UNIVERSITY OF LINCOLN

# Investigating how personality and mood impact perceived pain experience and expression in the Domestic Dog

**Sarah Jane Reaney-Wood**

A thesis submitted in partial fulfilment of the requirements of the University of Lincoln for the degree of Doctor of Philosophy

June 2019

# Acknowledgements

Having never been keen on talking or writing about myself the thought of writing an acknowledgement section that not only outlined the passion I have for my topic area and what fostered this passion, but also to thank the people who have helped me on this journey filled me with trepidation.  So here goes…

My passion for understanding behaviour started as a young child, when I was fanatical about anything to do with animals, especially the way they behaved and adapted to their environment.  I also was fascinated with people.  How is it possible that some individuals seem to cope with all that life throws them, whereas others don't?  These interests ultimately fostered a love of learning, understanding and researching, leading me to study Psychology and Animal Behaviour and Welfare.  I knew when studying for my MSc that I wanted to go on to study for a PhD, I didn't necessarily believe I would be 'lucky' enough for that to happen.  But here I am writing my doctoral thesis acknowledgements.

The process of undertaking a PhD has been extremely rewarding and challenging in equal measure; one of constant reflection, requiring strength, determination and academic creativity.  Whilst I have thoroughly enjoyed the process of undertaking my research it would be unfair to say I hadn't faced struggles at times.  I would like to acknowledge the endless amount of support and guidance that my parents and my husband (Tom) have given me.  Even when I had lost all confidence in my ability their support has been unfaltering.  Whether this has been with words of advice and courage, offering to read through my work or being

understanding about the lack of time I have had to visit and socialise-it has all been appreciated. As someone who tends to overwork and burnout, Tom's optimism, ability to know when and how to relax and determination that a 'work-life balance' is possible, have never been more needed and appreciated than they have throughout my PhD.

My personal motivation to carry out this PhD undoubtedly stemmed from my passion for animals, animal welfare and animal rights. I wanted to be in a position where I could make a difference in a practical way. It was important to me that this PhD reflected my values and was enacted in a way I felt morally aligned to. This has been supported at every step by my supervisory team, whilst they have also pragmatically reminded me of the importance of acknowledging the value of work I might not feel so closely morally aligned to.

Having heard stories where other PhD students have had less than positive supervisory experiences I feel humbled and lucky to have had such supportive and knowledgeable supervisors. They have not only provided the guidance needed to succeed academically, but have also been understating when I have had times of personal struggles. Prof. Collins (Lisa) has been a continued support from my initial enquiries about the PhD studentship right through to completion. Showing enthusiasm for the ideas I couldn't always quite communicate and encouraging me to be involved in conferences, workshops and university committees. These experiences have led to a dramatic increase in my confidence-which at times I thought wouldn't be possible. Dr Zulch (Helen) has not only provided extensive advice and expertise in how pain in dogs may manifest she has also (along with her

beautiful dogs) taken part in many force plate and accelerometer trials, with great energy and passion.  Finally, Dr Willmott (Sandy) has spent many hours in the biomechanics labs with me, giving expert advice whilst running trials with a range of dogs, for which I am very grateful.  I'm not so sure Sandy is what I would have initially described as a 'dog' person, but nevertheless his patience and enthusiasm has been unfaltering.

Finally, I'd like to thank all the dogs and their owners that have taken part in this research-without, this work wouldn't have been possible.  Some have travelled hundreds of miles at a financial cost to themselves to be part of this research. Ultimately, they shared my passion to want to help in understanding the behaviour and welfare of our animal companions.  It seems the only good way to end these acknowledgements is with a quote:

*"The question is not, "Can they reason?" nor, "Can they talk?" but "Can they suffer?"*

— ***Jeremy Bentham, the Principles of Morals and Legislation***

# Abstract

Across the human literature many successful attempts have been made to research how individual differences, such as; emotional predisposition, mood and personality both mediate and moderate how people express that they are in pain, cope with painful conditions and the impact painful conditions have on an individual's quality of life. As such, we have an understanding, albeit not full, of the ways in which pain can impact human life on many levels. We also know that individuals higher in positive affect cope better with compromised health. Despite there being pre-existing literature with nonhuman animals looking at both personality and pain independently, little research has attempted to look at the effect of one on the other. As such, it is unclear what impact, if any, emotional predisposition, mood or personality has on pain behaviour and coping in animals.

Dogs are one of the most popular animals to be kept as domestic pets worldwide; further to this they play a crucial role in society in many working roles. There are several health conditions that affect dogs across their lifetime which are thought to cause pain, making them an ideal species to look at the impact of personality and mood on pain behaviour. Pain is exceptionally difficult to assess and monitor in animals, and as such further work in this area is needed.

This PhD used a mixture of a systematic review, questionnaire data and biomechanical assessments of gait and pain to start to examine whether pain expression is associated with disease severity, or where other factors such as a dog's personality and mood moderates the relationship between disease severity

and pain behaviour. In addition, accelerometers were piloted as an alternative to force plate assessment, to provide accurate, objective pain assessment in clinical settings. The findings suggest that as we see in humans, positive affect is a source of resilience in pain and dogs in pain can be differentiated from their healthy counterparts by lower levels of positive affect. Neuroticism also moderates the effects of severity on pain; higher levels of neuroticism are suggestive of higher levels of pain. Using the method employed in this thesis, accelerometers do not appear to be an alternative tool to assess gait changes related to pain.

The implications from these findings are discussed in context with human literature on positive psychology to suggest a reconceptualization of how we view pain and its subsequent treatment in animals.

## Table of figures

## Table of tables

| | |
|---|---|
| **Acceleration** | The rate of change of velocity per unit of time |

## Glossary of terms

| | |
|---|---|
| **Acute Pain** | Short experience of pain that doesn't last beyond the recommended healing time |
| **Affective state** | Psychophysiological construct varying along three principal dimensions; valence, arousal and motivational intensity |
| **Animal carer** | Individual who is responsible for the health and wellbeing of an animal in an employed capacity. |
| **Chronic Pain** | Pain lasting longer than the expected duration and/or not alleviated with surgical intervention |
| **Emotional valence** | Emotion element of an experience or situation. The relative 'goodness' positive valence or the negative aspects negative valence. |
| **Ground reaction force (GRF)** | Reaction to the force the body exerts on the ground. |
| **Hip dysplasia** | The abnormal development of the hip socket |
| **Human-animal** | Animal with characteristics considered human |
| **Kinetic** | Study of forces that cause motion |
| **Mediator** | Explains the relationship between two variables |
| **Moderator** | A variable that strengthens the relationship between two other variables |
| **Mood** | A prevailing psychological state that can be habitual or temporary. A feeling or state of prolonged emotion that influences an individual's whole life. |
| **Non-human animal** | Any species other than a human |
| **Pain** | An aversive sensation and feeling associated with actual, or potential tissue damage |
| **Peak vertical force** | The maximum force exerted perpendicular to the surface during |

| | |
|---|---|
| | stance phase |
| **Personality** | A set of behaviours that are consistent over context and time. |
| **Pet owner** | Carer of an animal kept as a domestic pet, not the carer of an animal kept in rescue centres and/or other animal establishment (i.e. zoo). |
| **Psychological robustness** | How able an individual is to cope with adverse situations |
| **Reliability** | Consistency of a measure or test to achieve the same results at multiple testing points. |
| **Stance phase** | Gait phase that lasts from the point heel strike to the point of toe off. |
| **Temperament** | Develops and related to responses in a specific environment, i.e. 'handling temperament' |
| **Validity** | The ability of a test to measure what it is aiming to measure. |

# 1 Chapter One –Individual differences, welfare and pain in animals: bridging the gap between thought, theory and practice.

## 1.1 Between individual variation in behaviour

Between individual differences in behaviour are well documented in the research literature in many taxa (Gosling, 2001; Cleasby et al, 2015; Koolhaas and Van reenen, 2016; Nakayama et al, 2017), and in multiple experimental and natural settings. For example variation is seen; in cognitive performance (Carere and Locurto, 2011; Thornton and Lucas, 2012; Griffin, Guillette and Healy, 2015; Bushby et al, 2018), in social learning (Mesoudi et al, 2016), in movement strategies in marine wildlife (Austin, Bowen and McMillan, 2004; Spiegel et al, 2017), and in response to stressful and adverse situations (Reale et al, 2007; Dingenmanse and Wolf, 2010). The emergence of differences in behaviour between conspecifics in the same population is thought to be facilitated by the numerous and potentially competing selection pressures to which they are exposed (Sih, Bell and Johnson, 2004; Wolf and Weissing, 2010; Koolhaas and Reenen, 2016) and allows individuals to exploit different niches and hence survive to reproduce. Historically, the differences observed in non-human animal (hence forth 'animal') populations have been treated as variation around a mean that is biologically meaningful (Wilson, 1998). Contrary to in animals, this variation in humans has been studied for many years as a way of explaining some of the differences that underlie how individuals behave and cope with different experiences, such as; ill-health and chronic pain (Nettle, 2005). Over the past 20 years there has been a surge in the purposeful study of individual variation in animals.

Understanding the origins and mechanisms underlying between individual variations in behaviour is considered a major challenge (Koolhaas, 2008). However, previous work has suggested that; sex, breed, development, early life, personality, mood, motivation, diet (Bushby et al, 2018), and age (Mason and Mendl, 1993; Dall, Houston and McNamara, 2004) are all such mechanisms. The current introduction is focusing solely on personality and mood as mechanisms underlying inter-individual (between individual) variation in behaviour (from this point on 'individual variation'). A focus is being placed on personality and mood as mechanisms underlying variation in health and pain behaviour as these two mechanisms are relatively understudied in animals. Research with humans suggests that focusing on both personality and mood can aid understanding of how and why individuals respond differently to health and pain issues. The term 'Individual differences' throughout this thesis is therefore based on the definition in psychology, which refers to 'psychological characteristics' rather than other variables such as age or sex. It is beyond the scope of this introduction to also focus on intra-individual variation (variation occurring within an individual), but suggestions of papers that will give more of an insight into this are; Stamps, Briffa and Biro (2012); Biro and Adriaenssens (2013).

### *1.1.1 Defining personality and mood*

Personality is defined for this thesis as 'c*onsistent between individual differences in behaviour that are stable over both context and time'* (Dall, Houston and McNamara, 2004; Gartner, 2015; MacKay and Haskell, 2015) and can be measured in both humans and animals. Indeed, personality has been observed in many mammalian species such as; humans (Homo sapien), orangutan (Pongo pongo), chimpanzee (Pan troglodytes), horse (Equus ferus caballus), hedgehog (Atelerix spp), domestic dogs (Canis lupus familiaris), domestic cats (Felis silvestris catus), domestic rabbits (Oryctolagus cuniculus) (Gosling, 2008), many fish species (Brown et al, 2005; Colléter and Brown, 2011), insects (Jandt et al, 2013) such as the mustard leaf beetle (Phaedon cochleariae) (Tremmel and Muller, 2013) and in crustaceans such as the hermit crab (Pagarus bernhardus) (Briffa et al, 2013).

Animal personality studies have come under recent criticism for treating the personality as synonymous with mood and coping styles. This is problematic as if studies report to be measuring personality, when they may in fact be measuring temperament, emotions or mood, it can hamper understanding of any observed variation (Zidar et al, 2017). Furthermore, critics have also questioned whether research attempting to measure the same traits in different taxa is actually doing so (Carter et al, 2013). Research from the animal literature has demonstrated that personality and coping styles are capturing different aspects of behavioural variation, for example; in *checkered Puffer Fish* (Pleizer et al, 2015) and in *Red Jungle Fowl* (Zidar et al, 2017). However, little research to date has looked at comparing personality styles and coping style in animals (Zidar et al, 2017), as such further research in this area would be beneficial. Personality research in animals will be further critiqued in the preceding chapters, particularly chapters two and eight.

In contrast to personality, mood is defined as "*relatively enduring affective states that arise when negative or positive experience in one context or time period alters the individual's threshold for responding to potentially negative or positive events in subsequent contexts or time periods*" (Nettle and Bateson, 2012). Mood state is considered to be the integrative function of the emotional experiences an individual has over time (Mendl, Burman and Paul, 2010; Nettle and Bateson, 2012) and can be understood using a two dimensional framework that conceptualises emotions in terms of core affect, positive and negative (Mendl, Burman and Paul, 2010; Nettle & Bateson, 2012). In a two dimensional framework, those with a low level of arousal with negative valence are more likely to depressed, those with a high level of arousal and positive valence and more likely to be excited and energetic. Furthermore, individuals experiencing more threatening or compromised situations will have a more anxious baseline and those experiencing more rewarding situations, a more positive one (Nettle and Bateson, 2012). Therefore aversive experiences have an effect on the mood of individuals. Considering pain as an aversive experience, individuals in chronic pain would therefore potentially have a more anxious baseline. But the extent to which this influences behaviour may be mediated by the personality of the individual.

Aversive experiences arise when an individual encounters an unpleasant stimuli or event, and can be measured by '*the avoidance by an animal of the situations or* *behaviours that provoke a noxious event*') (Umberg and Pothos, 2011; Walters, 2018). Stress, (defined as *'a set of physiological and behavioural changes initiated by an aversive stimuli'*) (Levine, 2005; Manteca, Mainau and Temple, 2013) and aversive experiences, and their effects on the physical and psychological health of an animal has been the focus of much research (von Borrell, 1995; Armario, 2015; Das et al, 2016). Prolonged stress has a negative effect on reproduction in several species, for example, predator stress in snowshoe hares (Sheriff, Krebs and Boonstra, 2009) and heat stress in farmed pigs (Ross et al, 2017). Stress is also known to affect meat quality in beef cattle (Ferguson and Warner, 2008) and dairy production in dairy cattle (West, 2003; Jordan, 2003; De Rensis, Garcia-Ispierto and Lopez-Gatius, 2015). In the case of domestic pets, prolonged stress in the form of anxiety and fear in dogs is related to increased incidents of skin disorders (Dreschel, 2010). In cats there is a relationship between stress and respiratory tract infection (Tanaka et al, 2012; Amat, Camps and Manteca, 2016) and between stress and interstitial cystitis (Cameron et al, 2004; Buffington et al, 2006; Amat, Camps and Manteca, 2016). However, the mechanisms underlying these relationships are un-clear.

Aversive and stressful situations are diverse and will vary in the effect they have on an individual, dependent upon numerous factors including; the animals previous experience of the stressor, their perception of the stressor, the context of the stress and length of exposure (Mason and Mendl, 1993). Furthermore, situations only trigger a stress response if an individual animal perceives the situation to be aversive (Veissier and Boissy, 2007). Individual animals can differ greatly in how they adapt to changes in their environment and therefore have different thresholds at which they can cope with stressful situations. Both personality and mood could explain some of this variation.

### *1.1.2 Pain as a stressor*

Given the above discussion around aversive states and stress, disease, including pain can be considered as a stressor (National Research Council, 1992; Martini et al, 2000; Mellor, Cook and Stafford, 2000; Blackburn-Munro and Blackburn-Munro, 2001; Vierck, Green and Yezierski, 2010). Hence it is logical to suggest that pain, both acute and chronic should be conceptualised as stressful, having the potential to negatively impact on the welfare of an individual animal.

Pain is as an unpleasant sensory and emotional experience (Merskey and Bogduck, 1994) and can be acute (short-term pain usually lasting for less than twelve weeks) or chronic, which in earlier definitions was thought of as continuous, usually lasting more than twelve weeks (Merskey and Bogduck, 1994) and persisting past the normal healing time (Treede et al, 2015) in nature (pain is further discussed in chapter two). Studies of pain in animals have primarily focused on determining which species have the physiological capacity to experience pain, such as; the experience of pain in fish (Sneddon, 2003, 2009, 2011, Sneddon and Leach, 2016), pain and suffering in laboratory animals (Morton and Griffith, 1985, Carstens and Molberg, 2000), ways to assess pain (Bateson, 1991, Rutherford, 2002, Hansen, 2003) and the effect of pain on quality of life (QOL) / overall animal's welfare (Broom, 1991). From this research we now have an understanding that a great number of species can experience pain (see Sneddon, 2004 for a more detailed discussion on the specific criteria), that procedures related to testing (Morton and

Griffith, 1985, Carstens and Molberg 2000; Carbone and Austin, 2016) and farming practices (Gleerup et al, 2015) can cause pain and that pain can cause emotional and physiological changes that are indicative of compromised welfare and quality of life (Broom, 1991). However, with the complex nature of pain comes the difficulty in pain recognition and assessment.

Recognising pain in animals rests on our ability to be able to notice and acknowledge negative internal mental states in other species (Broom, 1998). Furthermore, different species express pain differently depending on the behavioural repertoire of that species, its physical conformation and the evolutionary pressures shaping their behaviour (Broom, 1991; Le Bar et al, 2001). For example, in social species using vocalisations to communicate they are in pain would be highly beneficial, as it would illicit help from conspecifics, whereas in a solitary living species it would be maladaptive as it may attract the attention of predators (Broom, 2001).

### *1.1.3 The potential mechanisms underlying individual differences in pain*

Studies on pain and disease in humans have emphasised the benefit of focusing on personality and mood to explain variation in health and treatment outcomes (Gosling, 2002; Cavigelli and McClintock, 2003). However, little research has explored how personality and mood interact with pain experience and expression in animals. It is therefore unclear whether the evidence that currently exists is sufficient enough to assert that as in humans, personality and mood mediate and moderate pain experience in animals.

Furthermore, in the few studies that do exist in this area, methodological limitations exist. Ijichi et al (2014) investigated whether personality moderated the expression of chronic pain in horses the findings suggested extraversion was associated with overt behavioural displays of pain and that neuroticism was associated with low pain tolerance. However, the subjective nature of how disease severity was assessed within this study (veterinary observations on using a 1-5 rating scale) compromises the quality of the findings. In a study investigating personality and acute pain in dogs, Lush and Ijichi (2018) found that dogs with higher level of extraversion had higher pain scores. However, the study focussed on pain in a clinical setting (post-surgery); as such the findings may be limited to responses to acute surgical pain in a veterinary setting only.

Animal studies that have focused on mood have illustrated that both mood and personality interact to determine judgement bias (Asher et al, 2016) and that aversive experiences, such as, neglect, pain or ill-health can impact mood (Briefer and McElliot, 2013; Reaney et al, 2017; Lecorps et al, 2019). However, these studies have focused on general health or short-term pain in response to surgical procedure. Undoubtedly, one-off cases of acute pain will not provide the same physiological and psychological challenges that chronic pain does. As such research is needed investigating the impact of mood on chronic pain.

While evidence now exists demonstrating that personality, coping styles and mood can explain (to a certain extent) why animals from the same population experience both positive and negative life experiences differently, little research has focused on how they may impact pain behaviour. Furthermore, little research has looked at how the methods used to assess personality; mood and pain (owner and veterinarian) impact the findings (discussed in further detail in chapters four, five and eight). The consequence of this is that if personality, coping styles and mood impact the threshold at which individual animals react to chronic pain, and/or the specific pain behaviour displayed (Mc Ewen, 2001; Koolhaas and Van Reenen, 2016), without consideration of this, successful pain diagnosis is impossible. This is especially pertinent in a field where pain diagnosis is reliant on the assumption that observed behaviours are indicative of clinical severity. This thesis aims to bridge that gap by investigating whether differences in personality and mood affect how companion animals cope with ill health and chronic painful conditions, using dogs as a model species. The thesis will start broadly by focusing on health conditions and pain in relation to mood and personality, and will then progress to focus specifically on pain in dogs that have a diagnosis of hip dysplasia.

### *1.1.4 Dogs as a model species*

Dogs are the most popular domestic pet in the United Kingdom and in the USA (King, Marston and Bennett, 2012; Croney, 2019). Population size estimates (when including pet and stray dogs) are over 600 million (Reed and UpJohn, 2018) and more than 50% of UK households report owning a dog (Goodwin et al, 2018). In addition, there are several health conditions that affect dogs across their lifetime which are thought to cause pain, for example, Otitis Externia, Spinal problems, skin complaints or hip dysplasia. Hip dysplasia (HD) is a common, chronic condition that affects a large number of dogs in the UK alone (Rettenmaier et al, 2002; Dennis, 2012; Souza et al, 2015). It is characterised by laxity in the hip joint and is often diagnosed using hip x-rays and scoring (Dennis, 2012). The results from hip x-rays and scoring are then used to determine if hip dysplasia is present, whether treatment is needed and if so, what level of treatment. However, research has suggested that hip scores and x-rays are of limited use, and are not always reflective of the pain experienced (Gordon et al, 2003; Ginja et al, 2010; Souza et al, 2015). Furthermore, for veterinary help to be sought the individual caring for that dog needs to notice a problem and see this problem as being of sufficient severity to warrant treatment. The research discussed so far indicates that the personality and the mood of an animal may influence the way they behave in times of pain, which in turn can affect diagnosis of conditions. Therefore, HD in dogs is considered to be an appropriate model to use to look at the relationship between personality, mood and pain in non-human animals.

## 1.2 Research objectives and aims

This thesis is comprised of eight chapters (including the current introductory chapter) and the overall aim of this thesis is to understand whether personality and mood in dogs affects how they cope with chronic pain. If so, to also suggest what this may mean for methods currently used to assess pain in animals. This aim will be met with five objectives:

1. To review the available literature to investigate whether there is evidence to suggest that individual differences have the potential to mediate or moderate pain behaviour in non-human animals (Chapter two).

*2.* To determine whether dogs with and without both previous and current experience of a pain causing conditions differ in their mood and personality (Chapters three and four).
3. To establish which (if any) human factors affect the assessments pet owners make about their pets' health and pain (Chapter five).
4. To determine whether disease severity, personality and subjective pain is associated with asymmetry in gait (Chapter six)
5. To run a 'proof on concept study' that focuses on validating cheaper and more accessible ways of assessing gait and pain in dogs, against the 'gold standard' of force plate analysis (Chapter seven).

## 1.3 Chapter summaries and research questions

**Chapter two** is a review of both the human and the animal literature from 2004-2018 and focuses on looking at the evidence that exists to suggest that individual differences, specifically personality, mediates and/or moderates pain behaviour in animals. This chapter was the first piece of work from this doctoral work and focuses on personality, only including mood when combined with personality in an initial attempt to not 'miss' any studies on pain and personality. The findings from this review are used to focus the methodology of the subsequent chapters, especially the inclusion of mood as a potential mechanism underlying individual differences in pain behaviour. In the absence of nonhuman animal literature, a focus on the human literature was adopted. **Research question one:** *Is there sufficient evidence available in the research literature to determine whether personality in non-human animal's impact pain experience?* **Research question**

**two:** *How can the human literature inform the direction of non-human animal research into pain and individual differences, such as, mood and personality?*

**Chapter three** is a secondary data analysis of an online survey looking at behaviour and health in dogs. The measure of individual differences in this chapter, is the Positive and Negative Activation Scale (PANAS) for dogs, and is used as a measure of mood throughout this thesis in dogs. **Research question three** *'do dogs with experiences of general health conditions differ in their positive and negative mood?'* **Research question four** *'do dogs with experiences of conditions thought to result in pain differ in their positive and negative mood?'*

**Chapter four** is a primary study into the associations between emotional predisposition, personality and pain in domestic dogs. It develops considerably on the findings of chapter three by; the addition of the Monash Canine Personality Questionnaire-Revised (MCPQ-R); the Canine Brief Pain Inventory (CBPI) and; the Helsinki Chronic Pain Index (HCPI). The inclusion of both a measure of emotional predisposition and personality will allow a comparison between their relationships to owner reported health complaints and pain in dogs. **Research question five** *'do dogs with different levels of pain differ in their personality?' and **Research question six** 'Do dog with different levels of pain differ in their mood?'*

**Chapter five** shifts in focus away from dogs and instead gives prominence to dog owners. It focuses on exploring whether the dog owner's characteristics, such as; their personality, pain experience, level of medical knowledge and age are associated with how they report their dog's health and pain. **Research question seven** *'do the characteristics of dog owners influence how they report on their dog's* *health?* and **research question eight** *'do the characteristics of dog owners influence how they report on their dog's pain?'*

**Chapter six** aims to develop on chapters three and four by explicitly testing whether personality moderates the effect of disease severity on pain behaviour. Biomechanical assessment of gait and signs of clinical severity (hip score, Femoral Head Coverage and Norberg Angle) are compared between healthy dogs and dogs with hip dysplasia. **Research question nine** *'are disease severity and gait asymmetry correlated?'* and **research question ten** *'does personality or mood mediate/moderate the relationship between disease severity and gait asymmetry?'*

**Chapter Seven** is the final data chapter within this thesis and explores whether accelerometers can be used as a gait assessment tool in dogs. Using force plates as the 'gold standard', this chapter is a 'proof on concept' study to validate the findings from gait analysis using accelerometer to those using force plates. **Research question eleven** *'can accelerometers be used as a replacement for force plates in gait assessment with dogs?'*

**Chapter Eight** focuses on the findings from this thesis in relation to the broader research literature. It moves away from the specific focus on personality and pain in domestic dogs and situates the findings within the literature of individual differences and welfare across species.

# 2 Chapter two: Is there evidence to support a link between personality and pain expression in animals and what can we learn from the human literature?

## 2.1 Abstract

Individual differences in pain perception, expression and coping are of great interest in human research. However, despite the ever-increasing body of evidence for different personality types within nonhuman species, and the prevalence of diseases causing pain in nonhuman animals, very little research has focused on how personality may affect the experience and expression of pain in nonhuman animals. Considering the difficulty veterinary professionals have in assessing pain in nonhuman animals it would be of great benefit to understand what factors, other than disease symptomology, affect the way that nonhuman animals experience and express pain.

I conducted a review using a systematic search process to look at the evidence for a relationship between personality and pain experience and expression across species. Following PRISMA guidelines, literature searches were conducted

using systematic combinations of keywords such as personality and pain, illness and personality, and disease and personality in both human and non-human animals. Articles were reviewed based on criteria for quantitative research and appraised on their content, reliability and validity reporting, sample size and study design. The results highlighted a clear disparity between human and nonhuman animal research, with more than 140 articles identified that focussed on pain and personality in humans, but only two articles found that focused on assessing both personality and pain in nonhuman animals.

The findings from the human literature were explored to determine the potential cross-species relevance.  Personality, affect, mood and cognition were all found to interact to have an impact on how humans express and experience pain. Extraversion was found to be related to greater behavioural expressions of pain in horses and dogs and could be perceived as a resilience factor for humans. In humans, neuroticism was found to be related to less pain tolerance and lowered pain threshold and is perceived to be related to the experience, rather than the expression of pain. Furthermore, similarities in some of the physiological reactions to pain and the personality traits found to be related to the affective element of pain in humans have been observed in nonhuman animals. The findings suggest that future research should focus on pain and personality in nonhuman animals.

## 2.2 Introduction

As early as Hippocrates' four humours, people have been trying to make sense of the difference that could be observed in the way humans behave, leading to the emergence of the field of personality psychology. The current prevailing theories of human personality have developed from earlier conceptualisations, such as Freud's Id and the Ego (1923), and now predominantly focus on five main personality traits; 'Openness', 'Conscientiousness', 'Extraversion', 'Agreeableness' and 'Neuroticism', often know by the popular acronym of OCEAN. As such, human personality studies tend to focus on broader dimensions of personality, such as the five-factor model (FFM) (Costa and McCrae, 1992) and some more specific trait measures (Table 2:1). Research has suggested there is a heritable, biological basis to personality and the Five Factor Model (FFM) (McCrae and Costa, 1997; Yamataga et al, 2006; Smith and Weiss, 2017). Many of the concepts and much of the terminology utilised in animal personality has been inspired or 'borrowed' from the work conducted with humans (Bell, 2017; Finkemeier, Langbein and Puppe, 2018).

As noted in chapter one personality has been observed in a large number of species, and our knowledge of animal personality has greatly advanced. However, despite advancement in knowledge in the field of animal personality it has come under recent criticism (Carter et al, 2013; David and Dall, 2016; Beekman and Jordan, 2017).

Researchers from animal behaviour and behavioural ecology have questioned the approaches taken when assessing animal personality, especially when using novel object tests (Carter et al, 2013), open field tests (Perals et al, 2017) and stress tests. Criticisms have included; there are many tests that aim to measure the same trait (Carter et al, 2013); some tests can be used as a measure of more than one trait (Carter et al, 2013; Peral, et al 2017); the same adjectives can be used to describe different behaviour (David and Dall, 2016); there are problems with test validity (Carter et al, 2013); differences in the definitions of traits adopted by the researchers (Carter et al, 2013, Uher, 2008) and problems with how findings are interpreted. Furthermore, critics have suggested than animal personality is too descriptive, pertaining to correlational research that is non-hypothesis driven (Beekman and Jordan, 2017). These criticisms are not to suggest that personality assessment in animals shouldn't take place, but rather stress the need for reliability and validity to be a key consideration and the need for consistent terminology across disciplines.

Despite the above criticisms, personality research is useful in advancing our understanding of the mechanisms underlying individual differences in behaviour. Differences in personality, coping styles and emotional pre-disposition are cited as important determinants of health outcomes and wellbeing in studies of human health and disease (Friedman and Kern, 2014; Strober, 2017). Furthermore, both coping styles and personality have been looked at in relation to stress in animals, however very little research has looked at the impact of personality on pain perception in animals. Therefore, cross-species comparisons are a good way of identifying the gaps in the animal literature, providing comparative benchmarks for future findings and thereby advancing the field (Gosling, John, Kwan, 2003).

As detailed in chapter one, the International Association for the Study of Pain (Merskey and Bogduck, 1994) defines pain as ‘an unpleasant sensory and emotional experience associated with actual or potential tissue damage’ (IASP). Pain can be acute (short-term pain usually lasting for less than twelve weeks) or chronic, which in earlier definitions was thought of as continuous, usually lasting more than twelve weeks (Merskey and Bogduck, 1994) and persisting past the normal healing time (Treede et al, 2015). However, definitions based on duration can be challenged, as lacking empirical support, not accounting for recurrent pain (Turk and Melzack, 2001) and ignoring the multidimensionality of pain (Von Korff and Dunn, 2008).

As highlighted in chapter one, chronic pain is an inescapable stressor which leads to activation of the hypothalamo-pituitary-adrenal (HPA) axis, which plays a part in appraisal and adaptation in the face of stressors (Blackburn-Munro and Blackburn-Munro, 2001), both in humans and in nonhuman animals. The related physiological changes to heart rate, arterial blood pressure, cortisol concentration, brain activation and HPA activation in relation to pain have been observed in both humans and animals (Mellor, 2000).

As with personality measurements, the effective measurement of pain in human and animal subjects is a difficult task (Morton and Griffiths, 1985). In humans the difficulties pertain to; quality of the information given (in both self-reports and surrogate reports), the disparity between pain experienced and physiological signs of pain and the assessment of pain intensity (Ong and Seymour, 2004). Several pain assessment methods have been developed for use with animals, the specific type dependent upon whether the pain is acute or chronic in nature and the species in question. They are, however, all based around either physiological indicators of pain (quantitative measures) and/or behavioural indicators of pain (qualitative & quantitative measures) (Morton and Griffiths, 1985; Mathews, 2000; Stasiak et al, 2003, Weary et al, 2006).

Acute and chronic pain questionnaires are frequently used in clinical pain assessments in dogs (Morton et al, 2005; Wiseman-Orr, 2004; Brown et al, 2007; Hielm-Bjorkman, Rita and Tulamo, 2009; Hielm-Bjorkman, Kapatkin and Rita, 2011), and cats (Brondani, Luna and Padovani, 2011; Calvo et al, 2014), and typically include behavioural questions and pain scales. Physiological measures such as respiratory function and heart rate can be used as a potential indicator of pain (Morton and Griffiths, 1985; Molony and Kent, 1997) but they lack specificity. A reduction in physiological and behavioural indices in response to pain medication can be used as an indicator of successful (or unsuccessful) pain alleviation (Murrell and Johnson, 2006; Brown et al, 2007; Miller et al, 2016; Akintola et al, 2017). However, if non-specific indicators are used as a way of assessing pain they need a context or other indicators to be reliable.

Behavioural responses to noxious stimuli measured in tests such as the von Frey test (Piel et al, 2014) and thermal sensitivity tests (Piel et al, 2014) can be used to test pain tolerance and to assess changes in sensitivity because of chronic pain. Whilst these methods link the physiological responses to a context, it can be difficult to separate nociception from experience of pain. Facial expression can be used as a measure of pain using a Facial Activation Coding system (FACs) in mice, rats, rabbits, horses and Cats (Langford et al, 2010; Sotocinal et al, 2011; Keating et al, 2012; Dalla costa et al, 2014; Holden et al, 2014). Finally, movement and gait assessments such as; Rotarod test in Rats, Dynamic Weight Bearing systems (Piel et al, 2014) and force plate analysis (Molony and Kent, 1997; Weeks et al, 2000; Piel et al, 2014) can be used as objective measures of pain, but again without other methods will tell us little about the emotional element of pain.

Whilst each method of assessing pain can be useful in the right context (Weary et al, 2006) they also have inherent weaknesses. These weaknesses are; 1. Questionnaires, dependent upon the individual completing them, may be subject to a lack of objectivity (Reid, Nolan and Scott, 2018); 2. Questionnaire development methods have lacked rigor (validity and reliability), 3. Difficulty in making distinctions between pain and nociception (Allen et al, 2004), 4. Lack of validation of response measures (Weary et al, 2006). Behavioural measures of pain are the most common methods used when assessing pain in animals (Sneddon et al, 2014) and are key in veterinary consultations. Additionally, there are several problems with using behavioural observations to assess pain – for example, behavioural changes in chronic pain can be subtle due to their slow onset and therefore hard to notice (Hansen, 2003); the overtness of behaviours seen do not always correlate with the severity of a disease (Lascelles, 2006; Ijichi et al, 2014); and pain is a highly subjective experience with sensory, cognitive and affective elements (Millman, 2013). As such, whilst behavioural observations are a good way of assessing pain, if used alone they will not give the whole picture. Therefore, assessments used to identify pain and assess severity can benefit from a triangulation approach (Rutherford, 2002; Rose et al, 2014; Sneddon et al, 2014).

This review aims to determine the extent of evidence available linking personality with the expression and experience of pain in animals and possible future directions for research in this area, by considering evidence from the human and non-human animal literature.

*Table 2:1 Personality assessment scales arising from the review process, the attributes they assess, in what species and the reference. A selection of common methods to assess animal personality has been included at the bottom of the table (shaded in grey) for comparative purposes only.*

| **Personality Measure** | **Attributes Measured** | **Species** | **References** |
|---|---|---|---|
| Eysenck Personality Questionnaire (EPQ) | Psychoticism, Extraversion and Neuroticism | Human | Eysenck and Eysenck (1975) |
| Minnesota Multiphasic Personality Inventory (Mini version) (MMPI) | Hypochondria, Depression, Hysteria, Psychopathic deviate, Masculinity/Femininity, Paranoia, Psychasthenia, Schizophrenia, Hypomania and Social Introversion | Human | Hathaway and McKinley (1951) |
| Temperament and Character Inventory (TCI) | Novelty seeking, Harm avoidance, Reward dependence, Persistence, Self-directedness, | Human | Cloninger et al, (1994) |

| | | | |
|---|---|---|---|
| | Cooperativeness, Self-Transcendence. | | |
| Type A personality test | Hostility, Time urgency, aggressiveness and Competitive need for achievement | Human | Myers (1962) |
| DS14 Type D personality test | Negative affectivity/Distress | Human | Denollet (2005) |
| Neo Five Factor Personality Inventory | Neuroticism, Extraversion, Openness, Agreeableness & Conscientiousness | Human | Costa and McCrae (1989) |
| Temperament evaluation of Memphis (TEMPS-A) | Traits along depressive, cyclothymic, hyperthymic, irritable and anxious | Human | Akiskal (1992) |

| | | | |
|---|---|---|---|
| Karolinska personality scale | Psychic anxiety, Socialisation, Somatic anxiety, Muscular tension, Psychasthenia, Aggression, Social desirability, Detachment, Impulsiveness, Sensation seeking, Guilt, Irritability. | Human | Klintenberg et al, (1992) |
| Positive and Negative Affect Scale (PANAS) | Positive and Negative Affect | Human, Dog | Watson et al, (1988); Sheppard and Mills (2002). |
| Toronto Alexythimia Scale (TAS) | Alexithymia | Human | Bagby et al (1994). |
| Personality Inventory for Children | Lie, Frequency, Defensiveness, Adjustment, Achievement, Intellectual screening, | Human | Wirt, Klinedisnt and Seat (1988) |

| | | | |
|---|---|---|---|
| | Development, Somatic concern, Depression, Family relations, Delinquency, Withdrawal, Anxiety, Psychosis, Hyperactivity, Social skills. | | |
| Big Five Inventory Questionnaire | Neuroticism, Extraversion, Openness, Agreeableness & Conscientiousness | Human | John, Donahue and Kentle (1991). |
| Junior Eysenck Personality Questionnaire | Extraversion, Neuroticism, Psychoticism and Lie | Human | Eysenck and Eysenck (1975) |
| Cloningers Tridimensional Personality Questionnaire | Novelty seeking, Reward dependence and Harm avoidance | Human | Cloninger et al (1994) |

| | | | |
|---|---|---|---|
| Personality Diagnostic Questionnaire Revised | Cluster A,B and C personality disorder | Human | Hyler (1988) |
| Maudsley Personality Inventory | Extraversion and Neuroticism | Human | Jensen (1958) |
| 120-item International Personality Item Pool (IPIP-NEO) | Neuroticism, Extraversion, Openness, Agreeableness & Conscientiousness | Human | Hendrick (1997) |
| Infant Behaviour Questionnaire Revised | Activity level, Distress to limitations, Approach, Fear, Duration of orienting, Smiling and laughter, Vocal reactivity, Sadness, Perpetual sensitivity, High and low intensity pleasure, Cuddliness, | Human | Rothbart (1981) |

| | | | |
|---|---|---|---|
| | Soothability and Falling reactivity/rate of recovery from distress. | | |
| Novel Object OR novel environment test | Boldness-Shyness | Cross species, for example; pigs, dogs, goats (rarely used with humans) | Ennaceur and Delacour (1988) |
| Open field test | Exploration, | Cross species, for example; pigs, dogs, goats (not used with humans) | Hall (1934) |
| MONASH | 5 trait personality test | Dogs | Ley et al (2007) |
| PANAS-D | Positive and negative emotional affectivity | Dogs | Sheppard and Mills (2002) |
| C-Barq | Temperament and Behaviour | Dogs | Hsu and Serpell (2003) |

| | | | |
|---|---|---|---|
| Dog personality<br><br>questionnaire (DPQ) | Five factor personality | Dogs | Jones (2009) |

## 2.3 Method

### *2.3.1 Search criteria and process*

A systematic approach for sourcing articles was used following the PRISMA (2009) guidelines. Initially, a literature search was conducted in Web of Science, Pub Med and Cab abstracts for literature published between the years 2000 and 2018 using the systematic combinations of keywords:

Pain

**+**

Personality ***OR*** temperament ***OR*** behavioural syndrome

+

Health ***OR*** disease ***OR*** ill-health

+

Humans ***OR*** animals

A six-step procedure was used in each literature search database:

**Step 1.** A chosen key word combination was entered into the research database to retrieve a corpus of research articles. The articles were then stored in a reference management system.

**Step 2.** Article titles were assessed to evaluate whether the title fit the topic of pain and personality.

**Step 3.** The abstracts of articles fitting the topic of pain and personality were assessed to confirm the suitability for inclusion. Any excluded were stored in an excel spreadsheet.

**Step 4.** The full text of studies fitting the systematic criteria were accessed and reviewed based upon an adapted evaluation tool for quantitative research.

**Step 5.** A selection of the references of the primary reviewed articles were assessed according to the inclusion/exclusion criteria.

**Step 6.** The search process was repeated twice a year to update the findings with new research.

#### *2.3.1.1 Inclusion criteria*

At step two, the title had to either include; personality OR temperament OR behavioural syndrome OR a specific trait OR positive affect OR negative affect OR emotional regulation or psychological OR adaption OR risk OR prediction OR resilience AND the word pain OR a condition known to result in pain. Common conditions known to cause pain were; arthritis, joint disorders etc.

At step three the abstract had to state that personality AND pain had been measured. Papers including only topics such as cognition, meta-cognition or mood were not included.

At step four it was confirmed that the test used was a pre-validated personality test and not measuring state dependent variables (i.e. behaviours that were temporary and related to specific context) and that there was a measure of pain.

#### *2.3.1.2 Exclusion criteria*

For articles screened, the criteria for exclusion were if an article met at least one of the following descriptors: (i) review articles; (ii) articles reporting only qualitative research; (iii) articles containing no measure of personality; (iv) articles containing no measure of pain; (v) articles focussing on personality disorder with no control group; or (vi) articles measuring mood alone rather than personality, as the initial aim was to focus on personality, not mood.

Excluded articles were kept in an Excel spreadsheet which included information on: (i) the authors' names; (ii) the title of the article; (iii) year of publication; (iv) journal title; (v) journal volume; (vi) journal page numbers; and (vii) reasons for exclusion. At each stage of the systematic process a random selection of articles was independently assessed by a second researcher to ensure agreement on inclusion/exclusion decisions.

### *2.3.2 Quality appraisal*

Each of the included full text articles was appraised based on a set of criteria for the evaluation of the quality of quantitative research articles. This involved extracting information on: (i) whether sample size was mentioned in the paper; (ii) whether power analysis was mentioned in the paper; (iii) whether the study design was mentioned in the paper; (iv) the personality/temperament measure used; and (v) if the associated validity and reliability of the personality or temperament measure was reported; (vi) how pain was assessed; and (vii) the internal consistency. A final score indicative of appraised quality and based on a traffic light system was given to each full text article (See table 2:2 and 2:3). Only those articles achieving amber or green were included in the results (See table 2:2 and 2:3). A final Excel spreadsheet was generated for all of the articles included within the review. From each of these articles the following data were recorded: (1) the author's name; (2) year of publication; (3) article title (4) journal of publication; (5) species of focus (6) the overall sample size; (7) control sample size; (8) how the sample was recruited; (9) whether a follow up study was done; (10) whether the sample was healthy or in pain; (11) cause of pain, (12) study design; (13) personality test used; (14) how pain was measured; (15) reliability and validity of personality measures; and (16) whether the internal consistency of questionnaires was given.

*Table 2:2 Validity and reliability appraisal criteria*

| **Validity and reliability evidence criteria** | **Evidence of reliability and validity (Y/N)** |
|---|---|
| 1. No acknowledgment of validity and/or reliability | N |
| 2. Reference to reliability and validity but no statistics or example reported | N |
| 3. States the measure/method is reliable and/or valid but only gives a verbal example | N |
| 4. States the measure/method is valid and/or reliable and gives statistical evidence of validity OR reliability | Y |
| 5. States the measure/method is valid and reliable and gives statistical evidence of both validity and reliability | Y |

*Table 2:3 Rating score criteria*

| Overall rating | Description (not an exhaustive list) |
|---|---|
| Red | No power analysis for sample size, no reference to validity or reliability, no acknowledgment of study limitations, small sample, inappropriate measures used (i.e. non-validated personality measures), individual case-report. |
| Amber | Sample size & study design appropriate. Acknowledges study limitations, reports at least one of; power analysis, reliability and validity of personality questionnaire used. |
| Green | Reference to reliability and validity, power analysis for sample size all reported & acceptable levels. Acknowledges limitations which reflects good methodology and is an RCT or case-control study. |

Worked example of an **amber** study: Lush and Ijichi (2018)

**Study design:** Cross Sectional

**Sample size:** 20 dogs, and further reduced in some analysis. This is a small sample size but it is a preliminary investigation so can be expected. No mention of sample size calculations or retrospective power analysis.

**Personality test:** Monash Canine Personality Questionnaire (MCPQ-R) previously validated showing good validity and reliability.

**Pain assessment:** Use of validated pain scale

**Positives**: Consistent source of pain/type of procedure in the sample; the statistical analysis undertaken clearly related to hypothesis and research questions.

**Limitations:** Sample size, two veterinary surgeries

*Figure 2:1 Worked example of quality appraisal used for each study evaluated as part of the review process*

## 2.4 Results

Out of the 148 papers included in this review only two focused on the relationship between personality and pain expression in animals. 14 papers were classified as red quality (see table 2:3 for definition of red). 133 papers were classified as amber in quality and none of the research papers were classed as green (see table 2:3 for definition of amber & green). Of the 148 full text articles appraised, 54 provided evidence of reliability and validity (levels 3 or 4) meaning 94 of the studies did not acceptably reference reliability and validity at all (See tables 2:2 and 2:3). Furthermore, 104 articles out of 148 did not report the internal consistency of the personality test within their own sample (See table 2:4). Of the studies reporting the internal consistency of their sample the values ranged from Cronbach's alpha between .47 and .97. Whilst there is no commonly accepted cut off value, we would usually expect Cronbach's alpha values to lie between 0.7 and 0.90 (Tavakol & Dennick, 2011). Finally, in general, the definitions of personality adopted by researchers were varied and at times not stated.

