogs	❍	❍	❍	❍	❍	❍
Went to doggie daycare	❍	❍	❍	❍	❍	❍
Interacted with cats	❍	❍	❍	❍	❍	❍
Interacted with other animals (e.g. livestock, horses)	❍	❍	❍	❍	❍	❍
Interacted with children (12 and under)	❍	❍	❍	❍	❍	❍
Interacted with teenagers (13 to 18)	❍	❍	❍	❍	❍	❍
Interacted with unfamiliar adults	❍	❍	❍	❍	❍	❍
Exposed to people with wheelchairs/canes/walkers	❍	❍	❍	❍	❍	❍
Exposed to large crowds of people (e.g. fair/festival)	❍	❍	❍	❍	❍	❍
Exposed to people on bicycles/skateboards/rollerskates	❍	❍	❍	❍	❍	❍
Exposed to sudden/loud noises (e.g. vacuum clear, dropped objects)	❍	❍	❍	❍	❍	❍
Exposed to fireworks/thunderstorms	❍	❍	❍	❍	❍	❍
Exposed to strange/unfamiliar objects	❍	❍	❍	❍	❍	❍
Went to pet store	❍	❍	❍	❍	❍	❍
Went to the vet office	❍	❍	❍	❍	❍	❍
Practiced nail trimming/handling feet	❍	❍	❍	❍	❍	❍
Practiced brushing teeth/handling mouth	❍	❍	❍	❍	❍	❍
Practiced grooming	❍	❍	❍	❍	❍	❍
Practiced bathing	❍	❍	❍	❍	❍	❍

On average, how did your puppy react to meeting new people?
Scared = may avoid the interaction, bark, whine, shake, or crouch with a tucked tail
Indifferent = neither scared nor excited; passive interaction
Excited = may move towards the person, seems alert and interested in the interaction

- ❍ Scared
- ❍ Indifferent
- ❍ Excited
- ❍ Don't Know

On average, how did your puppy react to meeting new dogs?
Scared = may avoid the interaction, bark, whine, shake, or crouch with a tucked tail
Indifferent = neither scared nor excited; passive interaction
Excited = may move towards the dog, seems alert and interested in the interaction

- ❍ Scared
- ❍ Indifferent
- ❍ Excited
- ❍ Don't Know

On average, how did your puppy react to being exposed to new environments and situations?
Scared = may avoid the interaction, bark, whine, shake, or crouch with a tucked tail
Indifferent = neither scared nor excited; passive interaction
Excited = may explore the environment, seems alert and interested in surroundings

- ❍ Scared
- ❍ Indifferent
- ❍ Excited
- ❍ Don't Know

Training

Have you ever participated in a professional dog training class with your dog?
- ❍ Yes
- ❍ No

What types of training have you completed with your dog? (Select all that apply)
- ❑ Socialization
- ❑ Puppy class
- ❑ Basic obedience
- ❑ Agility
- ❑ Advanced obedience
- ❑ Protection work
- ❑ Other (please specify): ____________________

What types of behaviours have you trained your dog to perform? (Select all that apply)
- ❑ Sit
- ❑ Down
- ❑ Stay
- ❑ Come
- ❑ Watch me/attention/focus
- ❑ Tricks
- ❑ Basic manners (not jumping up when greeting etc.)
- ❑ Relax/settle

How many hours do you currently spend actively training your dog (introducing new behaviours, or practicing existing commands) in an average week? _____

Do you use a "nothing in life is free" approach with your dog? (i.e. the dog must sit before they are given food, etc.)
- ❍ Yes
- ❍ No
- ❍ Unsure

What methods do you primarily use for training your dog? (Select all that apply)

- ❑ Give treats for correct responses
- ❑ Give verbal and/or physical praise for correct responses
- ❑ Give toy/play for correct responses
- ❑ Ignore correct responses
- ❑ Ignore incorrect responses
- ❑ Verbal reprimand for incorrect responses
- ❑ Leash correction (i.e. 'popping' or 'jerking' the leash) for incorrect responses
- ❑ Smacking for incorrect responses
- ❑ Time out for incorrect responses
- ❑ Other reward for correct responses (please specify): ____________________
- ❑ Other correction for incorrect responses (please specify): ____________________
- ❑ Other (please specify): ____________________
- ❑ Unsure/Don't remember

Do you, or have you ever, used any of the following training aids with this dog on a regular basis? (Select all that apply)

- ❑ Head halter (e.g. gentle leader, halti)
- ❑ No-pull harness (e.g. front clip, sporn)
- ❑ Prong collar
- ❑ Shock collar
- ❑ Vibration collar
- ❑ Bark/spray collar
- ❑ Choke chain
- ❑ Pheromones (e.g. aerosol, collar etc.)
- ❑ Other (please, specify): ____________________