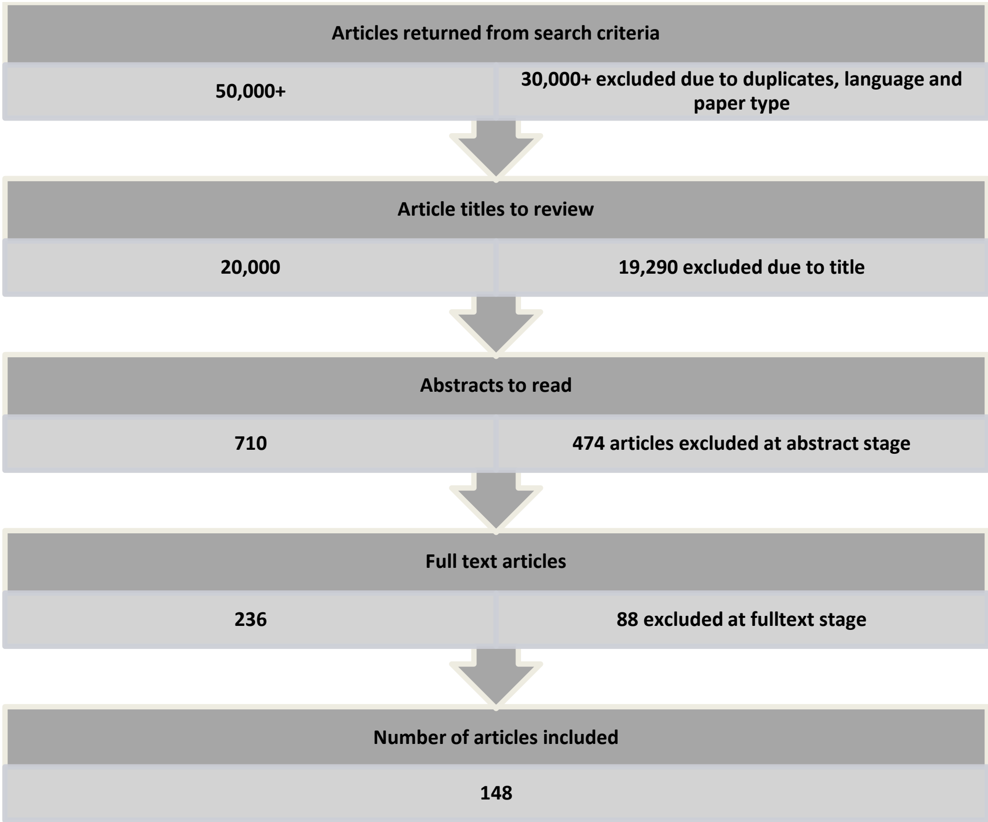



*Figure 2:2 Explanation of the search process and the number or articles included and excluded at each stage.*

*Table 2:4 A summary of the studies included from the full-text stage of the systematic search process. Including; theme, species of focus, sample size, pain type, personality measure, pain measure, study design and indications of reliability and validity.*

| Ref N.o | Theme | Species | SS | Control size | Power analysis | Pain/ Healthy | Personality measure | Pain measure | Design | Validity & reliability | Internal consistency reported | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | Personality and pain in dogs | Dogs | 20 | N/A | N | Acute pain from surgery | MCPQ | CMPS-SF | C | N | N | A |
| 1 | Pain expression and personality | Horse | 21 | N/A | Y | Lameness of varying aetiology | N & E from owner ratings | Score for clinical lamenes s, | CSe | N | N | A |
| 36 | Psychological factors predicting pain in IVF | Human | 34 | N/A | N | Acute pain | EPQ-R | Q | CrS | Y | Y | A |
| 90 | NA in intercourse pain | Human | 634 | N/A | N | Acute pain | NEO | VAS | CSe | N | N | A |
| 132 | Personality and pain from severe injury | Human | 75 | N/A | N | Acute pain | PANAS | Pain score | L | N | Y | A |

| Ref N.o | Theme | Species | SS | Control size | Power analysis | Pain/ Healthy | Personality measure | Pain measure | Design | Validity & reliability | Internal consistency reported | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 52 | Negative affect, control and acute pain | Human | 381 | N/A | N | Acute pain | PANAS (NA) | Q | CrS | N | Y | A |
| 129 | Coping, personality and pain from gallstones | Human | 28 | N/A | N | Acute Pain (gallstones) | EPQ | I, Q | C | N | N | |
| 27 | Can psychological tests predict labour pain | Human | 39 | N/A | N | Acute pain (labour) | EPQ-R | CA | C (P) | Y | N | A |
| 61 | Child temperament and pain | Human | 68 | N/A | N | Acute pain (surgical) | Behaviour style questionnaire | Q, Exp | CC | N | N | A |
| 141 | Psychological factors in pain intensity after acute pain | Human | 62 | N/A | N | Acute pan (orthopaedic) | TAS-20 ASI | VAS | CrS | N | N | A |

| Ref N.o | Theme | Species | SS | Control size | Power analysis | Pain/ Healthy | Personality measure | Pain measure | Design | Validity & reliability | Internal consistency reported | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 46 | Personality and physiological recovery | Human | 70 | 50 HNC | N | Chest pain | BFI-N, BFI-E, STAI | VAS, Exp | CrS | N | N | A |
| 94 | Chest pain and personality | Human | 523 | N/A | N | Chest pain | DS14 | NRS | CSe | Y | Y | A |
| 85 | Alexithymia, catastrophizing in relation to pain severity | Human | 80 | N/A | N | Chronic pain (myofacial) | Alexithymia | Exp, VAS | CrS | N | N | A |
| 24 | Cluster analysis of pain patients | Human | 178 | N/A | N | Chronic pain | BIDR, MPI | VAS | C (P) | N | N | A |
| 143 | Personality and psychological factors in adaption | Human | 275 | N/A | N | Chronic pain | E & N, PANAS | Sadness stimuli likert rating | Past RCT | N | Y | A |

| Ref N.o | Theme | Species | SS | Control size | Power analysis | Pain/ Healthy | Personality measure | Pain measure | Design | Validity & reliability | Internal consistency reported | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 86 | QOL in chronic pain | Human | 86 | 56 | N | Chronic pain | EPQ | Q | CrS | Y | N/C | A |
| 67 | Association between psych functioning & pain | Human | 154 | N/A | Y | Chronic pain | EPQ-R | S | CrS | N | N | A |
| 127 | Pain & emotional states | Human | 99 | N/A | N | Chronic pain | IPIP-NEO short form, PANAS | VAS, Q | CC | Y | N | A |
| 84 | Personality & disability in chronic pain | Human | 250 | 450 non pain | N | Chronic pain | Karolinska | Q, VAS and PDA. | CrS | Y | N | A |
| 113 | Personality traits in chronic pain | Human | 100 | N/A | N | Chronic pain | Millon Clinical Multiaxial Inventory | S | CC | Y | N | A |
| 123 | Psych profiles of pain patients | Human | 37 | 20 CD | N | Chronic pain | MMPI | VAS | CrS | N | N | R |

| Ref N.o | Theme | Species | SS | Control size | Power analysis | Pain/Healthy | Personality measure | Pain measure | Design | Validity & reliability | Internal consistency reported | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | Pain disorder and psychological factors | Human | 138 | 48 pain somatic, 48 non pain somatic | N | Chronic pain | MMPI | VAS | CrS | N | Y | A |
| 148 | Chronic Pain, Life event and personality, path analysis | Human | 147 | N/A | N | Chronic Pain | NEO-FFI | Q | CrS | Y | N | A |
| 66 | Neuroticism, depression, cognitions and pain | Human | 595 | N/A | N | Chronic pain | NEO-PI | Q | CrS | N | Y | A |
| 128 | Relationship between personality, health and chronic pain | Human | 495 | N/A | N | Chronic pain | NEO-SF | NRS | CrS | Y | Y | A |

| Ref N.o | Theme | Species | SS | Control size | Power analysis | Pain/Healthy | Personality measure | Pain measure | Design | Validity & reliability | Internal consistency reported | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 118 | Psychological features pain syndrome (CRPS) | Human | 140 | 54 (control) CD and 50 AD | N | Chronic pain | Personality diagnostic questionnaire | Q | CC | N | N | R |
| 43 | Emotional reactions to pain predict distress | Human | 67 | N/A | N | Chronic pain | SCL-90-R | Q and pain drawings | CrS | Y | N | A |
| 12 | Psychological profiles and pain in chronic prostatitis | Human | 65 | 20 | N | Chronic pain | SCLR-90 Bortner Type A | Q | C(P) | N | N | A |
| 39 | Personality as a risk factors for developing CRPS | Human | 50 | N/A | N | Chronic pain | TAS-20 | NRS | C (R) | N | Y | A |

| Ref N.o | Theme | Species | SS | Control size | Power analysis | Pain/ Healthy | Personality measure | Pain measure | Design | Validity & reliability | Internal consistency reported | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 55 | Personality traits and pain location | Human | 150 | 140 | N | Chronic pain | TAS-20 | S | CrS | N | N | A |
| 54 | Pain location and psychological characteristics | Human | 220 | 80 | N | Chronic pain | TAS-20 | VAS | C | N | Y | A |
| 71 | Relationship between temperament and anxiety in pain | Human | 100 | N/A | N | Chronic pain | TCI | Q | CC | N | Y | A |
| 138 | Illness behaviour, personality and pain disorder | Human | 73 | 36 carpal tunnel syndrom e, 37 PD | Y | Chronic pain | EPQ | Ob | CC | | | A |

| Ref N.o | Theme | Species | SS | Control size | Power analysis | Pain/Healthy | Personality measure | Pain measure | Design | Validity & reliability | Internal consistency reported | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 29 | Alexithymia and anxiety | Human | 67 | 37 HNC females | N | Chronic pain | TAS-26 | VAS, Exp | QE | N | N | A |
| 11 | Temperament and character in patients with chronic pain disorder | Human | 60 | 60 HNC | N | Chronic pain | TCI | Exp | QE | N | N | A |
| 35 | Temperament and stress response in juvenile FMS | Human | 48 | 16 HNC | N | Chronic pain & FMS | DOTS-R | Exp, NRS | CC | N | N | A |
| 112 | Can the MMPI discriminate between FMS and chronic pain | Human | 114 | 36 FMS, 44 chronic pain and 34 HNC | Y | Chronic pain & FMS | MMPI-2 | Q | CrS | N | N | A |

| Ref N.o | Theme | Species | SS | Control size | Power analysis | Pain/Healthy | Personality measure | Pain measure | Design | Validity & reliability | Internal consistency reported | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 63 | Abdominal pain and personality, Birth cohort | Human | 980 | N/A | N | Chronic pain (abdominal) | MPQ | S | CC | N | N | A |
| 103 | Heart rate variability, personality and recurrent abdominal pain in children | Human | 48 | 23 HNC | N | Chronic pain (abdominal) | Personality inventory for children PIC | Q | CrS | Y | N | A |
| 38 | QOL, pain and personality | Human | 262 | N/A | N | Chronic pain (back) | EPQ (Croatian) | VAS | CC | N | N | A |
| 7 | Biopsychosocial model of pain | Human | 46 | 23 | N | Chronic pain (back) | MMPI | Q | CrS | N | Y | A |
| 37 | Pain, personality and disability | Human | 29 | N/A | N | Chronic pain (back) | MMPI | Q | C (P) | Y | N | A |

| Ref N.o | Theme | Species | SS | Control size | Power analysis | Pain/ Healthy | Personality measure | Pain measure | Design | Validity & reliability | Internal consistency reported | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 131 | Personality characteristics in chronic low back pain | Human | 101 | N/A | N | Chronic pain (back) | MMPI | Q | CrS | N | N | A |
| 135 | Personality, psychopathology and treatment outcome in CBP | Human | 120 | N/A | N | Chronic pain (back) | MMPI-2 PSY-5 | Q | C | N | N | A |
| 53 | Personality, cognition and vigilance to pain | Human | 122 | N/A | N | Chronic pain (back) | NEO-FFI | Pain drawings and CA | CrS | N | N | A |
| 64 | Psychosocial functioning and pain | Human | 120 | N/A | N | Chronic pain (back) | NEO-FFI | Q | CC | Y | Y | A |

| Ref N.o | Theme | Species | SS | Control size | Power analysis | Pain/Healthy | Personality measure | Pain measure | Design | Validity & reliability | Internal consistency reported | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 82 | Neuroticism, pain recall and activity interference | Human | 70 | N/A | N | Chronic pain (back) | NEO-PI-R | S | Ex post facto | N | N | A |
| 56 | Personality, cognition and response to treatment | Human | 60 | N/A | N | Chronic pain (back) | NEO-PI-R N scale | Exp, NRS, VAS, Q | C(R), CSe, | N | N | A |
| 60 | Affect and low back pain | Human | 443 | | | Chronic pain (back) | PANAS | Q | CC | N | N | A |
| 50 | Attentional bias and personality | Human | 70 | 20 asymptomatic | N | Chronic pain (back) | STAI & MC SDS | VAS | C (P) | 1 | N | A |
| 111 | Self-efficacy, alexithymia and pain | Human | 112 | 53 HNC | N | Chronic pain (back) | TAS | Q | CrS | N | N | R |

| Ref N.o | Theme | Species | SS | Control size | Power analysis | Pain/ Healthy | Personality measure | Pain measure | Design | Validity & reliability | Internal consistency reported | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 145 | Temperament in failed back surgery | Human | 38 | 35 | N | Chronic pain (back) | TCI | Q and pain diary | C | N | N | R |
| 116 | Personality and pain experience | Human | 96 | N/A | N | Chronic pain (benign or oncological) | EPQ | VAS | CrS | N | N | R |
| 31 | The relationship mood and personality | Human | 57 | N/A | N | Chronic pain (bladder) | BPI | Exp, VAS and Q | C (R) | N | N | A |
| 23 | Robustness, chronic and acute pain in cancer | Human | 338 | N/A | Y | Chronic pain (cancer) | PANAS, LOT-R | Q | CrS | Y | Y | A |
| 74 | Personality, self-efficacy and pain management | Human | 150 | N/A | Y | Chronic pain (cancer) | TIPI, PANAS | Exp | CrS | N | N | A |

| Ref N.o | Theme | Species | SS | Control size | Power analysis | Pain/ Healthy | Personality measure | Pain measure | Design | Validity & reliability | Internal consistency reported | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 75 | Gender and personality in cancer pain | Human | 150 | N/A | N | Chronic pain (cancer) | TIPI, PANAS | Q and pain drawing s | CC | N | N | A |
| 19 | Predicting prolonged pain experiences | Human | 55 | N/A | N | Chronic pain (dental) | EAS | VAS | CrS CC | Y | N | A |
| 44 | Personality, temperament and pelvic pain | Human | 82 | 51 HNC | Y | Chronic pain (endometri osis) | TCI-R | Q | CrS | N | N | A |
| 124 | Personality, chronic foot and ankle pain | Human | 90 | 45 HNC | Y | Chronic pain (foot) | EPQ-R | | CC | | | A |
| 97 | Personality and subjective pain in head patients | Human | 317 | N/A | N | Chronic pain (headache & myofacial) | MMPI-2 | Q | CrS | Y | N | A |

| Ref N.o | Theme | Species | SS | Control size | Power analysis | Pain/Healthy | Personality measure | Pain measure | Design | Validity & reliability | Internal consistency reported | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 79 | Personality traits in child/adolescent headache sufferers | Human | 57 | N/A | N | Chronic pain (headache) | ESPQ, CPQ, HPQ | NRS, Exp | CrS | Y | Y | A |
| 146 | Chronic headache, pain and psychological symptoms | Human | 140 | N/A | N | Chronic pain (headache) | Factorial scale of Emotional Adjustment/ Neuroticism NFS | | | | | R |
| 96 | Personality and tenderness between headache types | Human | 75 | N/A | N | Chronic pain (headache) | MMPI | Maximum pain | C (R) | N | Y | A |
| 10 | Personality, head ache pain and response to | Human | 101 | 50 HNC | N | Chronic pain (headache) | MMPI | Q | CC | N | N | A |

| | treatment | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ref N.o | Theme | Species | SS | Control size | Power analysis | Pain/ Healthy | Personality measure | Pain measure | Design | Validity & reliability | Internal consistency reported | Score |
| 4 | Personality in migraine patients | Human | 184 | 75 | N | Chronic pain (headache) | TCI | S | CC | Y | N | A |
| 98 | Psychosocial functioning in pain disorder | Human | 40 | N/A | N | Chronic pain (MSK) | MMPI | Q | CrS | Y | Y | A |
| 140 | Fear avoidance, the role of neuroticism and NA | Human | 401 | N/A | N | Chronic pain (MSK) | NEO-N, PANAS NA | Q, NRS | C | Y | Y | A |
| 87 | Temperament and character in MSK pain | Human | 196 | 118 HNC | N | Chronic pain (MSK) | TCI | S | CrS | N | N | A |
| 83 | QOL, psychological factors in chronic pain | Human | 52 | N/A | N | Chronic pain (neck) | EPQ | Q | CrS | N | Y | A |

| Ref N.o | Theme | Species | SS | Control size | Power analysis | Pain/ Healthy | Personality measure | Pain measure | Design | Validity & reliability | Internal consistency reported | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 147 | PA, resilience and chronic pain | Human | 124 | N/A | N | Chronic pain (OA) & FMS | PANAS-EF, N assessed using 8 items | Q | CrS | N | N | A |
| 136 | Chronic orofacial pain and personality changes | Human | 415 | 238 pain, 177 healthy | N | Chronic pain (orofacial) | Developed own assessment test | Q | C | Y | N | R |
| 72 | Personality and treatment outcomes | Human | 66 | N/A | N | Chronic pain (prostatitis/ CPPS) | BFI | VAS/Diary | C(P)/L | Y | Y | A |
| 18 | Psychological distress and coping self-efficacy in pain | Human | 248 | 146 RA | N | Chronic pain (RA) | EPQ-RSS | NRS | C (P) | N | N | A |
| 100 | Personality, mood and coping in | Human | 71 | N/A | N | Chronic pain (RA) | FFM + Affects balance | Q | C (P) | N | Y | A |

| Ref N.o | Theme | Species | SS | Control size | Power analysis | Pain/ Healthy | Personality measure | Pain measure | Design | Validity & reliability | Internal consistency reported | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | chronic pain | | | | | | scale | | | | | |
| 59 | Affect and pain | Human | 81 | N/A | N | Chronic pain (RA) | PANAS | Pain sites | C (R) | N | N | A |
| 41 | Relationship between disease activity, QOL and personality | Human | 194 | N/A | | Chronic pain (RA) | Personality ABCD | Q | C (P) | Y | Y | A |
| 73 | Personality and pain in RA | Human | 213 | N/A | N | Chronic pain (RA) | TAS-20 | Q | CSe | Y | N | A |
| 22 | Personality and symptom severity | Human | | | | Chronic pain (RA) | | VAS, Exp | QE | N | N | A |
| 105 | Personality and anxiety in temporoman dibular patients | Human | 79 | 41 HNC | N | Chronic pain (TMJ) | EPQ | X-ray, VAS and Q | L | N | Y | A |

| Ref N.o | Theme | Species | SS | Control size | Power analysis | Pain/Healthy | Personality measure | Pain measure | Design | Validity & reliability | Internal consistency reported | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 91 | Pain, personality and psychopathy | Human | 76 | 76 | N | Chronic pain (TMJ) | MMPI | S | CC | N | N | A |
| 58 | Mutual pain personalities in chronic pain | Human | 69 | 37 | N | Chronic pain (TMJ) | TCI-R | VAS | C (R) | N | N | A |
| 93 | Pain, neuroticism and grey matter | Human | 34 | 17 HNC | N | Chronic pain (TMJD) | NEO | Q, VAS and Exp | CC | N | Y | A |
| 57 | Alterations in brain anatomy changing personality in pain | Human | 65 | 43 HNC | N | Chronic pain (trigemenial ) | TCI-R | Exp | C(R ) | Y | N | A |
| 88 | Variance in perceived | Human | 90 | 48 HNC | N | FMS | EPQ, EPQ-N, | Exp, MRI | QE | N | N | A |

| Ref N.o | Theme | Species | SS | Control size | Power analysis | Pain/ Healthy | Personality measure | Pain measure | Design | Validity & reliability | Internal consistency reported | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pain | | | | | | EPQ-L, TAS | and VAS | | | | |
| 99 | Personality and fibromyalgia | Human | 92 FMS | 65 HNC | N | FMS | EPQR-A | VAS | C (R) | N | Y | A |
| 114 | Biopsychosocial profiles in pain | Human | 661 | N/A | N | FMS | MMPI-2 | Exp | CSe | N | N | R |
| 89 | Fear avoidance personality and pain | Human | 74 | N/A | Y | FMS | NEO-FFI | VAS | CrS | N | N | A |
| 40 | Pain experience in fibromyalgia | Human | 159 | N/A | Y | FMS | TAS-20 | Q | CrS | Y | Y | A |
| 121 | Depression and personality in FMS | Human | 69 | N/A | N | FMS | TCI (Brazilian) | VAS | CC | N | N | A |
| 5 | Personality in FMS & | Human | 309 | N/A | N | FMS | TCI-R | VAS | CC | Y | Y | A |

| Ref N.o | Theme | Species | SS | Control size | Power analysis | Pain/ Healthy | Personality measure | Pain measure | Design | Validity & reliability | Internal consistency reported | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | chronic fatigue | | | | | | | | | | | |
| 108 | Personality and pain during birth | Human | 104 | N/A | N | Healthy | BFI | Q | CrS | N | N | A |
| 45 | Psycho & physiological human pain clusters | Human | 120 | N/A | ? | Healthy | BFI-N, BFI-E | Q | CrS (R) | N | N | A |
| 47 | Extraversion and pain tolerance | Human | 42 | N/A | N | Healthy | EPI, Rorschah's | NRS | CrS | Y | Y | A |
| 17 | Effect of neuroticism & catastrophising on pain responses | Human | 1322 | N/A | N | Healthy | EPQ | Q | CrS | N | N | A |
| 33 | Neuroticism and visceral pain | Human | 31 | N/A | N | Healthy | EPQ | S | CSe | Y | N | A |

| Ref N.o | Theme | Species | SS | Control size | Power analysis | Pain/ Healthy | Personality measure | Pain measure | Design | Validity & reliability | Internal consistency reported | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 106 | Catastrophising, personality and pain recall | Human | 56 | N/A | N | Healthy | EPQ | Q | C (P) | N | Y | A |
| 119 | Extraversion and brain activity during visceral pain | Human | 33 | N/A | N | Healthy | EPQ | S | CrS | N | N | R |
| 3 | Personality and distress in head pain patients | Human | 317 | N/A | N | Healthy | EPQ N scale and L scale | S, CA | CrS | N | N | A |
| 144 | Using personality to predict pre-labour pain | Human | 220 | N/A | N | Healthy | Goldberg's questionnaire | Q | CrS | Y | Y | A |
| 42 | Personality and pain perception | Human | 98 | N/A | N | Healthy | HEXACO-PI-R | VAS | CrS | N | N | A |
| 14 | Predicting later life pain | Human | 2332 | N/A | N | Healthy | MMPI | Q, Exp | CrS | N | N | A |

| Ref N.o | Theme | Species | SS | Control size | Power analysis | Pain/ Healthy | Personality measure | Pain measure | Design | Validity & reliability | Internal consistency reported | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 107 | Extraversion, responses to physical pain and sadness | Human | 51 | N/A | N | Healthy | NEO | VAS | CrS | N | N | A |
| 21 | Personality and physiological responses predict pain | Human | 41 | N/A | N | Healthy | NEO FFI and PANAS | Q | C (P) | Y | N | A |
| 26 | Personality, pain and depression | Human | 404 | N/A | N | Healthy | NEO-FFI | Q | CrS | N | N | A |
| 125 | Meta-cognition, personality and pain behaviour | Human | 308 | N/A | N | Healthy | NEO-FFI | Q | CrS | N | N | A |
| 133 | Personality and pain sensitivity | Human | 188 twins | N/A | N | Healthy | NEO-PI-R | | | | | A |

| Ref N.o | Theme | Species | SS | Control size | Power analysis | Pain/ Healthy | Personality measure | Pain measure | Design | Validity & reliability | Internal consistency reported | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 139 | Using neuroticism to predict pain. | Human | 3676 | N/A | N | Healthy | Neuroticism | Q | CrS, L | Y | Y | A |
| 78 | Moderating effect of NA on pain tolerance | Human | 25 | N/A | N | Healthy | PANAS | Blood pressure cuff | QE | Y | N/C | A |
| 110 | Pain regulation and personality | Human | 50 | N/A | N | Healthy | PANAS, NEO-PI | Q | CrS | N | N | R |
| 142 | Personality and pain perception | Human | 1402 | N/A | N | Healthy | SGC1 | NRS | CrS, CC | N | N | R |
| 122 | Alexithymia, NA, chronic pain and life satisfaction | Human | 927 | N/A | N | Healthy | TAS, NA, anxiety scales of SCL-90-R | Q, VAS | C | Y | N | A |
| 13 | Pain, personality | Human | 181 | N/A | N | Healthy | TCI | Q | CC | N | N | A |

and genes

| Ref N.o | Theme | Species | SS | Control size | Power analysis | Pain/Healthy | Personality measure | Pain measure | Design | Validity & reliability | Internal consistency reported | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 68 | Variance in experimental pain sensitivity | Human | 500 | N/A | N | Healthy | TCI | Muscle tender score, VAS | CrS | N | N | A |
| 115 | Sensitivity to pain and personality | Human | 191 | N/A | N | Healthy | TPQ | VAS | CrS | N | N | R |
| 104 | Visceral and somatic pain and personality | Human | 18 | N/A | N | Healthy | Big five inventory (E & N) | Q and VAS | C (R) | N | Y. | A |
| 34 | Type D personality as a pain risk factor | Human | 5012 | N/A | N | Healthy | DS14 | S | CC | Y | N | A |
| 81 | Psychological factors and experimental pain | Human | 189 | N/A | N | Healthy | EPQ, PANAS | Q | CC | Y | N | A |

| Ref N.o | Theme | Species | SS | Control size | Power analysis | Pain/ Healthy | Personality measure | Pain measure | Design | Validity & reliability | Internal consistency reported | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 80 | Personality, cognitions and exp pain | Human | 66 | N/A | N | Healthy | EPQ-R, PANAS | VAS, Q | QE | N | N | A |
| 126 | Pain regulation as an indicator of childhood temperament | Human | 130 child/parent dyads | N/A | N | Healthy | Infant behaviour questionnaire revised | Q, NRS, B coding | L, Co | Y | N | A |
| 109 | N, anxiety sensitivity and laboratory pain | Human | 99 | N/A | N | Healthy | Junior EPQ Neuroticism subscale | VAS and pain drawings | CrS | N | N | R |
| 6 | Personality and pain perception | Human | 400 | 200 | N | Healthy | NEO | EMG Cortisol | QE CC | N | N | A |
| 102 | Alexithymia and experimental pain tolerance | Human | 41 | N/A | N | Healthy | TAS | Q | CrS | Y | N | A |

| Ref N.o | Theme | Species | SS | Control size | Power analysis | Pain/ Healthy | Personality measure | Pain measure | Design | Validity & reliability | Internal consistency reported | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 51 | Pain tolerance and personality | Human | 22 | 11 controls | N | Healthy | TCI | Q | CrS | N | N | A |
| 65 | Cognition, affect and catastrophizing | Human | 104 | N/A | N | Heterogeneous chronic pain | AREQ | Q | CC | N | N | A |
| 92 | Psychosocial factors related to chronic pain in adolescents | Human | 370 +310 parents | 222 HNC, 127 parents | N | Heterogeneous chronic pain | Inadequacy scale | Q | CrS | N | N | A |
| 20 | Psychogenic and somatic factors in pain disorder | Human | 51 | 31 psychogenic and 19 organic | N | Heterogeneous chronic pain | Karolinska | Q | CC | Y | Y | A |
| 62 | Personality, cognition and adjustment | Human | 99 | N/A | N | Heterogeneous chronic pain | MCMI-II | Q | CrS | N | Y | A |

| Ref N.o | Theme | Species | SS | Control size | Power analysis | Pain/Healthy | Personality measure | Pain measure | Design | Validity & reliability | Internal consistency reported | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16 | Psychological dimensions in chronic pain | Human | 135 | 30 | N | Heterogeneous chronic pain | Mini-MMPI | Exp | CSe | N | Y | A |
| 76 | Chronic pain, physiological findings and psychological profiles | Human | 177 | N/A | N | Heterogeneous chronic pain | MMPI | VAS | CC | N | N | A |
| 95 | Personality and symptomology in TMJ | Human | 243 | N/A | N | Heterogeneous chronic pain | MMPI | Q | CrS | | Y | A |
| 32 | Coping in chronic pain | Human | 329 | N/A | N | Heterogeneous chronic pain | MMPI-2 | VAS, Q, Exp | L | Y | Y | A |
| 101 | Normal personality traits of chronic pain | Human | 81 | N/A | N | Heterogeneous chronic pain | NEO | Q | CC | N | N | A |

| Ref N.o | Theme | Species | SS | Control size | Power analysis | Pain/ Healthy | Personality measure | Pain measure | Design | Validity & reliability | Internal consistency reported | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 117 | Depression, neuroticism and pain recall | Human | 66 | N/A | N | Heterogeneous chronic pain | NEO | VAS and Q | CrS | N | N | R |
| 8 | Emotional regulation, adjustment and coping in chronic pain | Human | 128 | N/A | N | Heterogeneous chronic pain | PANAS | Exp, CBF | | Y | N | A |
| 25 | Somatization in chronic widespread pain | Human | 3,057 | Twin study | Y | Heterogeneous chronic pain | TIPI | VAS | C (P) | N | N | A |
| 120 | Personality in pain patients | Human | 3055 | N/A | N | Heterogeneous pain sample | MPI | Q | CrS | N | N | |
| 49 | Personality and psychiatric classification | Human | 43 | N/A | N | Heterogeneous pain sample | STIPO | Q, VAS | CrS | 2 | N | A |

| Ref N.o | Theme | Species | SS | Control size | Power analysis | Pain/ Healthy | Personality measure | Pain measure | Design | Validity & reliability | Internal consistency reported | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 30 | Negative affect and coping in migraine patients | Human | 100 | 50 HNC | N | Migraine and HNC | Type D scale 14, BFI | Exp | CC | N | N | A |
| 134 | Musculoskeletal complaints, depression and neuroticism | Human | 746 MZ + 770 DZ twins | N/A | N | Musculoskeletal complaints | NEO-PI-R | Q | C | Y | Y | A |
| 130 | Personality and pain interference | Human | 102 | N/A | Y | Musculoskeletal pain | DS14 | Q | CrS | Y | Y | A |
| 28 | Alexithymia and psychological distress in pain | Human | 90 | 45 HNC females | N | Myofascial pain females (MP) | TAS-20 | VAS, Q | CrS | Y | N | A |

| Ref N.o | Theme | Species | SS | Control size | Power analysis | Pain/ Healthy | Personality measure | Pain measure | Design | Validity & reliability | Internal consistency reported | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 137 | Alexithymia, anxiety sensitivity and chest pain | Human | 229 | N/A | N | Non cardiac chest pain | TAS-20 | Q | C (P) | Y | Y | A |
| 70 | Using distress reactivity /recovery in responses to pain as an early temperament predictor | Human | 26 | N/A | N | Pre-turn infants of low birth weight | NSCF, ECBQ | VAS | CSe | N | N | A |
| 9 | Personality and emotion on blood flow during painful stimulation in fibromyalgia | Human | 24 | N/A | N | Fibromyalgi a (experiment al pain) | EPQ | % improve ment in headach e | CC | N | N | A |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 48 | Affect, clinical and laboratory pain | 159 (79 for exp task ) | N/A | N | Chronic pain (knee osteoarthritis) | Asked questions regarding emotions based on PANAS | Heart rate, facial expressions, crying | C(P ) L | Y | N | A |

Summary of studies. Key: AD, Affective disorder; CA, Clinical assessment; CBP, Chronic back pain; CD, Conversion disorder; CC, Case control; CLBP, Chronic lower back pain; CM, Chronic migraine, CRPS, Complex regional pain syndrome; CS, Case study;; QE, Quasi-experiment; CrS, Cross-sectional; C(P), CP, Chronic prostatitis; CPPS, Chronic pelvic pain syndrome; Prospective cohort; C(R), Retrospective cohort; CSe, Case series; CR, Case report; CTTH, Chronic tension type headache; EMG, Electromyography, Exp, Experimentally induced pain; FMS, Fibromyalgia syndrome; HNC, Healthy normal controls; IVF, In vitro fertilisation; KOA, Knee osteoarthritis; NRS, Numerical rating scale; PDA, Pain drawing analogue; RA, Rheumatoid arthritis; S, Pain sample; TMD, Temporomandibular joint dysfunction; TMJ, Temporomandibular joint disorders; Q, Pain questionnaire/pain questions; VAS, Visual analogue scale.

1. Ijichi et al, (2014); 2. Lush and Ijichi (2018); 3. Aeseth et al, (2011); 4, Abbate-Daga et al, (2007); 5. Ablin et al, (2016); 6. Abu Alhaija et al, (2014); 7. Adams, (2006); 8. Agar –Wilson and Jackson, (2012); 9. Aguilar et al, (2018); 10. Aguirre et al, (2000); 11. Aker et al, (2017); 12. Anderson et al (2008); 13. Aoki et al (2010); 14. Applegate et al (2005); 15. Aragona et al (2008); 16. Ardic and Toraman (2002); 17. Banozic et al (2018); 18. Benka et al (2014); 19. Bergius et al (2008); 20. Binzer, Almay and Eisemann (2003); 21. Boggero et al (2014); 22. Braun et al (2008) 23.Bruce et al, (2012) 24. Burns et al (2001); 25. Burri et al (2017); 26. Calabrese et al (2006); 27. Carvalho, Zheng and Tagaloa (2014); 28. Castelli et al (2013); 29. Celikel and Saatcioglu (2006); 30. Chan and Consedine (2014); 31. Chen, Lee and Wu (2017); 32. Cipher, Clifford and Schumacker, (2002); 33.Coen et al (2011); 34. Condén et al,

(2013); 35. Conte, Walco and Kimura, (2003) 36. Cooper, Weaver and Hay (2000); 37. Coskun et al (2000); 38. Cvijetic et al (2014); 39. Dilek et al, (2012); 40. Di Tella et al (2017); 41. Donisan et al (2017); 42. Dumitre and Chraif (2015); 43. Edwards et al (2014); 44. Facchin et al, (2016); 45. Farmer et al, (2013a); 46. Farmer et al, (2013b); 47. Ferracut and DeCarolis (2005); 48. Finan, Quartana and Smith (2013); 49. Fischer-Kern et al (2011); 50. Franklin et al (2016); 51. Freund et al (2013); 52. Gedney and Logan (2007); 53. Goubert, Crombez and Van Damme (2004); 54. Gregory, Manring and Berry (2000); 55. Gregory, Manring and Wade (2005); 56. Groth-Marnat and Fletcher (2000); 57. Gustin et al (2011); 58. Gustin et al (2013); 59. Hamilton, Zautra and Reich (2007); 60. Hassett et al (2016); 61. Helgadottir and Wilson (2004); 62. Herrero , Ramirez-Maestre and Gonza (2008); 63. Howell et al (2003); 64. Janowski, Steuden and Kurylowicz (2010); 65. Jones et al (2003); 66. Kadimpati et al (2014); 67. Kennedy et al (2010); 68. Kim et al (2004); 69. Kleiber et al, (2007); 70. Klein et al (2009); 71. Knaster et al (2000); 72. Koh et al (2014); 73. Kojima et al (2014); 74. Krok and Baker (2014); 75. Krok, Krok-Schoen and Baker (2016); 76. Kvale, Ellertsen, Skouen (2001); 77. Kwissa-Gajewska and Dolegowska (2017); 78. Lacourt et al (2015); 79. Lanzi et al (2001); 80. Lee, Watson and Law (2010); 81. Lee, Watson and Frey-Law (2013); 82. Lefebvre and Keefe, (2013); 83. Lin et al, (2010); 84. Linder et al, (2000); 85. Lumley, Smith and Longo (2002); 86. Lung (2004); 87. Malmgren-Olsson and Bergdahl (2006); 88. Malt et al, (2002); 89. Martinez et al (2011); 90. Meana and Lykins (2009); 91. Meldolisi et al (2000); 92. Merlijn et al (2003); 93. Moayedi et a, (2011); 94. Momersteeg et al (2016); 95. Mongini et al (2000); 96. Mongini (2005); 97.Mongini et al (2009); 98. Monsen and Havik (2001); 99. Montoro and Reyes del Paso (2015); 100. Newth and

Delongis, (2004); 101. Nitch and Boone (2004); 102. Nyklicek and Vingerhoets (2000); 103. Olafsdottir et al (2001); 104. Paine et al (2009); 105. Pallegama et al, (2005); 106. Pallegama et al, (2017); 107. Park et al, (2014); 108. Pavaleanu et al, (2017); 109. Payne et al (2013); 110. Pecina et al (2014); 111. Pecukonis et al (2009); 112. Perez-Pareja et al (2010); 113. Poppe et al (2011); 114. Porter-Morfitt et al (2006); 115. Pud et al (2004); 110. Ramirez-Maestre, Martinez and Zarazaga (2004); 117. Raselli and Broderick, (2007); 118. Reedijk et al (2008); 119. Ruff et al (2015); 120. Sakakibara, Wang and Kasai (2014); 121. Santos et al (2011); 122. Shibata et al (2014); 123. Shiri et al (2003); 124. Shivarathre et al (2014); 125. Spada et al (2016); 126. Stevens et al (2013); 127. Strachan et al (2014); 128. Suso-Ribera and Gallardo-Pujol (2016); 129. Svebak et al (2000); 130. Talaei-Khoei et al (2018); 131. Tavallaii et al (2010); 132. Vassend et al (2011); 133. Vassend, Roysamb and Nielsen (2013); 134. Vassend et al (2017); 135. Vendrig, Verksen and de Mey (2000); 136. Vickers an Boocock, (2005); 137. White et al (2011); 138. White et al, (2003); 139. Wilner, Vranceanu and Blashill (2014); 140. Wong et al (2014); 141. Wood, Maclean and Pallister (2011); 142. Wranker et al, (2015); 143. Wright, Zautra and Going (2008); 144. Yadollahi et al (2014); 145. Yalbuzdag et al (2016); 146. Zampieri, Tognola and Galego, (2014); 147. Zautra, Johnson and Davis (2005); 148. Zeng et al, (2016).

## 2.5 Discussion

This review highlighted that there is a paucity of research existing looking at the association between personality and pain in animals. However, it did reveal a wealth of research in humans that can be used to illustrate where there is the potential for a relationship between pain and personality in animals and which traits are of importance. This discussion will be organised under three headings that I consider to be useful in informing future studies looking at the effect of personality on pain expression in animals. These are:

1) The biological link between personality and pain

2) Personality and pain expression/pain reporting in relation to severity

3) Personality and psychological impact of pain.

In themes one and two the research findings will be discussed and then explored to consider how it may apply to animals as well as humans. In addition, theme three is used to illustrate the complexity that may be needed in future studies with animals to understand the relationship between personality and pain expression in a more nuanced way.

### *2.5.1 The relationship between personality and physiological changes associated with pain*

Twenty of the articles specifically assessed the interaction between pain, physiology, and personality. Findings suggest that in healthy human participants, individuals with higher mean arterial blood pressure (MAP) have better pain tolerance, but only when levels of neuroticism are low. The findings suggest that the effects of pain on stress are dependent upon personality. When individuals have higher levels of neuroticism, MAP positively correlates with lower levels of pain tolerance (Boggero et al, 2014), thus an interaction between personality and physiology during pain (Boggero et al, 2014). MAP is an automatic cardiovascular response and elevated MAP has been used in previous studies with humans (Lipman et al, 2002) and animals (Bobrovskaya et al, 2013) as a measure of stress. Behavioural signs, such as flinching, or withdrawal responses to painful stimuli, are also correlated to cardiovascular outcomes, such as arterial blood pressure in rats (Taylor et al, 1995). In addition, studies in rats show that induced stress leads to elevation in blood pressure (Bobrovskaya et al, 2013). Therefore, whether individuals find painful situations stressful and the extent to which painful situations effect physiology is related to personality. If this is the case in animals as well as humans, use of these physiological signs as indicators of pain severity should be accompanied by a measure of personality.

Farmer et al (2013a ;2013b) demonstrated that participants with higher levels of neuroticism and anxiety showed less pain tolerance than those with lower levels of neuroticism and anxiety, both before and during experimental pain. These two distinct groups could also be differentiated by their brain activity and over-representation of the s allele of the serotonin transporter-linked polymorphic region (5HTTLPR) in the high neuroticism group (Farmer et al, 2013a). 5-HTTLPR is associated with amygdala responses during times of negative emotion. Research suggests that adverse life events in some individuals with the short variant allele have a more profound effect on depressive symptoms and these individuals may score higher on neuroticism (Lesch et al, 1996; Caspi et al, 2003; Munafò et al, 2009). These findings suggest there are certain biomarkers which may be useful in determining whether individuals are at risk of developing chronic pain conditions. Humans are not the only species to display this polymorphism; it has also been observed in other primate species (Dobson & Brent, 2013).

Individuals suffering from prolonged periods of pain can show differences in brain anatomy when compared with healthy individuals. For example, in a study by Moayedi et al, (2011) patients who had a longer history of temporomandibular joint disorder (TMJ) showed greater amounts of grey matter (GM) in the sensory thalamus (responsible for relaying sensory information from the body to the cerebral cortex) than healthy controls. Furthermore, reported pain unpleasantness was found to be negatively correlated with the cortical thickness in the orbitofrontal cortex (OFC) in healthy controls, yet positively correlated in patients with high levels of neuroticism. These findings may suggest that factors preceding the onset of pain, such as personality, may contribute to anatomical and physiological brain differences (Moayedi et al, 2011). Alternatively, these factors may influence how individuals perceive stimuli in different contexts. This can lead to a chicken and egg situation in which it is difficult to determine whether differences in grey matter contribute to the development of chronic pain conditions, or whether chronic pain conditions cause changes in grey matter.

The above findings suggest that the relationship between personality and pain in humans can be evidenced through some physiological measures, rather than just relying on self-report measures of pain alone. Traits such as neuroticism are related to less pain tolerance and heightened sensitivity, whereas traits such as extraversion may be beneficial to tolerance. When considering these findings in relation to animals there is a great deal of existing research which focuses on the behavioural, neurological and physiological responses of laboratory rats to experimentally-induced pain, mainly to form novel models for understanding human disease (Blackburn-Munro, 2004). In these studies, similar physiological responses (to those in humans) to induced pain are observed in rats. Similarities in the physiology and brain anatomy between humans and some animal species means that these findings could be used to direct future studies with animals. However, no research has explicitly explored the link between experimentally induced pain and personality in a range of animals.

### *2.5.2 The impact of personality on behavioural expressions (in animals) or self-reports (in humans) of pain*

The review highlighted that personality influences the relationship between behavioural expressions of pain (in animals) or self-reports of pain (in humans) and pain severity. Pain identification and severity diagnosis in both humans and animals is dependent upon a clinician being able to accurately determine pain based upon clinical signs and/or patient reports. In animals, the accuracy of the ability to assess clinical signs becomes even more important, due to an animal's inability to verbally convey their emotions (Reid et al, 2013). Behavioural indices are therefore used to inform treatment decisions, such as correct drug dosages, or in extreme situations end of life decisions (Ashley, Waterman-Pearson and Whay, 2005).

Research by Ijichi et al (2014) was the first paper (to my knowledge) to look at the relationships between personality, pain expression and pain severity in animals. The findings, (whilst not without limitation, such as subjective assessments of disease severity) suggest that in horses, pain expression (indicated by lameness) is not indicative of clinician assessed disease severity, rather it is positively correlated with extraversion. Conversely, horses with higher levels of neuroticism had a lower threshold for severity and were rated as less tolerant of pain by their owners (Ijich et al, 2014). The results suggest that extraversion is related to behavioural expressions of pain, whereas neuroticism is related to the experience of pain (Ijichi et al, 2014). These findings have important implications for pain assessments in animals; for example, lameness is used to assess the progression of disease and efficacy of analgesia (Ashley, Waterman-Pearson and Whay, 2005). If lameness is not indicative of disease severity veterinarians may be under or over treating animals.

In a more recent study by Lush and Ijichi (2018) the relationship between personality and behavioural indices of acute surgical pain was assessed in dogs. The findings suggested that dogs with higher levels of extraversion had higher pain scores, however, neuroticism showed no relationship with pain behaviour (Lush and Ijichi, 2018). In this study the positive correlations between extraversion and pain were based on behavioural observations of pain and support the notion that when in acute pain, behavioural expressions are related to personality.

Similarly, research with humans suggests that self-reports of pain are not always related to expected disease severity (Cooper et al, 2000; Coskun et al, 2000;

Krok and Baker, 2004; Paine et al, 2009), but related to personality. Self-reports of pain could be considered comparable to non-human animals' behavioural expressions of pain, as they are an indication of how pain is affecting that individual. Furthermore, if an individual's personality influences their perception of their own pain it is logical to suggest it may influence their perception of another individuals (whether human or animal) pain. As such, this is covered in chapter five of this thesis.

These findings suggest that personality in several species is associated with how they express and report on pain and as such points to several areas that could improve pain and welfare assessments. Currently in animals, most pain assessments are based upon observations of behaviour, with the assumption that behavioural displays of pain are indicative of disease severity. However, this review confirms that across species, physical indicators of disease severity, such as x-rays or the extent of tissue damage, do not always correlate with the presence of pain, the amount of pain experienced, and the behaviour observed (Coskun et al, 2000; Cvijetic et al, 2014; Ijichi et al, 2014, Lush and Ijichi, 2018).

### *2.5.3 Personality is related to the psychological impact of chronic pain*

The final finding from this review was that personality and mood appear to influence an individual's ability to cope and adapt to pain, meaning individuals differ in how psychologically robust they are.

Studies of patients with knee arthritis have identified that personality traits moderate the relationship between disease severity and physical disability. Individuals with knee arthritis report pain, distress and physical disability, yet in only around half of these individuals is radiographic joint damage apparent (Wright et al, 2008); this is also evident animals (Ijichi et al, 2014). Wright et al, (2008) found that neuroticism and negative affect are risk factors for physical disability and psychological distress in patients with knee arthritis. Whereas extraversion and positive affect are resilience factors for positive outcomes. Furthermore, positive affect and extraversion are more important than disease severity in determining how an individual experiences pain.

This can be thought of as psychological robustness. Bruce et al, (2012) examined 'psychological robustness' in a sample of cancer patients and found that higher levels of positive affect (PA) and optimism are associated with lower intensity acute pain and less movement evoked pain. Furthermore, Zautra et al, (2005) demonstrated higher levels of PA can help protect against the interaction between stress and NA, blunting the emotional effect of pain. Cognition is an important factor within this relationship. For example, maladaptive pain cognitions, such as pain catastrophizing and pain anxiety, are not predictive of disease severity and depression, but moderated by neuroticism, conscientiousness or negative affect (Martinez et al, 2011; Kadimpati et al,2014; Wong et al, 2014). This demonstrates that neuroticism is a risk factor for developing maladaptive cognitions in humans suffering from pain condition. Finally, neuroticism can be perceived as a vulnerability factor, reducing an individual's capacity at which pain is perceived as problematic (Goubert, Crombez and Van Damme, 2004).

From the human literature it is evident that personality and mood both moderate the extent to which pain causes physical disability and psychological distress. Extraversion and positive affect and neuroticism and negative affect interact to determine the effect chronic pain has on quality of life. Coping styles are linked to this relationship.

In humans, coping styles are varied and can involve specific coping strategies, for example coping during pain and more global coping styles for example, stress in general. Higher levels of neuroticism are related to more passive coping strategies (Ramirez-Maestre et al, 2004), more interpersonal distress and lower self-perceived competency (Nitch and Boone, 2004). Higher levels of extraversion are related to more active coping (Ramirez-Maestre et al, 2004); higher extraversion and openness are related to more adaptive coping, and lower anxiety, depression and vulnerability (Nitch and Boone, 2004).

Newth and Delongis, (2004) conducted research in humans suffering from rheumatoid arthritis (RA). Personality moderated the type of coping used, and the effectiveness of that coping measure. Emotional expression as a coping measure (expression of pain related distress and obtaining support from others) was used more by those with higher levels of neuroticism. Higher levels of extraversion were related to cognitive reframing- where individuals interrupted their maladaptive thoughts and reframed them in a more positive light. The use of appropriate coping styles is essential to minimising the impact pain has on psychological health.

Coping styles in the animal literature are different to those reported in the human literature and can be thought of as an adaptive response to a noxious stimulus or situation (Wechsler, 1995). In animals, coping styles are often classified into either ‘passive’ or ‘active’ coping, characterised by “immobility or the stopping of performed overt behaviours" and "the employment of strategies to remove oneself from the stressor or to move the stressor itself" respectively (Wechsler, 1995). Consistent behavioural and physiological differences between coping styles can be seen, with more proactive individuals employing the flight or fight response, potentially being more aggressive and explorative, and passive individuals showing a 'conservation-withdrawal' response with behavioural immobility, less aggression, lower sympathetic and higher parasympathetic activity (Koolhaas, 2008; Briefer et al, 2015). Furthermore, it is suggested that individual variation in coping styles has a biological function and may impact parameters of fitness, such as immunity (Koolhaas, 2008).

As was highlighted in chapter one, some research uses the terms coping styles and personality synonymously. These findings however suggest that future studies with animals may benefit from further examination of whether personality and coping styles are unique concepts in the species in question. If so, thought needs to be given to the appropriate methodology that can be used to measure the impact they may both independently or collectively have on pain experience and expression.

## 2.6 Conclusion

This review has highlighted that personality, pain experience and expression have only recently started to be studied together in animals, and as such little is known about how personality influences how animals experience and express pain. It has also summarised the main areas of research from the human literature that may be helpful in guiding future research into pain and personality in animals.

Findings from the limited research in animal's supports the notion that personality and pain in animals can interact, yet the level of evidence available to support causal relationships is low. The relationship between personality and pain in humans is not always direct, but is moderated by mood and cognition. These are not factors that are unique to humans and therefore, when appropriate, should be included in animal studies to further our understanding of this complex process. As such both mood and personality are looked at independently and their interaction in the next chapters (four, five and six). Finally, to aid future reviews and meta-analyses, it would be beneficial for any future studies using psychometric measures to include information on the reliability and validity of the measures used.

# 3 Chapter Three: Mood and the occurrence of owner reported health problems in the domestic dog.

*Reaney, S. J., Zulch, H., Mills, D., Gardner, S., & Collins, L. (2017). Emotional affect and the occurrence of owner reported health problems in the domestic dog. Applied Animal Behaviour Science, 196, 76-83.*

## 3.1 Abstract

This chapter has been published as a peer reviewed paper in 2017 in Applied Animal Behaviour Science and is based on a secondary analysis of a pre-existing data set. Interactions between health, behaviour and individual differences such as; mood, affect, and/or personality, have been studied more in humans than they have in non-human animals. In humans, links can be made between personality and the expression of health problems, and between personality, affect, mood, coping, treatment and recovery success. Previous research with animals has shown that personality and mood interact to determine judgement bias and that personality interacts with stress responses and pain expression. This suggests that the way animals deal with life events is dependent on interactions between personality and mood and that pain behaviours observed in animals are not always reflective of disease severity. As such, reliance only on behavioural displays of pain

in health assessments, without information on what may mediate or moderate that behaviour makes accurate treatment difficult.

The aim of this study was to look at the interactions between the occurrence of health conditions in pet dogs (as reported by their owner), behaviour and the dogs' score on (positive and negative) affect (mood). A survey collected information from dog owners about their dog's past and current medical conditions, occurrence of problem behaviours, and their dog's level of positive and negative affect, as well as biographical information on the breed, sex and age of the dog. Nine hundred and forty-three responses were obtained, of which 796 were fully completed and could be used in the analysis.

Binomial logistic regressions were conducted, with either presence/absence of a current or previous experience of a range of general health and pain-causing conditions included as dependent variables and Affectivity domains, aggression and age were included as independent variables. For most of the general health conditions (with the exception of the dental, vision and hearing problem category), only age was a predictor of both current and previous experience of a health condition. However, positive affect was associated with current experience of a pain-causing condition, with lower scores for positive affect predicting the presence of a current pain-causing condition. Only age was associated with experience of a previous condition. Finally, no difference in aggression scores was observed reported between dogs in any of the pain experience categories. These results provide novel findings for an association between health problems and affect in dogs.

## 3.2 Introduction

This chapter has been published as a peer reviewed paper in 2017 in Applied Animal Behaviour Science. Since publication the introduction has been updated to include newly published work and the table layout has been altered to be in keeping with the rest of the thesis. Furthermore, since this paper was published, and in light of further studies using the PANAS, the wording has been changed and a paragraph has been added to cautiously suggest that mood may be a better term to use to describe what the PANAS is measuring. The terms positive and negative affect are used to describe, positive and negative mood.

The associations between health problems such as coronary heart disease (Jerram and Coleman, 1999) or fibromyalgia, personality and behaviour have been frequently studied in the human literature, as has the presence of physical illnesses and the co-occurrence of mental health problems (Admunson and Katz, 2009), such as depression in cancer patients (Bodurka-Bevers et al, 2000). However, the causative direction of such associations and the possible mechanisms underlying them are unclear (Deary et al, 2010). Despite this, research has suggested that in humans, personality, affect and mood can all have both mediating and moderating effects on an individual's health.

Chronic health problems are considered to cause prolonged stress for an animal, resulting in the need for that individual to adapt (Martini et al, 2000; Lindley, 2011; Munro et al, 2012). Adaptation can be physiological such as altered neuroendocrine and autonomic nervous system (ANS) functioning, or psychological, such as changes in behaviour and emotional state (Martini et al, 2000). Adaptation requires substantial amounts of energy, and can be at the expense of other biological functions, such as growth and reproduction (Mariti et al, 2012). As such, it is reasonable to suggest that prolonged health conditions constitute a stressor and significantly impact the welfare of an individual animal.

In addition, internal factors, such as personality and mood, are thought to impact how individuals respond to life events (Briefer et al, 2015, Asher et al, 2016). However, as highlighted in chapter two, little research has been undertaken in non-human animals to directly investigate the interrelationship between personality and health or to determine the effect health conditions have on the affective state of an animal. Capitano et al (1999) demonstrated that personality can have a protective effect during compromised health, for example, rhesus macaques (*Macaca mulatta*) with higher levels of sociability were less likely to develop simian immunodeficiency virus (SIV) than those with lower levels of sociability. Furthermore, in infant rats, higher levels of the stable behaviour trait of neophobia were found to predict higher adult corticosterone levels and earlier death (Cavigelli & McClintock, 2003), demonstrating a link between personality (as assessed by level of neophobia), health parameters and life span. Whilst Neave et al (2013) found that pain resulted in a negative change in emotional state in dairy calves who had undergone disbudding (Neave et al, 2013), no longitudinal studies exist to determine whether chronic pain has a lasting impact on affective state, including mood, in animals. Furthermore, Asher et al (2016) demonstrated that in pigs, like in humans, personality and mood interact to determine judgements. This may suggest that negative changes in affective state that can result from stressful or painful situations may be mediated by stable personality traits. However, only two studies to date have focused on the impact of individual differences, such as personality on the experience and expression of pain in animals (horses: Ijichi et al, 2014; dogs: Lush and Ijichi, 2018).

Pain is a key component of many disease processes in animals, with implications for quality of life and welfare. Pain is defined as an emotional and sensory experience that is associated with actual and/or potential tissue damage (International Association of the Study of Pain, IASP). Therefore, pain goes beyond physical sensation, instead comprising a sensory element (location, intensity), an affective element (emotional response) and a cognitive element (appraisal of pain and the consequences on QOL) (Merola and Mills, 2015). It is also challenging to assess in animals (Merola and Mills, 2015), as it relies on human interpretation of behaviour, and pain behaviours will differ both within and between species. Whilst vets, owners and academics alike are reliant on the assumption that observable signs of pain are indicative of not only the presence of pain but also of the severity of the condition, the studies by Ijichi et al (2014) and Lush and Ijichi (2018) detailed in chapter two challenged the reliability of this assumption. Therefore, a more detailed understanding of the relationships between individual differences such as mood, personality and pain is needed to enable our assessments of pain in individuals to be undertaken more accurately.

In this study, we focus on associations between health and mood (positive and negative) in dogs. Dogs are the most popular domestic animals to be kept as pets worldwide, (PFMA, 2016). Many of these may suffer from painful conditions. In a study by O'Neill et al (2014) from a sample of 3,884 dogs the most common diagnosis-level disorders were, otitis externa (369, 10.2%), periodontal disease (361, 9.3%) and impacted anal sac (277, 7.1%), all of which have the potential to be painful conditions. Furthermore, musculoskeletal disorders were the 3rd most prevalent mid-level diagnoses with 457 (11.8%) of the sample being diagnosed (O'Neill et al, 2014). Internationally, the prevalence of pain causing disease will no doubt differ.

When assessing health problems in dogs, veterinarians are dependent upon clinical findings, behavioural observations and owner reports. Yet with some conditions, such as hip dysplasia, we know that clinical findings do not necessarily correlate with observed behaviours and therefore may not be a reliable indication on their own of the presence of disease, severity, progression or improvement (Ginja et al, 2009). Signs of chronic illness or pain are subtle and require an understanding of a dog's behaviour over time which means that owners are often considered to be the most reliable source of information (Wiseman et al, 2001; Mariti et al, 2012). However, this relies on the assumption that owners recognise behaviours that are related to pain or suboptimal health, rather than ascribing them to characteristic of their dog, as has been shown in the case of owner assessment of breathing problems in brachycephalic dog breeds (Packer et al, 2012). Owners may find it easier to recognise sudden changes in behaviour, for example owners often report changes in aggression (Camps et al, 2012), demeanour, "submissiveness", fearfulness, locomotion, and social behaviour when their dog is experiencing a painful condition (Wiseman et al, 2001). However, factors such as training, mood and personality could potentially mask pain behaviours, making it difficult to quantify the level of pain with any accuracy.

Despite the large number of studies investigating individual differences such as affectivity (Sheppard & Mills, 2002) and personality or temperament in dogs (Gartner, 2015), no previous research has looked at the impact mood has on a dog's health and behaviour or whether pain negatively impacts mood in dogs. Therefore, the aim of this study was to determine whether dogs with different experiences of health conditions (current, previous, no experience) could be differentiated by their levels of positive and negative affect (mood).

The Positive and Negative Activation Scale for Dogs (PANAS-D) (Sheppard and Mills, 2003), was initially developed to assess a dogs responses to positive and negative experiences in life. To date ten published papers can be found (including the paper based on chapter three of this thesis, Reaney et al, 2017 and the original validation paper by Sheppard & Mills, 2003) using the PANAS. The terminology used within and between papers is variable, with the terms 'temperament' (n=5 papers), 'emotional functioning' (n=1) 'emotional predisposition' (n=3), 'emotional sensitivity' (n=2), 'core affect' (n=4), 'personality' (n=3), 'mood' (n=1 paper), 'individual differences' (n=1) and 'sensitivity to punishing and rewarding stimulus' (n=1) being used to describe what the test is measuring. In addition, seven of the ten papers published (70%) have been published from the same research group/authors. Differences in terminology used both within and between papers leads to confusion as to what the PANAS scale is measuring.

Inconsistent and interchangeable use of terminology to describe different aspects of between-individual variation in behaviour is a common feature across animal welfare research (MacKay and Haskell, 2015). Temperament can be defined as 'context specific', for example handling temperament, and is thought to be biologically determined and influenced by early experience (MacKay and Haskell, 2015). Personality can be defined as 'an individual's behavioural variation in reference to the personality dimension found within the population' (MacKay and Haskell, 2015) and is thought to be consistent over different contexts and time (Dall, Houston and McNamara, 2004; Gartner, 2015; MacKay and Haskell, 2015). As such, it is reasonable to question whether the PANAS for dogs is measuring temperament, personality, or another form of between-individual variation. If personality is conceptualised as being consistent over context and time, then short term changes in environment wouldn't be expected to lead to a change in an individual's personality or temperament *per se*.

McPeake et al (2017) used the PANAS to look at the effect of Impetonin ™ and a behaviour modification programme (lasting 11-19 weeks) on fear and anxiety like behaviours in domestic dogs, reporting that a reduction in negative activation was observed. McPeake et al (2017) acknowledged that anxiety- and fear-like behaviours can operate at different levels. For example; a short-term emotional reaction, mood change (i.e. a longer lasting emotional state) or temperament (behaviour dispositions arising for a combination of genetic factors and early life experiences). Taking the definitions of temperament and personality provided in the previous paragraph, the change in negative activation observed in the McPeake et al (2017) study seems incongruent with these definitions. A behaviour modification programme and/or medication would not be expected to change consistent or inherited behaviour. Furthermore, during the development of the PANAS for dogs, mood descriptors, personality and behavioural tendencies thought to be associated with positive activation and negative activation were included; this was to improve the potential of the tool to measure the proposed constructs.

Therefore, I suggest that the most pragmatic approach to take (until further clarification is available) is that the PANAS is measuring something less stable than dispositional behaviour, based on the assumption that what it is measuring can change as a result of relatively short behavioural interventions or medication. As such, I posit that mood rather than emotional predisposition is a suitable terminology to use to describe what the PANAS is measuring. With this in mind, the PANAS will be used throughout this chapter and the remaining thesis as a measure of mood. As indicated in chapter one, the definition for mood adopted for this thesis is Nettle and Bateson's (2012) definition that mood is "*a relatively enduring affective state that arises when negative or positive experiences in one context or time period alters the individual's threshold for responding to potentially negative or positive events in subsequent context or time periods*".

### *3.2.1 Research questions and hypothesis*

Research question one: ***Do dogs with different experience of ill health and pain differ in their mood?***

It was hypothesised that dogs with different experiences of non-painful general health conditions would not differ in their mood, but that when specific health conditions known to cause pain were examined, a difference in mood would be evident. Specifically, dogs with current experience of a painful condition would have lower levels of positive affect.  A difference in positive affect rather than negative affect was expected as across the human literature positive affect is more sensitive to change than negative affect (Bair et al, 2003).

Research question two: ***Do dogs with higher pain scores show higher levels of aggression?***

It was hypothesised that dogs with more experience of pain causing conditions would have higher aggression scores.

## 3.3 Materials and methods

### *3.3.1 Ethical approval*

This study received ethical approval from the University of Lincoln Ethics Committee with the approval ID COSREC168.

### *3.3.2 Study Design*

A cross-sectional study design was used where a voluntary opportunity sample of dog owners (targeted based on their status as a dog owner) provided information about their dog's health and behaviour.  Data were collected between 2014 and 2015.  Dogs were not excluded based on their health status.

### *3.3.3 Survey*

A survey was designed to collect data about the health conditions experienced by pet dogs.  The online survey had four sections (A-D): demographic information, medical information, behavioural information and information on affect.

Section A contained three questions to collect information on the breed, age and sex/neuter status of each dog. Respondents were provided with a drop-down box with a list of purebred breeds, and a free-text box was also provided for owners of cross breed dogs.

Section B contained 29 general health conditions including conditions known to cause pain. Respondents were given the options of 'yes-treated/resolved' for dogs who had had the medical condition previously, 'yes-ongoing' for those currently suffering from the condition, or had been for a prolonged period; and 'N/a' for the respondents whose dog had never suffered from the condition. Specific health conditions were chosen based on expert opinion of frequency by veterinary clinicians. The clinical experts (DM, HZ) are both professionally recognised veterinary behaviour specialists.

Section C aimed to collect information on behaviours displayed by the dogs; owners were given a list of 22 behaviours and asked to rate how often their dog displayed each behaviour (never, rarely, sometimes, often, very often and all of the time). These behaviours were chosen (by HZ and DM) based upon literature searches for common problem behaviours in dogs. Aggression was focused on in this chapter as a way of exploring and adding to evidence linking changes in aggressive behaviour in dogs to pain. Aggression scores were calculated utilising the questions regarding the dog's frequency of aggression towards: known dogs, strange dogs, known humans and strange humans. For each of these categories a score of between zero and five was possible by assigning a numerical value to the available responses (never=0; rarely=1; sometimes=2; often=3; very often=4; all the time=5). After being explored separately for differences, the category scores were summed to give a total aggression score ranging between zero and 20.

Section D contained the positive and negative activation scale (PANAS),a questionnaire designed to assess negative and positive activation in dogs and developed using behavioural traits with a clear psychobiological basis relating to sensitivity to rewards and aversives, in a range of environmental contexts (Sheppard and Mills, 2002). This asks 21 questions that assess two broad personality domains, negative activation and positive activation (available from: http://www.lincolnanimalbehaviourclinic.co.uk/resources.php). Positive activation has three subordinate facets, energy and interest, persistence and excitement. Negative activation is characterised by the experience of negative emotions and anxiety and positive affect is characterised by positive emotions and interactions. An example question from the survey that contributed to the assessment of negative activation, is 'Your dog is easily startled by noises and / or movements'; an example question that contributed to the assessment of positive activation is 'Your dog is full of energy' (please refer to the Supplementary material for survey in full). Each question on the PANAS provides dog owners with a choice of six possible responses on a typical Likert scale (agree strongly, mainly agree, neither agree nor disagree, mainly disagree, disagree strongly) plus the option 'not applicable'. As detailed on page 113, for the purpose of this thesis, the PANAS is being used as a measure of mood, with a view that it is assessing something less consistent than personality.

### *3.3.4 Survey Dissemination*

The survey was accessible online, disseminated via social media and dog interest groups. Participation was voluntary. Respondents needed to own or care for a dog that had lived with them continuously for at least two months, so that respondents would have seen their dog's behaviour in a wide variety of contexts (Poulsen et al, 2010).

### *3.3.5 Subjects*

943 respondents filled out the online survey. Of these, 146 responses were excluded due to missing data, leaving 796 responses for the final analysis. Of 796 dogs, 120 had experience of a current painful condition as defined by the list provided in section B; 62 had experience of a previous painful condition (but no current painful condition); and 614 had no experience of a painful condition. The age of the dogs was as follows (Age category (AC): AC 1= 6 months - 2 years; AC 2= 2 - 6 years; AC 3= ≥ 6 years) (Table 1).

*Table 3:1 Frequency and percentage of dogs in sample*

| | **Frequency of dogs in age category** | **Percentage of dogs in age category %** |
|---|---|---|
| **6 months-2 years** | 158 | 20 |
| **2-6 years** | 352 | 44 |
| **Over the age of 6 years** | 286 | 36 |
| **Total** | 796 | 100 |

## 3.4 Statistical analyses

PANAS data were assessed with Principal Component Analysis (PCA) to determine whether it would replicate the original structure reported in Sheppard & Mills (2002). PCA demonstrated that with the exceptions of questions 9 and 18, the structure was upheld and the data split as expected into the two components of Negative Affect (NA) and Positive Affect (PA). Therefore, questions 9 (relating to garden escape behaviour), and 18 (relating to the use of verbal reprimands) were dropped from the analysis, as their reliability may have changed since the instrument's original development due to changes in dog management and culture in the UK in this time. A score of NA and PA was computed for each dog without the scores for these questions (appendix 1: PANAS scoring).

An initial correlation matrix was created to look at the relationships between all pairs of variables (e.g. behaviours included in section C of the survey, PA, NA, age and aggression scores). Those that were significantly correlated ($P<0.05$) were included in the regression models. The 29 health conditions specified in the online survey were divided into five broad categories based on system affected: upper gastrointestinal tract (UGI), lower gastrointestinal tract (LGI), musculoskeletal (MSK), dental/vision/hearing (DVH); and endocrine. Endocrine disorders were excluded from subsequent analysis due to small sample size and diversity of effects.

To investigate the interrelationship between the occurrence of painful health conditions and affect, a pain category was created. The conditions analysed as likely to have caused pain and the percentage of dogs among whom the conditions were reported were as follows; hip problems (15%), arthritis (13%), dental problems (12%), colitis (11%), bladder problems (10%), anal sac disease (9%), knee problems (9%), spinal problems (8%), cancer (7%) and elbow problems (7%).

A series of backwards (conditional P<0.05) binomial logistic regression models were conducted. Regression models for general health conditions (upper gastrointestinal tract, lower gastrointestinal tract, musculoskeletal and dental/vision/hearing) included either current vs no experience of health condition OR previous vs no experience of health condition as the dependent variables and each of the independent variables (negative affect, positive affect, age and aggression) as the predictors. Regression models for pain included either current vs no experience of pain OR previous vs no experience of pain as the dependent variables, independent variables were: negative affect score, positive affect score, aggression score and age. Kruskal-Wallis tests were used to compare aggression scores between the pain-causing condition groups (current, previous and none) and Mann-Whitney U tests in post-hoc analysis to determine which groups were different. All analyses were conducted using SPSS version 22.

## 3.5 Results

### *3.5.1 Risk factors for health problems and pain experience: Positive affect*

Across the three pain experience groups (current, previous and none) there was a significant difference in positive affect scores (PA) (Kruskal Wallis: X2=21.96, P<0.01, df=2). Furthermore, as PA scores increased the odds of having a previous dental, vision and/or hearing problem (DVH) also increased (Table 3.2). Higher PA scores were associated with lower odds of being in the current pain group (Table 3.3).

*Table 3:2 Final Model showing that negative affect, positive affect and older age predicted experience of previous dental, vision and hearing issues.*

| | B | df | Sig |
|---|---|---|---|
| **AGE** | | 2 | .010 |
| **2-6 years** | -18.604 | 1 | .995 |
| **6 + years** | -1.345 | 1 | .002 |
| **Negative affect** | 4.123 | 1 | .007 |
| **Positive affect** | -2.840 | 1 | .045 |
| **Constant** | 1.362 | 1 | .261 |

*b=slope of the line between the predictor variable and the dependent variable, df= degrees of freedom, sig=significance level*

*Table 3:3 Final Model showing that lower level of positive affect and older age predicted the experience of current pain condition.*

| | B | Df | Sig |
|---|---|---|---|
| **AGE** | | 2 | .000 |
| **2-6 years** | -1.191 | 1 | .000 |
| **6 + years** | -1.144 | 1 | .000 |
| **Positive affect** | -1.618 | 1 | .040 |
| **Constant** | .230 | 1 | .690 |

*b=slope of the line between the predictor variable and the dependent variable, df= degrees of freedom, sig=significance level*

### *3.5.2 Negative affect*

No significant difference in negative affect scores was observed across the pain experience groups (current, previous and none). However, increased negative affect increased the odds of having a previous DVH problem (Table 3.2).

### *3.5.3 Aggression*

Total aggression scores were combined from ordinal data as described in section C, and in the current sample ranged from 4 (lowest overall frequency of aggression) to 20 (highest overall frequency of aggression) out of the possible range of 0-20. There was no significant difference in aggression scores between individuals in each of the three pain experience groups (current, previous, none) (Kruskal Wallis: $X^2$=5.126, *P*>0.05, df=2) or between dogs with current or previous pain experience (Mann-Whitney U (df=1)=3613, P>0.05). Increased aggression scores were associated with increased odds of current UGI conditions (Table 3.4).

*Table 3:4 Final model showing that increased aggression was a predictor of current upper gastrointestinal tract problems.*

| | B | Df | Sig. |
|---|---|---|---|
| **2-6 years** | -1.102 | 1 | .047 |
| **6 + years** | -1.046 | 1 | .008 |
| **Aggression** | .102 | 1 | .050 |
| **Constant** | -3.158 | 1 | .000 |

*b=slope of the line between the predictor variable and the dependent variable, df= degrees of freedom, sig=significance level*

### 3.5.4 Age

Older age was a risk factor for the experience of previous pain and general health conditions. Binomial regression analysis showed that there is an association between current experience of a typically pain-causing condition and age. As age increased, the odds of being assigned to the current pain group also increased (Table 3.4). Furthermore, only age was predictive of a dog's previous experience of a potentially pain-causing condition, with older dogs having an increased likelihood of having previous experience of a pain-causing condition (Table 3.5).

Increased age was also associated with increased odds of that dog having a previous UGI problems (Table 3.6), current UGI problems (Table 3.4), previous DVH problems (Table 3.2), current DVH problems (Table 3.7) and current MSK conditions (Table 3.8). For previous MSK problems, as age decreased so did the odd likelihood of that dog having experienced previous MSK conditions (Table 3.9).

*Table 3:5 Final Model demonstrating that increased age was a predictor of a dog's previous experience of a painful condition.*

| | B | df | Sig. |
|---|---|---|---|
| **AGE** | | | |
| **2-6 years** | -.857 | 1 | .024 |
| **6 + years** | -.963 | 1 | .001 |
| **Constant** | -1.738 | 1 | .000 |

*b=slope of the line between the predictor variable and the dependent variable, df= degrees of freedom, sig=significance level*

*Table 3:6 Final model showing that age was the only predictor of previous upper gastrointestinal tract problems.*

| | b | df | Sig |
|---|---|---|---|
| **AGE** | | 2 | .003 |
| **2-6 years** | -.951 | 1 | .001 |
| **6+ years** | -.397 | 1 | .044 |
| **Constant** | -1.165 | 1 | .000 |

*b=slope of the line between the predictor variable and the dependent variable, df= degrees of freedom, sig=significance level*

*Table 3:7 Final regression model demonstrating that age predicted the experience of current dental, vision and hearing problems.*

| | B | df | Sig |
|---|---|---|---|
| **AGE** | | 2 | .000 |
| **2-6 years** | -19.166 | 1 | .995 |
| **6+ years** | -1.861 | 1 | .000 |
| **Constant** | -2.037 | 1 | .000 |

*b=slope of the line between the predictor variable and the dependent variable, df= degrees of freedom, sig=significance level*

*Table 3:8 Final regression model demonstrating that age predicted the experience of previous musculoskeletal problems.*

| | b | df | Sig |
|---|---|---|---|
| **AGE** | | 2 | .005 |
| **2-6 years** | -1.200 | 1 | .016 |
| **6+ years** | -.891 | 1 | .007 |
| **Constant** | -2.221 | 1 | .000 |

*b=slope of the line between the predictor variable and the dependent variable, df= degrees of freedom, sig=significance level*

*Table 3:9 Final regression model demonstrating that age was a significant predictor of current musculoskeletal problems.*

*Variables in the Equation*

| | **b** | **df** | **sig** |
|---|---|---|---|
| **AGE** | | 2 | .000 |
| **2-6 years** | -1.841 | 1 | .000 |
| **6+ years** | -1.721 | 1 | .000 |
| **Constant** | -1.391 | 1 | .000 |

*b=slope of the line between the predictor variable and the dependent variable, df= degrees of freedom, sig=significance level*

## 3.6 Discussion

The focus of this study was to investigate the hypothesis that health status is associated with mood in dogs. The results describe a relationship between a measure of positive and negative mood and the occurrence of a current health condition likely to cause pain. Specifically, higher scores on positive affect (PA) indicate a lower likelihood that an individual was currently suffering with a painful health condition, such as arthritis or cancer. Therefore, dogs with current painful conditions had lower levels of positive affect. These results support the hypothesis that dogs currently suffering from a condition likely to cause pain would differ in mood to those with previous experience or no experience of a health condition likely to cause pain. As expected, age was also a positive predictor for current pain experience.

The associations found between positive mood and current experience of a pain-causing condition have not, to our knowledge, previously been reported. These findings may demonstrate either an influence of mood on the expression of pain and/or changes in mood because of pain; both of which have important clinical significance. This adds weight to the results of a preliminary study by Wiseman et al (2001) which showed that owners felt their dog's demeanour changes in response to pain. Changes to their dog's fearfulness, excitability, aggressiveness, playfulness, curiosity, anxiety, vocalisations and activity were reported (Wiseman et al, 2001), however our results shed light, for the first time, on longer term effects and their relationship with mood, where the effect seems to be more clearly related to positive affect which is in line with the relationship described in people between painful conditions and depression (Bair et al, 2003). Furthermore, research by Goncalves et al (2008) also demonstrated that prolonged pain can cause depressive-like behaviours in rats. Alternatively, if our results indicate that dogs with lower PA are more likely to be diagnosed with painful conditions, it may be that positive mood mediates pain behaviour and the clinical implications of this need to be considered. Asher at al (2017) demonstrated that in pigs, stable personality traits and mood interacted to determine judgement bias, further supporting the assertion that to better understand our findings research is needed to determine the causal relationship between measures of both mood and personality. To determine this, it is vital to undertake longitudinal studies which make comparisons of PANAS scores between pain-or disease-free periods and at times when the dog is experiencing pain. This would allow it to be determined whether, for example, dogs with a certain mood style may express and cope with painful conditions by altering their movement and thus present as lame, making pain easier to diagnose, or whether dogs demonstrate a change in positive affect associated with pain. Research by Ijichi et al (2014) demonstrating the relationship between pain behaviour and personality in horses, shows the importance of also including personality measures in longitudinal studies, as the relationship between pain behaviour and personality may not only be relevant in horses, but may also have cross-species application.

Contrary to the hypothesis that aggression scores would be related to pain experience, the survey found no difference in aggression scores amongst pain groups (current vs no pain experience or previous vs no pain experience). It has previously been documented that aggressive behaviour can increase or occur in different contexts when a dog is experiencing pain (Wiseman et al, 2001; Camps et al, 2012). The finding of no difference between the current and historic pain group in aggression scores means that this hypothesis may need more careful evaluation and it may be that differences in aggressive behaviour are more qualitative than quantitative (Barcelos et al, 2015). Such changes may not have been detected in this study due to the design of this aspect of the current questionnaire.

## 3.7 Study limitations

One of the wider limitations of this research is that I had no direct measure of the presence or extent of pain experienced by the dogs, therefore, whilst I believe the conditions analysed would be very likely to cause pain, this could not be confirmed. However, this would simply increase the variance between groups and reduce effect size; therefore these findings should be considered a conservative estimate of the effects. With the exception of DVH category, the only difference observed was in affect scores between those dogs who had current experience of a condition likely to cause pain, not in those with current general health conditions (unlikely to cause pain). This suggests that something about those specific conditions (arthritis, cancer, hip dysplasia, dental problems etc.) is affecting emotional predisposition in dogs. Pain appears the most parsimonious explanation.

Furthermore, as discussed the PANAS has been used in this chapter and throughout the thesis as a measure of something less stable than personality, such as mood. As such, future work with the PANAS would benefit from longitudinal designs that enable this to be explored.

## 3.8 Further work

Future work needs to; look at the relationship between mood and pain using a validated method of pain assessment. Furthermore, where possible a longitudinal design should be employed that could determine the direction of the relationship found between mood and pain.

## 3.9 Conclusion

The findings from this chapter are amongst the first to demonstrate an association between current pain experience and lower levels of positive mood in animals, and the first in the domestic dog. This research demonstrates the need for future work to focus on the causal relationship between pain expression, mood and behaviour in dogs. Furthermore, aside from the benefits to dogs as a species, these results have cross-species relevance. Pain is a common sign of many illnesses across species and whilst it should be acknowledged that pain behaviours will differ between species, these findings highlight the importance of recognising the influence that individual differences, such as those grounded in feelings, can have on behaviour.

# 4 Chapter Four: Investigating the association between personality, mood and owner-reported pain ratings in domestic dogs.

## 4.1 Abstract

To date very few studies have investigated the links between personality and pain in domestic dogs. Of the research that has been undertaken, the findings demonstrate a positive correlational relationship between dog extraversion (as rated by owners) and acute pain (peak pain scores after castration) only. This chapter seeks to understand, in a non-clinical sample, using a validated pain scale with owners, whether the score owners give to their dog's pain is influenced by how they perceive their dog's personality and mood, as this may have implications for treatment seeking and subsequently dog welfare.

Correlational analysis was conducted to look at whether personality traits (using the Monash personality questionnaire revised - MCPQ-R) and mood (using the positive and negative activation scale - PANAS) were associated with the dog's pain scores on the Helsinki Chronic Pain Index (HCPI) and the dogs pain severity and pain interference of the Canine Brief Pain Inventory (CBPI). Ordinal regression

analysis was then used to look at which of the personality factors and which of the mood factors could predict aspects of the HCPI.

The results demonstrated that dogs with higher levels of positive affect vocalised their pain more and that personality (neuroticism) predicted how the owners rated their dog's alertness/mood. Correlations could be seen between personality and pain scores but only when using the HCPI not the CBPI. Dog extroversion and neuroticism were found to be associated with positive affect and negative affect, yet differentially associated with pain scores. These results demonstrate that personality assessment can be a useful tool in pain assessments and that an owner's view on their dog's personality may interact with how they perceive their dog's pain.

## 4.2 Introduction

Pain is an essential part of the evolutionary process and is an adaptive response serving to prevent future damage (Broom, 2001; Srokosz and Kolstoe, 2016). However, the suffering that can accompany the experience of pain is a key concern for animal welfare, with greater levels of suffering leading to more compromised welfare (Broom, 1991; Chapter 1). Indeed, within the Five Freedoms one of the five core requirements is to ensure that animals are prevented from suffering due to 'pain, injury or disease'.

Suffering covers a wide range of emotional states and can be defined as "the subjective experience of unpleasant emotions such as fear, pain and frustration..." (Dawkins, 1991; Dawkins, 2008). Suffering is a subjective concept and therefore for a species to be considered able to suffer they need to be considered sentient. Animal sentience can be understood as the ability for an animal to experience both positive and negative emotions such as joy, pleasure and fear (Proctor, Carder and Cornish, 2013). Whilst it is beyond the scope of this chapter to provide a review of the plentiful literature on animal sentience, it is important to note that this area is hotly debated (Beckoff, 2012; Harnad, 2016), with some researchers advocating employing the 'precautionary principle' (O'Riordan and Cameron, 1994; Bradshaw, 1998; Jones, 2016; Birch, 2017) "*when evidence is inconclusive, give the animal the benefit of the doubt*".

To understand how to prevent suffering, one needs to be able to recognise suffering, and to identify when suffering is at a level where treatment is required from a veterinary professional. Once veterinary guidance is sought, prevention of suffering is principally associated with the owner reliably following veterinary guidance for pain management.

As discussed in chapter one, there are a number of factors that may affect how an individual animal responds to pain and how observable these response are. Such as, species, breed, sex and age. However, personality and mood are the sole focus of this work (whilst accounting for age and sex) as I perceive these areas to be the most understudied.

As discussed in chapter two and chapter three, in recent years there has been some early evidence published for a relationship between personality and the expression of pain behaviour in animals (Ijichi et al, 2014; Lush and Ijichi, 2018), which adds to the substantial body of literature linking pain and personality in humans (Goubert, Crombez and Van damme, 2004; Zautra et al, 2005; Finan and Garland, 2015). If this is indeed the case for animal species, then the prevention of suffering becomes more complicated as owners need to recognise personality-specific differences in behaviour associated with the experience of pain. These differences may be due to different pain experience thresholds or may be due to differences in the way in which pain behaviour is expressed for the same level of pain in different individuals. The scientific literature is not yet at a stage where these two hypotheses can be separated.

Pain assessments are inherently difficult and whilst the development and use of objective measures of pain have been assessed in the animal literature (Morton and Griffiths, 1985; Bateson, 1991) these are often not applicable to clinical settings such as veterinary clinics or for use with owners (Reid et al, 2018).

Heart rate, pupil dilation and respiratory rate are of limited use in pain assessments with dogs (Holton et al, 1998), and changes in cortisol are not specific to pain (Morton and Griffith, 1985). Gait analysis provides an objective assessment of the sensory aspect of a dog's pain (Piel et al, 2014), but does not provide information on how differences in thresholds impact findings. Pain is a multi-faceted concept including emotional, cognitive and physical elements, force plates alone will not provide a full assessment of an animal's pain experience.

Single Numerical Rating Scales (NRS) and Visual Analogue Scales (VAS) are widely used as an alternative to more objective methods but alone their reliability has been considered weak (Holton et al, 1998a; 1998b) and when thinking of these being utilised with owners it is unclear how easy they find it to quantify the pain of their pets. Pain scales utilising multiple NRS and questions about psychological and physical functioning have been developed to assess acute (Heyer et al, 2006) and chronic pain (Brown et al, 2007; Hielm-Björkman, Rita & Tulamo, 2009) in dogs. However, whilst signs of acute postoperative pain, such as attention to a wound or wound guarding can be overt, signs of chronic pain are often a lot harder to gauge.

The Canine Brief Pain Inventory (CBPI) is a validated pain assessment tool to assess chronic pain associated with osteoarthritis (OA) and cancer-related pain (Brown et al, 2007; 2008; 2009; Brown, Boston and Farrar, 2013; 2014). It is based on NRS and one Likert-response question about quality of life over the past 7-days, which provides two pain scores for each dog - for interference and for severity. Numerous studies have now successfully used the CPBI as a chronic pain assessment tool (Brown et al, 2007; 2008; 2009; Wernham et al, 2011; Brown et al, 2013; 2014; Webster, Anderson and Gearling, 2014; Ragetly, 2017).

The Helsinki Chronic Pain Index-Revised (HCPI-R) (Hielm-Bjorkman, Rita and Tulamo, 2009) is another validated tool to assess chronic pain in dogs with OA (Hielm-Bjorkman, Rita and Tulamo, 2009; 2011; Wernham et al, 2011), and more recently chronic pain after injury (Molsa et al, 2013; O' Canapp et al, 2016). Both owners and clinicians can complete this survey by answering 11 Likert-response questions that rate their dog's mood, playfulness, vocalisations of pain and movement over the past seven days. Whilst these scales are validated, they are limited to replying on human interpretations of dog behaviour and alone cannot provide truly objective assessments of pain.

Several studies (Svartberg and Forkman, 2002; Ley, Bennett and Coleman, 2009; Mirkó, Dóka and Miklósi, 2013) have investigated the potential to be able to reliably assess personality in domestic dogs, using either behavioural assessment with standardised behaviour tests, or psychometric questionnaires. Due to the financial and time associated costs of standardised behavioural tests (Wiener and Haskell, 2016), psychometric assessments of personality have become increasingly popular. For example, the Canine Behavioural Assessment and Research Questionnaire (C-BARQ) (Serpell and Hsu, 2001; Hsu and Serpell, 2003) and the Monash Canine Personality Questionnaire (MCPQ-R) (Ley, Bennett and Coleman, 2009).

The MCPQ-R (Ley et al, 2007; Ley, Bennett and Coleman, 2009) is a validated questionnaire assessing personality on five domains existing in all domestic dogs;

these are Extraversion, Neuroticism, Motivation, Training Focus and Amicability. The MCPQ-R was developed using an adjective-based method adopted from studies of human personality (for example the Big-Five, John and Srivastava, 1999). Since development the MCPQ-R has been used in other studies (Carrier et al, 2013; Rayment et al, 2016; Posluns, Anderson and Walsh, 2017; Lush and Ijichi, 2018).

The Positive and Negative Activation Scale (PANAS) for dogs (Sheppard and Mills, 2001) is a measure mood and was developed based on the biological underpinning of behaviour (Sheppard and Mills, 2001), meaning unlike adjective based -tests the PANAS links behaviour, affect and motivation with neurobiology. Whilst good test re-test reliability was reported (Sheppard and Mills, 2001), this was only conducted in a single population (the same sample used to develop the test) and since its development PANAS has not been reported in many peer-reviewed research papers. The reasons for this may be that; the PANAS is used as a tool by clinical practitioners, rather than by academic researchers, meaning results are not published. Alternatively, other methods may be favoured by academic researchers for assessing mood in animals, such as attention bias (Monk et al, 2018). However, these methods are not suited to all study designs.

As previously mentioned, the first step to achieving appropriate pain management in domestic animals is the recognition by the owner of the presence of pain and identification of the level of its severity. Despite owners being used to assess their pet’s personality and pain, there is little published research on the accuracy and reliability of dog owners at recognising pain in dogs. In a double-blind randomised study by Brown, Boston and Farrar (2013) owners reported improvements in their dog's pain in response to pain medication, which suggests an awareness of an improvement in behaviour in response to pain treatment. However, the changes in Canine Brief Pain Inventory (CBPI) scores were not reflected in the force plate findings. The amount of time owners spends with their pet, and the variety of contexts owners have observed their dog's behaviour in can improve behavioural assessments (Rooney et al, 2004). Furthermore, it is known that owners can miss signs of ill-health and pain due to mistakenly believing these behaviours to be an inherent characteristic of the species or breed (Ireland et al, 2002, Packer, Hendricks and Burn, 2012). For example, research by Packer Hendricks and Burn (2012) demonstrated that owners of brachycephalic dogs reported signs indicative of severe brachycephalic obstructive airway syndrome (BOAS), yet also reported that their dog did not have a breathing problem.

The aim of this chapter is to investigate the link between owner assessments of dog personality and owner assessments of their dog's pain. There are three main research questions:

*Table 4:1 Research questions, hypotheses and accompanying evidence*

| | |
|---|---|
| ***Is a dog's personality associated with their pain score?*** | |
| 1) Dogs with higher levels of extraversion will show higher pain scores | Ijichi et al (2014) and Lush and Ijichi (2018) |
| ***Is a dog's mood associated with their pain score?*** | |
| 2a) Dogs with higher levels of positive affect will have lower pain scores | Reaney et al (2017) |
| 2b) Dogs with higher levels of negative affect will have higher pain scores | Wright et al (2008) |
| ***Can personality predict pain vocalisations?*** | |
| 3) Dogs with higher levels of extraversion will vocalise their pain more.<br>3b) Is there an association between mood and pain vocalisations? | Friel et al (2016) |

Additional exploratory analysis was conducted (not included in the above hypotheses) to look at the association between the two pain scales (HCPI and the CBPI). Both scales are used as brief measures to assess chronic pain in dogs, and as such should demonstrate a strong relationship to each other. However, they differ in their format, with the HCPI asking for owners to rate their dogs based on how well a series of descriptions reflect their dog and the CBPI asking owner to give a numerical rating for how their dogs pain is and has been.

## 4.3 Methods

### *4.3.1 Study design, dissemination and inclusion criteria*

A survey was developed in Survey MonkeyTM and disseminated online through social media (Facebook and Twitter); on UK-based dog breed websites, the healthy and positive pet interactions (HAPPI) lab website, various hydrotherapy and veterinary centres across the UK. Owners of all types of dogs could elect to take part, if their dog was over 6 months of age and dog owners were over the age of 16. The survey was piloted in October 2015, edited and then data were collected in two waves: wave 1 was from November 2015 until June 2016, wave 2 was from September 2016 until January 2017.

### *4.3.2 Survey content*

The survey comprised five sections, each relating either to the dog (D) or to the dog owners (DO):

1. Demographic information (D & DO)

2. Health information (D)

3. Personality assessment (D)

4. Mood assessment

5. Pain assessment (D)

A full copy of the survey can be found in Appendix 4.1, however a brief description of the content is provided below to aid understanding.

### *4.3.3 Demographic information*

Questions were included in Section One to collect information on the gender, age and country of residence of the owner. In relation to the dog, information was collected on its sex, neuter status, breed and age, as well as the length of time the respondent had owned the dog.

### *4.3.4 Health questions*

In Section Two, owners were asked a range of questions about their dog's health and any treatment they were currently receiving. Further questions were asked about how the respondent's own behaviour had changed towards the dog in the light of any recent diagnosis. This was to give an initial insight into whether there may be a relationship between changes in owner behaviour and in the dog's behaviour. Further to this, respondents were asked whether their dog had any hip problems, and if so to score the condition of their hips.

Finally, within the health section, all respondents (regardless of whether their dog had hip problems) were asked to indicate whether their dog had ever suffered from a set of other health conditions.

### *4.3.5 Assessment of dog personality and dog mood*

Two validated questionnaires, one for the assessment of dog personality and one for the assessment of dog mood were included in section three:

1. The Monash Canine Personality Questionnaire (MCPQ) (Ley et al, 2007)

2. The Positive and Negative Activation Scale for Dogs (PANAS) (Sheppard and Mills, 2001)

### *4.3.6 Assessment of dog pain*

Two validated questionnaires for the assessment of chronic pain in dogs were included in section four:

1. The Canine Brief Pain Inventory (CBPI) (Brown et al, 2007).

2. The Helsinki Chronic Pain Index (HCPI) (Hielm-Bjorkman et al, 2009) and was validated in English (Wernham et al, 2011, Walton et al, 2013).

To guard against influencing responses, the names of the questionnaires (which clearly signpost that the questionnaires measure pain) were re-labelled as 'behaviour questionnaire 1' or '2' respectively.

### *4.3.7 Data preparation*

The data set was downloaded from Survey MonkeyTM in the original text format. Respondents with missing data in essential fields (i.e. two or more missing responses on dog personality and mood test) were excluded from the analysis pertaining to that data only (therefore (n) may differ across tests). Responses were completely excluded from the analysis where (i) owners reported to be less than 16 years of age; or (ii) the canine subject was reported to be less than six months of age.

### 4.3.8 Statistical analysis

All statistical analyses were conducted in SPSS v21, apart from factor analysis, which was conducted in R. Factor analysis (FA) was conducted on each of the measures (PANAS, MCPQ-R, CBPI & HCPI-R) to check the factor structure reported in the original paper was replicated in this sample of dogs. Except for the PANAS (see appendices 4.2 for full details) the loadings for each of items on the factors were acceptable (using a 0.30 threshold).

Scores were computed for the dog's mood (NA and PA) and the personality traits of extraversion and neuroticism only following the standard scoring process for the PANAS and MCPQ-R (See appendix 4.3). A pain interference score and pain severity score were calculated from the CBPI using the standard scoring format reported in the publicly available CBPI user guide (Brown, 2017). A score for each of the questions and an overall score was computed for the HCPI using the standard scoring format for the HCPI (appendix 4.4). Normality testing was carried out on each of the continuous variables (dog personality) using Shapiro Wilk tests. As not all continuous variables were normally distributed, and as there were multiple ordinal and nominal variables in the data set, generalized linear models were used. Descriptive statistics were calculated to give information of the demographics of the dog population.

To test the hypothesis that dogs with higher levels of extraversion would have higher pain scores Spearman's rho correlations were used to test for associations between extraversion and the HCPI and CBPI. This method was then repeated with the PANAS to test the hypothesis that higher positive affect would be associated with lower pain scores and that higher levels of negative affect would be associated with higher pain scores. Bonferroni adjustments were made for multiple testing and significance values reported are based on adjusted values.

To test the hypothesis that personality would be associated with pain vocalisations an ordinal regression models was conducted with PA, extraversion and a dog's age as independent variables and the dog's propensity to vocalise pain in general as the dependent variable.

Furthermore, Spearman's rho correlations between both pain assessment measures were computed to see the extent of association between the measures. Bonferroni adjustments were made for multiple testing and significance values reported are based on adjusted values.

## 4.4 Results

### *4.4.1 Demographics of the study population*

737 responses were received from dog owners aged between 16 and 65+ (Table 4.2).

*Table 4:2 Respondent owners by age category. N/S is 'Not Stated' and represents those responses received where a binary gender was not reported.*

| **Age category of Owners** | **Number respondents (n)** | | | **% total respondents** |
|---|---|---|---|---|
| | Male | Female | N/S | Total |
| **16-24 years** | 4 | 48 | 3 | 7.40% |
| **25-34 years** | 13 | 158 | 2 | 23.50% |
| **35-44 years** | 11 | 150 | 2 | 22.20% |
| **45-54 years** | 17 | 181 | 1 | 26.90% |
| **55-64 years** | 17 | 88 | 1 | 14.30% |
| **65 years and over** | 5 | 36 | 0 | 5.70% |
| ***Total*** | 67 | 661 | 9 | *100%* |

The age of the dogs reported in the responses ranged between 6 months and 14+ years; most dogs (29%) were between 6-10 years (Table 4.2). Most of the dogs reported in the responses were neutered (Table 4.3)

*Table 4:3 The number of dogs in each age category*

| **Age of Dog Category** | **Number of dogs in each age category (n)** | **Percentage of total dogs (%)** |
|---|---|---|
| 6-12 months | 74 | 10% |
| 1-2 years | 177 | 24% |
| 2-6 years | 149 | 20% |
| 6-10 years | 212 | 29% |
| 10-14 years | 109 | 15% |
| 14 + years | 19 | 3% |
| Total | *737* | *100%* |

*Table 4:4 The number of dogs in each of the sex/neuter status categories*

| **Neuter Status** | **Sex** | **Number of dogs in each sex N/S category (n)** | **% total dogs** | **% total dogs** |
|---|---|---|---|---|
| **Entire** | Female | 57 | 8% | 19% |
| | Male | 82 | 11% | |
| **Neutered** | Female | 270 | 37% | 81% |
| | Male | 331 | 45% | |
| | | *Total 737* | *100%* | *100%* |

### *4.4.2 The association between dog personality and pain scores on the HCPI*

The hypothesis that dogs with higher levels of Extraversion will show higher pain scores was tested (Table. 4:5). Dog extraversion was negatively associated with the overall pain score on the HCPI, yet positively associated with pain vocalisations (Table. 4:5). This suggests that dogs with higher extraversion were less likely to be viewed as in pain, but more likely to vocalise.  Dog neuroticism was only positively related to one of the HCPI questions, which was about the dog's willingness to play. Whilst the association was weak it showed than dogs viewed as more neurotic by owners were less likely to be described as willing to play.

*Table 4:5 The Spearman's rho associations between the individual question on the HCPI and the dog's personality scores. df= degrees of freedom, ns=not significant*

| HCPI Question | Dog Neuroticism | Dog Extraversion |
|---|---|---|
| **My dog's mood is…** | *ns* | -0.18, df=737 , P=0.00 |
| **My dog plays…** | 0.11, df=737, P=0.00 | -0.09, df=737, P=0.00 |
| **Rate how often your dog vocalises pain…** | *ns* | 0.09, df=737, P=0.01 |
| **HCPI total** | *ns* | -0.12, df=737, P=0.00 |

### *4.4.3 The association between dog mood and pain scores on the HCPI*

The hypothesis that higher levels of PA will be associated with lower pain scores and that higher levels of NA will be associated with higher pain scores was tested. As PA increased, HCPI scores decreased, similarly, as NA increased, HCPI scored decreased. The individual questions of the HCPI all showed negative correlations with NA and PA with the exception of question three ‘Rate how often your dog vocalises pain…’ where a positive but weak correlation was reported for PA and no significant correlation was found for NA (Table. 4:6).