If your dog performs an unwanted behaviour, how do you respond in the following few seconds? (Select all that apply)

- ❑ Hold your dog down by the scruff
- ❑ Hold your dog down on their back
- ❑ Grab your dog's muzzle
- ❑ Ask for a different, incompatible behaviour (e.g. Sit)
- ❑ Ignore the behaviour
- ❑ Give a time out
- ❑ Spray your dog with water
- ❑ Avoid similar situations in the future
- ❑ Smack your dog
- ❑ Stare at your dog
- ❑ Redirect your dog's behaviour (get their attention on something else)
- ❑ Use a shock collar
- ❑ Use a spray collar
- ❑ Wait until your dog performs a wanted behaviour, then treat or praise
- ❑ Give a verbal correction (e.g. "No!")
- ❑ Bark/growl at your dog
- ❑ Make a loud noise (e.g. clap, stomp, shake a can of pennies)
- ❑ Other (please specify): ____________________

Have you ever consulted a professional behaviourist for a behaviour issue with your dog?

- ❍ Yes
- ❍ No

What behavioural issue did you consult a professional behaviourist about? (Select all that apply)

- ❑ Aggression
- ❑ Barking
- ❑ Chasing
- ❑ Destructive chewing
- ❑ Digging
- ❑ Fear
- ❑ Food Guarding
- ❑ House Soiling
- ❑ Jumping up
- ❑ Leash Reactivity
- ❑ Mounting/Humping
- ❑ Mouthing/Nipping
- ❑ Obedience (e.g. recall, leash pulling etc.)
- ❑ Obsessive behaviours (tail chasing, fly snapping etc.)
- ❑ Separation Anxiety
- ❑ Other (please specify): ____________________

Have you ever trained your dog using counter-conditioning techniques?
Counter-conditioning = creating a positive reaction to something they once feared/disliked by associating the feared thing with something good (e.g. giving treats every time the dog sees a bicycle, so that eventually, instead of reacting, the dog gets excited to receive treats whenever they see a bicycle)

- ❍ Yes
- ❍ No
- ❍ Unsure

Have you ever trained your dog using desensitization techniques?
Desensitization = gradually exposing dog to a less intense version of the thing he fears/dislikes, in such a way that his reaction isn't triggered (e.g. playing the sound of fireworks quietly, then gradually increasing the volume over a series of days)

- ❍ Yes
- ❍ No
- ❍ Unsure

Dog History

Does your dog have a confirmed history of abuse prior to you acquiring him/her?
- ❍ Yes
- ❍ No
- ❍ Unsure

Has your dog ever been bitten by another dog?
- ❍ Yes
- ❍ No
- ❍ Unsure

How many times?
- ❍ 1
- ❍ 2
- ❍ 3
- ❍ 4
- ❍ 5
- ❍ 6
- ❍ 7
- ❍ 8
- ❍ 9
- ❍ More than 10

How old was your dog at the time of the first incidence?
- ❍ <4 months
- ❍ 4-12 months
- ❍ 1-2 years
- ❍ 3-4 years
- ❍ 5-6 years
- ❍ 7-8 years
- ❍ 9-10 years
- ❍ 11+ years

Environment and Household

Where does your dog primarily live?
- ❍ In your house
- ❍ Outdoors
- ❍ Other (please specify): ____________________

How is your dog housed outdoors?
- ❍ Tethered with a shelter
- ❍ Tethered without a shelter
- ❍ In a barn
- ❍ In a kennel
- ❍ Other (please specify): ____________________

Where does your dog normally sleep? (Select all that apply)
- ❑ In your bed
- ❑ In your bedroom, somewhere other than your bed
- ❑ A room other than your bedroom
- ❑ In a crate
- ❑ Outside
- ❑ Other (please specify): ____________________

Where is your dog kept when left at home? (Select all that apply)
- ❑ Free run of house
- ❑ Confined to a room
- ❑ Crated
- ❑ Outside
- ❑ Other (lease specify): ____________________

How many total hours is your dog left alone (no human family members) on an average day?

On a typical day, does your dog have access to a vantage point where they can view pedestrian traffic outside the house during a majority of the day?
- ❍ Yes
- ❍ No

Is your dog allowed on furniture?
- ❍ Yes, all furniture
- ❍ Yes, some furniture
- ❍ No

Exercise

How much time (in minutes) does your dog spend exercising (i.e. physical activity) on an average day in total?