*Table 4:6 The Spearman's rho associations between the individual question on the HCPI and the dog's mood scores. df= degrees of freedom, ns=Not significant.*

| **HCPI Question** | **Dog Negative affect** | **Dog Positive affect** |
|---|---|---|
| **My dog's mood is…** | -0.25, df=737, P=0.00 | -0.20, df=737, P=0.00 |
| **My dog plays…** | -0.18, df=737, P=0.00 | -0.11, df=737, P=0.00 |
| **Rate how often your dog vocalises pain…** | *Ns* | 0.08, df=737, P=0.02 |
| **HCPI Total** | -0.24, df=737, P=0.00 | -0.15, df=737, P=0.00 |

### *4.4.4 Factors predicting pain vocalisations*

The hypothesis that higher scores on extraversion and higher scores on positive affect (PA) will be related to greater pain vocalisation in dogs was tested. Only PA was related to pain vocalisations. As positive affect increased the likelihood of a dog vocalising pain increased (Table 4:7).

*Table 4:7 Ordinal regression model output showing that a dogs level of positive affect and the number of conditions they currently had predicted how their owner perceived their mood to have been over the past 7 days.*

| | **b** | **df** | **Sig.** |
|---|---|---|---|
| **Dog PA** | 1.739 | 1 | .006 |
| **Current conditions** | .282 | 1 | .003 |

*b=slope of the line between the predictor variable and the dependent variable, df= degrees of freedom, sig=significance level*

### *4.4.5 Exploratory analysis*

Exploratory analysis was undertaken to explore whether the way questions about dog pain are presented to dog owners influences responding. Using Spearman's rho correlations, the individual questions on the HCPI correlated with the pain interference (PI) and pain severity (PS) of the CBPI after Bonferroni adjustment (Table. 4.8).  However, no significant correlations were reported between questions one – four of the HCPI and pain severity scores or between questions one and three of HCPI and pain interference.  When looking at the overall score of the HCPI and the PS and PI scores on the CBPI significant correlations were observed, PI ($r=0.50$, $p=0.00$, $df=86$) and PS ($r=0.58$, $p=0.00$, $df=86$) both with and without Bonferroni adjustment for multiple testing.  These results suggest that pain interference of the CPBI is more strongly related with the HCPI.

*Table 4:8 Spearman's Rho associations between the individual questions on the HCPI and the pain severity score and pain interference score of the CBPI. Df= degrees of free, ns=not significant (Bonferroni adjustment applied)*

| HCPI question | CBPI Pain Severity Score | CBPI Pain interference score |
|---|---|---|
| **'The dog's mood is…'** | *Ns* | *Ns* |
| **'The dog plays…'** | *Ns* | 0.40, df=86, P=0.02 |
| **'Vocalises pain…'** | *Ns* | Ns |
| **'The dog walks with…'** | *Ns* | 0.41, df=86, P=0.00 |
| **'The dog trots…'** | 0.28, df=86, P=0.00 | 0.42, df=86, P=0.00 |
| **'The dog gallops…'** | 0.26, df=86, P=0.00 | 0.49, df=86, P=0.00 |
| **'The dog jumps…'** | 0.28, df=86, P=0.00 | 0.48, df=86, P=0.00 |
| **'The dog lies down…'** | 0.33, df=86, P=0.00 | 0.41, df=86, P=0.00 |
| **'The dog rises from laying…'** | 0.34, df=86, P=0.00 | 0.47, df=86, P=0.00 |
| **'The dog moves after long rest…'** | 0.31, df=86, P=0.00 | 0.47, df=86, P=0.00 |
| **'The dog moves after major activity…'** | 0.31, df=86, P=0.00 | 0.40, df=86, P=0.00 |
| **Overall HCPI score** | 0.28, df=86, P=0.00 | 0.50, df=86, P=0.00 |

## 4.5 Discussion

The aim of this chapter was to be able to develop our understanding of the relationship between personality and pain, and mood and pain in dogs. Additional exploratory analysis was undertaken to investigate whether the way dog owners were presented with questions about their dog's pain influenced their responses.

The hypothesis that extraversion would be associated with higher pain scores was tested. Work by Ijichi et al, (2014) and by Lush and Ijichi (2018) has demonstrated that extraversion in horses and in dogs is related to more overt behavioural displays of pain. The results from this study demonstrate that personality is correlated with pain scores when using the Helsinki Chronic Pain Index (HCPI) but not the Canine Brief Pain Inventory (CBPI). However, contrary to the findings of previous work, in this study extraversion was negatively associated with overall pain scores on the HCPI and to questions about physical functioning, mood and willingness to play. However, extraversion was positively associated (albeit the strength of the correlation being weak) with vocalisations of pain. Initially, these findings may seem in contrast with the work of Ijichi et al (2014) and Lush and Ijichi (2018). However, what they might demonstrate is that the relationship between personality and pain is dependent on how pain is assessed and who is assessing the pain. Whilst Lush and Ijichi (2018) found that dogs higher in extraversion had higher pain scores, this was in times of acute surgical pain, rather than on a measure of chronic pain. Personality may interact with pain expression differently depending on whether the pain experience is acute or chronic in nature.

Neuroticism was found to be related to one aspect of the HCPI, a dog's willingness to play. A negative association was found meaning that dogs who were rated as more neurotic were also rated as less willing to play, suggesting they may appear more anhedonic. Neuroticism assessed by the MCPQ-R is characterised by fearfulness, nervousness and timidity (Ley and Bennett, 2007; Ley et al, 2009), therefore the relationship found between willingness to play and neuroticism is logical, but in the context of pain (without other significant correlations) the finding needs exploration. As in this study the HCPI was described as a behaviour questionnaire, rather than pain questionnaire (to prevent biases in owner reporting) the relationship found between play and neuroticism may reflect a more general finding that neurotic dogs demonstrated less willingness to play, rather than the underlying reason for less willingness to play being because of pain.

The second and third hypotheses tested was that positive affect would be related to lower pain scores and negative affect would be associated with higher pain scores. Both PA and NA were found to be related to pain as assessed by the HCPI but as with personality, not with the CBPI. As would be expected from the work by Reaney et al (2017) and Wiseman et al (2001), dogs with higher levels of PA are less likely to be considered to be 'in pain'. However, it was expected that a positive relationship may be found between NA and pain scores, when in fact the relationship was negative. This suggests that lower scores on negative affect (less anxious dogs) were related to higher pain scores. In Ijichi et al (2014) neuroticism was found to be negatively associated with pain severity. This was interpreted as these horses having a lower threshold for pain and therefore potentially being assessed for pain at an earlier stage in their illness. One possible explanation may be that dogs with lower levels of negative affect take longer to display pain behaviour, resulting in higher pain scores during disease progression.

Whilst none of the personality factors were found to predict pain vocalisations (despite a positive relationship in initial correlational analysis) PA was found to significantly predict pain vocalisations. Dogs scoring higher in positive mood were rated as being more likely to vocalise that they were in pain. Friel et al (2016) demonstrated that acoustic signalling in pigs reflected their personality. These findings may demonstrate that dogs higher in positive mood are more likely to vocalise they are in pain. However, they are complicated by the lack of equivalent finding between personality and vocalisations, given the strong correlation reported between PA and extraversion. As such, caution should be given when interpreting these findings until further work has been done to clarify this. To aid clarification, one suggestion may be that vocalisation of pain is a coping technique which is related to PA. In humans, PA (positive mood) can be seen as a resilience factor during pain (Zautra et al, 2005; Finan et al, 2015) and PA can help individuals actively engage in managing their pain (proactivity). It may be that dogs higher in PA use active ways of managing their pain (vocalising) to seek help, however, further research would be needed to investigate this.

Finally, the exploratory analyses demonstrated that the HCPI and CBPI scores were associated, with the association between the overall HCPI score and the pain interference (PI) score of the CBPI being stronger than the association between the overall HCPI and the pain severity (PS) score. When looking at the questions comprising the PI score they are related to the physical function of the dog, whereas the PS score is comprised of four NRS where owners rate their dogs pain (Brown et al, (2007). These findings suggest that there is a difference in how owners rate their dog's pain scores vs how they feel it is affecting their function. It may also suggest that the HCPI assesses how the sensory and emotional aspects of chronic pain, whilst the CBPI has more of a focus on the sensory element of pain.

### *4.5.1 Study limitations*

It is important to note that the results reported in this chapter are correlational, so causality cannot be inferred. In addition, there was a large female response bias that could not be explored. It is possible that this bias may have influenced the findings and should be explored in future research where sample size allows).

Furthermore, whilst the pain scales used in this chapter have been independently validated in previously published, peer-reviewed literature, they are subjective assessments of pain, rather than objective. An over-emphasis on subjective owner assessments of pain may ultimately mean that are at risk of making type 1 or type 2 errors.

### *4.5.2 Further work*

Future work would benefit from developing from the findings of this chapter by investigating whether personality and mood are only associated with subjective owner ratings of dog pain, or with more objective measure of pain. Furthermore, it would be beneficial when utilising owner's assessments on the behaviour and health of their dogs to determine whether their own characteristics have an influence on the assessments made.

## 4.6 Conclusions

Personality and mood are differentially associated with pain expression in dogs. However, the findings between personality and pain and mood and pain are not clear which has an impact on the extent to which clear interpretations can be made. The extent of this relationship depends on the scale used to assess pain behaviour.

# 5 Chapter Five: Investigating the association between dog owners' characteristics and the assessments they make on their dog's health and pain.

## 5.1 Abstract

Caregivers are most familiar with the behaviour of an animal in their care, yet their recognition and reporting of problems does not always reflect the severity of the animal's condition. There has been little research on how the owner's personal characteristics may influence if and how they report on their pet's health, welfare and quality of life. Therefore investigating this potential association is the focus of this chapter. This is the first study to my knowledge to look at the effect of owners' personal characteristics on the way they interpret and report on their dog's health and pain.

Using an online survey, dog owners were asked to provide information about their dog's current and previous health problems, their dog's level of pain, their dog's mood and personality. Owners were also asked to disclose information

about their dog's place within the family, their own level of medical literacy, their own experience of pain conditions and their personality.

The results were based on the responses from 388 dog owners. It was found that conscientiousness may be a positive trait in dog owners, related to how they report on their dog’s health.  Higher levels of owner neuroticism is related to a greater number of untreated medical conditions and lower pain scores in their dog. Owners who keep their dog as a working dog are more likely to give a higher pain score than other dog owners.  Exploratory statistical analysis suggests that the association between dog personality, mood and pain is dependent on which scale dog owners are given to assess this.  Whilst further research needs to be undertaken to establish causal mechanisms underlying any associations, these results suggest that an owner’s characteristics and experience should be considered when they are reporting on their dog’s health and pain.

## 5.2 Introduction

The welfare of animals is dependent upon the actions of the humans looking after them and the attitudes that they hold (McInerney, 2004). As such, it is important that we understand what influences an individual's actions and attitudes towards an animal/s. There has been increasing interest in human-animal interactions across multiple disciplines (Amiot and Bastain, 2015; Reed and Upjohn, 2018, Waldhorn, 2019) and studies are being developed to benefit both the health and welfare of humans and animals. For example, studies investigating how humans interpret dog behaviour and the associated consequences have been used to reduce the incidence of dog bites (Lakestani and Donaldson, 2015). Furthermore, it is essential that humans understand the behaviour of animals in their care to ensure the maintenance of that animal's physiological and psychological health.

### *5.2.1 Human factors influencing human-animal interactions*

Over the past 20 years it has been accepted that the characteristics of those interacting with animals can impact on the welfare of the animals in their care (Hemsworth, 2007; Finka et al, 2019). Negative interactions between stockpersons and the farm animals in their care impact on the animals' health, productivity, behaviour and mood (Bertenshaw & Rowlinson, 2009; Zukifli, 2013; Ellingsen et al, 2014). Heifers experiencing more negative handling (careless, rough) show higher levels of reactivity (Ceballos et al, 2018); in poultry, negative handling experiences result in panic, extreme escape behaviour and in some cases death (Jones et al, 1996; 1997). In pigs, negative handling is linked to high adrenal weight (indicative of chronic stress), impaired growth and performance (Hemsworth, Coleman and

Hay, 1998), fear of humans (Brajon et al, 2015; Tallet et al, 2018) and stress behaviour (Muns, Rault and Hemsworth, 2015).

In companion animals, a dog owner's attitude towards exercise and weight in general is linked to canine obesity (Muñoz-Prieto et al, 2018). Similarly, a cat owner's understanding of the healthy body composition of cats influences their cat's obesity (Rowe et al, 2017). There is also thought to be an association between dog owner personality and the types of dog (aggressive vs nonaggressive) owned (Wells and Hepper, 2012). Owner levels of neuroticism impact handling styles in dogs (Kis et al, 2012) and can link to aggressiveness and behaviour problems in both dogs (Dodman et al, 2018) and cats (Finka et al, 2019).

Whilst the above research has illustrated that owner personality may impact on the pets in their care, they have failed to determine how this is associated with animal welfare. Furthermore, as Finka et al (2019) asserted, where research has included parameters that directly assess animal welfare the results have been unclear. Work to date looking at human-animal interactions has focused primarily on the animal welfare consequences of the environment, management practices and resources that humans provide for animals. Although owners are commonly utilised in health and pain assessments (Innes and Barr, 1998, Whitham and Wielebnowski, 2009, Mellanby et al, 2003; Schork, Azevedo and Young, 2018), little work has been conducted to specifically investigate the impact of characteristics that an owner may have on the health and pain assessments they make about their pets.

### *5.2.2 Humans reporting on the health and personality of animals*

Research has demonstrated that a lack of understanding in dog owners of what clinical signs of ill-health mean, may prevent timely help being sought.  A study by Packer, Hendricks and Burn (2012) highlighted that owners didn't identify severe clinical signs of ill-health as concerning, viewing them as an inherent characteristic of that breed. This demonstrates that whilst owners are able in some cases able to recognise signs of clinical problems, these are not always perceived as a welfare problem. Where clinical problems have been identified and therefore treatment has been sought, dog owner reports indicate that that they do notice improvements in pain behaviour following pain medication (Brown et al, 2013) or surgical interventions (Innes and Barr, 1998).

Accuracy is not only important in the assessments humans make about the health of an animal. Indeed, humans also make judgements on the behaviour and personality of animals, especially for domestic pets, working animals and animals kept in captivity.  For example, potential dog owners often use their perception of temperament or personality when deciding whether to adopt a dog (Deisel et al, 2007; Weiss et al, 2012; Siettou, Fraser and Fraser, 2014), and when deciding whether to relinquish their dog to a rescue facility (Wells and Hepper, 2000; Diesel, Pfeiffer and Brodbelt, 2010).  Inaccuracy in the initial assessment of behaviour and character by potential dog owners is one of the main reasons for relinquishment (Casey et al, 2009). As with health assessments, it is common to use assessments humans make about an animal’s personality, such as; pet owners (i.e. when assessing dog personality) (Ley et al, 2009), animal keepers (i.e. zoo animal personality) and animal handlers (i.e. working police dog and horses).  However, little research to date has determined whether judgements people make about animals are accurate and what factors influence accuracy. Ijichi et al (2014) used personality assessments owners made about their horses to determine whether personality influenced pain behaviour. When appraising the findings of such studies it would be beneficial to consider whether owner assessments of their pet's personality are accurate.

### *5.2.3 Factors influencing health assessments*

The relationship between owners and their pets has been likened to that of the parent-child relationship (Finka et al, 2019). Using both the human and animal literature, the factors that may moderate how humans answer health and pain assessments about their pets are; health literacy, emotional predisposition, personality, empathy and relationship to the individual being assessed.

An individual’s health literacy, and their ability to gain, process and act on health information is related to human health outcomes. For example, the health literacy of parents can impact health outcomes for their children (DeWalt and Hink, 2009; Driessnack et al, 2014; Lowery, 2016). A parent’s level of anxiety (often associated with higher levels of neuroticism) can lead to the expectation of greater pain intensity in newborn babies (Bailey et al, 2018). Conscientiousness and agreeableness are predictive of positive health behaviours in humans (Bogg and Roberts, 2004; Freidman and Kern, 2014; Strickhouser and Krizan, 2017); high levels of conscientiousness are thought to be related to fewer inconsistencies in health reporting (Balck et al, 2017) and in parents, are also related to better adherence to medical advice relating to their child’s care.

Empathy levels can affect health and pain recognition in human-human interactions and in human-animal interactions (Ellingsen et al, 2010; Norring et al, 2014). In a correlational study investigating how humans rated dog pain, empathy levels were the best predictor of pain scores (Ellingsen et al, 2010). Furthermore, in humans, previous experience of the same condition can increase empathy, particularly in females (Bateson et al, 1996). However, no research has looked at whether previous life experiences lead to greater empathy in human-animal interactions. Ellingsen et al (2010) found that owners who kept their dog as a companion animal - rather than as a working or hunting dog - generally had more positive attitudes towards, and higher levels of empathy toward animals, and generally also gave higher pain scores (Ellingsen et al, 2010). Whilst causal pathways cannot be determined in this research, the findings suggest that how individuals utilise their animals may be related to empathy levels.

The main aim of this chapter is to understand whether there is an influence of owner characteristics (personality, pain experience, health literacy and their dog's place within the family) on how they report on health and pain information about their dog. If dogs differ in how they respond to compromised health and pain, are they due to; the dog's personality and mood; the characteristics of their owner and how they perceive and interpret their dog's behaviour, or a combination of the two?

### *5.2.4 Research questions and hypotheses*

*Table 5:1 Research questions, hypothesis made and the supporting literature*

| | |
|---|---|
| ***Is the personality of a dog owner associated with how they report on their dog's health and pain?*** | |
| Hypothesis 1a) More neurotic owners would report a higher number of health conditions in their dog | Bailey et al (2018) |
| Hypothesis 1b) More neurotic owners would report higher pain scores | Bailey et al (2018) |
| Hypothesis 1c) More conscientiousness owners would report a higher number of health conditions in their dog | Bogg and Roberts, (2004); Freidman et al, (2014); Strickhouser and Krizan, (2017) |
| ***Does a dog owner's orientation towards their dog interact with how they perceive their dog's pain?*** | |
| 2a) Dog owners who viewed their dog as a working dog would give lower pain scores | Ellingsen et al (2010) |
| 2b) Dog owners who viewed their dog as a like a member of the family would give higher pain scores | Ellingsen et al (2010) |
| ***Does a dog owner's own experience of pain interact with how they report on their dog's pain?*** | |
| 3a) Dog owners who have experienced either multiple short or chronic painful illnesses would give higher pain reports for their dog | Bateson et al (1998); Ellingsen et al (2010) |
| ***Does a dog owner's self-perceived medical knowledge interact with how they report on their dog's health and pain?*** | |
| 4a) Owners with a self-reported higher level of medical knowledge would report a higher number of health condition in their dog | DeWalt and Hink, (2009); Driessnack et al, (2014); Lowery, (2016) |
| 4b) Owners with a self-reported higher level of medical knowledge would report a higher pain score in their dog | DeWalt and Hink, (2009); Driessnack et al, (2014); Lowery, (2016) |

Finally, exploratory analysis will be undertaken to look at the concept of consistency and reliability in owner reporting by exploring the relationship between pain scores achieved on the HCPI-R, CBPI and reported health conditions.

## 5.3 Materials and methods

### *5.3.1 Survey design*

The data in this chapter are part of a larger data set (Chapter 4) collected from an online survey using opportunity sampling. The survey was designed to collect information from dog owners about their dog's health and personality as well as information about their own personality, their experience of a painful condition, their level of health literacy, and how they viewed their dog. These questions were added at a later time point.

### *5.3.2 Owner characteristics*

Owner personality was assessed using the 44 item Big Five Inventory (BFI-44) (John & Strivastava, 1999). The BFI-44 has five dimensions, Extraversion, Neuroticism, Agreeableness, Conscientiousness and Openness and has been used internationally as a valid measure of human personality.

Owners were asked to indicate how they viewed their dog. For example; as a working dog; as just a dog; as a member of the family or like a child.

An owner's self-perceived level of medical knowledge was assessed by asking them to choose which statement they felt best described their level of medical knowledge; I know little about medical issues; I know as much as most people about medical issues; I know more than most people about medical issues; I have extensive knowledge of medical issues; I have a medical degree.

An owners experience of a pain causing condition was assessed by asking owners to indicate which statement best described their experience of a pain condition; I have never experienced a condition causing pain; I have experienced a single incident of short lived pain, such as; a minor break, minor muscle injury; I have experienced several bouts of short-lived pain; I experience a single condition that causes me long-term pain; I experience more than one condition that causes me long-term pain.

Dog personality, mood and pain were assessed as reported in Chapter four section 4.3. A full copy of the survey can be found in Appendix 4.1.

### *5.3.3 Respondents*

388 respondents completed the sections related to the research questions and hypotheses in this chapter.

### *5.3.4 Data preparation*

Respondents with multiple missing answers from essential sections (for example, age of owner and owner personality) were excluded from the data set. All responses from owners under the age of 16 years old and all responses about dogs aged less than one year of age were excluded. Consistency in dog personality increases with age (Gartner, 2015), and a meta-analysis of studies by Fratklin et al (2013) demonstrated that assessment of dog personality when dogs were 12 months or older were 1.7x more consistent. Any respondents with more than one missing answer on each section of the personality questionnaires (PANAS, MONASH & BFI) were also excluded from the data set, as per protocol. The factor structure for both the PANAS and the MONASH was assessed as in the previous chapter.

## 5.4 Statistical analysis

Statistical analyses were conducted in SPSS v21 and R. R was used to conduct factor analysis (FA); FA was conducted on each of the measures (PANAS, MCPQ-R, CBPI, HCPI-R-R & BFI) to check the factor structure reported in the original paper was replicated in this sample of dogs. Except for the PANAS the loadings for each of the items on the factors was acceptable (0.30>, Samuels, 2016). Scores were computed for the dog's mood (NA and PA) and the personality traits of extraversion, and neuroticism following the standard scoring process for the PANAS and MCPQ-R. A pain interference score and pain severity score were calculated for the CBPI using the standard scoring format reported in the publicly available CBPI user guide (Brown, 2017) (appendix 4.3). A score for each of the questions and an overall score was computed for the HCPI-R using the standard scoring format for the HCPI-R. Scores for owner personality (Openness, Conscientiousness, Extraversion, Agreeableness and Neuroticism) on the Big Five Inventory were calculated using the format reported in the BFI guide (John and Srivastava, 1999) (appendix 5.1)

Normality testing was carried out on each of the continuous variables (dog personality and owner personality factors) using Shapiro Wilk tests. As not all continuous variables were normally distributed, and as there were multiple categorical and nominal variables in the data set, nonparametric statistical tests &

generalised linear models were used. Descriptive statistics were calculated to give information of the demographics of the dog owner population. Analyses were conducted on a final sample size of 388 respondents. Where analyses are conducted on less than 388 respondents, this is documented as follows, e.g. n=233.

*Table 5:2 Hypothesis and corresponding statistical tests tabulated to aid interpretation*

| Hypothesis | IV | DV | Statistical test used |
|---|---|---|---|
| 1a) Owners higher in neuroticism would report higher pain scores | Owner personality | Dog pain score | Generalised Linear Model |
| 1b) More neurotic owners would report a higher number of health conditions in their dog | Owner personality | Number of health conditions | Generalised Linear Model |
| 1c) More conscientiousness owners would report a higher number of health conditions in their dog | Owner personality | Dog pain score | Generalised Linear Model |
| 2a) Dog owners who viewed their dog as a working dog would give lower pain scores | Owner view of dog | Dog pain score | Generalised Linear Model |
| 2b) Dog owners who viewed their dog as a like a member of the family would give higher pain scores | Owner view of dog | Dog pain score | Generalised Linear Model |
| 3a) Dog owners who have experienced either multiple short or chronic painful illnesses would give higher pain reports for their dog | Owners pain experience | Dog pain score | Generalised Linear Model |
| 4a) Owners with a self-reported higher level of medical knowledge would report a higher number of health condition in their dog | Owners medical knowledge | Number of dog health conditions reported | Generalised Linear Model |
| 4b) Owners with a self-reported higher level of medical knowledge would report a higher pain score in their dog | Owners medical knowledge | Dog pain score | Generalised Linear Model |

Exploratory analysis was conducted to look at whether the association between pain scores and owner characteristics was dependent on the pain scale used.

## 5.5 Results

86% of the dog owner population identified as female and were also between the ages of 25-54. However, responses were achieved from owners across all age categories (Table 5:3).

*Table 5:3 Age of owner sample stratified by their gender.*

| | **Female** | | **Male** | | **Prefer not to disclose** | | **Total** | |
|---|---|---|---|---|---|---|---|---|
| | **N** | **%** | **n** | **%** | **N** | **%** | **N** | **%** |
| 16-24 | 33 | 80 | 8 | 20 | 0 | 0 | 41 | 11 |
| 25-34 | 84 | 86 | 13 | 13 | 1 | 1 | 98 | 25 |
| 35-44 | 79 | 85 | 12 | 13 | 2 | 2 | 93 | 24 |
| 45-54 | 79 | 85 | 13 | 14 | 1 | 1 | 93 | 24 |
| 55-64 | 39 | 83 | 8 | 17 | 0 | 0 | 47 | 12 |
| 65+ | 10 | 77 | 3 | 23 | 0 | 0 | 13 | 3 |
| Total | 324 | 84 | 57 | 15 | 4 | 1 | 385 | 100 |

### *5.5.1 Owner personality and their disclosure of health problems and pain in their dog*

The hypothesis that owners with higher levels of neuroticism would give higher pain scores in their dog was tested. Owner neuroticism scores were negatively associated with the pain severity scores they gave their dogs. Increased owner neuroticism predicted lower pain scores on the CBPI (table 5:4). However, owner neuroticism was positively associated with a dog's Helsinki chronic pain index-revised (HCPI-R) score. Higher levels of owner neuroticism predicted a higher pain score on the HCPI-R (table 5:4).

The hypothesis that higher levels of neuroticism would be related to the reporting of more health conditions in their dog was tested. Higher owner levels of neuroticism were positively associated with the total number of conditions they reported their dog suffered from and the number of illnesses they disclosed that their dog was currently suffering from, but that were **not** under treatment.

The hypothesis that owners higher in conscientiousness would report a higher number of health conditions was tested. Conscientiousness was negatively associated with the total number of current conditions owners reported their dog's to be suffering with, however in a GLM this didn't reach significance (table 5:5)

*Table 5:4 Generalized Linear Model demonstrating the relationship between owner levels of neuroticism and their dogs pain scores.*

| | | | | |
|---|---|---|---|---|
| ***Pain Severity score*** | | | | |
| | **b** | **Std.error** | **df** | **Sig** |
| (Intercept) | 1.447 | .1690 | 1 | .000 |
| Owner neuroticism | .146 | .0549 | 1 | .008 |
| (Scale) | .839[a] | .0603 | | |
| ***HCPI pain score*** | | | | |
| | **b** | **Std.Error** | **df** | **Sig** |
| (Intercept) | 3.715 | .5873 | **1** | .000 |
| Owner neuroticism | -.487 | .1850 | **1** | .009 |
| (Scale) | 1.625[a] | .2569 | | |

*b=slope of the line between the predictor variable and the dependent variable, df= degrees of freedom, sig=significance level*

*Table 5:5 Generalized Linear Model looking at the effect of neuroticism and conscientiousness on the number of health conditions they report their dog is/has suffering/ed from*

| ***Current n.o of conditions-no treatment*** | | | | |
|---|---|---|---|---|
| | **B** | **Std.error** | **df** | **Sig** |
| (Intercept) | -3.381 | .1690 | 1 | .000 |
| Owner neuroticism | .434 | .0549 | 1 | .010 |
| (Scale) | 1[a] | .0603 | | |
| ***Total n.o of conditions*** | | | | |
| | **B** | **Std.Error** | **df** | **Sig** |
| (Intercept) | -.277 | .3670 | 1 | .451 |
| Owner neuroticism | .175 | .0567 | 1 | .002 |
| Owner conscientiousness | -.005 | .0728 | 1 | .944 |
| (Scale) | 1[a] | | | |

*b=slope of the line between the predictor variable and the dependent variable, df= degrees of freedom, sig=significance level*

### *5.5.2 The influence of an owners view of their dog on how they report on their dogs health and pain*

The hypothesis that owners who viewed their dog as a 'working dog' would give lower pain scores was tested. Owners who viewed their dog as 'just a dog' a 'member of the family' or 'like a child' were all less likely to give their dog a higher pain score than those viewing their dog as 'a working dog' (table 5.6).

The predicted pain score for owners in the 'working dog' category was 3.292, in the 'just a dog' category 2.159, for the 'member of the family' it was 1.744 and for the 'like a child' category it was 1.613.

*Table 5:6 Generalised linear models demonstrating that; owner neuroticism is ; health literacy doesn't impact on the pain scores owners give; that owner's viewing their dog as a working dog were more likely to give higher pain scores.*

| ***Owner personality*** | | | | |
|---|---|---|---|---|
| | **b** | **std.error** | **Df** | **sig** |
| (Intercept) | 2.931 | .3195 | 1 | .000 |
| Owner neuroticism | .104 | .0498 | 1 | .037 |
| (Scale) | .645[b] | .0467 | | |
| ***Health literacy*** | | | | |
| | **b** | **std.error** | **Df** | **sig** |
| Degree level | .093 | .3061 | 1 | .760 |
| Extensive | -.199 | .2667 | 1 | .456 |
| More than most | .018 | .2501 | 1 | .943 |
| Same as most | -.008 | .2533 | 1 | .975 |
| Very little | 0[a] | . | . | . |
| ***Owner view of dog*** | | | | |
| | **b** | **std.error** | **Df** | **sig** |
| Like a child | -1.614 | .1924 | 1 | .000 |
| Member of the family | -1.468 | .1503 | 1 | .000 |
| Just a dog | -1.140 | .2531 | 1 | .000 |
| Working dog | 0[a] | . | . | . |

*b=slope of the line between the predictor variable and the dependent variable, df= degrees of freedom, sig=significance level*

### *5.5.3 Influence of owner pain experience and medical knowledge on dog health and pain reports*

The hypothesis that an owner’s pain experience would influence how they reported on their dog's pain was tested. No difference was observed across the owner pain experience groups in any of the health or pain reports they made about their dog.

The hypothesis that an owner's self-reported level of health literacy would influence how they reported on their dog's health and pain was tested. No relationship was found between an owner's health literacy and the pain scores they gave their dog. However, when compared, owners who had lower self-reported health literacy reported that their dog had suffered from fewer health conditions when compared to owners that had a medical degree (Table 5:7).

*Table 5:7 Generalized linear model demonstrating that owners with a higher level of health literacy would report a greater number of conditions that their dog has had.*

| **Owner level of health literacy** | | | | |
|---|---|---|---|---|
| | **b** | **std.error** | **Df** | **sig** |
| (Intercept) | .666 | .1644 | 1 | .000 |
| Less than most | -.356 | .1865 | 1 | .244 |
| As much as most | -.635 | .1865 | 1 | .001 |
| More than most | -.405 | .1773 | 1 | .022 |
| Extensive | -.403 | .2038 | 1 | .0.48 |
| Degree | 0[a] | . | | |

*b=slope of the line between the predictor variable and the dependent variable, df= degrees of freedom, sig=significance level*

### *5.5.4 Exploratory analysis: Consistency of owner health and pain reports*

Total scores on the HCPI-R and both the pain severity score and interference score were positively related (Table 5.4). HCPI-R pain scores were positively correlated with current conditions receiving treatment (r=.212, P=0.00, n=387), current conditions receiving no treatment (r=.186, P=0.00, n=387), resolved conditions (r=.165, P=0.00, n=387) and total number of overall health conditions (r=.293, P=0.00, n=387). However, no correlations were observed between the CBPI pain severity or interference scores with the number of current conditions receiving treat, current conditions receiving no treatment, resolved condition or total number of overall health condition.

*Table 5:8 Spearman's rho correlation to look at the correspondence between pain scores on the CBPI and the HCPI-R*

| | **Pain Severity** | **Pain Interference** | **Helsinki Chronic Pain Index Total** |
|---|---|---|---|
| Pain Severity | | 0.48, p=0.00, n=73 | 0.33, p=0.00, n=80 |
| Pain Interference | 0.48, p=0.00, n=73 | | 0.49, p=0.00, n=80 |
| Helsinki Chronic Pain Index Total | 0.33, p=0.00, n=80 | 0.49, p=0.00, n=80 | |

Table legend; n= number of participants

## 5.6 Discussion

The aim of this chapter was to establish whether there was an association between a dog owner's characteristics, such as their personality, their orientation towards their dog, their own levels of pain experience and their self-reported medical knowledge, and the assessments they make about their dog's personality and health.

The first hypothesis tested was that owners with different types of personality would differ in how they reported on their dog's health and pain. It was found that an owner's personality type was significantly associated with the reports they gave on their dog's health: More conscientious owners reported fewer conditions overall, and fewer current conditions. These findings fit with the hypothesis made about conscientiousness. Conscientiousness and agreeableness are related to a range of positive behaviours for human health (Bogg and Roberts, 2004; Freidman et al, 2014; Strickhouser and Krizan, 2017) and out of the other personality variables (extraversion, neuroticism and openness) have the largest effect on health outcomes (Strickhouser and Krizan, 2017). The negative association between owner conscientiousness and the number of current conditions may demonstrate that conscientious dog owners are more likely to seek help and treatment for their dog, leading to fewer current and historic health complaints. Work by Finka et al (2019) also demonstrated that agreeableness and conscientiousness were related to more positive cat behaviour and wellbeing.

As hypothesised, neuroticism in owners was positively associated with the number of untreated conditions they disclosed their dog was suffering from. Neuroticism in humans is thought to reflect subjective rather than objective health status (Johnson, 2003), with heightened symptom perception precipitated by neuroticism (Cohen et al, 1995) which leads to over reporting of symptoms. Furthermore, neuroticism in humans has a negative relationship with positive health outcomes; anxiety and worry are both facets of neuroticism related to hypochondriasis and pain catastrophising (Cheng et al, 2016; Spada et al, 2016). Further research would be needed to confirm this, but it may be that owners with higher levels of neuroticism, due to worry and anxiety, report a greater number of illnesses in their dog, that are not confirmed and therefore not treated. This fits well with findings of a study looking at human-cat interactions, finding that owners with higher levels of neuroticism reported more health conditions (Finka et al, 2019).

A negative association was found between owner neuroticism and the pain severity scores given on the CBPI but a positive association was found between neuroticism and the pain scores given on the HCPI-R-R. This suggests that the association between owner characteristics and dog pain scores is dependent on the measure of pain used. One explanation for this finding is that pain severity (CBPI) is calculated from questions around physical capability, rather than including measure of affective pain experience, whereas the HCPI-R focuses on the affective element of pain as well. As the human research demonstrates, neuroticism is usually related more to the psychological aspects of pain experience, rather than physical severity or intensity (Goubert, Crombez and Damme, 2004; Spada et al, 2016).

The second hypothesis tested was that owners would differ in the pain scores they gave their dog based on how they viewed their dog (just a dog, a working dog, member of the family or like a child). Specifically, that owners who viewed their dog as a working dog would give lower pain scores than those viewing their dog as a member of the family or like a child. However, owners viewing their dog as a working dog were in fact more likely to assign their dogs a higher pain score using the HCPI-R. These findings are initially contradictory to previous literature as Ellingsen et al (2010) found that how owners 'used' their dog (companion, working, gundog) was related to the pain scores owners gave. Companion dog owners gave higher pain scores than those who kept their dog as a working dog and gun dog. There is however important distinctions to make between the Ellingsen et al (2010) work and the findings reported in this chapter. Firstly, dog owners in the current chapter were reporting how they rated their dog's pain over the last seven days; in the Ellingsen et al (2010) study owners of dogs were asked to rate how painful they perceived an unknown dog's medical condition to be based on a picture, not assigning a pain score to their own dog.

The findings of this study demonstrate that owners viewing dogs as a member of the family or like a child are less likely to view their dogs as being in pain over the past 7 days, but don't tell us anything about the causal mechanisms underpinning this.

Therefore, these findings could be because of several factors. Owners in these categories may be more attuned to their dog's everyday behaviour, thereby noting when problematic behaviours occur and seeking help, resulting in a lower pain score. Alternatively, pain in working dogs may become more apparent to owners because their dogs are unable to continue fulfilling tasks they were previously able to do. Additionally, working dogs may be more likely to get injured (due to their working role) than other dogs. Finally, the findings may be spurious. Further work is clearly needed to determine the causal mechanisms underlying these findings.

The hypothesis that owners with greater experience of pain would give higher pain scores to their dog was tested. None of the findings supported this hypothesis. As this was only tested in this study it is not enough evidence to assume that an owner's own experience of painful conditions wouldn't increase their understanding of pain in their pets. Furthermore, this hypothesis was tested with the answers provided by owners from one question on the survey. Empathy is a complex concept to research (Cuff et al, 2015); the use of one question to address this may not have been enough. Future studies may benefit from exploring this further by integrating owner pain assessments and animal attitudes/empathy scales.

The final hypothesis tested in this chapter was that owners with a higher level of health literacy would also report higher pain scores and a higher number of health conditions in their dog. The findings from this chapter demonstrate that self-professed higher level of medical knowledge was related to reporting both a higher number of current and/or previous health conditions in their dogs. This suggests that owners, who perceive they have a high level of health literacy, are perceptive about their dog's health. They may either have a better understanding of the health problems their dog has suffered from or are better at knowing when their dog 'doesn't seem right'. To contextualise this within the wider (human) literature, low health literacy in parents is related to worse health behaviours and outcomes for children, but health literacy doesn't always impact use of health care services (DeWalt and Hink, 2009). This suggests that better health literacy relates to better health outcomes. Therefore, the findings of this chapter may demonstrate a similar concept in the owner-pet relationship, in that owners with a higher level of self-reported medical knowledge demonstrate this by more comprehensive reporting of previous and current health conditions. However, an alternative explanation worth exploration is the 'availability heuristic' (Rothman and Hardin, 1997).

The availability heuristic is where the ease by which information can be drawn (i.e. in the case or the current online survey, number of current and previous conditions the dog has suffered with) impacts decision-making (Rothman and Hardin, 1997). For example, if someone can recall a larger list of problems their dog has suffered from, they perceive this as higher level of medical knowledge, regardless of accuracy. It would have been beneficial to have information on where the owners had acquired their knowledge. To contextualise this for the present study, owners who report having more knowledge about medical issues may be overestimating their skill because they can list many health conditions.  This only becomes useful if the owners are accurately assessing these conditions.

Finally, as with chapter four exploratory analysis was conducted to look at the consistency of owner pain reports. The pain severity score and the pain interference score from the CBPI did not correlate with the number of current, resolved or total health conditions reported for the dog. However, the total score for the Helsinki chronic pain scale did.  This may reflect a sample of dogs with health conditions without an element that manifests physically, as opposed to musculoskeletal illnesses that may be accompanied by gait change and visually apparent interference.  As only a small number of dogs in our sample had a diagnosis of musculoskeletal problems (presumably due to the inclusion of this on the survey in the second wave of data collection) these pain questionnaires may have not been broad enough for owners of dogs with other sources of pain.  Particularly considering the CBPI was initially developed to assess pain severity and its effect on function in dogs with osteoarthritis (Brown et al, 2007) and later bone cancer (Brown et al, 2009).  However, this doesn't explain the findings between the HCPI-R and the number of current, resolved or total health conditions reported for each dog.  The main difference between the two measures of chronic pain is in the wording of the questions.  For example, the HCPI-R asks, 'please rate your dog's ability and/or willingness to run' from 'very willing and able to does not run at all', in contrast the CBPI asks 'how in the past 7 days has your dog’s pain interferes with your dog’s ability to run, on a scale of 1-10 (0=no interference-10=completely interferes). One requires the owner to agree that pain is what is causing the physical interference (CBPI), whereas the other does not (HCPI-R). These findings suggest owners do not link disturbances with physical functioning to pain, rather just an inevitable consequence of having a musculoskeletal problem. This is reminiscent of the literature on brachycephalic dogs (Packer et al, 2012) where problematic health signs (breathing issues) is seen by owners as an inherent characteristic of the breed of the animal. Contextualising this within the human literature, Steinkopf (2016) used an evolutionary psychological approach to postulate that because of the costly nature of helping others, pain behaviour on its own is not legitimate. Rather that it becomes ‘legitimised’ with contextual information, such as bleeding from a wound. Without this contextualisation in non-human animal pain, humans may be unlikely to surmise that pain may be occurring.

## 5.7 Limitations

This study has made the first step in acknowledging that owner characteristics may specifically impact if and how they report on their dogs health and pain. If this is the case and owner characteristics lead to over or under reporting of pet health and pain problems, pet welfare could be compromised. However, three limitations are worth consideration when interpreting the findings. These are; the distribution of owners amongst the 'view of dog' categories were not even with the majority of owners viewing their dog as 'a member of the family'; an owners level of pain related health literacy were subjective and not validated by other means; and the effect of previous pain experience on their dog's health and pain reports was only tested using one question.

## 5.8 Further work

More in depth work should be conducted to look specifically at how owner characteristics impact animal pain assessment specifically. Evidence from Ellingsen et al (2010) and the current chapter are sufficient enough to warrant further investigation. Future work should move beyond looking at correlational associations to determine the underlying causal mechanism behind these relationships.

## 5.9 Conclusion

This chapter found several significant associations between an owner's characteristics and dog health and pain reporting, highlighting that how owners viewed their dog may impact how they assess their level of pain, owner personality may affect how pain is scored and the number of health conditions reported and that owners with better medical knowledge are more attuned with their dog's health. These findings suggest that an owner's personality, health literacy and how they view their dog (within the family) may be beneficial (or non-beneficial) to a dog's welfare. Whilst pain scores from owners can be useful, especially in indicating that something may be wrong (rather than assessing extent) the specific pain scales used may influence this.

# 6 Chapter Six: The association between pain behaviour, disease severity, personality and mood in dogs with hip dysplasia.

## 6.1 Abstract

Hip dysplasia is a common and chronic polygenic disease characterised by the abnormal development of the coxofemoral joint/s, resulting in chronic pain. It is reported in both human and non-human animals and is difficult to diagnose and treat. In dogs suffering from hip dysplasia x-rays and hip scores are often used as indicators of disease severity. However, it is unclear whether these indicators of severity correspond to objective assessments of gait asymmetry and pain, or whether an individual dog's mood state and/or their personality moderate their pain behaviour.

In total 21 dogs were included in the study, 11 had asymmetrical hind-limb peak vertical force (PVF) when using non-parametric tests to determine asymmetry. Dogs completed a total of between 30 and 45 force plate trial repetitions trotting across a force plate, dependent upon their physical capability, handled by their owner or by the

researcher. Owners also filled in an online questionnaire detailing their dog's personality, behaviour and their own personality.

The results suggest that there is an association between clinical severity and gait asymmetry, however, clinical severity alone does not account for 100% of the observed variation. Furthermore, a medium positive association was observed between the dog's scores on the HCPI and their asymmetry value. Owners' views of their dog's pain over the past seven days are not necessarily reflected in the pain scores they give, and dog personality and mood moderated the association between disease severity and subjective pain scores. Personality and mood in dogs are associated more with the experience of pain than disease severity.

## 6.2 Introduction

Hip dysplasia (HD) is a common and chronic polygenic disease characterised by the abnormal development of the coxofemoral joint/s (Rettenmaier et al, 2002; Dennis, 2012; Souza et al, 2015) resulting in chronic pain, and has been reported in both human and non-human animals (Rettenmaier et al, 2002, ). Whilst HD was previously thought to mainly affect medium to large breeds of dogs (Jaeger et al, 2006), subsequent research has suggested that all dogs can be susceptible to hip dysplasia (Collins et al, 2010). This is also clear from prevalence estimates, which include both purebred and mix breed dogs, including those much smaller in size, such as Dachshund, Miniature Schnauzer, Shih Tzu and the Yorkshire Terrier (Rettenmaier et al, 2002). Available prevalence estimates for hip dysplasia vary dependent upon the country, breed and classification method used (Paster et al, 2005), with some being around 19.7% in purebred dogs (n=2885) and 17.7% in cross breed dogs (n=649) (Rettenmaier et al, 2002), making the need for further research, inclusive of all dog sizes, into this condition ever more pertinent.

Veterinarians struggle when diagnosing a dog with hip dysplasia and when assessing the subsequent severity of the disease, as structural changes in the hip joint/s detected on radiographic images do not often correlate with other clinical signs of the disease (Gordon et al, 2003; Ginja et al, 2010). Furthermore, alterations to hip joints can occur, such as fibrotic changes and thickening of the capsule, leading to improved joint conformation (Ginja et al, 2010). Because of these changes, spontaneous improvement in hip function can be observed, leading to fragmented periods of pain and a further difficulty in diagnosis. Therefore, the extent to which a dog is in pain and is suffering, and what factors contribute to this, is difficult to ascertain.

Pain is one of the major elements of hip dysplasia and is thought to be associated with the secondary development of osteoarthritis (OA) (Sharkey, 2013, Hielm-Bjorkman et al, 2004). Animals that are in pain often alter their behaviour to avoid future damage, leading to the absence of some normal behaviours (Bateson, 1991, Sharkey, 2013), which in dogs with hip dysplasia often manifests as lameness. Assessment of pain and severity in dogs is challenging because of their innate propensity to adopt protective characteristics and mask their pain (Sharkey, 2013). Furthermore, across species pain behaviour is not always correlated with the severity of tissue damage (Gordon et al, 2003; Ijichi et al, 2014, Lush and Ijichi, 2018).

Many of the pain assessment methods used in veterinary assessments are subjective in nature. For example, lameness has historically been assessed in a range of domestic and farm species using subjective visual assessments (Callaghan et al, 2003; Waxman et al, 2008; Barker et al, 2010; Ijichi et al, 2014). However, this is problematic given that evidence suggests that observable signs of pain (lameness) are not indicative of disease severity (Ijichi et al, 2014), but are in part related to the personality of the individual being observed (Ijichi et al, 2014, Lush and Ijichi, 2018).

Apart from Ijichi et al, (2014) and Lush and Ijichi (2018) no other studies have explored the relationship between personality and pain severity in nonhuman animals, but a plethora of research exists looking at the relationship in humans. Comprehensive detail of this research is available in Chapter 2, but in summary, both positive and negative affect and personality are associated with pain behaviour and reporting (Coskun et al, 2000, Krok and Baker, 2014) and coping (Cipher et al, 2002, Newth and Delongis, 2004) in humans. This relationship is not dependent on disease severity (e.g. Coskun et al, 2000). However, the causative nature of this relationship is unclear (Deary et al, 2010).

In chapters four and five a more detailed and critical account of subjective pain assessment is made. Whilst surrogate pain assessments can be useful and credible (Herr et al, 2006), they are limited to potentially being able to differentiate between the presence and absence of pain based on factors such as, physical ability or changes in psychological characteristics of an individual dog, rather than being able to determine differing levels of pain severity. Therefore, where possible multiple methods to assess pain and pain severity should be used (Herr et al, 2006).

Pain in dogs with hip dysplasia has been assessed in numerous ways, including pain questionnaires to assess pain severity and pain interference (Brown et al, 2013), quality of life (QOL) questionnaires and gait analysis including force plate assessments (Piel et al, 2014). However, considering the prevalence of hip dysplasia in a dog population further research is undoubtedly warranted. Force plate analysis records the reaction to the force the body exerts on the ground, in each direction, mediolaterally (frontal plane, side-to-side), craniocaudally (sagittal plane forward-backwards) and dorsoventrally (transverse plane up and down). There has been an increased use of Ground Reaction Forces (GRF) with dogs over the past two decades (Moreau et al, 2014) which is a progressive step forward in controlling for the subjective nature of visual assessments of lameness. Ground reaction forces are often used to look at the amount of load dogs place on their limbs (Bennett et al, 1996; Decamp, 1997; Poy et al, 2000; Bockstahler et al; 2007, Katic, Bockstahler and Mueller, 2009; Krotscheck et al, 2014; Souza et al, 2015) and comparisons between healthy and non-healthy dogs and affected and non-effected limbs can be useful, especially when looking at illness and disease progression. For example, research with dogs suffering from disease related reduced limb function and dogs with experimentally induced reduced hind-limb functioning (Bennett et al, 1996; Madore et al, 2007; Katic et al, 2009; Fischer et al, 2013) have consistently observed reduced GRF in affected limbs.