What type of exercise does your dog do on an average day? (Select all that apply)

- ❑ Walking on a leash
- ❑ Running/jogging on a leash
- ❑ Walking off leash
- ❑ Running/jogging off leash
- ❑ Cycling
- ❑ Playing fetch
- ❑ Dog park
- ❑ Practicing dog sports (i.e. agility, flyball)
- ❑ Loose in the yard
- ❑ Other (please, specify): ____________________

How often do use food dispensing toys/puzzles, or play other games with your dog?

- ❍ Never
- ❍ A few times a year
- ❍ Once or twice a month
- ❍ Once or twice a week
- ❍ Everyday

Food

What type of dog food do you typically feed your dog each day? (Select all that apply)

- ❑ Commercial dry dog food
- ❑ Commercial wet dog food
- ❑ Commercial semi-moist dog food
- ❑ Commercial raw dog food
- ❑ Homemade cooked food
- ❑ Homemade raw food
- ❑ Other (please specify): ____________________

Do you ever feed your dog table scraps?

- ❍ Yes
- ❍ No

How many times per day is your dog fed meals?

- ❍ 1
- ❍ 2
- ❍ 3
- ❍ 4+
- ❍ Free-fed

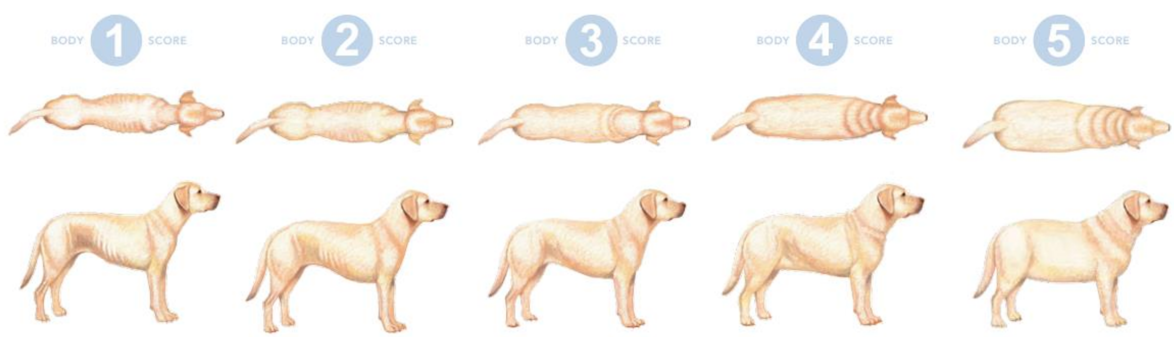
Do you feed your dog the same time(s) every day?

- ❍ Yes
- ❍ No

Does your dog have unrestricted access to water all day?

- ❍ Yes
- ❍ No

Considering the following body condition score chart, which image most closely resembles your dog today?



Owner Demographics

Do you live in an area that is:
- ❍ Rural
- ❍ Urban
- ❍ Suburban

What type of dwelling do you live in?
- ❍ Single-detached house
- ❍ Semi-detached house
- ❍ Row house
- ❍ Apartment in a duplex
- ❍ Apartment in a building that has 5 or more storeys
- ❍ Apartment in a building that has fewer than 5 storeys
- ❍ Mobile home
- ❍ Other (please specify) ____________________

Do you have a yard?
- ❍ Yes, fenced
- ❍ Yes, not fenced
- ❍ No

What is the highest level of education you have completed?
- ❍ Less than high school degree
- ❍ High-school graduate or equivalent (e.g., GED)
- ❍ Some college, no degree
- ❍ Associate degree
- ❍ Bachelor degree
- ❍ Graduate degree
- ❍ Professional degree
- ❍ None of the above
- ❍ Prefer not to answer

Which of the following includes your total household income (CAD)?
- ❍ Less than $20,000
- ❍ $20,000-34,999
- ❍ $35,000-49,999
- ❍ $50,000-74,999
- ❍ $75,000-99,999
- ❍ $100,000-149,999
- ❍ $150,000-199,999
- ❍ $200,000 or more
- ❍ Prefer not to answer

How old are you? ____ [prefer not to answer option available]

What is your gender?
- Male
- Female
- Other
- Prefer not to answer

How many people live in your household (including yourself)?
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- More than 10

Excluding yourself, what are your household member's genders and ages?
Gender: ___________ Age:__________ [For each household member]

How many dogs live with you in your household? _________

Did you have a dog(s) as a child (under 18 years old) not including your current dog?
- Yes
- No

Have you ever been the primary caregiver (over 18 years old) for a dog before your current dog(s)?
- Yes
- No

How many dogs have you been the primary caregiver for before your current dog(s)?

- ❍ 1
- ❍ 2
- ❍ 3
- ❍ 4
- ❍ 5
- ❍ 6
- ❍ 7
- ❍ 8
- ❍ 9
- ❍ more than 10

It is often suggested that owner personality can influence dog behaviour. The following questions are designed to measure different personality traits. Please note that all questions are optional, and if any make you feel uncomfortable you may skip ahead.

Here are a number of personality traits that may or may not apply to you. Please indicate the extent to which you agree or disagree with that statement. You should rate the extent to which the pair of traits applies to you, even if one characteristic applies more strongly than the other.

I see myself as:

	Disagree strongly	Disagree moderately	Disagree a little	Neither agree no disagree	Agree a little	Agree moderately	Agree strongly
Extraverted, enthusiastic	❍	❍	❍	❍	❍	❍	❍
Critical, quarrelsome	❍	❍	❍	❍	❍	❍	❍
Dependable, self-disciplined	❍	❍	❍	❍	❍	❍	❍
Anxious, easily upset	❍	❍	❍	❍	❍	❍	❍
Open to new experiences, complex	❍	❍	❍	❍	❍	❍	❍
Reserved, quiet	❍	❍	❍	❍	❍	❍	❍
Sympathetic, warm	❍	❍	❍	❍	❍	❍	❍
Disorganized, careless	❍	❍	❍	❍	❍	❍	❍
Calm, emotionally stable	❍	❍	❍	❍	❍	❍	❍
Conventional, uncreative	❍	❍	❍	❍	❍	❍	❍

Over the last 2 weeks, how often have you been bothered by the following problems?

	Not at all	Several days	Over half of the days	Nearly everyday
Feeling nervous, anxious or on edge	❍	❍	❍	❍
Not being able to stop or control worrying	❍	❍	❍	❍
Worrying too much about different things	❍	❍	❍	❍
Trouble relaxing	❍	❍	❍	❍
Being so restless that it's hard to sit still	❍	❍	❍	❍
Becoming easily annoyed or irritable	❍	❍	❍	❍
Feeling afraid as if something awful might happen	❍	❍	❍	❍

Would you like to complete this survey for more dogs? You will receive an extra lottery draw for each dog completed (up to 5 dogs).

- ❍ Yes
- ❍ No

[If yes is selected all dog questions (but not owner questions, or fear/aggression videos) repeated]

APPENDIX D

Identification of fear behaviours shown by puppies in response to social and non-social stimuli

D. 1: Recruitment poster
D. 2: Consent form

D. 1: Recruitment poster

D. 2: Consent form

UNIVERSITY of GUELPH

Behavioural responses of puppies to unfamiliar people and objects

You and your puppy are asked to participate in a research study conducted by Dr. Lee Niel and Hannah Flint (PhD Student) from the Department of Population Medicine at the University of Guelph.

If you have any questions or concerns about this research, please feel free to contact:
Dr. Lee Niel at 519-824-4120 x53030, niell@uoguelph.ca or Hannah Flint at flinth@uoguelph.ca

PURPOSE OF THE STUDY & PROCEDURES

- We are interested in collecting videos of puppies showing various normal behaviours in response to unfamiliar objects and people. These videos are being collected to determine what behaviours puppies show in response to novel stimuli, and in later studies they will be used to assess whether dog owners are able to accurately identify these behaviours.
- Your puppy will be placed in a run with a novel stimulus at the far end and encouraged to approach with a food reward placed on the ground in front of the stimulus. These sessions are not expected to have any negative effects on your puppy. Testing will be terminated at any time if either the researcher or the owner feels that the puppy's response to the stimuli is excessive. Further the puppy will be counter conditioned to any stimuli that it reacts to immediately after exposure using food rewards and praise.
- All procedures with your puppy will be videotaped, and if you are interacting with your puppy you may also be recorded.

CONFIDENTIALITY

- All information that might identify owners and is recorded for the purposes of this study will only be accessible to the research team and will either be stored in a locked file cabinet in a secure room, or on a password-protected computer. Data will be kept for 10 years after which they will be destroyed.
- Photos and video clips of your puppy completing the behaviour tasks may be used in publications, presentations, and future studies, but your image and identity will not be associated with these photos or videos.

You are not waiving any legal claims, rights or remedies because of your participation in this research study. If you have concerns regarding involvement of your animal in this research project, please contact either the primary investigator, Dr. Lee Niel, at (519) 824-4102 ext. 53030 or the Interim Director, Animal Care Services at (519) 824-4120, ext. 53110.

SIGNATURE OF ANIMAL OWNER

I have read the information provided for the study "Behavioural responses of dogs to unfamiliar people and objects" as described herein.

- ☐ **I agree to allow my puppy to be video-recorded for this study.**
- ☐ **I agree to allow videos of my puppy to be used in publications, presentations and**

future studies.

Name of Animal Participant

Name of Owner/Guardian (please print)

Signature of Owner/Guardian

Date