Despite research documenting reduced GRF in response to reduced limb functioning, little research has contextualised this in relation to the severity of a dog's disease as assessed using a radiograph. The first piece of research (to my knowledge) to overcome this was by Souza et al (2015); this study correlated hip grades (based on the Brazilian scoring system A-E, A being healthy, E being HD associated with degenerative changes) to peak vertical force (PVF). Mean PVF was lower in groups C, D and E (dysplastic dogs) than groups A and B.  The findings from this study appear to support the notion that hip scores correlate with decreased limb functioning in severely dysplastic dogs.  However, only including dogs with similar right and left hip grades misses a proportion of dysplastic dogs with asymmetrical limb functioning. This is problematic as there may be something unique in cases where dogs have distinctly different right and left hip grades.  Furthermore, in cases of asymmetrical limb functioning the relationship between hip grade and decreased limb functioning may be different.

Whilst various biomechanical characteristics can be indicative of hip dysplasia - such as; alterations in movement in a range of joints, including the coxofemoral and tarsal joints (Bennett et al, 1996) and subtle changes in the characteristics of dynamic flexion, extension angles and angular velocities (in each joint) (Bennett et al, 1996) - peak vertical force correlates directly with how much weight a dog bears on each limb (Krotscheck et al, 2014). As such, force plates are considered to be a standard objective method of evaluating limb function and use (Seibert et al, 2012; Voss et al, 2010), allowing comparisons between individual dogs so long as characteristics such as the weight of the dog (Fischer et al, 2013; Krotscheck et al, 2014) are accounted for.

Despite the findings from previous research, it is unclear whether changes in kinetic parameters observed in relation to dysplasia/lameness are in fact related to the severity of an individual dog’s disease or, as Ijichi et al (2014) suggested, are influenced by the mood and/or personality of the individual dog. Considering the gaps identified in the current literature on pain expression and personality in non-human animals and dogs more specifically, the aim of this research was to understand the relationship between disease severity, pain expression, personality and mood in dogs. In order to meet this aim the work answers five research questions:

Research question one: ***Is peak vertical force asymmetry positively associated with clinical diagnosis of hip dysplasia and disease severity?***

Hypothesis two) Based on research by Souza et al (2015) it was hypothesised that there would there would be an association between disease severity (assessed using hip scores or x-rays) and gait asymmetry.

Research question two: ***Are owner made pain assessments positively associated with peak vertical force asymmetry?***

Hypothesis two) There will be a moderate positive correlation between owner pain assessments and gait asymmetry.

Research question three: ***Is peak vertical force asymmetry associated with dog personality and mood?***

Hypothesis three) Dogs with lower levels of positive affect will have higher asymmetry scores and dogs with higher levels of extraversion will have higher asymmetry scores.

Research question four: ***Is there an association between dog personality or mood and the pain scores owners give their dogs?***

Hypothesis four) Based on the findings from chapters three and four it was hypothesised that dogs with lower levels of positive affect would have higher pain scores. It was also hypothesised that neuroticism would be related to pain scores; due to the persistent characteristic of HD related pain.

Research question five: ***Do personality and mood moderate asymmetry values and the pain scores owners give their dogs?***

Hypothesis 5) Personality and mood will moderate the relationship between disease severity and asymmetry scores and the disease severity and a dog's HCPI score.

## 6.3 Methods

### *6.3.1 Sample recruitment*

Owners and their dogs were recruited from; the University of Lincoln dog database, online advertisements on UK websites, through the Kennel Club (KC) breed health coordinators, local veterinary surgeries and hydrotherapy centres. A strict set of inclusion and exclusion criteria was employed as follows:

**Inclusion / exclusion criteria**: dogs to be either healthy (i.e. no known health problems that would affect gait) or have a veterinary diagnosis of hip dysplasia; have either a hip x-ray and/or a Kennel Club hip score; be over one year of age and have no other comorbid musculoskeletal problems, such as cruciate ligament injury or elbow dysplasia.

### *6.3.2 Animal sample*

24 dogs in total took part in the study; however, data from three dogs were excluded. In the final sample (n=21) several breeds of dogs were represented including pedigree dogs and cross-breeds. The body masses ranged from 10.4 kg for a Cavalier King Charles Spaniel to 57.1 kg for a Bernese Mountain dog. Dogs were aged between 13.5 and 154 months of age.

## 6.4 Materials and data collection process

### *6.4.1 Gait analysis*

Two Kistler force plates (model number 9287) were used to collect GRF data at a sampling rate of 1500 Hz, with force ranges selected to be appropriate to the size of each individual dog based on their weight and projected corresponding force. Each force plate was set into the floor, flush with the floor level. The surface of each plate was covered by a 3mm thick non-slip rubber mat cut to size and secured in place using double sided carpet tape. Additional matting at each side of the plates ensured a smooth surface for the dogs. (Appendix 6.1 for full visual details). The direction of travel across the force plates was chosen by the owner based on which side of the owner the dog walked. Data were recorded and exported using BioWare (version

5.3.07, Kistler Instruments, London, UK); each repetition produced a time series of vertical, anteroposterior and mediolateral ground reaction forces for each plate. Only the vertical forces were analysed as peak vertical force correlates directly with how much weight a dog bears on each limb (Krotscheck et al, 2014) and is most relevant to hip dysplasia. Dogs were required to be in a trotting gait when passing over the force plates. The speed for each dog's trotting gait was established during practice trials, the GRF trace was examined to ensure distinct peaks could be established. Each dog took part in between 30 and 45 trial repetitions.

A Casio FH-100 high-speed camera (Casio, Tokyo, Japan) was used for video recordings. The settings were also kept consistent across trials and across participants. Appendix 6:1 gives a visual representation of the experimental set up.

Quintic Biomechanics (version 29, Quintic, Sutton Coldfield) was used to look at the order of footfall in the dog's gait cycle to be able to match the force values to the correct limbs. This process involved each of the videos being watched from start to finish and the order of footfall being recorded in an Excel sheet. Further to this, Quintic Biomechanics was also used to calculate the speed of each of the gait cycles. This was done using calibrations taken prior to each data collection session, when a 1.5m calibration stick was placed in the plane of motion (of the dog's trotting path) and filmed. This was to determine whether the speed of each of the trials was within an acceptable range of consistency. If more than one gait cycle could be observed (be it a full cycle or half a gait cycle) then the speed of that was also calculated. To determine whether any variability in speed was at an acceptable level the average speeds were plotted in SPSS and outliers were identified. Custom MATLAB code (version R2016b, Mathworks, Natick, MA) was used to identify the peak force for each footfall, as identified from the video. Peak vertical forces were only recorded when a single foot was in contact with the plate, and average and median values were computed for each trial.

### *6.4.2 Questionnaire formation*

In addition to the gait analysis that owners and their dogs took part in, they were also required to fill in an online questionnaire. Full details of the questionnaire can be found in Chapter 4 and 5 and in appendix 4.1. In Brief; dog personality was assessed using the MONASH personality questionnaire (Ley et al, 2007) and mood was assessed using the PANAS (Sheppard and Mills, 2002). Subjective owner assessments of pain were obtained using the Canine Brief Pain Inventory (CBPI) (Brown et al, 2007) and the Helsinki Chronic Pain Index (HCPI) (Hielm-Bjorkman et al, 2009)..

## 6.5 Data Preparation and Statistical analysis

### *6.5.1 Diagnosis of Hip Dysplasia (HD)*

For dogs to be classed as having hip dysplasia a diagnosis from a veterinarian must have been given or a hip x-ray/hip score must have shown signs indicative of hip dysplasia.  The interpretation of hip scores for each individual dog was carried out in relation to the Dennis (2012) (Table 6:1) article. A score of 11 and over was considered to represent changes in the hip joint indicative of hip dysplasia; scores of below 11 are indicative of healthy hips.  For the dogs without hip scores their x-rays were examined, and measurements of Norberg Angle and the extent of femoral head coverage was calculated.  X-rays were examined by an orthopaedic veterinary specialist (RM) and measurements were taken; a sample of was then cross-checked by the principal researcher.

*Table 6:1 British Veterinary Association/Kennel Club (BVA/KC) Hip score classification taken from Dennis (2012)*

| **Total Score** | **Status** | **Description** |
|---|---|---|
| 0-4 | Perfect/near perfect | Near perfect hip with very little change. |
| 5-10 | Borderline | Borderline changes that are considered to not be at risk of changing/developing with age. |
| 11-20 | Mild changes | Changes can be seen that are mild in nature, however, may worsen with age and potentially leading to the development of secondary osteoarthritis. |
| 21-50 | Moderate/marked hip dysplasia | Moderate hip dysplasia is observed alongside the development of prominent osteoarthritis OR severe hip dysplasia without arthritic changes being evident. |
| 50+ | Severe/very severe | In addition to hip dysplasia there is evidence of severe secondary osteoarthritis. |

*Calculation of Norberg Angle and Extent of Femoral Head Coverage*

For those dogs without a hip score, Norberg Angle (NA) and extent of femoral head coverage (FHC) were calculated from their x-ray using ImageJ (Appendix 6.2). X-rays were anonymised and sent to an orthopaedic specialist veterinarian (RM) at the Royal Veterinary College. Norberg Angle is the measurement of the extent of femoral head displacement from the acetabulum. NA should be $\geq$105; values of <105 are considered to represent laxity within the joint. Femoral Head Coverage (FHC) is the amount of the femoral head that it covered by the acetabulum; the lower the percentage (%) the more laxity present in the joint. Therefore, to determine whether an individual dog would clinically be considered healthy we used either a hip score of below 10 or a Norberg Angle of above 105 and femoral head coverage of above 50%, which ever was available for each dog.

*Dog and Human Personality Scores*

Full information on how both dog and owner personality and dog mood data was analysed can be found in chapter three (section 3.3.3), four (section 4.3.9) and chapter five (section 5.4) respectively.

*Peak Vertical Force Asymmetry*

Ground reaction forces were normalised to the dog's body weight, and the vertical component was extracted for further analysis. Mean peak vertical reaction forces were calculated for each dog on a trial by trial limb-by-limb basis and then averaged across trials by calculating the differences between right and left hind-limb mean. Mean absolute difference asymmetry values [1] and relative asymmetry values[2] were then calculated. None of the dogs in the sample had bilateral hip dysplasia. No literature is available to determine cut off value for symmetry / asymmetry scores, studies usually use the symmetry values of the known healthy dogs to determine the cut off value for none healthy dogs (i.e. Fisher et al, 2013). However, in the current sample we found great variability in asymmetry values regardless of their clinical health status. Therefore, to determine individual level asymmetry non-parametric t-tests (due to non-normality of data, Shapiro-Wilk $P<0.05$) were conducted to compare the GRF from each individual dog's left and right hind-limbs only (as dogs with co-occurring elbow dysplasia were excluded from this study). Where a significant finding was observed that dog was classed as asymmetrical. Using this method, the power was 0.70 with a small effect size (0.11).

Descriptive statistics were undertaken to provide an overview of the characteristics of the dogs' hip health and asymmetry. Correlations were conducted to determine whether Norberg Angle and Femoral Head Coverage were associated with hip scores. Personality, mood and pain scores were calculated as in chapters three, four

---

[1] Absolute mean difference asymmetry for unhealthy dogs= Healthy hind limb – unhealthy hind limb, absolute mean difference asymmetry for healthy dogs= Left hind limb – right hind limb

[2] Relative asymmetry values for unhealthy dogs= absolute mean difference/healthy limb GRF * 100, relative asymmetry values for healthy dogs absolute mean difference/left limb GRF * 100

and five. However, in this sample only the Helsinki Chronic Pain score was used, due to the scores on the Canine Brief Pain Inventory being '0' for most dogs.

Dogs with and without a clinical diagnosis of HD were compared in their asymmetry, pain scores and personality using Mann-Whitney U tests, as were dogs that were considered healthy and non-healthy based on their hip score or x-ray. To allow comparability between the groups of dogs with hip scores as a measure of severity and those with x-rays as a measure of severity, a grading system was formulated ranging from 1, which indicated healthy and 4 which indicated severe signs of hip dysplasia (table. 6.2).

Firstly, to test the hypothesis that the diagnosis of hip dysplasia and disease severity would be associated with asymmetry in peak vertical force (PVF) a generalised linear model was conducted. Peak vertical force was included as the dependent variable and both diagnosis of hip dysplasia (binary response yes/no) and severity group were included as the independent variables.

To test the hypothesis that there would be a moderate association between owner pain assessments (HCPI-R and CBPI) and peak vertical force asymmetry Spearman's rho correlations were conducted. Furthermore, a Mann-Whitney U test was conducted to look at whether owners differed in whether they thought their dog had been in pain over the last 7-days dependent on their diagnosis.

To test the hypothesis that dog personality and dog mood would be associated with mean peak vertical force asymmetry a generalized linear model was conducted with mean PVF asymmetry as the dependent variable and the dog personality traits (extraversion and neuroticism), mood (positive affect and negative affect) and the interaction between positive affect and neuroticism as independent variables.   This was then repeated with the pain score owners had given their dog on the HCPI as the dependent variable to test the hypothesis that dog personality and dog mood would be associated with owner pain scores.

To test the hypothesis that personality and mood moderated the relationship between clinical severity and pain using PVF asymmetry two generalized linear models were conducted. One with only severity as the independent variable and PVF asymmetry as the dependent variable, then a second model including personality and mood variables as independent variables, models were then compared for fit. This was then repeated with the HCPI score as the dependent variable to test the hypothesis that personality and mood moderated the relationship between clinical severity and owner reports of dog pain. Finally, interaction effects were plotted to visually explore the interactions.

Table 6:2 Severity grade for dogs with a hip score or a hip x-ray, the number and percentage of dogs in each group.

| **Severity Grade** | **Number of dogs (n)** | **Percentage of dogs (%)** |
|---|---|---|
| 1 | 5 | 24 |
| 2 | 7 | 33 |
| 3 | 4 | 19 |
| 4 | 5 | 24 |

# 6.6 Results

## 6.6.1 Clinical picture of dog health and gait asymmetry in dogs

### 6.6.1.1 Healthy dogs

When using the absence of a clinical diagnosis of HD to determine a dog's health status, only one healthy dog had 100% symmetrical gait with no difference in PVF between the right and left hind-limbs and a mean asymmetry value of 0. Asymmetry values (the absolute value of the difference between left and right hind limbs) created from mean GRF across trials ranged from 0 -13.55, relative asymmetry values in healthy dogs ranged from -2.43-6.06. When using NA (≥105°), FHC (≥50%) or hip score (≤ 10) as a measure of a healthy dog, one dog was on the border between being classed as healthy from their NA of 105.95 in their affected limb, 50.4% FHC with an asymmetry value of 6.31 and a relative asymmetry value of 5.73. Furthermore, one dog was on the border between healthy or not based on their hip score (10, which indicates borderline changes unlikely to progress with age) with an asymmetry value of 13.55 and relative asymmetry of 11.34.

#### *6.6.1.2 Unhealthy dogs*

When using a previous diagnosis of HD to determine unhealthy dogs the extent of asymmetry was variable. Mean asymmetry values ranged from 3.48 – 28.39 and relative asymmetry values ranged from 4.71-45.10. When using NA (≤105°), FHC (≤50%) or hip score (≥ 11) to determine the health status of dogs, the absolute difference asymmetry values for unhealthy dogs still varied ranging from 2.36-28.39 and relative asymmetry value ranged from 0-45.10, which at the lower end is less than when using a previous veterinary diagnosis of HD. Therefore, irrespective of the method used to determine a healthy or unhealthy dog, dogs with both symmetry and asymmetrical gait appear in each category.

*Table 6:3 Range, Mean and Standard Deviation of asymmetry in hind limb peak vertical force for healthy (no diagnosis of HD) and unhealthy (veterinary diagnosis of HD) dogs*

| | **Range** | **Mean** | **Std Dv** |
|---|---|---|---|
| No diagnosis of Hip Dysplasia (n=12) | 0-12.50 | 3.27 | 3.87 |
| Diagnosis of Hip Dysplasia (n=9) | 0-30.00 | 7.87 | 8.06 |

### 6.6.2 Using NA and FHC in replacement of hip scores

An strong negative association was found between left femoral head coverage (FHC) (%) and asymmetry values (r=-.75 (n=12), P=0.03), however, significant correlations were not observed between right FHC and asymmetry values, or right and left Norberg Angle (NA) and asymmetry values. Similarly, a significant difference was observed between dogs with and without a diagnosis of hip dysplasia in their % of femoral head coverage, with those dogs with a diagnosis of HD having lower left FHC (Mann Whitney U(3,9)=0.00, P=0.00).

### 6.6.3 The relationship between asymmetry values and disease severity

The hypothesis that the diagnosis of hip dysplasia and disease severity would be associated with asymmetry in peak vertical force (PVF) was tested. Disease severity using the 4-point grading system was associated with peak vertical force asymmetry. Dogs in the no severity group and the low severity group had significantly lower peak vertical force asymmetry when compared to dogs in the high severity group. However, whilst dogs in the medium severity group had lower peak vertical force asymmetry than the high severity group it didn't reach significance (table 6:4).

*Table 6:4 Generalized linear model to show that disease severity is associated with mean asymmetry in peak vertical force*

| | **b** | **Std. error** | **df** | **sig** |
|---|---|---|---|---|
| (Intercept) | 10.325 | 2.7967 | 1 | .000 |
| Veterinary diagnosis of Hip Dysplasia | .508 | 2.4761 | 1 | .838 |
| No veterinary diagnosis of Hip Dysplasia | 0[a] | . | . | . |
| No severity | -8.079 | 3.3873 | 1 | .017 |
| Low severity | -6.274 | 3.1985 | 1 | .050 |
| Medium severity | -6.278 | 3.5735 | 1 | .079 |
| High severity | 0[a] | . | . | . |

*b=slope of the line between the predictor variable and the dependent variable, df= degrees of freedom, sig=significance level*

### *6.6.4 Correlations between severity measures, asymmetry values and owners' reported pain scores*

The hypothesis that there would be a moderate association between the pain scores owners gave their dog (HCPI-R and CBPI) and the dog's PVF asymmetry was tested. There was very little variation between the scores owners gave their dogs. A significant positive association could be seen between HCPI scores and the dogs' mean PVF asymmetry ($r=0.43$, $P=0.02$, $n=21$), meaning dogs with higher pain scores showed greater asymmetry.

Despite an association between asymmetry values and pain scores only three out of 21 dog owners (14.3%) reported that they thought their dog had been in pain over the last seven days. When looking at the pain scores from owners who thought their dog had been in pain over the last seven days, this was not reflected (table 6:5). Furthermore, when looking at differences between dogs with and without a diagnosis of hip dysplasia in the answers owners gave when they were asked *"do you think your dog has been in any pain over the last 7 days?"* no difference could be observed between the two groups $U=24.00$, $P=0.72$. Furthermore, no significant difference in pain scores (HCPI, pain severity and pain interference) was observed between dogs who owners did or didn't view them to be in pain $P>0.05$.

*Table 6:5 Pain scores in dogs with severe hip dysplasia*

| | HCPI (1=lowest pain 5=highest) | Pain Severity | Pain Interference |
|---|---|---|---|
| P001 | 1.00 | 0.00 | 0.00 |
| P002 | 1.73 | 0.00 | 0.00 |
| P024 | 1.91 | 1.00 | 0.00 |

### *6.6.5 The association between dog personality, mood and objective pain*

The hypothesis that personality and/or mood would be associated with a dog's level of peak vertical force asymmetry between their left and right hind limbs was tested. Both extraversion and neuroticism and negative affect and positive affect were associated with asymmetry scores when tested independently. However, when accounting for the interaction between neuroticism and positive affect only neuroticism and the interaction term stayed significant. As such, an interaction plot (Fig. 6.1) was created and illustrated that when a dog's score on positive affect is higher than the mean, asymmetry scores are high even when neuroticism is also high. However, when a dogs score on positive affect is lower than the mean, higher scores on neuroticism are associated with much lower asymmetry scores.

*Table 6:6 Final Model demonstrating the factors predicting a dog's level of mean peak vertical force asymmetry values (objective pain) is impacted by personality and mood*

| | **b** | **std.error** | **df** | **sig** |
|---|---|---|---|---|
| (Intercept) | 30.553 | 24.0383 | 1 | .204 |
| Veterinary diagnosis of hip dysplasia | 5.167 | 1.6605 | 1 | .002 |
| No veterinary diagnosis of hip dysplasia | 0[a] | . | . | . |
| Helsinki Chronic Pain Score | 14.375 | 2.2498 | 1 | .000 |
| Dog neuroticism | -19.029 | 7.2108 | 1 | .008 |
| Interaction between positive affect and neuroticism | 21.395 | 8.7164 | 1 | .014 |
| (Scale) | 10.68[b] | 3.2959 | | |

*b=slope of the line between the predictor variable and the dependent variable, df= degrees of freedom, sig=significance level*

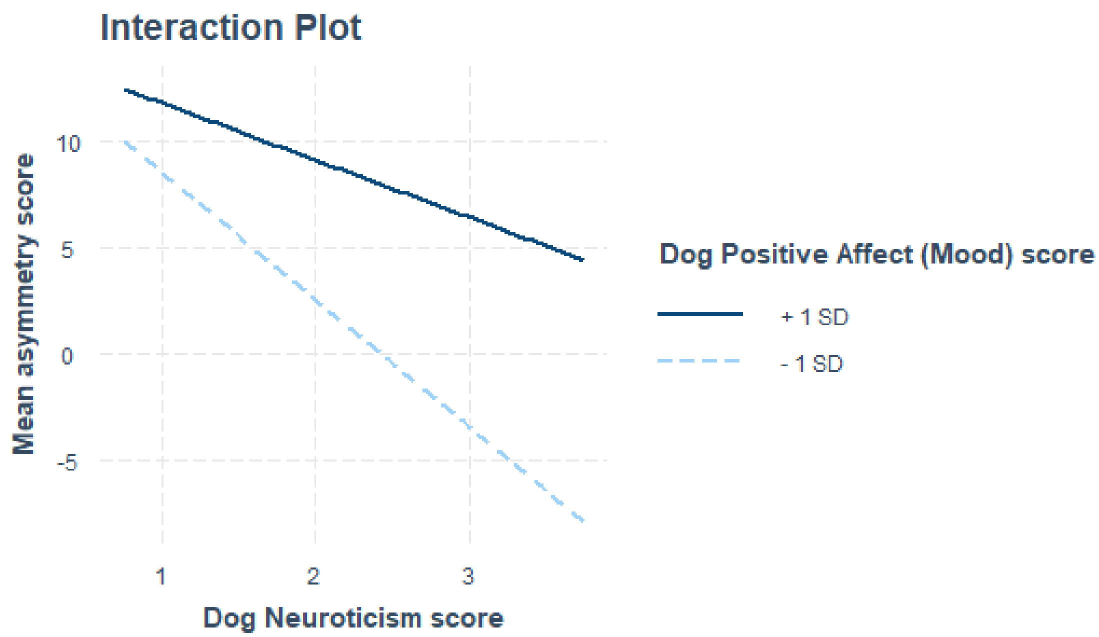



*Figure 6:1 Interaction plot to explore the interaction between dog positive affect and dog neuroticism on mean asymmetry scores in peak vertical force*

### *6.6.6 Modelling the association between mood, personality, asymmetry and owner rated pain.*

The hypothesis that a dog's personality and mood would predict the pain scores dog owners gave their dog was tested. Positive affect when tested independently significantly predicated pain scores.  However, as with peak vertical force asymmetry when accounting for the interaction between neuroticism and positive affect only neuroticism and the interaction stayed significant. An interaction plot (Fig. 6:2) illustrated that a for dogs with a positive affect score lower than the mean (lower positive mood),  an increase in neuroticism leads to a much larger increase in pain scores that dogs with higher positive affect scores.

*Table 6:7 Final model of demonstrating that asymmetry, positive affect and neuroticism predicted a dogs HCPI scores*

| | **b** | **std.error** | **df** | **sig** |
|---|---|---|---|---|
| (Intercept) | 2.279 | 2.2779 | 1 | .317 |
| Veterinary diagnosis of hip dysplasia | -.266 | .1502 | 1 | .076 |
| No veterinary diagnosis of hip dysplasia | 0[a] | . | . | . |
| Dog neuroticism | 1.512 | .6167 | 1 | .014 |
| Interaction between dog positive affect and neuroticism | -1.752 | .7541 | 1 | .020 |
| (Scale) | .100[b] | .0310 | | |

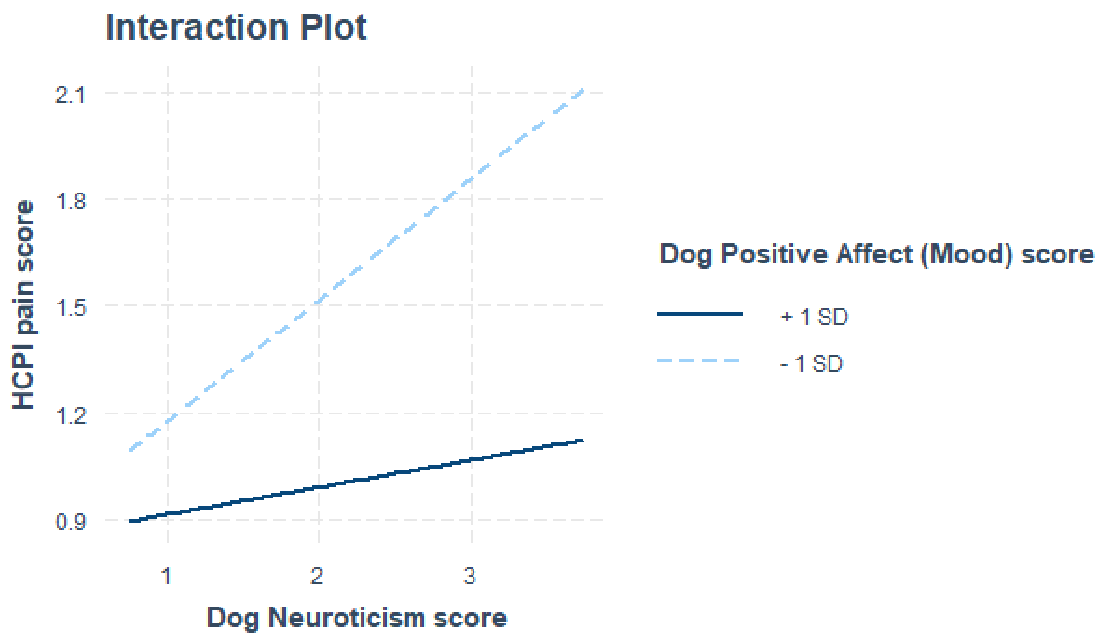



*Figure 6:2 Interaction plot to explore the interaction between dog positive affect and dog neuroticism on owner reported Helsinki Chronic Pain Scores*

### 6.6.7 The moderating effect of personality and mood on the relationship between disease severity and objective pain assessments

The hypothesis that personality and mood would moderate the relationship between disease severity and objective pain was tested. When disease severity was included in the model the significant relationship between personality, mood variables and asymmetry values became non-significant ($P>0.05$). This illustrates that disease severity therefore has a larger effect on asymmetry than personality or mood does.

### 6.6.8 The moderating effect of personality and mood on the relationship between disease severity and owner pain assessments

Finally, the hypothesis that personality and mood would moderate the relationship between disease severity and owner rated dog pain was tested. When including disease severity in the model the interaction between positive affect and neuroticism and neuroticism alone had a greater association with the pain scores owners gave their dog. Furthermore, the difference in pain scores between severity groups and their significance changed. When including the interaction between positive affect and neuroticism and neuroticism alone in the model, the difference in pain scores between medium and high severity dogs became greater and reached significance (-0.49, $P=0.00$).

*Table 6:8 Generalized linear regression output to determine the moderating effect of mood and personality on owner reported dog pain*

| | b | std. error | df | sig |
|---|---|---|---|---|
| (Intercept) | -.113 | 1.2079 | 1 | .925 |
| Normal hips | -.741 | .1733 | 1 | .000 |
| Low severity | -.561 | .1589 | 1 | .000 |
| Medium severity | -.492 | .1822 | 1 | .007 |
| High severity | 0[a] | . | . | . |
| Veterinary diagnosis of hip dysplasia | -.317 | .1278 | 1 | .013 |
| No veterinary diagnosis of hip dysplasia | 0[a] | . | . | . |
| Dog neuroticism | 1.655 | .4630 | 1 | .000 |
| The interaction between positive affect and dog neuroticism | -1.826 | .5855 | 1 | .002 |
| (Scale) | .069[b] | .0213 | | |

*b=slope of the line between the predictor variable and the dependent variable, df= degrees of freedom, sig=significance level*

## 6.7 Discussion

The aim of this chapter was to understand whether there is an association between disease severity and pain in dogs with hip dysplasia, and whether personality and mood moderate the relationship between clinical severity and pain.

The first hypothesis tested was that a dog's asymmetry score would be associated with the severity of their clinical disease as determined radiographically. Dogs with more severe hip dysplasia had higher asymmetry in their hind limbs. However, not all dogs with a clinical diagnosis of unilateral HD had asymmetrical PVF in their hind -limbs nor did all healthy dogs have symmetrical PVF in their hind limbs. This suggests that whilst disease severity is associated with asymmetrical gait, it doesn't account for all of the variation that can be seen. The findings that both symmetrical and asymmetrical PVF can be observed in unhealthy dogs are contrary to some previous research, as studies have consistently observed reduced GRF in affected limbs (Bennett et al, 1996; Madore et al, 2007; Katic et al, 2009; Fischer et al, 2013). What is clearly of importance here is what 'cut-off' value is used to classify a dog as asymmetrical or not, and whether compensatory changes have taken place in the contralateral limb-leading to a false symmetry/asymmetry.

Indeed, when making comparisons between ipsilateral and contralateral limbs there are methodological issues associated with using the contralateral limb as a healthy control. The assumption can be made that the contralateral limb is healthy (as radiographic images do not show changes indicative of HD). However, throughout the course of HD compensatory changes may occur in 'healthy' limbs. Furthermore, in some cases, dogs can have bilateral hip problems, making the contralateral limb an unsuitable control (as you'd be comparing one unhealthy limb to another). However, in the current sample only unilateral HD was represented. Despite this, it does still need to be acknowledged that compensatory changes in 'healthy' limbs can arise in dogs with hip dysplasia, such that decreased load in unhealthy limbs can lead to increased load in contralateral limbs (Fanchon et al, 2007).

Souza et al (2015), using the European Federation Cynologique Internationale (FCI) system, also found that peak vertical force was related to disease severity, but only in dogs with severe hip dysplasia (grade E), rather than dogs of all hip grades. This was also evident in the current sample, as dogs with medium levels of severity did not differ in their asymmetry to those in the high severity group. Traditionally, when calculating a BVA hip score other anatomical features in addition to NA and FHC are taken (Dennis, 2012). It is possible that NA and FHC alone are not indicative of hip status, leading to a distorted picture in the present sample. In future studies, where hip scores are not available, but x-rays are available; an alternative diagnostic may need to be used.

The second hypothesis tested was that there would be a moderate association between a dog's level of PVF asymmetry and the subjective pain scores owners gave. It is clear from our findings that the assessment of pain in dogs with hip dysplasia is complex. Whilst there was an association between asymmetry and owner pain scores, not all dogs who would be considered to have asymmetric gait and who were undergoing treatment for their dysplasia were considered by their owners to be in pain. In fact, little variation was observed in the pain scores owners gave their dogs. Even in cases where it was known that the dog was having surgery for severe hip dysplasia, the owners did not give their dog a high pain score. This is extremely concerning given that dogs are reliant on their owners to not only perceive there to be a physical problem, but to also deem that issue of adequate severity to warrant veterinary opinion. In the case of the dog owners in this study, the majority had sought a veterinarian's opinion on their dog's health; however, this didn't appear to translate to them perceiving that their dog was in pain. Two explanations for these findings may be that either veterinary treatment has successfully controlled the dog’s pain or that owners perceive their dog to be in less pain due to treatment being sought. Indeed, research has demonstrated that both dog owners and veterinarians are subject to judgement bias when assessing improvement when treatment has been sought (Innes et al, 2003; Moreau et al, 2007; Hercock et al, 2009; Conzemius & Evans, 2012).

The third and fourth hypotheses tested were that dogs with higher levels of positive affect would have lower PVF asymmetry scores and owner rated pain scores and that dogs with higher levels of extraversion would have higher PVF asymmetry scores. Both mood and personality were found to be associated with the extent of hind limb asymmetry, yet the specific traits associated differed from those hypothesised. The interaction between positive affect and neuroticism was associated with higher peak vertical force asymmetry. However, high levels of neuroticism alone were associated with lower peak vertical force asymmetry. The opposite relationship was seen between these traits and owner pain scores. This suggests that neuroticism and positive affect are differentially associated with the sensory aspect of pain and the affective elements of pain.

Contextualising this within the wider literature the relationships found mirror those seen within the human literature. For example, numerous studies have ascertained that positive emotions are associated with positive outcomes in pain (Guillory et al, 2015; Hanssen et al, 2017). Furthermore, neuroticism has been related to the experience of pain (Ijichi et al, 2014), less successful coping in pain, higher levels of pain related fear and catastrophising about pain and a lower threshold for which pain in conceptualised as threatening (Goubert et al, 2004; Gheldof et al, 2006; Leeuw et al, 2007). However, it is important to consider a potential alternative explanation for these findings, for example, that owners are less likely to think pain affects a dog's everyday life if the dog has higher levels of positive affect; future longitudinal studies would further help to disentangle these findings.

Based on the available literature (Ijichi et al, 2014) I expected to find an association between lameness (greater levels of asymmetry) and extraversion.

However, extraversion was non-significant when accounting for positive affect and neuroticism. Three explanations for the difference in findings are possible. Firstly, the most likely explanation is that the specific traits interacting with pain behaviour may differ between species. Secondly, Ijichi et al (2014) used subjective visual assessments of lameness conducted by veterinarians, yet in the current study objective biomechanical assessments of lameness were used. Previous research with horses has demonstrated that in mild cases of lameness subjective ratings lack reliability between and within observers (Keegan et al, 1998; Keegan et al, 2009, Conzemius and Evans, 2012). Furthermore, subjective assessments of lameness are not always reflective of objective measures of lameness (Waxman et al, 2008) and subjective assessments made by both owners and veterinarians are subject to bias (Innes et al, 2003; Moreau et al, 2007; Hercock et al, 2009; Conzemius & Evans, 2012. Therefore, it may be possible that the findings of the Ijichi et al (2014) study were affected by this subjectivity. The last explanation could be that the personality test used in the Ijichi et al (2014) study was actually assessing behaviour indicative of positive affect, rather than extraversion. This would link to the criticism that mood, personality and coping styles are often viewed as analogous in animal personality studies (Zidar, 2017) when they are in fact different forms of individual variation.

The last hypothesis tested was that personality and mood would moderate the relationship between clinical severity and asymmetry score and between clinical severity and a dog's owner reported pain score. In chapter three ‘emotional affect and the occurrence of owner reported health problems' (Reaney et al, 2017) a relationship was found between emotional affect and health problems. In this chapter, again, positive affect was found to contribute to predicting dog's pain. However, in the current chapter neuroticism as also found to predict pain higher owner pain scores, but lower asymmetry. These findings reflect previous research by Wiseman et al (2001) finding that owners perceived that their dog's demeanour changed when they were suffering from pain and that owners often associated reduced playfulness and excitability and increased fearfulness with pain experience in their pets (Wiseman et al, 2001). The interaction between positive affect and neuroticism moderated the effect of disease severity on pain scores.

## 6.8 Limitations

When considering the contribution this chapter makes to the overall aim of the thesis and to the scientific area of study it is important to acknowledge the limitations of the research and to consider how this work may pave the way for future work.

Firstly, the sample size in this study was small (n=21) as the recruitment of suitable dogs was particularly difficult. The inclusion criteria specified that any dogs included couldn't have a diagnosis of other musculoskeletal problems. This is problematic, given that hip dysplasia is often comorbid with other problems such as elbow dysplasia. However, for us to be able to associate the GRF with the severity of each dog's disease we needed to be sure that no other known condition could have contributed.  Future studies could aim to collect a much larger sample size, including dogs with comorbid diagnosis, but aim to account for comorbidities in subsequent statistical analysis.

A further limitation of this study was that not all dogs who have diagnosed hip problems had appropriate x-rays and hip scores, therefore the sample included dogs with either hip scores or hip x-rays.  Whilst relaxing the initial inclusion criteria (dogs had to have a BVA hip score) resulted in a larger sample size, the interpretation of the findings has been difficult, because none of the dogs had both a hip score and an x-ray (for us to measure NA and extent of FHC) therefore we are unable to say that one measure completely reflects the other.  Furthermore, a natural bias may have also occurred in this sample, as the dogs with hip scores were only scored because of their breed, rather than having a suspected diagnosis of HD.  Certain breeds of dog have to undergo an x-ray and hip scoring to ensure that they are healthy to be bred from.  Once a hip score has been assigned to that dog their owners are then put on the breed assured scheme. Therefore, the severity measures associated with diagnosed HD were NA and FHC only, rather than hip scores.

## 6.9 Conclusion

This chapter addressed many areas that haven't been included in previous published gait analysis studies of canine hip dysplasia, such as; the inclusion of several different breeds of dogs, including cross-breeds; the inclusion of dogs below 12kg in weight and acknowledgement that factors other than disease severity may account for gait and pain scores, such as, dog personality and mood. Irrespective of the measure used, clinical severity alone does not predict asymmetry scores in dogs with and without HD. When using a measure of pain that takes into account the multidimensional nature of pain (sensory and affective) disease severity, personality and mood are all associated with pain scores. However, when using an objective assessment of the sensory aspect of pain related to hip dysplasia, disease severity is associated more with pain scores. This suggests that in dogs, personality and mood are associated with the affective element of pain.

# 7 Chapter seven: Could accelerometers be used as a form of gait and pain assessment in dogs: a pilot study.

## 7.1 Abstract

Biomechanical methods to assess gait, such as force plate analysis and accelerometer analysis have been used extensively with humans, and research has found that both methods are successful in demonstrating signs of normal and abnormal gait. With non-human animals, force plate or pressure plate analysis has been validated as an objective way of assessing gait and pain. However, accelerometers are not as widely used, and, to date, little research has looked at validating individual limb accelerations against force readings in dogs.

This chapter utilised a sample of healthy dogs and a sample of non-healthy dogs. Dogs were aged between 24 months and 124 months and were a mixture of breeds and their masses ranged from 3.92 kg – 36.49kg. Peak vertical force was assessed without and then with accelerometers attached to each limb. Between 15-20 trials were collected without accelerometers and a further 15-20 trials with accelerometers. Peak accelerations were calculated and compared between healthy

and non-healthy dogs.  The aim was to determine whether accelerometers could be validated against force plates and an alternative method of gait assessment.

The findings from this 'proof of concept' study demonstrate that whilst accelerometers do not appear to affect gait in dogs, they are not a suitable replacement to force plate analysis to look at quantifying signs of disease such as lameness, at this stage.  Further studies should be conducted using alternative methods and accelerometers to develop on these findings further.

## 7.2 Introduction

Gait analysis has proven utility in humans as a way of understanding the characteristics of diseases such as Parkinsons and Multiple Sclerosis and the changes that take place across the disease trajectory (Halliday et al, 1998; Wurdeman et al, 2011; Ren et al, 2016). As discussed in chapter six, force plate analysis is a widely used method for gait assessment in humans and animals and is an objective way of assessing lameness and pain (Voss et al, 2010; Miquelito et al, 2013). However, arguably, when appraising the usefulness of any assessment instrument it is not only its accuracy that is of concern, but also its ease of use, availability of use and cost (Clark et al, 2014). Force plates are an expensive tool (Alvarenga et al, 2011; Clark et al, 2014) that require adequate space and expertise to use. Therefore, force plates are unlikely to be freely available as an assessment tool in a wide range of clinical settings, yet the need to be able to reliably quantify gait parameters in a range of animals is still high.

Indeed, health issues such as lameness are difficult to quantify accurately using subjective assessments alone. Irrespective of the variance in lameness estimates that can be seen between species (Mohsina et al, 2014), the prevalence of lameness is high. For example, lameness is seen in livestock; such as dairy cattle (Blowey et al, 2005) and sheep (Liu et al, 2018; Witt and Green, 2018) because of increased herd size and stocking density (Blowey et al, 2005), and in domestic dogs because of pain associated with Hip Dysplasia (HD) and Osteoarthritis (OA). If a tool to assess features of lameness as indicators of disease severity, progression and improvement could be validated against force plate analysis the impact it could have on veterinary practices and therefore animal welfare would be huge.

Accelerometers are widely and successfully used as a method of assessing gait and physical activity in humans (Bouten et al, 1997; Colley et al, 2011a; Colley and Tremblay, 2011b) across a range of age groups (Freedson, Pober and Janz, 2005; Troiano et al, 2008). They have also been used as an aid for clinical decision making to look at the efficacy of surgical procedures in treatment and recovery and as a way of detecting falls from normal activities of daily living (ADL) in vulnerable populations (Bourk, O'brien and Lyons, 2007; Turcot et al, 2008; Li et al, 2009; Bagalà et al, 2012; Tao et al, 2012).

Accelerometers have also been utilised in animal science to: assess activity levels (Hansen et al, 2007; Martin et al, 2016; Muller et al, 2018); determine the efficacy of weight loss programmes (Wakshlag and Panasevich, 2012, Morrison et al, 2014, ); assess stress in shelter dogs (Jones et al, 2014); and assess gait (Pillard, Gibert and Viguier, 2012; Bailly et al, 2009; Barthelemy et al, 2009; Chapinel et al, 2010; Clark et al, 2014). However, except for equine science, accelerometers are not been widely used in clinical practice with animals (Ladha et al, 2017). Furthermore, the methods that have been previously used with dogs have impeded the interpretation of findings.

Most of the research using accelerometers to look at patterns in canine gait has used a tri-axial accelerometer fixed below the sternum of the dog (Pillard, Gibert and Viguier, 2012, Barthelemy et al, 2009) (fig 7.1) or around the lumbar spine (Clark et al, 2014). Whilst this research has been essential in initially determining that accelerometers can be used to record repeatable patterns in a dog's gait, it only shows whole body movements, which obstructs the ability to determine the source of any irregularities in gait. Recent work by Ladha et al (2017) overcame this methodological limitation by attaching an accelerometer to each of the dog's limbs (above the carpal joint of the thoracic limbs and below the tarsal joint of the pelvic limbs) (fig 7.2). Findings from the study demonstrated that precise step delineation and initial and final contact times could be measured (Ladha et al, 2017). However, these are only characteristics of temporal gait, whereas studies of peak vertical forces are seen to be the most useful for signs such as lameness (Fanchon et al, 2007). As the benefit of force plate analysis in dogs with musculoskeletal problems has already been demonstrated (Braden et al, 2004; Van Klaveren et al, 2005; Voss et al, 2007; Brown et al, 2013) it would be of advantage to determine whether the use of accelerometers can be validated against the 'gold standard' force plate methods in assessments of dog gait.

Therefore, the aim of the study was to determine whether accelerometers could be used as an alternative tool to force plate analysis to examine both healthy and non-healthy dogs' gait.

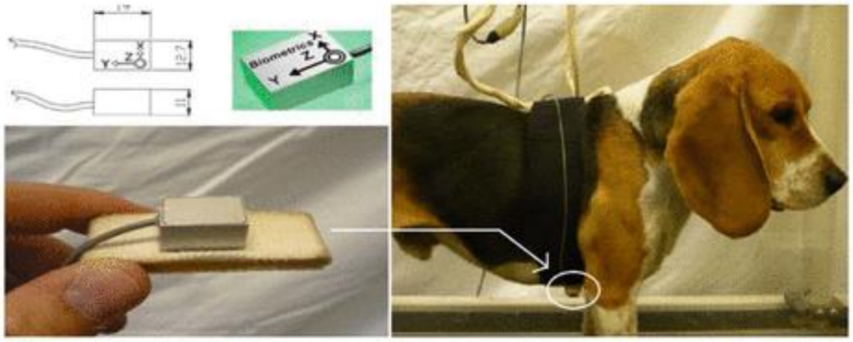



*Figure 7:1 Accelerometer fitted below the sternum of the dog (Clark et al, 2014)*

*Figure 7:2 Accelerometers affixed to each of the dog's limbs (Ladha et al, 2017).*

### *7.2.1 Research questions*

Research question one: ***Does attaching accelerometers to dogs' hind and fore-limbs affect their gait?***

Research question two: ***Is there a positive association between peak vertical force and acceleration in both healthy and non-healthy dogs?***

Research question three: ***Can healthy dogs be differentiated from non-healthy dogs using accelerometer results?***

## 7.3 Materials and methods

Data were collected between January 2017 and May 2017. Dogs were recruited from the University of Lincoln dog database. Initially, only healthy dogs, with no known musculoskeletal problems were recruited. Once the data collection method had been tested with healthy dogs, dogs with a range of musculoskeletal and locomotive problems (for example, hip dysplasia or spondylosis) were recruited to further test validation with non-healthy dogs.

A total of 24 dogs took part in this study. Data from four dogs were excluded due to insufficient or missing accelerometer data. A range of dog breeds took part including both pedigree dogs and crossbreed dogs, and the masses ranged from 3.92 kg – 36.49 kg. Dogs were classified as either healthy (n=12), meaning they had no known health problems, or non-healthy (n=11). Non-healthy dogs had a wide range of clinical diagnoses, such as elbow dysplasia, spondylosis and nonspecific back problems.

### 7.3.1 Gait analysis

Dogs were trotted over the force plate, next to their owners (on the side they most frequently walked) without accelerometers for a maximum of 30 trials (clean peaks to indicate trotting were identified using the same method as described in chapter 6).

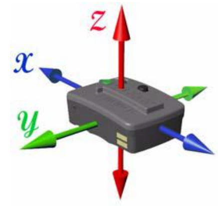
#### 7.3.1.1 Ground reaction forces

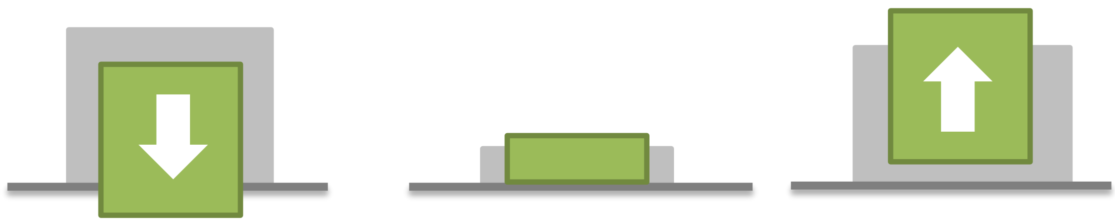
Two Kistler™ force plates (model 9287, size 900x600mm) were used. Each force plate was set into the floor of the University of Lincoln's Sport Performance Laboratory, flush with the floor level. The surface of each plate was covered by a 3mm thick non-slip rubber mat cut to size and secured in place using double sided carpet tape. Additional matting at each side of the plates ensured a smooth surface for the dogs. (Appendix 6.1 for full visual details). Each dog was weighed prior to trotting over the force plate. A Casio™ EX-FH100 high-speed camera (Casio, Tokyo, Japan) was used to record the footfall of each dog and the speed, the settings were kept consistent across trials and between dogs.

#### 7.3.1.2 Accelerometers

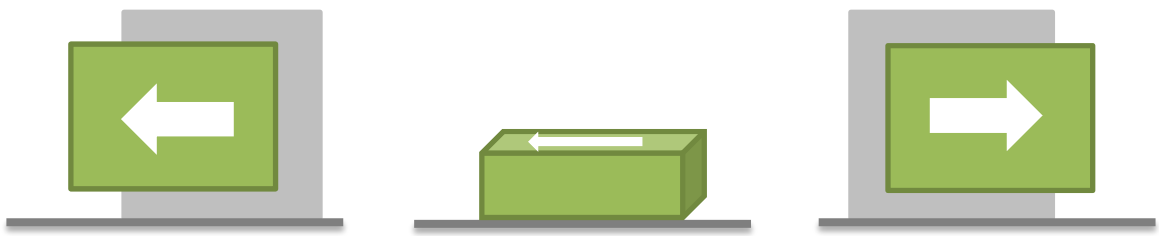
Four Delsys Trigno™ tri-axial accelerometers sampling at 148.1 Hz were used. An accelerometer was attached to each of the hind limbs and each of the forelimbs of each dog (appendix 7.1 shows details of the accelerometer set up and their placement on each dog). Prior to each data collection session, the accelerometers were calibrated by recording the output voltage for 10s with each accelerometer in each of nine orientations to represent -1 g, 0 g and +1 g in the x, y and z directions (fig 7.3). A line of best fit between the voltages and accelerations was calculated for each sensor and direction, to allow later conversion of voltage outputs to accelerations.

Accelerometer Calibration



**X=-1g X=0g X=+1g**



**Y=-1g Y=0g Y=+1g**

**Z=-1g Z=0g Z=+1g**

*Figure 7:3 Visual representation of the accelerometer calibration process.*

Accelerometers were placed in a custom-made pouch (made from polyester & elastane fabric) that was fixed round the limb of the dog with a Velcro fastening. The pouch was wrapped around the thoracic limbs (forelimb) just above the carpal joint; on the pelvic limbs (hind-limb) the accelerometers were wrapped around just below the tarsal joint. A self-securing VetWrap™ bandage was then applied to ensure the accelerometers were securely fixed. Having accelerometers on each of the pelvic and thoracic limbs enabled the accelerations along approximately the cranio-caudal, medio-lateral and dorso-ventral aspect of each limb to be recorded. Once the accelerometers had been attached the dogs were given between five and ten minutes to habituate to wearing them. Once dogs had returned to walking in their regular gait, as observed from the first set of force plate trials, habituation was deemed to have taken place and data collection started.

Each dog performed between 15-25 force plate trials without accelerometers and between 15-30 force plate trials with accelerometers. If a dog showed any signs of impending fatigue and/or discomfort, then trials were discontinued. Each trial produced one video (side-view) with an average of between 1 and 1.5 gait cycles. Quintic Biomechanics was used to determine the order of footfall – for subsequent labelling of contacts in the force plate data – as well as cycle time and distance travelled. The latter was calculated using footage taken prior to each data collection session, when a 1.5m calibration stick was placed in the plane of motion (of the dog's trotting path). If more than one gait cycle (see glossary on page) could be observed (be it a full cycle or half a gait cycle) then the speed of that was also calculated. To determine whether any variability in speed was at an acceptable level (no more than 10% difference) the average speeds were plotted in SPSS and outliers were identified. This gave resultant average speed across the trial. Custom MATLAB code (R2016b, Mathworks, Natick, MA) was used to identify the peak force for each footfall, as identified from the video. The custom MATLAB code also gave the accelerations (g) in each direction, using the conversion equations determined during sensor calibration, and the resultant (combined) acceleration.

*Figure 7:4. Hind and forelimb placement of accelerometers prior to adhesion with bandage wrap*

Several test studies were carried out to work out the correct placement of the accelerometers on the dog, and to check that there was only minimal movement of the pouches and the accelerometers relative to the leg. Pilot tests were also used to determine the correct accelerometer ranges, which were set to 9 g, and to select appropriate an appropriate cut-off frequency (30Hz) for a low-pass Butterworth filter that was applied to smooth the accelerometer data.

### *7.3.2 Data preparation*

The average speed for each trial was calculated using Quintic Biomechanics software (version 29, Quintic, Sutton Coldfield). Each video trial was uploaded, and the speed and distance travelled was calculated for one whole gait cycle. A gait cycle was defined as the time or sequence of events from when one-foot contacts the ground to when that same foot contacts the ground again. The process used was the same as detailed in chapter six.

## 7.4 Statistical analyses

All analyses were conducted using SPSS version 21. Descriptive statistics were created to look at the distribution of accelerations forces for both healthy and non-healthy dogs. This included mean peak vertical force (normalised to body weight) and average peak accelerations across each individual dog's trials to be calculated. When healthy and non-healthy dogs were looked at independently (as separate samples) data on healthy dogs were normally distributed (Shapiro-Wilks >P=0.05) and unhealthy dogs were not normally distributed (Shapiro-Wilks <P=0.05). Therefore, both parametric and non-parametric tests are used throughout.

To answer **research question one** '*does the presence of accelerometers being affixed to both hind and fore-limbs affect the gait of dogs?*' for healthy dogs and unhealthy dogs independently the differences between peak vertical force (PVF) with and without accelerometers were investigated using t-tests (Wilcoxon signed-rank for non-healthy dogs). This allowed me to determine whether wearing accelerometers was having an impact of parameters of gait.

To answer **research question two** *'is there a positive association between peak vertical force and accelerations in both healthy and non-healthy dogs?'* correlation analysis was conducted to look at the association between average peak vertical force for each limb separately and peak accelerations for each limb separately across dogs.

To answer **research question three** *'can healthy dogs be identified from non-healthy dogs using accelerometer results?'* chi-square tests were then conducted to look at whether any differences could be detected in average peak vertical force and peak acceleration between healthy and non-healthy dogs.

## 7.5 Results

Data from 20 dogs were included in the analysis. Out of these, eight dogs were classed as unhealthy and 12 dogs were classed as healthy. Unhealthy dogs had a range of diagnoses including hip dysplasia, arthritis, back problems and elbow dysplasia.

### *7.5.1 Age and sex*

The age and sex of the dog had no association with either peak vertical force values or peak acceleration values ($P>0.05$).

### *7.5.2 The effect of accelerometers on gait*

For healthy dogs, no significant differences between trials with and without accelerometers were observed between each dog's peak vertical force values in their left-fore limb ($t=-2.10$, $P=0.057$), however for the right fore-limb a statistically significant difference was observed ($t=2.57$, $P=0.026$) without and with accelerometers attached. For the left hind-limb ($t=-.664$, $P=0.520$) and for the right hind limb ($t=-2.17$, $P=0.053$) no difference in peak vertical force was observed with and without accelerometers attached.

For non-healthy dogs, no significant difference could be observed between limbs with and without accelerometers; left fore-limb ($z=-0.98$, $P=0.327$), right fore-limb ($z=-0.420$, $P=0.674$), left hind-limb ($z=-0.84$, $P=0.401$) and right hind-limb ($z=-1.120$, $P=0.263$).

*Table 7:1 Means and standard deviation for peak vertical force (%BW) with and without accelerometers PVF=Peak vertical force.*

| | **Healthy Dogs (n=12)** | | | | **Non-healthy dogs (n=8)** | | | |
|---|---|---|---|---|---|---|---|---|
| | PVF without accelerometers | | PVF with accelerometers | | PVF without accelerometers | | PVF with accelerometers | |
| | Mean (N) | SD (n) | Mean (n) | SD (n) | Mean (n) | SD (n) | Mean (n) | SD (n) |
| Left Fore | 125.77 | 13.34 | 128.81 | 11.07 | 178.80 | 147.19 | 185.62 | 162.93 |
| Right Fore | 125.80 | 16.58 | 128.90 | 13.80 | 177.52 | 151.16 | 184.74 | 171.95 |
| Left Hind | 82.07 | 9.13 | 83.13 | 7.03 | 119.57 | 111.67 | 117.99 | 110.34 |
| Right Hind | 78.36 | 10.1 | 81.17 | 7.16 | 119.70 | 112.00 | 128.43 | 134.17 |

### *7.5.3 Correlation between Force and acceleration*

No significant correlations were observed between the acceleration and force values on the same limbs ($P>0.05$) (fig. 7.3 and 7.4). Furthermore, the pattern in correlations across the sample was extremely variable. For example, a negative relationship (non-significant) was found in some dogs (fig. 7.5), no relationship in other dogs (fig. 7.6) and in other dogs the data indicated that the forelimbs and the hind limbs were vastly different in their peak accelerations and peak vertical force, and the relationships between them (fig. 7.7).

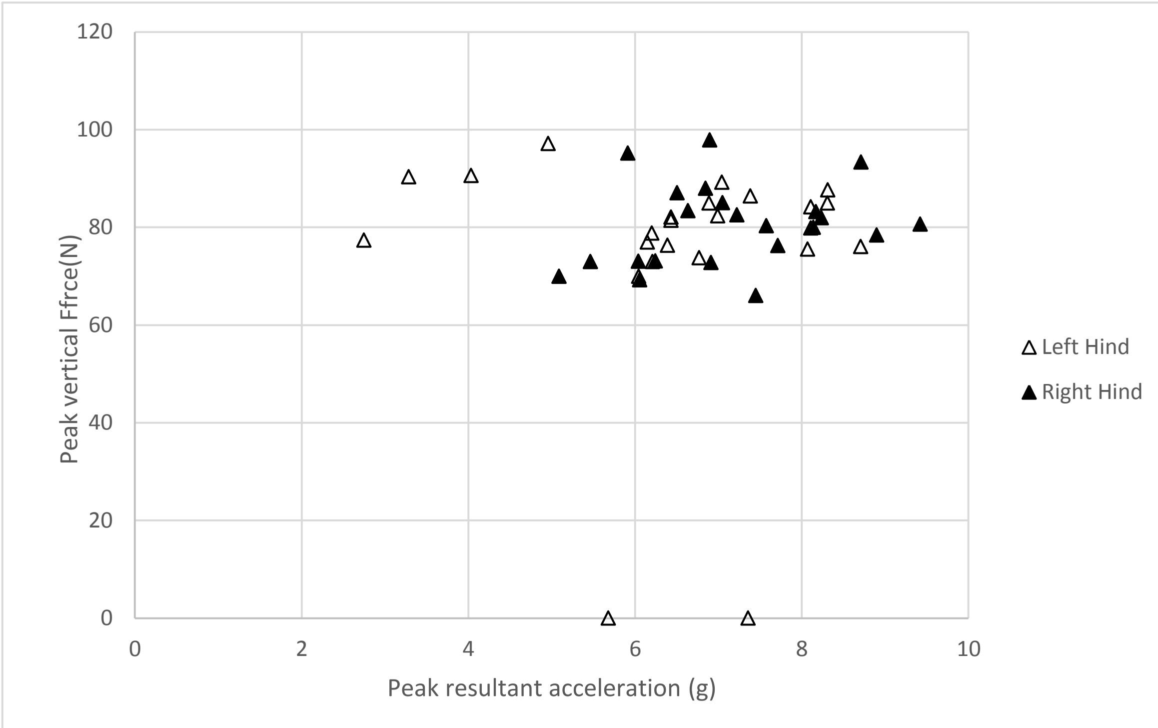



*Figure 7:5 Peak vertical force (% of body weight by N) and peak resultant acceleration plotted for entire sample. Demonstrating significantly different values in both force and acceleration between left and right hind and fore-limbs*

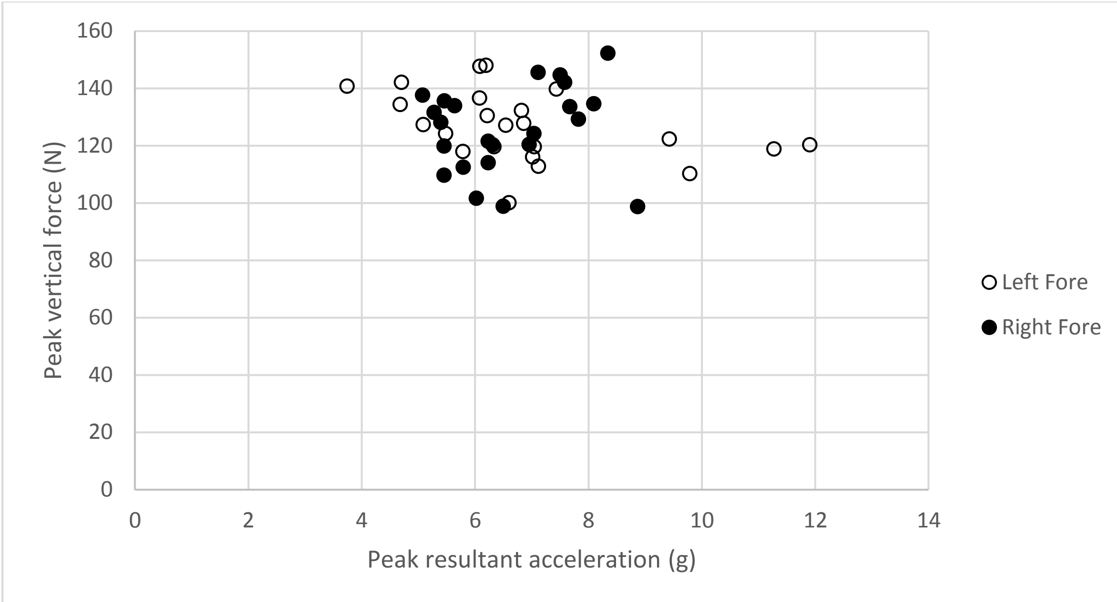



*Figure 7:6 Peak vertical force (% of body weight by N) and peak resultant acceleration plotted for entire sample. Demonstrating association between force and acceleration between left and right fore-limbs*

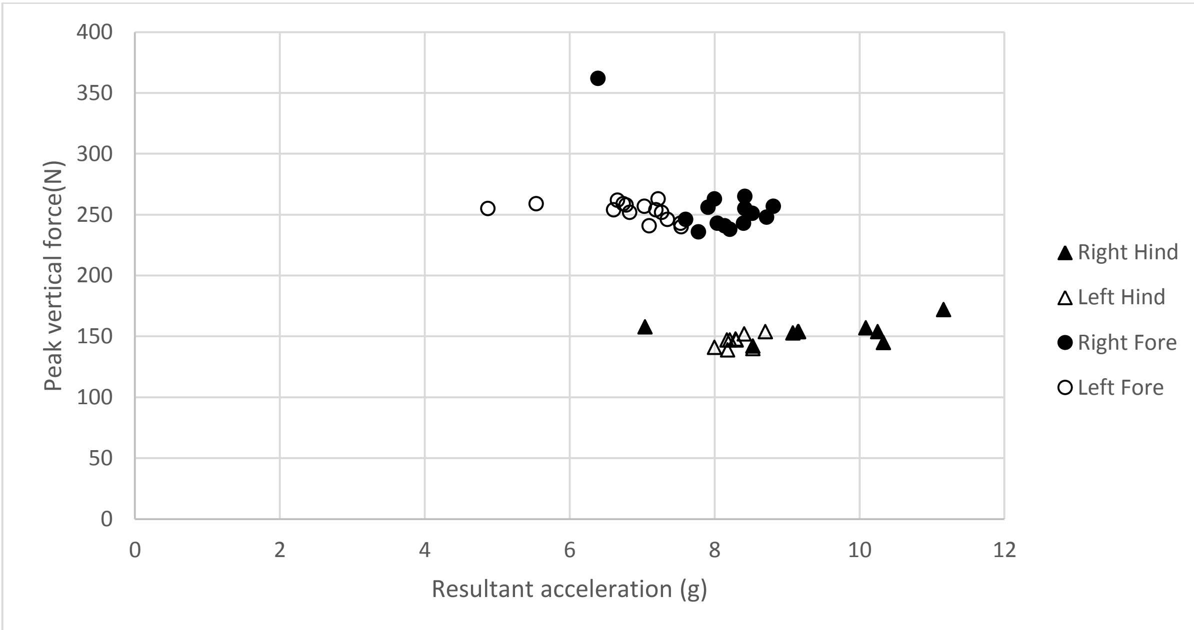



*Figure 7:7 Peak vertical force (% of body weight by N) and peak resultant acceleration plotted for participant three (P03), healthy category. Demonstrating a trend towards a negative relationship between force and acceleration values.*


*Figure 7:8 Peak vertical force (% of body weight by N) and peak resultant acceleration plotted for participant six (P06), healthy category. Demonstrating no relationship between force and acceleration values.*

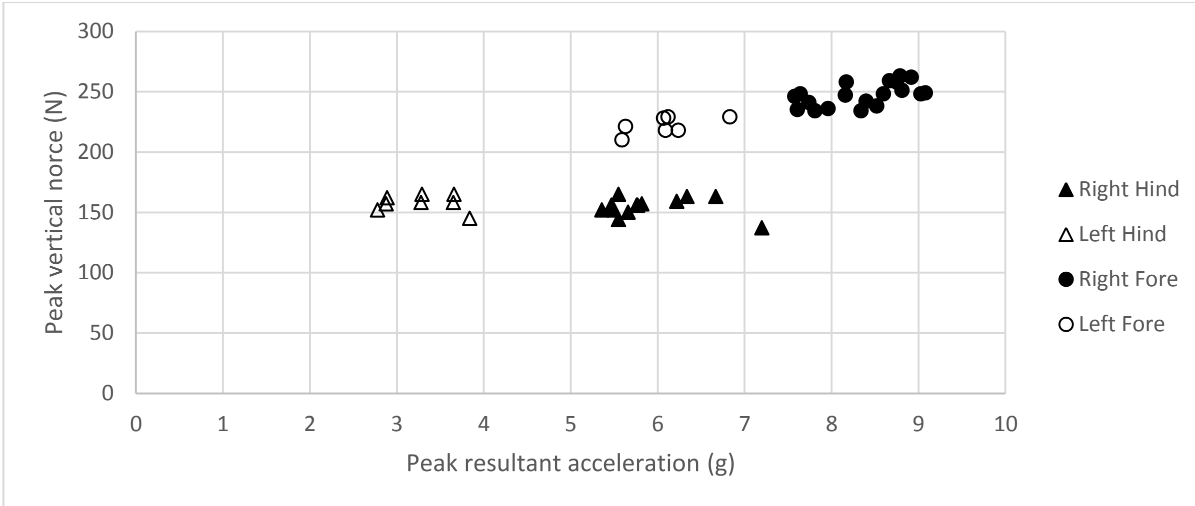



*Figure 7:9 Peak vertical force (% of body weight by N) and peak resultant acceleration plotted for participant ten (P010), healthy category. Demonstrating significantly different values in both force and acceleration between left and right hind and fore-limbs*

### *7.5.4 Using gait analysis to differentiate between healthy and non-healthy dogs*

Using Mann-Whitney u tests healthy dogs could not be differentiated from non-healthy dogs using peak vertical force (normalised to body weight) in any limb: left fore-limbs U=41.00, P=0.624; right fore-limbs U=43.00, P=0.734; left hind-limbs U=42.00, P=0.678; or right hind-limb U=40.00, P=0.571. Healthy dogs could also not be differentiated from non-healthy dogs using their peak accelerations: left fore-limbs U=64.00, P=0.238; right fore-limbs U=57.00, P=0.528; left hind-limbs U=54.00, P>0.678; or right hind-limb U=44.00, P=0.792.

## 7.6 Discussion

The aim of this chapter was to determine whether accelerometers could be used as an alternative to force plate analysis in assessments of a dog's gait.

Research question one asked whether the act of wearing accelerometers affected the dog's gait. As if so, accelerometers would need to be investigated further to determine what aspects of wearing accelerometers affected gait. For non-healthy dogs, no difference was found in peak vertical ground reaction forces (normalised to body weight) force readings with and without accelerometers, demonstrating that after habituation, wearing accelerometers did not affect the gait of the dog. For healthy dogs, again no difference was found in three limbs, however, a difference could be seen in the right fore-limb. Given that in all other limbs this difference was not observed, further work needs to be done repeating the methodology used in this study, to determine whether the difference was artificial and due to placing of the accelerometers, or a unique feature of the sample of healthy dogs. The method used in this chapter was comparable to that reported in Ladha et al (2017), in which no reference was made to whether or not the dog's gait was conserved when accelerometers were attached.

Despite the finding with healthy dogs, the results do suggest that any differences in gait found with and between individual dogs should not be attributable to the presence of accelerometers. As previous studies with dogs have tended to place the accelerometers around the lumber spine or sternum (Barthelemy et al, 2009; Pillard et al, 2012; Clark et al, 2014) it was essential to determine that fixing the accelerometers on each of the limbs did not affect gait. It is however worth consideration that data from one small breed dog could not be collected due to the individual dog not being able to cope with wearing the accelerometers (due to the size of the accelerometers and limb placement). Therefore, whilst 96% of the sample of dogs in this study coped with wearing accelerometers, this may not be the case for all dogs.

It would be expected that if accelerometers were a suitable alternative to force plate analysis there would be a strong positive relationship, with high predictive ability between each individual dog's peak vertical force and their peak accelerations. The results of this chapter do not demonstrate this: no consistent relationship was found between the force and the accelerometer readings, or in some cases a trend towards a negative relationship. Previously, Clark et al (2014) reported that there was moderate agreement (CCC=0.51) between PVF as measured by a force platform and by accelerometers. However, due to the placement of the accelerometers (over the lumbar spine) PVF of individual limbs could not be assessed, which limits clinical usability. As, this was only a 'proof of concept' study, further research would be needed to confirm that there is no significant agreement between force and acceleration when using tri-axial accelerometers on each of the dog's limbs. In subsequent research focus should be given to increasing the sample size and use of more than just the vertical component of acceleration.

The final research question was to ask whether healthy and non-healthy dogs could be differentiated from their accelerometer readings. As the sample in the study included both healthy and non-healthy dogs we would have expected that they could be differentiated by both peak ground reaction force as demonstrated in the previous chapter and other studies (Fischer et al, 2013; Katic et al, 2015) and in peak accelerations. However, no difference in either peak vertical force or peak acceleration was observed. One fundamental difference between this chapter and the previous chapter that could have accounted for the difference in results was the mixture of musculoskeletal conditions represented; these were hip dysplasia, elbow dysplasia, arthritis and spondylosis. However, research has demonstrated that forces are seen to be affected in these types of conditions (Conzemius et al, 2003; Kapatkin et al, 2006; Fischer et al, 2013; Katic et al, 2015). Furthermore, the classification of non-healthy in this sample was less precise than the previous chapter. Therefore, further research would be beneficial to determine whether with a more controlled sample a difference between healthy and non-healthy dogs could be observed.

Ladha et al (2017) demonstrated that systems incorporating accelerometers and gyroscopes could be useful in assessing temporal aspects of gait in healthy dogs and that micro-gait characteristics were consistent in healthy dogs. However, whether micro-gait features are useful in a clinical setting when trying to assess signs of disease such as lameness is yet to be established. Furthermore, as Ladha et al (2017) was limited to healthy dogs, as such it is unclear how unhealthy dogs would perform using this system.

## 7.7 Limitations

The sample size in this study is small, and therefore a larger sample size could have reduced the likelihood of type II errors. Future studies using accelerometers could overcome this by working with a larger sample of dogs. Furthermore, the types of ill health represented in the 'unhealthy' group of dogs was diverse, this lack of specificity in the types and areas affected by pain may have contributed to the null findings.

## 7.8 Conclusion

This chapter described the findings of a proof-of-concept study to investigate whether accelerometers could be used as an alternative to force plate analysis in canine gait assessment, and the data collected have helped to increase our knowledge in this area greatly. In general, the findings suggest that accelerometers do not affect the gait of dogs (size dependent), yet further research should be undertaken with a larger sample to ensure this can be replicated. As no relationship was seen between force values and accelerometers values and as healthy and non-healthy dogs did not differ in their accelerations, the technology and approach used within this chapter does not appear to be a suitable alternative to the use of force plates yet. Future studies would benefit from looking at the individual aspects of acceleration rather than vertical or resultant accelerations.  Work in this area will no doubt become more accessible as the size and quality of the equipment available expands.

# 8 Chapter eight: Discussion and concluding thoughts

### 8.1.1 *Revisiting the PhD aims*

The overall aim of this thesis, to understand whether personality and mood interact with how animals experience and express pain, has been met. In doing so, several overarching research questions have been addressed:

1. Is there enough research evidence to determine whether individual differences such as personality and mood mediate pain expression in non-human animals? If not, what can be gleaned from the human literature that could inform subsequent work with animals?
2. Can we see a difference across a large population of dogs in their experience of health and pain conditions, which may be accounted for by individual differences in mood?
3. Do dogs with different pain experiences differ in their mood and personality?
4. Do the characteristics of dog owners influence how they report on their dog's pain and health?

5. Does personality mediate or moderate the relationship between pain severity and pain expression?
6. Can accelerometers be used as an alternative to force plates in gait assessment?

The systematic review detailed in chapter two clearly outlined the paucity of research looking at the concept of personality impacting on pain experience and expression in animals. As only two studies were found that explicitly focused on personality and pain expression in animals, these alone could not provide conclusive evidence to answer whether personality mediates or moderates pain expression across species. However, the review did illustrate that the relationship between personality and pain behaviour is extremely complex. Furthermore, a key finding from the review was that personality and mood interact. Due to this chapter being the first piece of work from my PhD, studies looking at mood were only considered if they included personality. However, should the review be updated or conducted again, the inclusion of mood (and potentially synonymous terms) would be essential.

Three aspects of the review that are most relevant to the findings of this PhD are:

1. Characterising the impact personality has on an individual's physical responses to pain
2. Illuminating the role that extraversion and positive affect have on how resilient individuals are in coping with painful conditions

3. Illustrating how neuroticism and negative affect can be detrimental to successful adaptation and coping during pain

Chapters three and four highlighted that differences in both mood and personality can be seen in dogs with different levels and types of ill-health and pain. Previous research had only demonstrated anecdotal evidence from dog owners that was interpreted to suggest that compromised health influences mood (Wiseman et al, 2001). The relationship between pain scores, personality and mood are, however, dependent on the methods used to assess pain.

When using a measure of pain that considers the multidimensional nature of pain (sensory and affective) disease severity, personality and mood are all associated with pain scores. However, when using an objective assessment of the sensory aspect of pain (force plate analysis) related to hip dysplasia, only disease severity was significant in predicting pain scores. This suggests that a dog’s personality and mood are associated with the affective element of pain.

Throughout each chapter utilising owner assessments of pain, agreement was seen between the owner’s answers on two pain scales (suggesting consistency in how dog owners appraised their dog's pain) and in chapter six they were also associated with objective assessments of pain. However, the correlations were not a high as might have been expected, if both pain scales were to assess the same thing. Whilst both pain scales are validated to assess chronic pain associated with musculoskeletal issues, the HCPI has a focus on the emotional component of pain, whereas the CBPI is focused more on physicality.

Chapter six aimed to move beyond findings of a simple correlational relationship to determine whether personality and mood moderate pain behaviour. Whilst causation still cannot be claimed (until a more controlled, longitudinal study has taken place) further information on the structure of the relationships between personality, mood and pain is gained. Both mood and personality interact with pain, however, not necessarily the physical expression of pain as measured by force plate analysis (i.e. asymmetry). Furthermore, moderation analysis demonstrated that both personality and mood interact with disease severity to determine pain scores, but again, not the physical measure of pain. These findings are the first, to my knowledge, to demonstrate the interaction between personality, mood and pain experience in animals and, as such, add to a small but growing body of literature in animals focused on individual differences and pain. Mood and personality interact differently with the experience of pain in dogs.

Considering the findings of this thesis within the broader literature, they add to the recent criticisms made about animal personality studies (Zidar et al, 2017). It is essential that the terminology used when studying animal personality is consistent. In addition, that personality, mood and coping styles are not used as analogous terms. Mood and personality in dogs differentially interact with their experience of pain, and without looking at their effects independently and combined, the understanding gained would be inaccurate.

### 8.1.2 ***T***he relationship between Extraversion, Neuroticism and pain behaviour

The earliest aim of this research was to look at the relationship between personality and pain behaviour in animals, however, as the thesis developed a focus was also placed on mood and pain behaviour. From the findings of each chapter, higher scores of neuroticism in dogs are associated with lower owner reported pain scores. Furthermore, a negative relationship was observed between neuroticism and peak vertical force asymmetry. Dogs with higher levels of neuroticism had lower levels of gait asymmetry, a suggested indicator of healthy gait. Higher levels of dog extraversion are also related to lower levels of owner reported pain and greater pain vocalisations.

Previous research looking at personality and pain behaviour in animals has yielded dissimilar findings. As previously discussed throughout the thesis, Ijichi et al (2014) demonstrated that horses with higher levels of neuroticism expressed pain at a lower threshold, and owners of horses with high levels of neuroticism rated their horses as less tolerant of pain. Work by Lush and Ijichi (2018) found no relationship between neuroticism and either physiological or behavioural responses to acute surgical pain. However, the study did demonstrate that dogs with higher level of extraversion had higher pain scores, despite comparable tissue damage.

The potential reasons for the differences in these findings were discussed in the relevant chapters, but as a summary, it is likely that any relationship observed between personality and pain will not be the same across species. Furthermore, personality and acute pain may interact differently that personality and chronic pain. Despite this, these finding add to the body of literature suggesting that personality and pain expression interact in multiple species of animal.

As extraversion in dogs is thought to be indicative of 'sociability' and 'energy', acute pain that prevents behaviours related to this trait may be more noticeable in dogs that are highly extrovert. In humans with chronic pain, extraversion is a source of resilience leading to active coping mechanisms and less depression. Therefore, during time of acute pain high level of trait extraversion better at communication of pain, but over time, these individuals may be better at coping with and compensating for chronic pain.

Extraversion and neuroticism are the most frequently researched personality traits in the human literature when looking at the effect of personality on pain threshold and coping, and evidence from this thesis suggests they are also relevant in dogs. However, the correlational nature of the data in this thesis prevents the ability to make causal claims. Furthermore, the reliability of owners in both personality and pain assessment needs further work.

### *8.1.3 Positive affect and psychological resilience*

A finding throughout this thesis was that a dog's level of positive affect (PA) is related to lower pain scores from dog owners. Whilst it is not clear whether pain itself impacts an individual dog's level of PA (leading to higher pain scores in those lower in PA), or whether PA is a source of resilience in times of pain in dogs (hence dogs with higher levels of PA prior to pain have lower owner pain scores), contextualising this with the papers by Mendl, Burman and Paul (2010), Nettle and Bateson (2012) and the human literature, both of the suggestions are plausible.

Chronic pain acts as a constant cause of stress, causing negative emotions and thereby leading to lowered levels of PA, as per the integrative function hypothesis (Mendl, Burman and Paul, 2010; Nettle and Bateson, 2013). Furthermore, given that pessimistic mood was seen to increase during acute pain and then decrease following pain treatment in cattle (LeCorps et al, 2019) it can be suggested that pain appears to lead to decreased PA. However, the findings are also reflective of the relationship reported between PA and pain in humans. Positive affect is associated with psychological resilience/robustness in humans (Zautra et al, 2005; Strand et al, 2006; Sturgeon and Zautra, 2013; Finan and Garland, 2015), lowering levels of negative affect and helping individuals to find pain less distressful. Furthermore, PA has a greater influence on chronic pain than negative affect (NA) does (Finan and Garland, 2015) and positive emotions in general down regulate the effect of negative emotions (Fredrickson and Levenson, 1998; Fredrickson et al, 2000). I propose that the findings of this thesis suggest that a similar picture can be seen in dogs. Future studies would benefit from longitudinal analysis of the relationship between mood, personality and naturally occurring pain to explore this further, and to confirm the direction of the relationships.

A recent review by Hanssen et al (2017) has summarised what is known about the role of positive affective state and positive psychology-based interventions in attenuating pain. Positive affect is not only associated with psychological resilience but is also related to biological processes taking place during pain. For example, PA is related to both spinal and supraspinal pain modulation (for example, Rhudy et al, 2005; Roy et al, 2009) in humans and evidence suggests it may also lower both peripheral and central pain facilitation through a reduction of inflammation, in cases of arthritis (Steptoe et al, 2008; Steptoe, Dockray and Wardle, 2009). As such, pain interventions focusing on improving positive emotions have been successful in reducing negative pain perceptions and pain interference (Guillory et al, 2015), reduced bodily pain (Hausmann et al, 2014) and less intense pain experience (Rhudy et al, 2008). It is evident that psychological well-being is crucial in cases of chronic pain management (Sturgeon and Zautra, 2010) and individuals suffering from persistent pain are more likely (OR between 4.14, Gureje et al, 1998) to suffer from depressive and anxiety related symptoms (Gureje et al, 1998). Of course, the human research looking at positive affect and pain is much more advanced than the animal literature and no studies have looked at improving psychological resilience in animals.

Yeates and Main (2008) highlight in their review of assessing positive welfare in animals that previous work has centred around assessing negative welfare in animals (Yeates and Main, 2008), assuming the absence of negative welfare equates to positive welfare. The human literature however, has indicated that positive mood (not just the absence of negative mood) is beneficial when suffering from chronic pain (Sturgeon & Zautra, 2010; Yeung Anewasikporn, and Zautra, 2012). As such, pain treatment and management in humans incorporate interventions that promote positive mood.

Positive psychology is concerned with studying what makes people thrive and function at an optimal level. Moving from what has been perceived as an overemphasis on what is wrong with individuals or an emphasis on negative states and how to fix it/them, to focusing on 'building what is strong' (Masten and Reed, 2002). These sentiments are directly comparable to the progressive change that is being seen in theories of animal welfare that indicate wellbeing is not just about the absence of negative states but also about the presence of positive states (Seligman and Csikszentmihalyi, 2014, Burgdorf and Panksepp, 2006, Boissy et al, 2007; Mellor, 2012; Mellor and Beausoliel, 2015; Lawrence, Newberry and Spinka, 2018). Seligman and

Csikszentmihalyi (2014) argue in their seminal paper that an overemphasis on pathological disease models neglects those individuals and groups who are 'full-filled' and thriving; arguing for a shift from only repairing negative experiences but building positive qualities. Furthermore, Mellor and Beausoliel (2015) have argued that the five freedoms should be amended to include positive welfare.  In times of ill-health and pain there can be an overemphasis on treating behaviours that are indicative of reduced welfare, this is essential, but should be accompanied by the focus on improving positive welfare too.

Future research in animals should focus on health-related quality of life with a focus on improving and fostering positive states as well as diminishing negative ones. However, this is where an already complex subject (pain in animals) becomes complicated further.  How do we build and foster positive mood in non-human animals?  Promoting positive states in animals will be highly species and individual specific. In some individual animal's pain medication may provide all that is needed to see positive mood increase, however, in others this will not be the case.

Mellor has suggested in various papers (Mellor, 2012; 2016) that emotions such as 'comfort, pleasure, interest, confidence and a sense of control' (Mellor, 2012) need to be encouraged to promote positive states.  McCormick (2012) labels these as 'luxury', stating that these are often some of the first behaviours to be lost in challenging situations.  As has been frequently asserted throughout this thesis, chronic pain can be conceptualised as a challenging situation and is often unpredictable. Furthermore, certain behaviours may be physically impossible in cases of pain that affect movement and gait. As such above future research needs to be undertaken to determine, in dogs, what interventions can be implemented to improve their levels of positive mood.

As stated, the direction of these relationships does need further exploration. Based on this principle that positive experiences can foster positive emotions, studies could look at the differences in how dogs cope with chronic pain coming from stressful vs non-stressful situations (outside the context of pain), such as, rescue environments. From the interpretive function approach, dogs from more challenging situations would have lower levels of positive affect and higher anxious baseline, which in turn could lead to less adaptive coping in chronic pain. Knowledge of this would no doubt be crucial in adequate pain management. In addition, longitudinal studies could be conducted to track the personality and mood of dogs across the course of their disease trajectory.

### *8.1.4 Using psychometric tools to assess personality and mood*

Throughout this thesis three psychometric tools have been used to assess individual differences in dog's and humans. To reiterate, the term individual differences throughout this thesis is based on the definition in psychology, which refers to 'psychological characteristics' rather than other variables such as age or sex. The

PANAS was initially developed as a tool to assess emotional predisposition, which assumes an underlying stability, such that it has been viewed as a measure of temperament or personality. However, through reviewing the literature where the PANAS has been used, the terminology and what it is used to assess differs between papers. Furthermore, changes in an individual dog's score on the PANAS are reported to be observed in response to relatively short-term behaviour interventions and medication (McPeake et al, 2017). As such, I suggested (in chapter 3) that (until further research is done) it would be more cautious to assume that the PANAS is assessing something less stable than a dispositional trait (i.e. personality or temperament) and suggest that mood is being assessed.

In support of the assumption that the PANAS may not be assessing personality, the relationship between the PANAS and pain behaviour the MONASH and pain behaviour is different. However, this is a conceptually difficult area and further research using the PANAS should be undertaken to determine what it is measuring, and whether what it is measuring depends upon the time period it is assessed. For example, it is possible that the PANAS could if used at several time points close to each other measure states (less stable characteristics) rather than 'traits.

Two ways this could be done are as follows.

1. Studies could be undertaken to explore the longitudinal-development of what the PANAS is measuring over the lifetime and a series of time-points in both a population

of dogs and individual dogs.  This would allow the data to be analysed at both the individual level and at the group level.  Thereby exploring consistency and variance indicative of state and trait level variation.

2. Studies could be undertaken to examine the relationship between the PANAS and other measures of mood and personality. For example, cognitive bias or judgement bias tests, whilst not suitable for the sample in the study (due to musculoskeletal issues), are an objective way of assessing mood and/or emotional state in animals.

### *8.1.5 Surrogate reporting of health and personality in non-human animals*

Throughout chapters four to six dog owners provided an assessment of their dog's level of chronic pain using both the Canine Brief Pain Inventory (CBPI) and the Helsinki Chronic Pain Index (HCPI).  In part, this thesis sought to investigate whether the characteristics of dog owners influenced if and how they reported on their dog's health and pain and how owner pain assessments were related to parameters indicative of physical pain.

Owner assessments of pain show a moderate correlation with objective pain assessments. However, owners don't always suspect that their dog is in pain, even when diagnosed with a severe disease. Qualitative notes were taken during force plate trials summarising how owners perceived their dog's health and their pain, from which it was evident that even in cases where imminent bilateral hip replacement was scheduled no pain was suspected. The extent to which humans link disability in physical function with pain in their pets needs further investigation.

For example, anecdotal comments were made relating to their dogs not being in pain despite their condition, their dogs' condition having no real impact on quality of life and their dogs' ‘hardiness’ (ergo they are not in pain) or ‘anxious nature’ (ergo, that make them seem like they are in pain). As chronic pain behaviour is more subtle to notice than acute pain, a push is needed to educate owners that the absence of overt negative welfare does not always equate to positive welfare.

Theories from evolutionary psychology are a useful framing device to consider the difficulty humans may have in recognising pain (specifically chronic) in animals in a wider context. Steinkopf (2016) postulates that pain behaviour alone is not 'credible' but can become so with a 'legitimising' context, for example, an open wound. When applying this principle to dogs with chronic pain related to an 'unobservable' illness, such as arthritis, the contextual element is not provided. What is unclear is whether a diagnosis alone provides that missing context, the findings from chapter six would suggest this not to be the case.

Furthermore, within health psychology the Health Belief Model (HBM) (Hochbaum, Rosenstock and Kegels, 1952) gives a framework to help to predict help seeking health behaviours. One of the major concepts within this model that influences help seeking is whether the condition is severe enough. If the condition is perceived as not being severe or of consequence, help may not be sought. In addition, Zola (1973) states that people don't seek help at their sickest state, but when they can no longer accommodate the changes they have to make. There is clearly a need for dog owners and pet owners to understand the potential signs of chronic pain, and to dispel myths around pain experience and vocalisations.

Qualitative studies need to be undertaken with pet owners to gain an understanding of what indicators they use to determine ill-health and pain in their pets and what factors influence their actions. The findings from these studies could then be used to form education programmes, with the goal of increasing knowledge of how to understand pain. In research from a range of disciplines it is accepted that quantitative research is most suited to understanding whether one variable influences another variable, or whether some type of treatment or intervention has the desired effect on an outcome variable. To compliment this, qualitative research often helps to determine the why, how and 'so what' element, this however is missing in animal welfare research.

### *8.1.6 Improving pain assessment in animals*

The final part of this thesis was focused on how this work could inform veterinary diagnostic practices. Studies by Bennet et al (1996); Madore et al (2007); Katic et al, (2009) and Fischer et al (2013) all documented decreased limb functioning in dogs who had been subject to experimentally induced lameness. These studies have been instrumental in objectively demonstrating asymmetry in gait when comparing diseased vs healthy limbs. However, they do not consider the effect that length of disease; personality and mood have on the adaptations made by dogs with musculoskeletal problems.

In chapter six of this thesis asymmetrical gait was observed in both healthy and unhealthy dogs and disease severity didn't account for 100% of the variation observed in asymmetry. Collectively, these findings suggest that objective methods of pain assessment, such as force plate analysis can be useful to indicate that a dog's gait is affected, but that it doesn't tell us information about how individual animals are experiencing the pain they are in. The relationship between disease severity and pain behaviour goes beyond purely functional explanations (i.e. behaviour occurs due to a physiological inability or sensory pain). Therefore, methods based on function alone are limited in their use. It could be assumed from clinical signs that an animal isn't suffering or that the likelihood of pain is low, yet that individual animal's threshold for coping may be lower. As such, lesser extent of disease severity may cause compromised welfare.

It is therefore suggested that the diagnostic practices that clinicians use to assess and monitor painful conditions needs to be broadened to incorporate owner pain assessments, mood and personality. If not, and treatment is determined only on severity (as diagnosed through radiograph) in some cases dogs will be over or undertreated. Longitudinal studies need to be conducted looking at the development of asymmetry across the course of a dog's disease trajectory, whilst also considering their mood and personality.

Chapter seven of this thesis examined the potential to use accelerometers as a tool to assess gait in clinical practice, by determining whether wearing accelerometers impacts a dog's gait and whether accelerometers have ability to differentiate between healthy and non-healthy dogs. As previously discussed, the findings of this chapter were not as promising as hoped, as healthy and non-healthy dogs could not be differentiated by their accelerations. However, accelerometers may be more suited to tracking the progress of an individual dog in response to treatment, rather than a tool to distinguish between healthy and non-healthy dogs. As such, further studies exploring the use of accelerometers to explore changes of gait within an individual dog would be beneficial. For example, examining changes in acceleration before, after and during treatment for a condition known to effect gait may be a useful way to determining treatment effectiveness.

A limitation of this thesis that needs to be considered is the correlational nature of the data. The use of correlational data means that causal claims about the relationships between variables reported cannot be made. As such, further work in this field would benefit from moving beyond a correlational approach to determine the causal nature of the relationships between personality and perceived pain expression and mood and perceived pain expression detailed in this thesis

## 8.2 Conclusion

The findings from this thesis provide compelling evidence that both personality and mood are associated with how dogs experience and cope with pain. However, advancements in our knowledge of how these manifests across the disease trajectory still need to be made. The use of a 'cross-species' approach has helped to contextualise the findings in relation to both the human literature and the other animal literature. Knowledge of the chronic pain process in humans alongside the appreciation of its complexity has provided a framework to explore what the findings mean in relation to current and future treatment perspectives in animal chronic pain. Positive affect in dogs as with humans appears to act as a source of resilience in times of chronic pain. Without an understanding of how mood and personality influence pain behaviour on an individual basis, diagnosis and treatment is compromised.

# References

Aaseth k,. et al. (2011) Personality traits and psychological distress in persons with chronic tension-type headache. The Akershus study of chronic headache. *Acta Neurologica Scandinavica*, 124(6):375-, 82.

Abbate-Daga, G., et al. (2007) Anger, depression and personality dimensions in patients with migraine without aura. *Psychotherapy and Psychosomatics*, 76(2), 122-8.

Ablin, J. N., et al. (2016). Distinctive personality profiles of fibromyalgia and chronic fatigue syndrome patients. *PeerJ*, *4*.

Abu Alhaija, E.S., et al. (2014) Comparison of personality traits, attitude toward orthodontic treatment, and pain perception and experience before and after orthodontic treatment. *Angle Orthodontist*. Epub 2014/10/04.

Adams, N. (2006) Psychological, electromyographic, and neurochemical aspects of chronic low back pain: Can a biopsychosocial model be confirmed? *Journal of Musculoskeletal Pain*, 14(2), 33-44.

Admunson, G.J.G., Katz, J., (2009). Theoretical review.  Understanding the co-occurrence of anxiety disorders and chronic pain: State-of-the-art. *Depression and Anxiety*, 26, 888-901.

Agar-Wilson, M., & Jackson, T. (2012). Are emotion regulation skills related to adjustment among people with chronic pain, independent of pain coping? *European Journal of Pain*, 16(1), 105-14.

Aguilar, C. I., et al. (2018). An exploratory analysis of the influence of personality and emotional factors on cerebral blood flow responses during painful stimulation in Fibromyalgia. *Scandinavian Journal of Psychology*, *59*(3), 301-310.

Aguirre, J., et al. (2000) Cluster of MMPI personality profiles in chronic tension-type headache and predictable response to Fluoxetine. *Cephalalgia*, 20(1), 51-6.

Ahner, C. E., et al. (2019). Protein biomarkers in serum and urine for determining presence or absence of hip dysplasia in a canine model. *Journal of Orthopaedic Research®*.

Aker, D.A., et al. (2017) Temperament and character dimensions of personality in patients with chronic pain disorders. *Journal of Mood Disorders*, 7(1), 1-9.

Akintola, T., at al. (2017). The grimace scale reliably assesses chronic pain in a rodent model of trigeminal neuropathic pain. *Neurobiology of Pain*, 2, 13-17.

Alvarenga, R., et al. (2011). Construction and calibration of a low-cost force plate for human balance evaluation. I*n ISBS-Conference Proceedings Archive* (Vol. 1, No. 1).

Amat, M., Camps, T., & Manteca, X. (2016). Stress in owned cats: behavioural changes and welfare implications. *Journal of Feline Medicine and Surgery*, 18(8), 577-586.

Amiot, C. E., & Bastian, B. (2015). Toward a psychology of human–animal relations. *Psychological Bulletin*, 141(1), 6.

Anderson, R.U., et al. (2008) Psychometric profiles and HPA axis function in men which chronic prostatitis/chronic pelvic pain syndrome (CP/CPPS). *Journal of Urology*, 179 (3), 956-960.

*Animal Welfare Act 2006*, (c.45)

Aoki, J., et al. (2010) The association between personality, pain threshold and a single nucleotide polymorphism (rs3813034) in the 3 '-untranslated region of the serotonin transporter gene (SLC6A4). *Journal of Clinical Neuroscience*, 17(5), 574-8.

Applegate, K. L., et al. (2005) Does personality at college entry predict number of reported pain conditions at mid-life? A longitudinal study. Journal of Pain, 6(2), 92-7.

Aragona, M., et al (2008) DSM-IV-TR "pain disorder associated with psychological factors" as a nonhysterical form of somatization. *Pain Research & Management*, 13(1), 13-8.

Archer, J. (1997). Why do people love their pets? *Evolution and Human Behavior*, 18(4), 237-259.

Ardic, F., & Toraman, F. (2002) Psychological dimensions of pain in patients with rheumatoid arthritis, fibromyalgia syndrome, and chronic low back pain. *Journal of Musculoskeletal Pain*, 10(4), 19-29.

Armario, A. (2015). Studying chronic stress in animals: purposes, models and consequences. *Neuroendocrinology of Stress*, 143-168.

Asher, L. et al. (2016) Mood and personality interact to determine cognitive bias in pigs. *Biology Letters,* 12, 1-4.

Ashley, F. H., Waterman-Pearson, A. E., & Whay, H. R. (2005). Behavioural assessment of pain in horses and donkeys: application to clinical practice and future studies. *Equine Veterinary Journal*, 37(6), 565-575.

Austin, D., Bowen, W. D., & McMillan, J. I. (2004). Intraspecific variation in movement patterns: modeling individual behaviour in a large marine predator. *Oikos*, 105(1), 15-30.

Bagalà, F., et al. (2012) Evaluation of accelerometer-based fall detection algorithms on real-world falls. *PloS one*, *7*(5), e37062.

Bailey, K. (2018). Examining the Relationship Between NICU-Parent Anxieties, their Perceptions of Neonatal Pain and Desire for Participation in Pain Care. (Published thesis) Dalhousie University.

Bair, M.J., et al. (2003) Depression and pain comorbidity: a literature review. *Archives of Internal Medicine*, 163(20), 2433-2445.

Banozic, A., et al. (2018) Neuroticism and pain catastrophizing aggravate response to pain in healthy adults: an experimental study. *Korean Journal of Pain*, 31(1), 16-26.

Barcelos, A.M., Mills, D.S. and Zulch, H., 2015. Clinical indicators of occult musculoskeletal pain in aggressive dogs. *Veterinary Record*, 176(18), pp.465-465.

Barker, Z. E., et al. (2010). Assessment of lameness prevalence and associated risk factors in dairy herds in England and Wales. *Journal of Dairy Science*, 93(3), 932-941.

Barthelemy, I., et al. (2009) Gait analysis using accelerometry in dystrophin-deficient dogs. *Neuromuscular Disorders*, 19(11), 788-796.

Bateson, P. (1991). Assessment of pain in animals. *Animal Behaviour*, *42*(5), 827-839.

Bekoff, M. (2012). Animals are conscious and should be treated as such. *New Scientist*, 215(2883), 24-25.

Beekman, M., & Jordan, L. A. (2017). Does the field of animal personality provide any new insights for behavioral ecology? *Behavioral Ecology*, 28(3), 617-623.

Bell, A. M. (2017). There is no special sauce: a comment on Beekman and Jordan. *Behavioral Ecology*, 28(3), 626-627.

Benka, J,. et al. (2014) Is coping self-efficacy related to psychological distress in early and established rheumatoid arthritis patients? *Journal of Development Physical Disability*, 26, 285-297.

Bennett, R. L., et al. (1996) Kinematic gait analysis in dogs with hip dysplasia. *American Journal of Veterinary Research*, *57*(7), 966-971.

Bergius. M., et al. (2008) Prediction of prolonged pain experiences during orthodontic treatment. *American Journal of Orthodontics and Dentofacial Orthopedics*, 133(3).

Bertenshaw, C., & Rowlinson, P. (2009). Exploring Stock Managers' Perceptions of the Human—Animal Relationship on Dairy Farms and an Association with Milk Production. *Anthrozoös*, 22(1), 59-69.

Binzer, M., Almay, B., Eisemann, M. (2003) Chronic pain disorder associated with psychogenic versus somatic factors: A comparative study. *Nordic Journal of Psychiatry*, 57(1), 61-6.

Biro, P. A., & Adriaenssens, B. (2013). Predictability as a personality trait: consistent differences in intraindividual behavioural variation. *The American Naturalist*, 182(5), 621-629.

Blackburn-Munro, G. (2004) Pain-like behaviours in animals–how human are they? *Trends in Pharmacological Sciences*, *25*(6), 299-305.

Blackburn-Munro, G., & Blackburn-Munro, R. E. (2001). Chronic pain, chronic stress and depression: coincidence or consequence? *Journal of Neuroendocrinology*, 13(12), 1009-1023.

Blowey, R. (2005). Factors associated with lameness in dairy cattle. *In Practice*, 27(3), 154-162.

Bobrovskaya, L., et al. (2013). Does exposure to chronic stress influence blood pressure in rats? *Autonomic Neuroscience*, 177(2), 217-223.

Bockstahler, B., et al. (2007). Reliability of ground reaction forces measured on a treadmill system in healthy dogs. *The Veterinary Journal*, *173*(2), 373-378.

Bodrka-Bevers, D. et al. (2000) Depression, anxiety and quality of life in patients with epithelial ovarian cancer. *Gynecologic Oncology,* 78, 302-308.

Bogg, T., & Roberts, B. W. (2004). Conscientiousness and health-related behaviors: a meta-analysis of the leading behavioral contributors to mortality. *Psychological Bulletin*, 130(6), 887.

Boggero, I.A., et al. (2014) Neuroticism and resting mean arterial pressure interact to predict pain tolerance in pain-free adults. *Personality and Individual Differences.* 69, 140-3.

Boissy, A., et al. (2007). Assessment of positive emotions in animals to improve their welfare. *Physiology & Behavior*, 92(3), 375-397.

Bourke, A. K., O'brien, J. V., & Lyons, G. M. (2007). Evaluation of a threshold-based tri-axial accelerometer fall detection algorithm. *Gait & Posture*, *26*(2), 194-199.

Bouten, C. V., et al. (1997) A triaxial accelerometer and portable data processing unit for the assessment of daily physical activity. *IEEE Transactions on Biomedical Engineering*, *44*(3), 136-147.

Braden, T. D., et al. (2004). Objective evaluation of total hip replacement in 127 dogs utilizing force plate analysis. *Veterinary and Comparative Orthopaedics and Traumatology*, 17(02), 78-81.

Brajon, S., et al. (2015). Persistency of the piglet's reactivity to the handler following a previous positive or negative experience. *Applied Animal Behaviour Science*, 162, 9-19.

Braun, I.M., et al. (2008) A personality characteristic, somatic absorption, and the perception of somatic symptoms in rheumatoid arthritis patients. *Journal of Rheumatology*, 35(5), 783-789.

Briefer, E. F., & McElligott, A. G. (2013). Rescued goats at a sanctuary display positive mood after former neglect. *Applied Animal Behaviour Science*, 146(1-4), 45-55.

Briefer, E.F., Oxley, J.A., McElligott, A.G. (2015) Autonomic nervous system reactivity in a free-ranging mammal; effects of dominance rank and personality. *Animal Behaviour,* 110, 121-132.

Briffa, M., Bridger, D., & Biro, P. A. (2013). How does temperature affect behaviour? Multilevel analysis of plasticity, personality and predictability in hermit crabs. *Animal Behaviour*, 86(1), 47-54.

Brondani, J. T., Luna, S. P. L., & Padovani, C. R. (2011). Refinement and initial validation of a multidimensional composite scale for use in assessing acute postoperative pain in cats. *American Journal of Veterinary Research*, 72(2), 174-183.

Broom, D. M. (1991). Animal welfare: concepts and measurement. *Journal of Animal Science*, *69*(10), 4167-4175.

Broom, D. M. (1998). Welfare, stress, and the evolution of feelings. *In Advances in the Study of Behavior* (Vol. 27, pp. 371-403). Academic Press.

Broom, D. M. (2001). Evolution of pain. *Vlaams Diergeneeskundig Tijdschrift*, 70(1), 17-21.

Brown, C., Jones, F., & Braithwaite, V. (2005). In situ examination of boldness–shyness traits in the tropical poeciliid, Brachyraphis episcopi. *Animal Behaviour*, 70(5), 1003-1009.

Brown, D.C., et al. (2007) Development and psychometric testing of an instrument designed to measure chronic pain in dogs with osteoarthritis. *American Journal Veterinary Research*, 68 (6): 631-637.

Brown, D. C., et al. (2009). A novel approach to the use of animals in studies of pain: validation of the canine brief pain inventory in canine bone cancer. *Pain Medicine*, 10(1), 133-142.

Brown, D. C., Boston, R. C., & Farrar, J. T. (2013). Comparison of force plate gait analysis and owner assessment of pain using the canine brief pain inventory in dogs with osteoarthritis. *Journal of Veterinary Internal Medicine*, *27*(1), 22-30.

Bruce, J., et al. (2012) Chronic preoperative pain and psychological robustness predict acute postoperative pain outcomes after surgery for breast cancer. *British Journal Cancer*, 107(6), 937-46.

Budsberg, S.C., et al (1993) Progressive evaluation of ground reaction forces in dogs undergoing unilateral total hip replacement. *American Journal of Veterinary Research*, 57(12), 1781-1785.

Budsberg, S. C., et al. (1996). Prospective evaluation of ground reaction forces in dogs undergoing unilateral total hip replacement. *American Journal of Veterinary Research*, 57(12), 1781-1785.

Buffington, C., et al. (2006). Risk factors associated with clinical signs of lower urinary tract disease in indoor-housed cats. *Journal of the American Veterinary Medical Association*, 228, 722–725.

Burns, J.W., et al. (2001) A fourth empirically derived cluster of chronic pain patients based on the Multidimensional Pain Inventory: Evidence for repression within the dysfunctional group. *Journal of Consulting and Clinical Psychology*, 69(4),663-73.

Burri, A., et al. (2017) Exploring symptoms of somatization in chronic widespread pain: latent class analysis and the role of personality. *Journal of Pain Research*, 10, 1733-1740.

Bushby, E. V., et al. (2018). Factors influencing individual variation in farm animal cognition and how to account for these statistically. *Frontiers in Veterinary Science*, 5.

Butler, J. R., & Gambino, J. (2017). Canine hip dysplasia: Diagnostic imaging. *Veterinary Clinics: Small Animal Practice*, 47(4), 777-793.

Burgdorf, J., & Panksepp, J. (2006). The neurobiology of positive emotions. *Neuroscience & Biobehavioral Reviews*, *30*(2), 173-187.

Calabrese, S.K., et al. (2006) Personality and the association of pain and depression. *American Journal of Geriatric Psychiatry*, 14(6), 546-9.

Callaghan, K. A., et al. (2003). Subjective and objective assessment of pain and discomfort due to lameness in dairy cattle. *Animal Welfare-Potters Bar Then Wheathampstead-*, 12(4), 605-610.

Calvo, G., et al. (2014) Development of a behaviour-based measurement tool with defined intervention level for assessing acute pain in cats. *Journal of Small Animal Practice*, *55*(12), 622-629.

Cameron, M. E., et al. (2004). A study of environmental and behavioural factors that may be associated with feline idiopathic cystitis. *Journal of Small Animal Practice*, 45(3), 144-147.

Camps, T., et al. (2012) Pain-related aggression in dogs: 12 clinical cases. *Journal of Veterinary Behaviour*, 7, 99-102.

Capitanio, J.P,. Et al. (2007) Personality and serotonin transporter genotype interact with social context to affect immunity and viral set-point in simian immunodeficiency virus disease. 2007. *Brain Behaviour Immunity*, 22(5), 676–689.

Capitano, JP., Mendoza, SP., & Baroncelli, S. (1999) The relationship of personality dimensions in adult male rhesus macaques to progression of simian immunodeficiency virus disease. *Brain Behaviour and Immunity*, 13 (2), 138-154.

Carbone, L., & Austin, J. (2016). Pain and laboratory animals: publication practices for better data reproducibility and better animal welfare. *PloS one*, 11(5), e0155001.

Carere, C., & Locurto, C. (2011). Interaction between animal personality and animal cognition. *Current Zoology*, 57(4), 491-498.

Carrier, L. O., et al. (2013). Exploring the dog park: Relationships between social behaviours, personality and cortisol in companion dogs. *Applied Animal Behaviour Science*, 146(1-4), 96-106.

Carstens, E, Molberg, G.P. (2000) Recognising pain and distress in laboratory animals. *ILAR*, 41 (2): 62-71.

Carter, A. J., et al. (2013). Animal personality: what are behavioural ecologists measuring? *Biological Reviews*, 88(2), 465-475.

Carvalho, B., Zheng, M., Tagaloa, L.A.L. (2014) A prospective observational study evaluating the ability of prelabour psychological tests to predict labour pain, epidural analgesic consumption. *A & A Case Report*.

Casey, R. A., et al. (2009). Reasons for relinquishment and return of domestic cats (Felis silvestris catus) to rescue shelters in the UK. *Anthrozoös*, 22(4), 347-358.

Caspi, A., et al. (2003). Influence of life stress on depression: moderation by a polymorphism in the 5-HTT gene. *Science*, 301(5631), 386-389.

Castelli, L., et al. (2013) Alexithymia, anger and psychological distress in patients with myofascial pain: a case-control study. *Frontiers in Psychology*, 4.

Cavigelli, S.A., & McClintock, M.K. (2003) Fear of novelty in infant rats predicts adult corticosterone dynamics and an early death. *PNAS*, 100(26), 16131-16136.

Ceballos, M. C., et al. (2018). Frequent handling of grazing beef cattle maintained under the rotational stocking method improves temperament over time. *Animal Production Scienc*e, 58(2), 307-313.

Celikel, F.C., & Saatcioglu, O. (2006) Alexithymia and anxiety in female chronic pain patients. *Annals of General Psychiatry*, 5:13.

Chan, J.K.Y., Consedine, N.S. (2014) Negative affectivity, emotional regulation, and coping in migraine and probable migraine: a New Zealand case control study. *International Journal of Behavioural Medicine*, DOI 10.1007/s12529-013-9370-6

Chapinal, N., et al. (2010). Automated methods for detecting lameness and measuring analgesia in dairy cattle. *Journal of Dairy Science*, 93(5), 2007-2013.

Chaturvedi, M., & Chander, R. (2010) Development of emotional stability scale. *Industrial Psychiatry Journal*, *19*(1), 37.

Chen, W. C., Lee, M. H., & Wu, H. C. (2017). Relationship among symptoms, mood, and personality traits in patients with interstitial cystitis/bladder pain syndrome. *Urological Science*, *28*(3), 147-151.

Cipher, D.J, Clifford, P.A, & Schumacker, R.E. (2002) The heterogeneous pain personality: diverse coping styles among sufferers of chronic pain. *Alternative Therapies in Health and Medicine*, 8(6), 60-9.

Clark, K., et al. (2014) Evaluation of a novel accelerometers for kinetic gait analysis in dogs. *The Canadian Journal of Veterinary Research*, 78, 226-232.

Cleasby, I. R., Nakagawa, S., & Schielzeth, H. (2015) Quantifying the predictability of behaviour: statistical approaches for the study of between-individual variation in the within-individual variance. *Methods in Ecology and Evolution*, 6(1), 27-37.

Coen, S.J., et al. (2011) Neuroticism influences brain activity during the experience of visceral pain. *Gastroenterology*, 141(3), 909-17.

Cohen, S., et al. (1995). State and trait negative affect as predictors of objective and subjective symptoms of respiratory viral infections. *Journal of Personality and Social Psychology*, 68(1), 159.

Coleman, G. J., Hemsworth, P. H., & Hay, M. (1998). Predicting stockperson behaviour towards pigs from attitudinal and job-related variables and empathy. *Applied Animal Behaviour Science*, 58(1-2), 63-75.

Colléter, M., & Brown, C. (2011). Personality traits predict hierarchy rank in male rainbowfish social groups. *Animal Behaviour*, 81(6), 1231-1237.

Colley, R. C., & Tremblay, M. S. (2011). Moderate and vigorous physical activity intensity cut-points for the Actical accelerometer. *Journal of Sports Sciences*, *29*(8), 783-789.

Colley, R. C., et al. (2011). Physical activity of Canadian adults: accelerometer results from the 2007 to 2009 Canadian Health Measures Survey. *Health Reports*, *22*(1), 7.

Collins, L. M., et al. (2010) Welfare epidemiology as a tool to assess the welfare impact of inherited defects on the pedigree dog population. *Animal Welfare*, *19*(1), 67-75.

Condén, E,. (2013) Type D personality is a risk factor for psychosomatic symptoms and musculoskeletal pain among adolescents: a cross-sectional study of a large population-based cohort of swedish adolescents. *BMC Pediatrics*, 13(11).

Conte, P.M., Walco, G.A., Kimura, Y. (2003) Temperament and stress response in children with juvenile primary fibromyalgia syndrome. *Arthritis Rheumatology*, 48(10):2923-30.

Conzemius, M. G., Aper, R. L., & Corti, L. B. (2003). Short-term outcome after total elbow arthroplasty in dogs with severe, naturally occurring osteoarthritis. *Veterinary Surgery*, 32(6), 545-552.

Conzemius, M. G., & Evans, R. B. (2012). Caregiver placebo effect for dogs with lameness from osteoarthritis. *Journal of the American Veterinary Medical Association*, 241(10), 1314-1319.

Cook, D. A., & Beckman, T. J. (2006) Current concepts in validity and reliability for psychometric instruments: theory and application. *The American Journal of Medicine*, *119*(2), 166-e7.

Cooper, W.H., Weaver, S.M., Hay, D.M (2000) The psychological predictors of pain during IVF egg retrieval. *Journal of Reproductive and Infant Psychology*, 18(2):97-104.

Coskun, E,. et al. (2000) Relationships between epidural fibrosis, pain, disability, and psychological factors after lumbar disc surgery. *European Spine Journal*, 9(3), 218-23.

Costa, P. T., & McCrae, R. R. (1980). Influence of extraversion and neuroticism on subjective well-being: happy and unhappy people. *Journal of Personality and Social Psychology*, 38(4), 668.

Costa, P.T., & McCrae, R.R. (1992) Four ways five factors are basic. *Personality and Individual Differences*, 13, 653–665.

Croney, C. C. (2019). Turning up the Volume on Man's Best Friend: Ethical Issues Associated with Commercial Dog Breeding. *Journal of Applied Animal Ethics Research*, 1, 1-22.

Cuff, B. M., et al. (2016). Empathy: a review of the concept. *Emotion Review*, 8(2), 144-153.

Cvijetic S,. et al. (2014) Quality of Life, Personality and Use of Pain Medication in Patients with Chronic Back Pain. *Applied Research in Quality of Life*. 9(2), 401-11.

Dall, S. R., Houston, A. I., & McNamara, J. M. (2004). The behavioural ecology of personality: consistent individual differences from an adaptive perspective. *Ecology Letters*, 7(8), 734-739.

Dalla Costa, E., et al (2014). Development of the Horse Grimace Scale (HGS) as a pain assessment tool in horses undergoing routine castration. PLoS one, 9(3).

Das, R., Sailo, L., Verma, N., Bharti, P., & Saikia, J. (2016). Impact of heat stress on health and performance of dairy animals: A review. *Veterinary World*, 9(3), 260.

David, M., & Dall, S. R. (2016). Unravelling the philosophies underlying 'animal personality'studies: A brief re-appraisal of the field. *Ethology*, 122(1), 1-9.

Dawkins, M. S. (2001). Who needs consciousness? *Animal Welfare*, 10, S19-29.

Dawkins, M. S. (2008). The science of animalsuffering. *Ethology*, 114(10), 937-945.

De Carolis A, Ferracuti S. (2010) Extraversion and accuracy of aspects of memory for pain in the cold water pressor test. *Perceptual and Motor Skills*. 111(1):91-104.

De Rensis, F., Garcia-Ispierto, I., & López-Gatius, F. (2015). Seasonal heat stress: Clinical implications and hormone treatments for the fertility of dairy cows. *Theriogenology*, 84(5), 659-666.

Deary, I.J., Weiss, A. & Batty, G.D. (2010) Intelligence and personality as predictors of illness and death. *Psychological Science in the Public Interest*, 11, 53–79.

DeCamp, C. E. (1997). Kinetic and kinematic gait analysis and the assessment of lameness in the dog. *Veterinary Clinics: Small Animal Practice*, *27*(4), 825-840.

DeWalt, D. A., & Hink, A. (2009). Health literacy and child health outcomes: a systematic review of the literature. *Pediatrics*, 124(Supplement 3), S265-S274.

Diesel, G., Pfeiffer, D. U., & Brodbelt, D. (2008). Factors affecting the success of rehoming dogs in the UK during 2005. *Preventive Veterinary Medicine*, 84(3-4), 228-241.

Diesel, G., Brodbelt, D., & Pfeiffer, D. U. (2010). Characteristics of relinquished dogs and their owners at 14 rehoming centers in the United Kingdom. *Journal of Applied Animal Welfare Science*, 13(1), 15-30.

Dennis, R. (2012) Interpretation and use of BVA/KC hip scores in dogs. *In Practice*, 34, 198-194.

Dilek, B., et al. (2012) Anxious personality is a risk factor for developing complex regional pain syndrome type I. *Rheumatology International*, 32(4), 915-20.

Di Tella, M., et al. (2017). Pain experience in Fibromyalgia Syndrome: The role of alexithymia and psychological distress. *Journal of Affective Disorders*, *208*, 87-93.

Dingemanse, N.J. & Réale, D. (2005). Natural selection and animal personality. *Behaviour*, 142: 1165-1190.

Dingemanse, N. J., & Wolf, M. (2010). Recent models for adaptive personality differences: a review. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 365(1560), 3947-3958.

Dobson, S. D., & Brent, L. J. (2013). On the evolution of the serotonin transporter linked polymorphic region (5-HTTLPR) in primates. *Frontiers in Human Neuroscience*, 7, 588.

Dodman, N. H., Brown, D. C., & Serpell, J. A. (2018). Associations between owner personality and psychological status and the prevalence of canine behaviour problems. *PloS one*, 13(2), e0192846.

Donisan, T., et al. (2017). The relationship between disease activity, quality of life, and personality types in rheumatoid arthritis and ankylosing spondylitis patients. *Clinical Rheumatology*, *36*(7), 1511-1519.

Dreschel, N. A. (2010). The effects of fear and anxiety on health and lifespan in pet dogs. *Applied Animal Behaviour Science*, 125(3-4), 157-162.

Driessnack, M., Chung, S., Perkhounkova, E., & Hein, M. (2014). Using the "Newest Vital Sign" to assess health literacy in children. *Journal of Pediatric Health Care*, 28(2), 165-171.

Dumitre D, Chraif M. (2015) Correlative study between the personality factors and pain perception at young students at psychology. *Procedia Social & Behavioural Sciences*, 180, 321-325.

Edwards, C.L,. Et al. (2014) Emotional reactions to pain predict psychological distress in adult patients with sickle cell disease (SCD). *International Journal Psychiatry Medicine*, 47(1), 1-16.

Ellingsen, K., et al. (2010) The relationship between empathy, perception of pain and attitudes toward pets among Norwegian dog owners. *Anthrozoös*, *23*(3), 231-243.

Ellingsen, K., Coleman, G. J., Lund, V., & Mejdell, C. M. (2014). Using qualitative behaviour assessment to explore the link between stockperson behaviour and dairy calf behaviour. *Applied Animal Behaviour Science,* 153, 10-17.

Epstein, M. E., et al. (2015). 2015 AAHA/AAFP pain management guidelines for dogs and cats. *Journal of Feline Medicine and Surgery*, 17(3), 251-272.

Esteve, R. et al. (2016) Development and initial validation of the activity patterns scale in patients with chronic pain. *American Pain Society*, 17(4), 451-461.

Facchin, F., et al. (2016). Personality in women with endometriosis: temperament and character dimensions and pelvic pain. *Human Reproduction*, *31*(7), 1515-1521.

Fanchon, L., & Grandjean, D. (2007). Accuracy of asymmetry indices of ground reaction forces for diagnosis of hind limb lameness in dogs. *American Journal of VeterinaryResearch*, 68(10), 1089-1094.

Farmer, A.D., et al. (2013) Psychophysiological responses to pain identify reproducible human clusters. *Pain*, 154(11), 2266-76.

Farmer, A.D., et al. (2013) Psychological traits influence autonomic nervous system recovery following esophageal intubation in health and functional chest pain. *Neurogastroenterology and Motility*, 25(12), 950

Ferguson, D. M., & Warner, R. D. (2008). Have we underestimated the impact of pre-slaughter stress on meat quality in ruminants? *Meat Science*, 80(1), 12-19.

Ferracuti, S., & DeCarolis, A. (2005) Relationships among Eysenck's extraversion, Rorschach's Erlebnistypus, and tolerance of experimental tonic pain (cold water pressor test). *Perceptual Motor Skills*, 100(1), 237-48.

Finan, P.H, Quartana, P.J, Smith, M.T. (2013) Positive and negative affect dimensions in chronic knee osteoarthritis: effects on clinical and laboratory pain. *Psychosomatic Medicine*, 75(5), 463-70.

Finka, L. R., et al. (2019). Owner personality and the wellbeing of their cats share parallels with the parent-child relationship. *PloS one*, 14(2), e0211862.

Finkemeier, M. A., Langbein, J., & Puppe, B. (2018). Personality research in mammalian farm animals: Concepts, measures, and relationship to welfare. *Frontiers in Veterinary Science*, 5.

Fischer, S., et al. (2013) Compensatory load redistribution in walking and trotting dogs with hind limb lameness. *The Veterinary Journal*, *197*(3), 746-752.

Fischer-Kern, M,. et al. (2011) The relationship between personality organisation and psychiatric classification in chronic pain patients. *Psychopathology*, 44(1), 21-26.

Fleeson, W., & Noftle, E. (2008) The end of the person–situation debate: An emerging synthesis in the answer to the consistency question. *Social and Personality Psychology Compass*, *2*(4), 1667-1684.

Franklin, Z. C., et al. (2016). Personality Type Influences Attentional Bias in Individuals with Chronic Back Pain. *PloS One*, *11*(1), e0147035.

Fratkin, J. L., et al. (2013). Personality consistency in dogs: a meta-analysis. *PLoS One*, 8(1), e54907.

L. Fredrickson, B., & Levenson, R. W. (1998). Positive emotions speed recovery from the cardiovascular sequelae of negative emotions. *Cognition & Emotion,* 12(2), 191-220.

Fredrickson, B. L., et al. (2000). The undoing effect of positive emotions. *Motivation and Emotion*, 24(4), 237-258.

Freedson, P., Pober, D., & Janz, K. F. (2005). Calibration of accelerometer output for children. *Medicine & Science in Sports & Exercise*, *37*(11), S523-S530.

Freud (1960). *The ego and the id*. (J. Riviere, Trans.). New York: W. W. Norton. (Original work published 1923)

Freund, W,. et al. (2013) Ultra-Marathon Runners Are Different: Investigations into Pain Tolerance and Personality Traits of Participants of the TransEurope FootRace 2009. *Pain Practice*, 13(7), 524-32.

Friedman, H. S., & Kern, M. L. (2014). Personality, well-being, and health. *Annual Review of Psychology*, 65, 719-742.

Friel, M., Kunc, H. P., Griffin, K., Asher, L., & Collins, L. M. (2016). Acoustic signalling reflects personality in a social mammal. *Royal Society Open Science*, 3(6), 160178.

Gartner, M.C., 2015. Pet personality: A Review. *Personality and Individual Differences* 75, 102-113.

Gatchel, R. J., et al. (2007). The biopsychosocial approach to chronic pain: scientific advances and future directions. *Psychological bulletin*, *133*(4), 581.

Gatchel, R. J., et al. (2014). Interdisciplinary chronic pain management: past, present, and future. *American Psychologist*, *69*(2), 119.

Gedney, L.L., & Logan, H. (2007) Perceived control and negative affect predict expected and experienced acute clinical pain: a structural modelling analysis. *Clinical Journal of Pain*, 23(1):35-44.

Gentle, M.J. (2011) Pain issues in poultry. *Applied Animal Behaviour Science*, 135, 252-258.

Gheldof, E. L., et al. (2006). Pain and pain-related fear are associated with functional and social disability in an occupational setting: evidence of mediation by pain-related fear. *European Journal of Pain*, 10(6), 513-525.

Giesecke, T., et al. (2003) Subgrouping of fibromyalgia patients on the basis of pressure-pain thresholds and psychological factors. *Arthritis Rheumatology*, 48(10), 2916-22.

Ginja, M.M.D., et al. (2010) Diagnosis, genetic control and preventative management of canine hip dysplasia: A Review. *The Veterinary Journal* 184, 269-276.

Gleerup, K. B., et al. (2015). Pain evaluation in dairy cattle. *Applied Animal Behaviour Science*, 171, 25-32.

Goldberg, L. R. (1993). The structure of phenotypic personality traits. *American Psychologist*, *48*(1), 26.

Goodwin, K., et al. (2018). Email reminders increase the frequency that pet owners update their microchip information. *Animals*, 8(2), 20

Gordon, W. J., et al. (2003). The relationship between limb function and radiographic osteoarthrosis in dogs with stifle osteoarthrosis. *Veterinary Surgery*, 32(5), 451-454.

Gosling, S. D. (2001) From mice to men: what can we learn from personality from animal research. *Psychological Bulletin*, 127 (1): 45-86.

Gosling S. (2008) Personality in non-human animals. *Social Personality Psychology Compass*, 2(2):985-1001.

Gosling, S. D., & Vazire, S. (2002). Are we barking up the right tree? Evaluating a comparative approach to personality. *Journal of Research in Personality*, 36(6), 607-614.

Gosling, S.D, John, O.P., & Kwan, V.S.Y. (2003) A dog's got personality: A cross-species comparative approach to personality judgements in dogs and humans. *Journal of Personality and Social Psychology*, 85 (6), 1161-1169.

Goubert, L., Crombez, G., & Van Damme, S. (2004) The role of neuroticism, pain catastrophizing and pain-related fear in vigilance to pain: a structural equations approach. *Pain*, 107(3):234-41.

Gregory, R.J., Manring, J., Berry, S.L. (2000) Pain location and psychological characteristics of patients with chronic pain. *Psychosomatics*, 41(3):216-20.

Gregory, R.J, Manring, J, Wade, M.J. (2005) Personality traits related to chronic pain location. *Annals of Clinical Psychiatry: Official Journal of the American Academy of Clinical Psychiatrists,* 17(2), 59-64.

Griffin, A. S., Guillette, L. M., & Healy, S. D. (2015). Cognition and personality: an analysis of an emerging field. *Trends in Ecology & Evolution*, 30(4), 207-214.

Gross, J. J., Sutton, S. K., & Ketelaar, T. (1998). Relations between affect and personality: Support for the affect-level and affective-reactivity views. *Personality and Social Psychology Bulletin*, 24(3), 279-288.

Groth-Marnat, G., & Fletcher, A. (2000) Influence of neuroticism, catastrophizing, pain duration, and receipt of compensation on short-term response to nerve block treatment for chronic back pain. *Journal of Behavioural Medicine*, 23(4), 339-50.

Guillory, J., et al. (2015). Piloting a text message-based social support intervention for patients with chronic pain: establishing feasibility and preliminary efficacy. *The Clinical Journal of Pain*, *31*(6), 548.

Gureje, O., et al. (1998). Persistent pain and well-being: a World Health Organization study in primary care. *The Journal of the American Medical Association*, *280*(2), 147-151.

Gustin, S.M., et al. (2013) Unravelling the Effects of Plasticity and Pain on Personality. *Journal of Pain*, 14(12):1642-52.

Gustin, S. M., et al. (2011). Different pain, different brain: thalamic anatomy in neuropathic and non-neuropathic chronic pain syndromes. *Journal of Neuroscience*, *31*(16), 5956-5964.

Halliday, S. E., et al. (1998). The initiation of gait in young, elderly, and Parkinson's disease subjects. *Gait & Posture*, 8(1), 8-14.

Hamilton, N.A, Zautra, A.J, Reich, J. (2007) Individual differences in emotional processing and reactivity to pain among older women with rheumatoid arthritis. *Clinical Journal of Pain*, 23(2), 165-72.

Hansen, B. D. (2003). Assessment of pain in dogs: veterinary clinical studies. *ILAR journal*, 44(3), 197-205.

Hansen, B. D., et al. (2007). Evaluation of an accelerometer for at-home monitoring of spontaneous activity in dogs. *American Journal of Veterinary Research*, *68*(5), 468-475.

Hanssen, M.M., et al. (2017) Can positive affect attenuate (persistent) pain? State of the art and clinical implications. *Current Rheumatology Reports*, 19 (80).

Harnad, S. (2016). Animal sentience: The other-minds problem. *Animal Sentience: An Interdisciplinary Journal on Animal Feeling*, 1(1), 1.

Hassett, A. L., et al. (2016). Affect and low back pain: More to consider than the influence of negative affect alone. *The Clinical Journal of Pain*, *32*(10), 907.

Hausmann, L. R., et al. (2014). Reduction of bodily pain in response to an online positive activities intervention. *The Journal of Pain*, *15*(5), 560-567.

Helgadottir, H.L, Wilson, M.E. (2004) Temperament and pain in 3 to 7-year-old children undergoing tonsillectomy. *Journal of Pediatric Nursing*, 19(3), 204-13.

Hemsworth, P. H. (2007). Ethical stockmanship. *Australian Veterinary Journal*, 85(5), 194-200.

Hercock, C. A., et al. (2009). Validation of a client-based clinical metrology instrument for the evaluation of canine elbow osteoarthritis. *Journal of Small Animal Practice*, 50(6), 266-271.

Herr, K., et al (2006). Pain assessment in the nonverbal patient: position statement with clinical practice recommendations. *Pain Management Nursing*, *7*(2), 44-52.

Herrero, A.M, Ramirez-Maestre, C, & Gonza. (2008) Personality, cognitive appraisal and adjustment in chronic pain patients. *Spanish Journal of Psychology*, 11(2):532-541

Hielm-Björkman, A. K., Rita, H., & Tulamo, R. M. (2009) Psychometric testing of the Helsinki chronic pain index by completion of a questionnaire in Finnish by owners of dogs with chronic signs of pain caused by osteoarthritis. *American journal of Veterinary Research*, *70*(6), 727-734.

Hielm-Björkman, A. K., Kapatkin, A. S., & Rita, H. J. (2011). Reliability and validity of a visual analogue scale used by owners to measure chronic pain attributable to osteoarthritis in their dogs. *American Journal of Veterinary Research*, 72(5), 601-607.

Hochbaum, G., Rosenstock, I., & Kegels, S. (2016). Health Belief Model. United States Public Health Service; 1952. doi.org/10.1177/109019817400200403 Institute of Medicine. (2001). Health and Behavior: The Interplay of Biological, Behavioral, and Social Influences. Washington, D.C. National Academies Press.

Holden, E., et al. (2014). Evaluation of facial expression in acute pain in cats. *Journal of Small Animal Practice*, 55(12), 615-621.

Howell, S., et al. (2003) Relationship between abdominal pain subgroups in the community and psychiatric diagnosis and personality: A birth cohort study. *Journal of Psychosomatic Research*,55(3):179-187.

Hsu, Y., & Serpell, J. A. (2003). Development and validation of a questionnaire for measuring behavior and temperament traits in pet dogs. *Journal of the American Veterinary Medical Association*, 223(9), 1293-1300.

Ijichi, C., Collins, L.M., & Elwood, R.W., 2014. Pain expression is linked to personality in horses. *Applied Animal Behaviour Science,* 152, 38-43.

Innes, J. F., & Barr, A. R. S. (1998). Can owners assess outcome following treatment of canine cruciate ligament deficiency*? Journal of Small Animal Practice*, 39(8), 373-378.

Innes, J. F., et al. (2003). Randomised, double-blind, placebo controlled parallel group study of P54FP for the treatment of dogs with osteoarthritis. *The Veterinary Record*, 152(15), 457-460.

Jaeger, G. T., et al. (2006) Papers & Articles. *The Veterinary Record*, *158*, 722-726.

Jandt, J. M., et al. (2014). Behavioural syndromes and social insects: personality at multiple levels. *Biological Reviews*, 89(1), 48-67.

Janowski, K., Steuden, S., & Kurylowicz, J. (2010) Factors accounting for psychosocial functioning in patients with low back pain. *European Spine Journal*, 19(4), 613-23.

Jerram, K,L., & Coleman, P.G. (1999) The big five personality traits and reporting of health problems and health behaviours in old age. *British Journal of Health Psychology* 4, 181-192.

John, O. P., & Srivastava, S. (1999). The Big Five trait taxonomy: History, measurement, and theoretical perspectives. *Handbook of Personality: Theory and Research*, 2(1999), 102-138.

Johnson, M. (2003). The vulnerability status of neuroticism: over-reporting or genuine complaints? *Personality and Individual Differences*, 35(4), 877-887.

Jones, R. B. (1996). Fear and adaptability in poultry: insights, implications and imperatives. *World's Poultry Science Journal*, 52(2), 131-174.

Jones, R. B., Satterlee, D. G., & Marks, H. L. (1997). Fear-related behaviour in Japanese quail divergently selected for body weight. *Applied Animal Behaviour Science*, 52(1-2), 87-98.

Jones, D.A,. et al. (2003) The relationship between cognitive appraisal, affect and catastrophizing in patients with chronic pain. *Journal of Pain*, 4(5):267-277.

Jones, S., et al.  (2014). Use of accelerometers to measure stress levels in shelter dogs. *Journal of Applied Animal Welfare Science*, *17*(1), 18-28.

Jordan, E. R. (2003). Effects of heat stress on reproduction. *Journal of Dairy Science*, 86, 104-114.

Kadimpati, S., et al. (2014) Associations between neuroticism and depression in relation to catastrophizing and pain-related anxiety in chronic pain patients. *PLoSOne*:  DOI:10.1371/journal.pone.0126351

Kapatkin, A. S., et al. (2006). Effects of electrostimulated acupuncture on ground reaction forces and pain scores in dogs with chronic elbow joint arthritis. *Journal of the American Veterinary Medical Association*, 228(9), 1350-1354.

Kappesser, J., Williams, A., & Prkachin, K.M. (2006) Testing two accounts of pain underestimation. *Pain*, 124, 109-116.

Katic, N., Bockstahler, B.A., & Mueller, M.P. (2009) Fourier analysis of vertical ground reaction forces in dogs with unilateral hind limb lameness caused by degenerative disease of the hip and joint in dogs. *American Journal of Veterinary Research*, 70(1), 118-126.

Kealy, R. D., et al. (1992). Effects of limited food consumption on the incidence of hip dysplasia in growing dogs. *Journal-American Veterinary Medical Association*, *201*, 857-857.

Keating, S. C., et al. (2012). Evaluation of EMLA cream for preventing pain during tattooing of rabbits: changes in physiological, behavioural and facial expression responses. *PloS one*, 7(9), e44437.

Keegan, K. G., et al. (1998). Evaluation of mild lameness in horses trotting on a treadmill by clinicians and interns or residents and correlation of their assessments with kinematic gait analysis. *American journal of veterinary research*, 59(11), 1370-1377.

Keegan, K. G., et al. (2010). Repeatability of subjective evaluation of lameness in horses. *Equine Veterinary Journal*, 42(2), 92-97.

Kennedy, S.A., et al. (2010) Association between psychosocial factors and pain in patients with trigger finger. *Journal of Hand and Microsurgery*, 2(1), 18-23.

Kim, H., et al. (2004). Genetic influence of variability in human acute experimental pain sensitivity associated with gender, ethnicity and psychological temperament. *Pain*, 109(3), 488-496.

King, J.E., & Figueredo, A.J. (1997) The five-factor model plus dominance in chimpanzee personality. *Journal Research Personality*, 31, 257–271.

King, T., Marston, L. C., & Bennett, P. C. (2012). Breeding dogs for beauty and behaviour: Why scientists need to do more to develop valid and reliable behaviour assessments for dogs kept as companions. *Applied Animal Behaviour Science*, 137(1-2), 1-12.

Kis, A., Turcsán, B., Miklósi, Á., & Gácsi, M. (2012). The effect of the owner's personality on the behaviour of owner-dog dyads. *Interaction Studies*, 13(3), 373-385.

Kleiber, C., et al. (2007) Pain-sensitive temperament and postoperative pain. *Journal for Specialists in Pediatric Nursing*, 12(3), 149-58.

Klein, V.C., et al. (2009) Pain and distress reactivity and recovery as early predictors of temperament in toddlers born preterm. *Early Human Development,* 85(9), 569-76.

Knaster, P, et al. (2000) Temperament Traits and Chronic Pain: The Association of Harm Avoidance and Pain-Related Anxiety. *PLoS One*, 7(10).

Koh, J.S., et al. (2014) The association of personality trait on treatment outcomes in patients with chronic prostatitis/chronic pelvic pain syndrome: An exploratory study. *Journal of Psychosomatic Research*, 76(2), 127-33.

Kojima, M, et al,. (2014) Alexithymia, depression, inflammation, and pain in patients with rheumatoid arthritis. *Arthritis Care Research,* 66(5),679-86.

Koolhaas, J. M. (2008). Coping style and immunity in animals: making sense of individual variation. *Brain, Behavior, and Immunity*, 22(5), 662-667.

Koolhaas, J. M., et al. (2011). Stress revisited: a critical evaluation of the stress concept. *Neuroscience & Biobehavioral Reviews*, 35(5), 1291-1301.

Koolhaas, J. M., & Van Reenen, C. G. (2016). Animal behavior and well-being symposium: Interaction between coping style/personality, stress, and welfare: Relevance for domestic farm animals. *Journal of Animal Science*, 94(6), 2284-2296.

Korte, S. M., et al. (2005). The Darwinian concept of stress: benefits of allostasis and costs of allostatic load and the trade-offs in health and disease. *Neuroscience & Biobehavioral Reviews*, 29(1), 3-38.

Koski, S. E. (2011). *How to measure animal personality and why does it matter? Integrating the psychological and biological approaches to animal personality*. In From genes to animal behavior (pp. 115-136). Springer, Tokyo.

Krok, J.L, Baker, T.A. (2014) The influence of personality on reported pain and self-efficacy for pain management in older cancer patients. *Journal of Health Psychology*, 19(10), 1261-70.

Krok-Schoen, J. L., & Baker, T. A. (2016). Gender differences in personality and cancer-related pain among older cancer patients. *Journal of Gender Studies*, *25*(5), 507-521

Krotscheck, U., et al. (2014). Precision and accuracy of ground reaction force normalization in a heterogeneous population of dogs. *Veterinary Surgery*, *43*(4), 437-445.

Kujala, V.M., et al (2017) Human empathy, personality and experience affect the emotion ratings of dog and human facial expressions. *PLoS One*, 12(1)

Kvale, A., Ellertsen, B., & Skouen, J., S. (2001) Relationship between physical findings (GPE-78) and psychological profiles (MMPI-2) in patients with long lasting musculoskeletal pain. *Nordic Journal of Psychiatry*, 55, 177-184.

Kwissa-Gajewska, Z., & Dolegowska, M. (2017) Personality, cognitive appraisal and labour pain. *Health Psychology Report*, 5(4), 304-313.

Lacourt, E.T., et al. (2015) Negative affectivity predicts decreased pain tolerance during low grade inflammation in healthy women. *Brain Behaviour Immunity* , 44:326.

Ladha, C., et al. (2017) GaitKeeper: A system for measuring canine gait. *Sensors*, 17(12), 1-17.

Lakestani, N., & Donaldson, M. L. (2015). Dog bite prevention: effect of a short educational intervention for preschool children. *PloS one*, 10(8), e0134319.

Langford, D. J., et al. (2010). Coding of facial expressions of pain in the laboratory mouse. *Nature Methods*, 7(6), 447.

Lanzi, G., et al. (2001) Personality in childhood and adolescent headache. *Cephalalgia,* 21(1):53-60

Larsen, R. J., & Ketelaar, T. (1991). Personality and susceptibility to positive and negative emotional states. *Journal of Personality and Social Psychology*, 61(1), 132.

Lascelles, B. D. X., et al. (2006). Evaluation of a pressure walkway system for measurement of vertical limb forces in clinically normal dogs. *American Journal of Veterinary Research*, 67(2), 277-282

Latzman, R.D., et al. (2014) Personality in chimpanzees (Pan troglodytes): Exploring the hierarchical structure and associations with the vasopressin V1A receptor gene. *PLoS One*, 9(4),1-12.

Lavrijsen, I. C. M., et al. (2014). Prevalence and co-occurrence of hip dysplasia and elbow dysplasia in Dutch pure-bred dogs. *Preventive Veterinary Medicine*, *114*(2), 114-122.

Lawrence, A. B., Newberry, R. C., & Špinka, M. (2018). Positive welfare: What does it add to the debate over pig welfare? In Spinka, M (ed.) *Advances in Pig Welfare* (pp. 415-444). Woodhead Publishing.

Lazarus R, Folkman S. (1984) Stress, Appraisal, and coping. New York: Springer.

Le Bars, D., Gozariu, M., & Cadden, S. W. (2001). Animal models of nociception. *Pharmacological Reviews*, 53(4), 597-652.

Lee, J.E., Watson, D., & Frey-Law, L.A. (2013) Psychological factors predict local and referred experimental muscle pain: A cluster analysis in healthy adults. *European Journal of Pain*, 17(6), 903-15.

Lee, J.E., Watson, D., & Law, L.A.F. (2010) Lower-Order Pain-Related Constructs Are More Predictive of Cold Pressor Pain Ratings than Higher-Order Personality Traits. *Journal of Pain*, 11(7), 681-91.

Leeuw, M., et al. (2007). The fear-avoidance model of musculoskeletal pain: current state of scientific evidence. *Journal of Behavioural Medicine*, 30(1), 77-94.

Lefebvre, J.C, & Keefe, F.J. (2013) The effect of neuroticism on the recall of persistent low-back pain and perceived activity interference. *Journal of Pain*, 14(9), 948-956.

Lesch, K. P., et al. (1996) Association of anxiety-related traits with a polymorphism in the serotonin transporter gene regulatory region. *Science*, 274(5292), 1527-1531.

Lethem, J., et al. (1983) Outline of a fear-avoidance model of exaggerated pain perception. *Behaviour Research and Therapy*, 21(4), 401-8.

Levine, S., 2005. Developmental determinants of sensitivity and resistance to stress. *Psychoneuroendocrinology*, 30, 939–946.

Ley, J. M., & Bennett, P. C. (2007). Understanding personality by understanding companion dogs. *Anthrozoös*, 20(2), 113-124.

Ley, J., Bennett, P., & Coleman, G. (2008) Personality dimensions that emerge in companion canines. *Applied Animal Behaviour Science*, (3-4), 305-317.

Ley, J. M., Bennett, P. C., & Coleman, G. J. (2009) A refinement and validation of the Monash Canine Personality Questionnaire (MCPQ). *Applied Animal Behaviour Science*, *116*(2), 220-227.

Ley, J. M., McGreevy, P., & Bennett, P. C. (2009) Inter-rater and test–retest reliability of the Monash Canine Personality Questionnaire-Revised (MCPQ-R). *Applied Animal Behaviour Science*, *119*(1), 85-90.

Li, Q., et al. (2009) Accurate, fast fall detection using gyroscopes and accelerometer-derived posture information. In Lo, B.P.L., and Mitcheson, P (Eds.) *Wearable and Implantable Body Sensor Networks, 2009. BSN 2009. Sixth International Workshop on* (pp. 138-143). IEEE.

Lin RF,. et al. (2010) Correlations between quality of life and psychological factors in patients with chronic neck pain. *Kaohsiung Journal of Medical Science,* 26(1), 13-20.

Linder, J. (2000) Does personality or psychopathology predict disability in chronic pain patients? *Disability and Rehabilitation*, 22(6), 281-7.

Lindley, S., (2011) The effects of pain on behaviour and behavioural problems: Part 1. *Companion Animal*, 16, 45–48.

Lipman, R. D., Grossman, P., Bridges, S. E., Hamner, J. W., & Taylor, J. A. (2002). Mental stress response, arterial stiffness, and baroreflex sensitivity in healthy aging. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, 57(7), 279-284.

Liu, N. L., et al. (2018). Sheep farmers' attitudes to farm inspections and the role of sanctions and rewards as motivation to reduce the prevalence of lameness. *Animal Welfare Journal*, 27(1), 67-79.

Lowery, K., A. (2016) the influence of child and parent health literacy status on health outcomes from a childhood obesity treatment program. (Published master's thesis). Virginia Polytechnic Institute and State University

Lucas, R. E., & Baird, B. M. (2004). Extraversion and emotional reactivity. *Journal of Personality and Social Psychology*, 86(3), 473.

Lumley, M.A, Smith, J.A, & Longo, D.J. (2002) The relationship of alexithymia to pain severity and impairment among patients with chronic myofascial pain: comparisons with self-efficacy, catastrophizing, and depression. *Journal of Psychosomatic Research*, 53(3), 823-30.

Lung, F.W. (2004) Parental rearing style, premorbid personality, mental health, and quality of life in chronic regional pain: A causal analysis. *Comprehensive Psychiatry*, 45(3), 206-12.

Lush, J., & Ijichi, C. (2018). A preliminary investigation into personality and pain in dogs. *Journal of Veterinary Behavior*, *24*, 62-68.

MacKay, J. R., & Haskell, M. J. (2015). Consistent individual behavioural variation: the difference between temperament, personality and behavioural syndromes. *Animals*, *5*(3), 455-478.

Madore, E., et al. (2007) Comparison of trot kinetics between dogs with stifle or hip arthrosis. *Veterinary and Comparative Orthopaedics and Traumatology*, *2*(02), 102-107.

Malmgren-Olsson, E.B, & Bergdahl, J. (2006) Temperament and character personality dimensions in patients with nonspecific musculoskeletal disorders. *Clinical Journal of Pain*, 22(7), 625-31.

Malt, E.A., et al. (2002) Factors explaining variance in perceived pain in women with fibromyalgia. *BMC Musculoskeletal Disorders*, 3.

Mainau, E., Temple, D., & Manteca, X. (2016). Experimental study on the effect of oral meloxicam administration in sows on pre-weaning mortality and growth and immunoglobulin G transfer to piglets. *Preventive Veterinary Medicine*, 126, 48-53.

Manchikanti, L., et al (2002) Comparison of psychological status of chronic pain patients and the general population. *Pain Physician*, 5(1), 40-8.

Mariti, C., et al. (2012) Perception of dogs' stress by their owners. *Journal of Veterinary Behaviour,* 7, 213-219.

Marsac, M.L., & Funk, J.B. (2008) Relationships among psychological functioning, dental anxiety, pain perception, and coping in children and adolescents. *Journal of Dentistry for Children*, 75(3), 243-51.

Martin, K. W., et al. (2016). The method of attachment influences accelerometer-based activity data in dogs. *BMC Veterinary Research*, 13(1), 48.

Martinez, M.P., et al. (2011) The relationship between the fear-avoidance model of pain and personality traits in fibromyalgia patients. *Journal Clinical Psychology Medical Settings*,18(4),380-91.

Martini, L., et al, (2000) Evaluation of pain and stress levels of animals used in experimental research. *Journal of Surgical Research*, 88, 114-119.

Mason, G. J., & Mendl, M. (1993). Why is there no simple way of measuring animal welfare? *Animal Welfare*, 2, 301-319.

Masten, A.S., & Reed, M, G. (2002) Resilience in development. In C. R. Snyder, & S. J. Lopez (Eds.), Handbook of positive psychology (pp. 74-88). London

Mathews, K. A. (2000). Pain assessment and general approach to management. *Veterinary Clinics: Small Animal Practice*, 30(4), 729-755.

McCormick, W. D. (2012). Recognising & assessing positive welfare: developing positive indicators for use in welfare assessment. *Proceedings of Measuring Behaviour,* 241-243.

McEwen, B. S. (2001). Plasticity of the hippocampus: adaptation to chronic stress and allostatic load. *Annals of the New York Academy of Sciences*, 933(1), 265-277.

McInerney, J. (2004). *Animal welfare, economics and policy*. Report on a study undertaken for the Farm & Animal Health Economics Division of Defra, 68.

McPeake, K. J., & Mills, D. S. (2017). The use of imepitoin (Pexion™) on fear and anxiety related problems in dogs–a case series. *BMC veterinary research*, *13*(1), 173.

Meana, M., & Lykins, A. (2009) Negative affect and somatically focused anxiety in young women reporting pain with intercourse. *Journal of Sex Research*, 46(1),80-88.

Meldolesi, G.N., et al. (2000) Personality and psychopathology in patients with temporomandibular joint pain-dysfunction syndrome - A controlled investigation. *Psychotherapy and Psychosomatics*, 69(6), 322-8.

Mellanby, R. J., Herrtage, M. E., & Dobson, J. M. (2002). Owners' assessments of their dog's quality of life during palliative chemotherapy for lymphoma. *Journal of Small Animal Practice*, 43(3), 100-103.

Mellor, D. J., Cook, C. J., & Stafford, K. J. (2000). Quantifying some responses to pain as a stressor. *The Biology of Animal Stress: Basic Principles and Implications for Welfare*, 171-198.

Mellor, D. J. (2012). Animal emotions, behaviour and the promotion of positive welfare states. *New Zealand Veterinary Journal*, 60 (1), 1-8.

Mellor, D.J., & Beausoliel, N.J. (2015) Extending the 'five domains' model for animal welfare assessment to incorporate positive welfare states. *Animal Welfare*, 24, 241-253.

Mellor, D. J. (2016). Updating animal welfare thinking: Moving beyond the "five freedoms" towards "a life worth living". *Animals*, *6*(3), 21.

Mendl, M., Burman, O. H., & Paul, E. S. (2010). An integrative and functional framework for the study of animal emotion and mood. *Proceedings of the Royal Society B: Biological Sciences*, 277(1696), 2895-2904.

Merlijn, V, et al. (2003) Psychosocial factors associated with chronic pain in adolescents. *Pain*, 101(1-2), 33-43.

Merola, I., & Mills, D.S., (2015) Systematic review of the behavioural assessment of pain in cats. *Journal of Feline Medicine and Surgery,* 1-17.

Merskey, H., & Bogduk, N. (1994). *Classification of chronic pain,* IASP Task Force on Taxonomy. Seattle, WA: International Association for the Study of Pain Press (Also available online at www. iasp-painorg).

Miqueleto, N. S. M. L., et al. (2013). Kinematic analysis in healthy and hip-dysplastic German Shepherd dogs. *The Veterinary Journal*, 195(2), 210-215.

Miller, A. L., et al. (2016). Using the mouse grimace scale and behaviour to assess pain in CBA mice following vasectomy. *Applied Animal Behaviour Science*, 181, 160-165.

Millman, S. T. (2013). Behavioural responses of cattle to pain and implications for diagnosis, management, and animal welfare. *Veterinary Clinics: Food Animal Practice*, 29(1), 47-58.

Mirkó, E., Dóka, A., & Miklósi, Á. (2013). Association between subjective rating and behaviour coding and the role of experience in making video assessments on the personality of the domestic dog (Canis familiaris). *Applied Animal Behaviour Science*, 149(1-4), 45-54.

Mesoudi, A., Chang, L., Dall, S. R., & Thornton, A. (2016). The evolution of individual and cultural variation in social learning. *Trends in Ecology & Evolution*, 31(3), 215-225.

Miura, A., Bradshaw, J. W., & Tanida, H. (2002). Attitudes towards assistance dogs in Japan and the UK: a comparison of college students studying animal care. *Anthrozoös*, *15*(3), 227-242.

Moayedi, M., et al. (2011) Contribution of chronic pain and neuroticism to abnormal forebrain gray matter in patients with temporomandibular disorder. *Neuroimage,* 55(1), 277-286.

Molony, V., & Kent, J. E. (1997). Assessment of acute pain in farm animals using behavioral and physiological measurements. *Journal of Animal Science*, 75(1), 266-272.

Momersteeg, Et al. (2016). Personality subtypes and chest pain in patients with non obstructive coronary artery disease from the TweeSteden Mild Stenosis study: mediating effect of anxiety and depression. *European Journal of Pain*, *20*(3), 427-437.

Mongini, F., et al. (2000) Personality characteristics and accompanying symptoms in temporomandibular joint dysfunction, headache, and facial pain. *Journal of Orofacial Pain*, 14(1), 52-8.

Mongini, F., (2005) A comparative analysis of personality profile and muscle tenderness between chronic migraine and chronic tension-type headache. *Neurological Sciences*, 26(4):203-7.

Mongini, F., et al. (2009) Personality profiles and subjective perception of pain in head pain patients. *Pain*, 144(1-2), 125-9.

Monk, J. E., et al. (2018). Towards a more practical attention bias test to assess affective state in sheep. *PloS one*, 13(1), e0190404.

Monsen, K, & Havik, O.E. (2001) Psychological functioning and bodily conditions in patients with pain disorder associated with psychological factors. *British Journal of Medical Psychology*, 74(2), 183-195.

Montoro, C.I., & Reyes del Paso, G.A. (2015) Personality and fibromyalgia: Relationships with clinical, emotional and functional variables. *Personality and Individual Differences*, 85, 236-244.

Moreau, M., et al. (2007). Efficacy of licofelone in dogs with clinical osteoarthritis. *Veterinary Record*, 160(17), 584-588.

Moreau, M., et al (2014) Kinetic measurements of gait and osteoarthritis research in dogs and cats. *Canadian Veterinary Journal*, 55, 1057-1065.

Morrison, R., et al. (2014) A 6-month observational study of changes in objectively measured physical activity during weight loss in dogs. *Journal of Small Animal Practice*, *55*(11), 566-570.

Morton, D. A., & Griffiths, P. H. M. (1985) Guidelines on the recognition of pain, distress and discomfort in experimental animals and a hypothesis for assessment. *Veterinary Record*, *116*(16), 431-436.

Morton, F.B., et al. (2013) Personality structure in brown capuchin monkeys (Sapajus apella): Comparison with chimpanzees (Pan troglodytes), orangutans (Pongo ssp.), and Rhesus macaques (Macaca mulatta). *Journal of Comparative Psychology*, 127(3), 282-298.

Morton, C. M., et al. (2005). Application of a scaling model to establish and validate an interval level pain scale for assessment of acute pain in dogs. *American Journal of Veterinary Research*, 66(12), 2154-2166.

Mohsina, A., et al. (2014). A retrospective study on incidence of lameness in domestic animals. *Veterinary World*, 7(8), 601-604.

Muller, C., et al. (2018). Evaluation of the effect of signalment and owner-reported impairment level on accelerometer-measured changes in activity in osteoarthritic dogs receiving a non-steroidal anti-inflammatory. *The Veterinary Journal*, 242, 48-52.

Munro, G., (2002) Chronic pain, chronic stress and depression: Coincidence or consequence. *Journal of Neuroendocrinology,* 13, 1009-1023.

Munafò, M. R., et al. (2009). 5-HTTLPR genotype and anxiety-related personality traits: A meta-analysis and new data. *American Journal of Medical Genetics Part B: Neuropsychiatric Genetics*, 150(2), 271-281.

Muns, R., Rault, J. L., & Hemsworth, P. (2015). Positive human contact on the first day of life alters the piglet's behavioural response to humans and husbandry practices. *Physiology & Behavior*, 151, 162-167.

Muñoz-Prieto, A., et al. (2018). European dog owner perceptions of obesity and factors associated with human and canine obesity. *Scientific Reports*, 8(1), 13353.

Muris, P.,et al. (2007) Personality and temperament correlates of pain catastrophizing in young adolescents. *Child Psychiatry & Human Development*, 38(3), 171-81.

Murrell, J. C., & Johnson, C. B. (2006). Neurophysiological techniques to assess pain in animals. *Journal of Veterinary Pharmacology and Therapeutics*, 29(5), 325-335.

Mutzel, A., et al. (2013). Parental provisioning behaviour plays a key role in linking personality with reproductive success. *Proceedings of the Royal Society B: Biological Sciences*, 280(1764), 20131019.

Nakayama, S., Rapp, T., & Arlinghaus, R. (2017). Fast–slow life history is correlated with individual differences in movements and prey selection in an aquatic predator in the wild. *Journal of Animal Ecology*, 86(2), 192-201.

National Research Council. (1992). *Recognition and alleviation of pain and distress in laboratory animals*. National Academies Press.

Neave, H.W,. et al. (2013) Pain and pessimism: Dairy calves exhibit negative judgement bias following hot-iron disbudding. *PLoS One*, 8(12):1-6.

Nettle, D. (2005). An evolutionary approach to the extraversion continuum. *Evolution and Human Behavior*, 26(4), 363-373.

Nettle, D., & Bateson, M. (2012). The evolutionary origins of mood and its disorders. *Current Biology*, 22(17), R712-R721.

Newth, S., & Delongis, A. (2004) Individual differences, mood, and coping with chronic pain in rheumatoid arthritis: A daily process analysis. *Psychology & Health*, 19(3), 283-305.

Nitch, S.R., & Boone, K. B. (2004) Normal personality correlates of chronic pain subgroups. *Journal of Clinical Psychology in Medical Settings*, 11(3), 203-209.

Norring, M., et al. (2014). Empathic veterinarians score cattle pain higher. *The Veterinary Journal*, 200(1), 186-190.

Nyklicek, I., & Vingerhoets, A.J. (2000) Alexithymia is associated with low tolerance to experimental painful stimulation. *Pain*, 85(3), 471-5.

O'Neill, D., et al. (2014) Prevalence of disorders recorded in dogs attending primary-care veterinary practices in England. *PLoS One*, 9 (3), 1-16.

O'Riordan, T., & Cameron, J. (1994). The history and contemporary significance of the precautionary principle. *Interpreting the precautionary principle*, 12, 16.

Ong, K. S., & Seymour, R. A. (2004). Pain measurement in humans. The *Surgeon*, 2(1), 15-27.

Olafsdottir, E,. et al. (2001) Personality profiles and heart rate variability (vagal tone) in children with recurrent abdominal pain. *Acta Paediatrica*, 90(6), 632-7.

Oreyzi, H., Mohammadabadi, A.N., & Askari, A. (2010) The role of positive affect in relation between pain and stress, and negative affect in employed women. *Journal of Mazandaran University of Medical Sciences*, 20(75),55-63.

Packer, R.M.A., Hendricks, A., & Burn, C.C., (2012) Do dog owners perceive the clinical signs related to conformational inherited disorders as ‘normal’ for the breed? A potential constraint to improving canine welfare. *Animal Welfare*, 21, 81-93.

Paine, P., et al. (2009) Exploring relationships for visceral and somatic pain with autonomic control and personality. *Pain*, 144(3), 236-44.

Pallegama, R.W., et al. (2005) Anxiety and personality traits in patients with muscle related temporomandibular disorders. *Journal Oral Rehabilitation*, 32(10):701-7.

Pallegama, R. W., et al. (2017). Influence of catastrophizing and personality traits on recalled ratings of acute pain experience in healthy young adults. *Pain Medicine*, *18*(1), 49-60.

Park, M, S., et al. (2014) Degree of extraversion and physiological responses to physical pain and sadness. *Scandinavian Journal of Psychology*, 55(5), 483-8.

Park, S. H., et al. (2016). Elevated cortisol content in dog hair with atopic dermatitis. *Japanese Journal of Veterinary Research*, 64(2), 123-129.

Pastell, M., (2009) A wireless accelerometer system with wavelet analysis for assessing lameness in cattle. *Biosystem Engineering*, 104, 545-551.

Paster, E. R., et al. (2005). Estimates of prevalence of hip dysplasia in Golden Retrievers and Rottweilers and the influence of bias on published prevalence figures. *Journal of the American Veterinary Medical Association*, 226(3), 387-392.

Păvăleanu, I., et al. (2017). Pain perception at birth depending on the personality of the parturient woman. *International Journal of Medical Dentistry*, *21*(1)

Payne, L.A,. et al.  (2013) Relationship of neuroticism and laboratory pain in healthy children: Does anxiety sensitivity play a role? *Pain*, 154(1), 103-9.

Pecina, M., et al. (2014) Effects of the Mu Opioid Receptor Polymorphism (OPRM1 A118G) on Pain Regulation, Placebo Effects and Associated Personality Trait Measures. *Neuropsychopharmacology.* 40(4), 947.

Pecukonis, E.V., (2009) Physical self-efficacy and alexithymia in women with chronic intractable back pain. *Pain Management Nursing*, 10(3), 116-123.

Perals, D., et al. (2017). Revisiting the open-field test: what does it really tell us about animal personality? *Animal Behaviour*, 123, 69-79.

Perez-Pareja, J., et al. (2010) Fibromyalgia and chronic pain: Are there discriminating patterns by using the Minnesota Multiphasic Personality Inventory-2 (MMPI-2)? *International Journal of Clinical and Health Psychology*, 10(1), 41-56.

Piel, M. J., et al (2014). Pain assessment in animal models of osteoarthritis. *Gene*, *537*(2), 184-188.

Pilar-Martinez M., et al. (2011) The Relationship Between the Fear-Avoidance Model of Pain and Personality Traits in Fibromyalgia Patients. *Journal of Clinical Psychology in Medical Settings*, 18(4), 380-91.

Pillard, P., Gibert, S., & Viguier, E. (2012). Development of a 3D accelerometric device for gait analysis in dogs. *Computer Methods in Biomechanics and Biomedical Engineering*, *15*(1), 246-249.

Piotti, P. (2017). Positive emotions and quality of life in dogs. *Animal Sentience: An Interdisciplinary Journal on Animal Feeling*, 2(14), 17.

Pleizier, N., et al. (2015). Puffed and bothered: personality, performance, and the effects of stress on checkered pufferfish. *Physiology & Behaviour*, 152, 68-78.

Posluns, J. A., Anderson, R. E., & Walsh, C. J. (2017). Comparing two canine personality assessments: Convergence of the MCPQ-R and DPQ and consensus between dog owners and dog walkers. *Applied Animal Behaviour Science*, 188, 68-76.

Poppe, C, et al. (2011) Personality traits in chronic pain patients are associated with low acceptance and catastrophizing about pain. *Acta Clinica Belgica*, 66(3),209-15.

Porter-Morfitt, S., et al. (2006) Biopsychosocial profiles of different pain diagnostic groups. *Journal of Pain*, 7(5), 308-318.

Poy, N. S., et al. (2000). Additional kinematic variables to describe differences in the trot between clinically normal dogs and dogs with hip dysplasia. *American Journal of Veterinary Research*, 61(8), 974-978.

Proctor, H., Carder, G., & Cornish, A. (2013). Searching for animal sentience: A systematic review of the scientific literature. *Animals*, 3(3), 882-906.

Pud, D., et al. (2004) The tridimensional personality theory and pain: harm avoidance and reward dependence traits correlate with pain perception in healthy volunteers. *European Journal of Pain*, 8(1):31-8.

Quinn, M. M., et al. (2007). Evaluation of agreement between numerical rating scales, visual analogue scoring scales, and force plate gait analysis in dogs. *Veterinary Surgery*, *36*(4), 360-367.

Ramirez-Maestre, C., Martinez, A.E.L., & Zarazaga, R.E. (2004) Personality characteristics as differential variables of the pain experience. *Journal of Behavioural Medicine,* 27(2), 147-65.

Raselli, C, & Broderick, J.E. (2007) The association of depression and neuroticism with pain reports: A comparison of momentary and recalled pain assessment. *Journal of Psychosomatic Research*, 62(3), 313-20.

Rayment, D.J., et al. (2015) Applied personality assessment in domestic dogs: limitations and caveats. *Applied Animal Behaviour Science,* 163, 1-18.

Rayment, D. J., et al. (2016). Investigating canine personality structure using owner questionnaires measuring pet dog behaviour and personality. *Applied Animal Behaviour Science*, 180, 100-106.

Réale, D., et al. (2007). Integrating animal temperament within ecology and evolution. *Biological Reviews*, 82(2), 291-318.

Reaney, S. J., et al. (2017) Emotional affect and the occurrence of owner reported health problems in the domestic dog. *Applied Animal Behaviour Science*, *196*, 76-83.

Reed, K., & Upjohn, M. M. (2018). Better Lives for Dogs: incorporating Human Behaviour change into a theory of change to improve canine Welfare Worldwide. *Frontiers in Veterinary Science*, 5.

Reedijk, W.B., et al. (2008) Psychological features of patients with complex regional pain syndrome type I related dystonia. *Movement Disorders*, 23(11):1551-9.

Regan, T. (1987). The case for animal rights. In Fox, M.W., and Mickley, L.D (eds.) *Advances in Animal Welfare Science 1986/87* (pp. 179-189). Springer, Dordrecht.

Reid, J., Scott, M., Nolan, A., & Wiseman-Orr, L. (2013). Pain assessment in animals. *In Practice*, 35(2), 51-56.

Reid, J., Nolan, A. M., & Scott, E. M. (2018). Measuring pain in dogs and cats using structured behavioural observation. *The Veterinary Journal*, 236, 72-79.

Reimert, I., et al. (2014). Social support in pigs with different coping styles. *Physiology & Behavior*, 129, 221-229.

Ren, P., et al. (2016). Analysis of gait rhythm fluctuations for neurodegenerative diseases by phase synchronization and conditional entropy. *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, 24(2), 291-299.

Rettenmaier, J. L., et al. (2002) Prevalence of canine hip dysplasia in a veterinary teaching hospital population. *Veterinary Radiology & Ultrasound*, *43*(4), 313-318.

Rhudy, J. L., et al. (2005). Affective modulation of nociception at spinal and supraspinal levels. *Psychophysiology*, *42*(5), 579-587.

Riggio, M.P., et al. (2010) Molecular identification of bacteria associated with canine periodontal disease, *Veterinary Microbiology*, 150 (3-4), 394-400.

Robinson, L.M., et al. (2017) Chimpanzees with positive welfare are happier, extraverted, and emotionally stable. *Applied Animal Behaviour Science*, 191, 90-97.

Rooney, N. J., & Bradshaw, J. W. (2004). Breed and sex differences in the behavioural attributes of specialist search dogs—a questionnaire survey of trainers and handlers. *Applied Animal Behaviour Science*, 86(1-2), 123-135.

Rooney, N.J., Sargan, D.R., (2010) Welfare concerns associated with pedigree dog breeding in the UK. *Universities Federation for Animal Welfare,* 19, 133-140.

Rose, J. D., et al. (2014). Can fish really feel pain? *Fish and Fisheries*, 15(1), 97-133.

Ross, J. W., et al. (2017). Physiological mechanisms through which heat stress compromises reproduction in pigs. *Molecular reproduction and development*, 84(9), 934-945.

Rothman, A. J., & Hardin, C. D. (1997). Differential use of the availability heuristic in social judgment. *Personality and Social Psychology Bulletin*, 23(2), 123-138.

Rowe, E. C., et al. (2017). Early-life risk factors identified for owner-reported feline overweight and obesity at around two years of age. *Preventive Veterinary Medicine*, 143, 39-48.

Roy, M., et al. (2009). Cerebral and spinal modulation of pain by emotions. *Proceedings of the National Academy of Sciences*, *106*(49), 20900-20905.

Ruff, J.K., et al. (2015) The influence of extraversion on brain activity at baseline and during the experience and expectation of visceral pain. *Personality and Individual Differences*, 74:248-253.

Rutherford, K. M. D. (2002). Assessing pain in animals. *Animal Welfare*, *11*(1), 31-53.

Sakakibara, T., Wang, Z., & Kasai, Y. (2014) Personality of Patients with Pain. *Journal of Musculoskeletal Pain*, 22(2), 125-8.

Samuels, P. (2016). Advice on exploratory factor analysis. Technical Report. Centre for Academic Success, Birmingham City University.

Santos Dde M., et al. (2011) The association of major depressive episode and personality traits in patients with fibromyalgia. *Clinics (Sao Paulo),* 66(6):973-8.

Schork, I. G., de Azevedo, C. S., & Young, R. J. (2018). Personality, abnormal behaviour, and health: An evaluation of the welfare of police horses. *PloS one*, 13(9), e0202750.

Seibert, R., Marcellin-Little, D. J., Roe, S. C., DePuy, V., & Lascelles, B. D. X. (2012). Comparison of body weight distribution, peak vertical force, and vertical impulse as measures of hip joint pain and efficacy of total hip replacement. *Veterinary Surgery*, *41*(4), 443-447.

Seligman, M. E., & Csikszentmihalyi, M. (2014). Positive psychology: An introduction. In *Flow and the foundations of positive psychology* (pp. 279-298). Springer Netherlands.

Sharkey, M. (2013). The challenges of assessing osteoarthritis and postoperative pain in dogs. *The AAPS Journal*, *15*(2), 598-607.

Sheppard, H. and Mills, D,S., 2001. The development of psychometric scale for the evaluation of the emotional predispositions of dogs. *The International Journal of Comparative Psychology* 15, 201-222.

Sheriff, M. J., Krebs, C. J., & Boonstra, R. (2009). The sensitive hare: sublethal effects of predator stress on reproduction in snowshoe hares. *Journal of Animal Ecology*, 78(6), 1249-1258.

Shibata, M., et al. (2014) Alexithymia Is Associated with Greater Risk of Chronic Pain and Negative Affect and with Lower Life Satisfaction in a General Population: The Hisayama Study. *PloS One*,9(3).

Shiri, S., et al. (2003) Similarities between the psychological profiles of complex regional pain syndrome and conversion disorder patients. *Journal of Clinical Psychology in Medical Settings*, 10(3):193-9.

Shivarathre, D.G,. et al. (2014) Psychological Factors and Personality Traits Associated With Patients in Chronic Foot and Ankle Pain. *Foot Ankle International*, 35(11), 1103-1107.

Siettou, C., Fraser, I. M., & Fraser, R. W. (2014). Investigating some of the factors that influence “consumer” choice when adopting a shelter dog in the United Kingdom. *Journal of Applied Animal Welfare Science*, 17(2), 136-147.

Sih, A., Bell, A., & Johnson, J. C. (2004). Behavioural syndromes: an ecological and evolutionary overview. *Trends in Ecology & Evolution*, 19(7), 372-378.

Singer, P. (1995). *Animal Liberation*. Random House: London

Smith, G. K., Biery, D. N., & Gregor, T. P. (1990). New concepts of coxofemoral joint stability and the development of a clinical stress-radiographic method for quantitating hip joint laxity in the dog. *Journal of the American Veterinary Medical Association*, *196*(1), 59-70.

Smith, C. G., & Weiss, A. (2017). *Evolutionary aspects of personality development: Evidence from nonhuman animals*. In Specht, J (ed.) Personality Development Across the Lifespan (pp. 139-156). Academic Press.

Sneddon, L. (2011). Pain perception in fish. *Journal of Consciousness Studies*, *18*(9-10), 209-229.

Sneddon, L. U. (2003). The evidence for pain in fish: the use of morphine as an analgesic. *Applied Animal Behaviour Science*, *83*(2), 153-162.

Sneddon, L. U. (2009). Pain perception in fish: indicators and endpoints. *ILAR journal*, *50*(4), 338-342.

Sneddon, L. U., Elwood, R. W., Adamo, S. A., & Leach, M. C. (2014). Defining and assessing animal pain. *Animal Behaviour*, 97, 201-212.

Sneddon, L. U., & Leach, M. C. (2016). Anthropomorphic denial of fish pain. *Animal Sentience: An Interdisciplinary Journal on Animal Feeling*, *1*(3), 28.

Soltis, J., et al. (2012) Accelerometers in collars identify behavioural states in captive African elephants *Loxodonta africana*. *Endangered Species Research*, 18, 255-263

Soo, M., & Worth, A. J. (2015). Canine hip dysplasia: phenotypic scoring and the role of estimated breeding value analysis. *New Zealand Veterinary Journal*, *63*(2), 69-78.

Sotocinal, S. G., et al. (2011). The Rat Grimace Scale: a partially automated method for quantifying pain in the laboratory rat via facial expressions. *Molecular Pain*, 7(1), 55.

Souza, A. N. A., et al. (2015). Vertical forces assessment according to radiographic hip grade in German shepherd dogs. *Journal of Small Animal Practice*, *56*(2), 108-111.

Spada, M. M., et al. (2016). Meta-cognitive beliefs about worry and pain catastrophising as mediators between neuroticism and pain behaviour. *Clinical Psychologist*, *20*(3), 138-146.

Spiegel, O., et al. (2017). What's your move? Movement as a link between personality and spatial dynamics in animal populations. *Ecology Letters*, 20(1), 3-18.

Srokosz, M. A., & Kolstoe, S. (2016). Animal suffering, the hard problem of consciousness, and a reflection on why we should treat animals well. *Science and Christian Belief*, 28(1), 3-19.

Stamps, J. A., Briffa, M., and Biro, P. A. (2012). Unpredictable animals: individual differences in intraindividual variability (IIV). *Animal Behaviour*, 83(6), 1325-1334.

Stasiak, K. L., et al. (2003). Species-specific assessment of pain in laboratory animals. *Journal of the American Association for Laboratory Animal Science*, 42(4), 13-20.

Steinkopf, L. (2016). An evolutionary perspective on pain communication. *Evolutionary Psychology*, *14*(2), 1474704916653964.

Stephens, R., & Umland, C. (2011). Swearing as a response to pain—Effect of daily swearing frequency. *The Journal of Pain*, *12*(12), 1274-1281.

Serpell, J. A., & Hsu, Y. (2001). Development and validation of a novel method for evaluating behaviour and temperament in guide dogs. *Applied Animal Behaviour Science*, 72(4), 347-364.

Stevens, S.A, et al. (2013) Infant pain regulation as an early indicator of childhood temperament. *Pain Research Managemen*t, 18(6), 313-8.

Steptoe, A., et al. (2008). Neuroendocrine and inflammatory factors associated with positive affect in healthy men and women: the Whitehall II study. *The American Journal of Epidemiology*, 167(1), 96-102.

Steptoe, A., Dockray, S., & Wardle, J. (2009) Positive affect and psychobiological processes relevant to health. *Journal of Personality*, 77(6), 1747–1776

Strachan, E, et al. (2014) Clinical and evoked pain, personality traits, and emotional states: Can familial confounding explain the associations? *Journal of Psychosomatic Research*, 78(1), 58-63.

Strand, E. B., et al. (2007). Higher levels of pain readiness to change and more positive affect reduce pain reports–a weekly assessment study on arthritis patients. *Pain*, *127*(3), 204-213.

Strelau, J. (1987). The concept of temperament in personality research. *European Journal of personality*, 1(2), 107-117.

Strickhouser, J. E., Zell, E., & Krizan, Z. (2017). Does personality predict health and well-being? A metasynthesis. *Health Psychology,* 36(8), 797.

Strober, L. B. (2017). Personality in multiple sclerosis (MS): impact on health, psychological well-being, coping, and overall quality of life. *Psychology, Health & Medicine*, 22(2), 152-161.

Stubsjøen, S. M.,et al. (2009). Exploring non-invasive methods to assess pain in sheep. *Physiology & Behavior*, 98(5), 640-648.

Sturgeon, J. A., & Zautra, A. J. (2010). Resilience: a new paradigm for adaptation to chronic pain. *Current Pain and Headache Reports*, *14*(2), 105-112.

Sullivan,  M.J.L., et al. (2006) The relation between catastrophizing and the communication of pain experience. *Pain,* 122:282-288.

Sullivan, M.J.L., et al. (2006) Catastrophic thinking and heightened perception of pain in others. *Pain*, 37-44.

Suso-Ribera, C., & Gallardo-Pujol, D. (2016). Personality and health in chronic pain: Have we failed to appreciate a relationship?. *Personality and Individual Differences*, *96*, 7-11.

Svartberg, K, Forkman, B. (2002) Personality traits in the domestic dog (*Canis familiaris*). *Applied Animal Behaviour Science,* 79, 133-155.

Svebak. S,. et al. (2000) The significance of personality in pain from gallbladder stones. *Scandinavian Journal of Gastroenterology*, 35(7),759-64.

Tait, R.C, Chibnall, J.T, & Kalauokalani, D. (2008) Provider judgments of patients in pain: Seeking symptom certainty. *Pain Medicine*, 10, 11-34.

Talaei-Khoei, M., et al. (2018). Type D personality in patients with upper extremity musculoskeletal illness: Internal consistency, structural validity and relationship to pain interference. *General hospital psychiatry*, 50, 38-44.

Tallet, C., et al. (2018). *Pig–human interactions: Creating a positive perception of humans to ensure pig welfare.* In Spinka, M (ed.) Advances in Pig Welfare (pp. 381-398). Woodhead Publishing.

Tanaka, A., et al (2012). Associations among weight loss, stress, and upper respiratory tract infection in shelter cats. *Journal American Veterinary Medical Association*, 240, 570–576.

Tao, W., et al. (2012). Gait analysis using wearable sensors. *Sensors*, 12(2), 2255-2283.

Tavallaii, A., et al. (2010) Personality characteristics of patients with chronic low back pain. *Procedia- Social and Behavioural sciences,* 5, 372-6.

Taylor, B. K., Peterson, M. A., & Basbaum, A. I. (1995). Exaggerated cardiovascular and behavioural nociceptive responses to subcutaneous formalin in the spontaneously hypertensive rat. *Neuroscience Letters*, 201(1), 9-12.

Tellegen, A. (1985). *Structures of mood and personality and their relevance to assessing anxiety, with an emphasis on self-report*. In A. H. Tuma & J. D. Maser (Eds.), *Anxiety and the anxiety disorders* (pp. 681-706). Hillsdale, NJ, US: Lawrence Erlbaum Associates, Inc.

Thornton, A., & Lukas, D. (2012). Individual variation in cognitive performance: developmental and evolutionary perspectives. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 367(1603), 2773-2783.

Todhunter, R.J., et al. (2005) Quantitative trait loci for hip dysplasia in a crossbreed canine pedigree. *Mammalian Genome* 16 (9), 720-730.

Treede, R. D., et al. (2015). A classification of chronic pain for ICD-11. *Pain*, 156(6), 1003.

Tremmel, M., & Müller, C. (2012). Insect personality depends on environmental conditions. *Behavioral Ecology*, 24(2), 386-392.

Troiano, R. P., et al. (2008) Physical activity in the United States measured by accelerometer. *Medicine and Science in Sports and Exercise*, *40*(1), 181.

Tugade, M. M., Fredrickson, B. L., & Feldman Barrett, L. (2004). Psychological resilience and positive emotional granularity: Examining the benefits of positive emotions on coping and health. *Journal of Personality*, 72(6), 1161-1190.

Turcot, K.,et al. (2008). New accelerometric method to discriminate between asymptomatic subjects and patients with medial knee osteoarthritis during 3-d gait. *IEEE Transactions on Biomedical Engineering*, 55(4), 1415-1422.

Turk, D.C. (2002) A diathesis-stress model of chronic pain and disability following traumatic injury. *Pain Research Management*, 71, 9-19.

Turk, D. C., & Melzack, R. (2001). *The measurement of pain and the assessment of people experiencing pain*. In D. C. Turk & R. Melzack (Eds.), *Handbook of pain assessment* (pp. 1-11). New York, NY, US: The Guilford Press.

Uher, J., & Asendorpf, J. B. (2008). Personality assessment in the Great Apes: Comparing ecologically valid behaviour measures, behaviour ratings, and adjective ratings. *Journal of Research in Personality*, 42(4), 821-838.

Umberg, E. N., & Pothos, E. N. (2011). Neurobiology of aversive states. *Physiology & Behavior,* 104(1), 69-75.

Vaidya, J.G,. et al. (2002) On the temporal stability of personality: Evidence for differential stability and the role of life experiences. *Journal of Personality and Social Psychology*, 83(6), 1469-1484.

Van Klaveren, N. J., et al. (2005). Force plate analysis before and after dorsal decompression for treatment of degenerative lumbosacral stenosis in dogs. *Veterinary Surgery*, 34(5), 450-456.

Vassend, O,. et al (2011) Predicting the long-term impact of acquired severe injuries on functional health status: the role of optimism, emotional distress and pain. *Spinal Cord*, 49(12), 1193-1197.

Vassend, O., Roysamb, E., & Nielsen, C.S. (2013) Five-factor personality traits and pain sensitivity: A twin study. *Pain*, 154(5), 722-8.

Vassend, O., et al. (2017). Musculoskeletal complaints, anxiety–depression symptoms, and neuroticism: A study of middle-aged twins. *Health Psychology*, *36*(8), 729.

Veissier, I., & Boissy, A. (2007). Stress and welfare: Two complementary concepts that are intrinsically related to the animal's point of view. *Physiology & Behavior*, 92(3), 429-433.

Vendrig, A.A., Derksen, J.J.L., & de Mey, H.R. (2000) MMPI-2 Personality Psychopathology Five (PSY-5) and prediction of treatment outcome for patients with chronic back pain. *Journal of Personality Assessment*, 74(3), 423-38.

Vickers, E., & Boocock, H. (2005) Chronic orofacial pain is associated with psychological morbidity and negative personality changes: A comparison to the general population. *Australian Dental Journal*, 50(1), 21-30.

Vierck, C. J., Green, M., & Yezierski, R. P. (2010). Pain as a stressor: effects of prior nociceptive stimulation on escape responding of rats to thermal stimulation. *European Journal of Pain*, 14(1), 11-16.

Vincent, I.C., Michell, A.R., (1996) Relationship between blood pressure and stress-prone temperament in dogs. *Physiology &Behaviour*, 60, 135-138.

Von Borell, E. (1995). Neuroendocrine integration of stress and significance of stress for the performance of farm animals. *Applied Animal Behaviour Science*, 44(2-4), 219-227.

Von Korff, M., & Dunn, K. M. (2008). Chronic pain reconsidered. *Pain,* 138(2), 267-276.

Voss, K., Imhof, J., Kaestner, S., & Montavon, P. M. (2007). Force plate gait analysis at the walk and trot in dogs with low-grade hind limb lameness. *Veterinary and Comparative Orthopaedics and Traumatology*, 20(04), 299-304.

Voss, K., et al. (2010). Relationships of body weight, body size, subject velocity, and vertical ground reaction forces in trotting dogs. *Veterinary Surgery*, *39*(7), 863-869.

Wakshlag, J., Panasevich, M. (2012) Evaluation of dietary intake and physical activity in dogs undergoing a controlled weight-loss programme. *Journal of the American Veterinary Medical Association*, 240(4), 414-419.

Waldhorn, D. R. (2019). Toward a New Framework for Understanding Human–Wild Animal Relations. *American Behavioural Scientist*, 0002764219830465.

Walters, E. T. (2018). Defining pain and painful sentience in animals. *Animal Sentience*, 3(21), 14.

Waxman, A. S. (2008). Relationship between objective and subjective assessment of limb function in normal dogs with an experimentally induced lameness. *Veterinary Surgery*, *37*(3), 241-246.

Weary, D. M., et al. (2006). Identifying and preventing pain in animals. *Applied Animal Behaviour Science*, 100(1-2), 64-76.

Wechsler, B. (1995). Coping and coping strategies: a behavioural view. *Applied Animal Behaviour Science*, 43(2), 123-134.

Weeks, C.A, et al. (2000) The behaviour of broiler chickens and its modification by lameness. *Applied Animal Behaviour Science*, 67, 111-125.

Weiss, A., King, J.E., & Perkins, L. (2006) Personality and subjective well-being in orangutans (Pongo pygmaeus and Pongo abelii). *Journal of Personality and Social Psychology*, 90, 501–511.

Weiss, E., et al. (2012). Why did you choose this pet? Adopters and pet selection preferences in five animal shelters in the United States. *Animals*, 2(2), 144-159.

Wells, D. L., & Hepper, P. G. (2000). Prevalence of behaviour problems reported by owners of dogs purchased from an animal rescue shelter. *Applied Animal Behaviour Science*, 69(1), 55-65.

West, J. W. (2003). Effects of heat-stress on production in dairy cattle. *Journal Of Dairy Science*, 86(6), 2131-2144.

Wiener, P., & Haskell, M. J. (2016). Use of questionnaire-based data to assess dog personality. *Journal of Veterinary Behaviour*, 16, 81-85.

Wilson, D. S. (1998). Adaptive individual differences within single populations. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences*, 353(1366), 199-205.

Wiseman-Orr, M. L., et al. (2004). Development of a questionnaire to measure the effects of chronic pain on health-related quality of life in dogs. *American Journal Of Veterinary Research*, 65(8), 1077-1084.

Witt, J., & Green, L. (2018). Development and assessment of management practices in a flock-specific lameness control plan: A stepped-wedge trial on 44 English sheep flocks. *Preventive Veterinary Medicine*, 157, 125-133.

White, P.D., et al. (2003) Illness behaviour and psychosocial factors in diffuse upper limb, pain disorder: A case-control study. *Journal of Rheumatology*, 30(1), 139-45.

White, K. S., McDonnell, C. J., & Gervino, E. V. (2011). Alexithymia and anxiety sensitivity in patients with non-cardiac chest pain. *Journal Of Behaviour Therapy And Experimental Psychiatry*, 42(4), 432-439.

Whitham, J. C., & Wielebnowski, N. (2009). Animal-based welfare monitoring: using keeper ratings as an assessment tool. *Zoo Biology: Published in affiliation with the American Zoo and Aquarium Association*, 28(6), 545-560.

Whyte, C., et al. (2014) Canine stage 1 periodontal disease: A latent pathology, *The Veterinary Journal*, 201(1), 118-201.

Wilner, J.G., Vranceanu, A.M., & Blashill, A.J. (2014) Neuroticism prospectively predicts pain among adolescents: Results from nationally representative sample. *Journal of Psychosomatic Research*, 77(6),474-476.

Wiseman, M.L., et al. (2001) Preliminary study on owner-reported changes associated with chronic pain in dogs. *Veterinary Record*, 149, 423-424.

Wolf, M., & Weissing, F. J. (2010). An explanatory framework for adaptive personality differences. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 365(1560), 3959-3968.

Wong, W.S., et al. (2014) The Fear-Avoidance Model of Chronic Pain: Assessing the Role of Neuroticism and Negative Affect in Pain Catastrophizing Using Structural Equation Modelling. *International Journal of Behavioural Medicine*, 22(1), 118-131.

Wood, R.L., Maclean, L., & Pallister, I. (2011) Psychological factors contributing to perceptions pain intensity after acute orthopaedic injury. *Injury-International Journal of the Care of the Injured*, 42(11), 1214-8.

Worth, A. J., et al. (2012). Seasonal variation in the hip score of dogs as assessed by the New Zealand Veterinary Association Hip Dysplasia scheme. *New Zealand Veterinary Journal*, *60*(2), 110-114.

Wranker, L.S,. et al. (2015) The influence of personality traits on perception of pain in older adults-Findings from the Swedish national study on aging and care-Blekinge study. *Scandinavian Journal of Pain*, 7, 3-8.

Wright, L.J., Zautra, A.J., & Going, S. (2008) Adaptation to early knee osteoarthritis: The role of risk, resilience, and disease severity on pain and physical functioning. *Annals of Behavioural Medicine*, 36(1), 70-80.

Wurdeman, S. R., et al. (2011). Multiple sclerosis affects the frequency content in the vertical ground reaction forces during walking. , 26(2), 207-212.

Yadolla, P,. et al. (2014) The study of the predicting role of personality traits in the perception of labour pain. *Iran Journal of Nursing and Midwifery Research*, 19(7), 97-102.

Yalbuzdag, S. A., et al. (2016). Temperament and character profile in failed back surgery syndrome: a cross-sectional clinical study. *Turkish Neurosurgery*, 26(6), 912-7.

Yamagata, S., et al. (2006). Is the genetic structure of human personality universal? A cross-cultural twin study from North America, Europe, and Asia. *Journal Of Personality And Social Psychology*, 90(6), 987

Yeates, J. W., & Main, D. C. (2008). Assessment of positive welfare: a review. *The Veterinary Journal*, 175(3), 293-300.

Yeung, E. W., Arewasikporn, A., & Zautra, A. J. (2012). Resilience and chronic pain. *Journal of Social and Clinical Psychology*, 31(6), 593-617.

Zampieri, M.A.J., Tognola, W.A., & Galego, J.C.B. (2014) Patients with chronic headache tend to have more psychological symptoms than those with sporadic episodes of pain. *Arquivos De Neuro-Psiquiatria*, 72(8), 598-602.

Zautra, A.J., Johnson, L.M., & Davis, M.C. (2005) Positive affect as a source of resilience for women in chronic pain. *Journal of Consulting and Clinical Psychology*. 73(2), 212-20.

Zeng, F., et al. (2016). Life events, anxiety, social support, personality, and alexithymia in female patients with chronic pain: A path analysis. *Asia-Pacific Psychiatry*, 8(1), 44-50.

Zidar, J., et al. (2017). A comparison of animal personality and coping styles in the red jungle fowl. *Animal Behaviour*, 130, 209-220.

Zola, I. K. (1973). Pathways to the doctor—from person to patient. *Social Science & Medicine*, *7*(9), 677-689.

Zulkifli, I. (2013). Review of human-animal interactions and their impact on animal productivity and welfare. *Journal of Animal Science and Biotechnology*, 4(1), 25.

## Appendix 3.1 PANAS scoring sheet

Positive and negative activation scale for dogs

For each of the statements below, please place a cross in the box which most accurately describes your level of agreement with how your dog behaves in general in this situation. Please consider whether your dog's behaviour is of similar intensity and occurs as frequently as described. For example, if in item 2 you dog **always** becomes **a little** excited when it is about to go for a walk, you would mainly agree with the statement.

If your dog has never encountered the situation and you are unable to predict the behaviour, please use the not applicable option

| | | Agree strongly | Mainly agree | Partly agree, partly disagree | Mainly disagree | Disagree strongly | Not applicable | Office use only |
|---|---|---|---|---|---|---|---|---|
| 1 | Your dog is rarely frightened | | | | | | | |
| 2 | Your dog becomes very excited when it is about to go for a walk (e.g. when it sees its lead, or when it hears "walkies", etc.) | | | | | | | |
| 3 | Your dog is easily startled by noises and / or movements | | | | | | | |
| 4 | Your dog is very persistent in its efforts to get you to play | | | | | | | |
| 5 | Your dog shows little interest in its surroundings | | | | | | | |
| 6 | Your dog appears nervous and / or jumpy for several minutes after it has been startled | | | | | | | |
| 7 | Your dog is easily excited | | | | | | | |
| 8 | Your dog has a specific fear or phobia | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 9 | Your dog tries to escape from the garden | | | | | | | |
| 10 | Your dog appears calm in noisy, crowded places | | | | | | | |
| 11 | Your dog is full of energy | | | | | | | |
| 12 | Your dog is frightened by noises from the television or radio | | | | | | | |

| | | Agree strongly | Mainly agree | Partly agree, partly disagree | Mainly disagree | Disagree strongly | Not applicable | Office use only |
|---|---|---|---|---|---|---|---|---|
| 13 | Your dog usually appears relaxed | | | | | | | |
| 14 | Your dog is lazy | | | | | | | |
| 15 | Your dog adapts quickly to changes in its environment (eg. being cared for by different people, moving house or a family member leaving home) | | | | | | | |
| 16 | Your dog appears afraid of the vacuum cleaner or any other familiar household appliance | | | | | | | |
| 17 | Your dog requires a great deal of encouragement to take part in energetic activities | | | | | | | |
| 18 | Your dog persists in being naughty despite being told off for the behaviour | | | | | | | |
| 19 | Your dog appears calm in unfamiliar environments | | | | | | | |
| 20 | Your dog is very boisterous | | | | | | | |
| 21 | Your dog appears unsettled by changes to its routine (e.g. if it is not fed at the usual time, if it is left alone for longer than usual) | | | | | | | |

## Appendix 4.1 Dog health and personality questionnaire detailed in chapters four and five

**Dog personality and health survey**

Thank you for taking the time to take part in this survey about personality and health in dogs.

As part of this survey you will be asked to provide some basic information about your dog, alongside filling in a range of questionnaires about your dog's; personality, health and behaviour. You will also be asked to provide some information about your own personality, pain experience and knowledge of medical issues. We understand that there may appear to be similar questions in several of the questionnaires; however, they are designed to assess slightly different things, so please answer all of the questions.

If you own more than one dog, please complete the survey for the dog whose name comes first alphabetically.

You are reminded that you have the right to withdraw from this study at any point during filling in the survey. However, once you have posted the survey it will not be possible to withdraw your data as analysis may have already begun. If you choose to withdraw from this study, no questions will be asked.

This research has been approved by the University of Lincoln's College of Science Research Ethics Committee (CoSREC). Should you have any comments or questions with regards to ethics you can speak to the researcher who can give you details for the committee. Furthermore, should you have any general comments about this survey the primary researcher can be contacted on sreaney@lincoln.ac.uk. Please only fill this questionnaire in once.

Finally, thank you again for taking part in this research. Please proceed to the next page to start the survey.

**Consent form**

Please read the following statements and indicate your agreement.

- ☐ I understand that my participation in the survey is voluntary and that I can decide at any point before posting the survey that I do not want to be involved.
  - ☐ Yes
  - ☐ No
- ☐ I understand that the information I give is anonymous?
  - ☐ Yes
  - ☐ No
- ☐ I understand that once I have posted this survey I cannot withdraw my answers?
  - ☐ Yes
  - ☐ No

1. Have you previously filled in our other survey titled "Dog personality and health"?

- ☐ Yes
- ☐ No

2. As well as filling in this survey, are you also taking part in walking tasks with your dog at the University of Lincoln?

- ☐ Yes
- ☐ No

If the answer you provided to this question is 'yes', please provide the unique study code you were allocated by our researcher:

Unique study code:___________________________

3. What gender do you identify as?

☐ Male

☐ Female

☐ Prefer not to disclose

4. How old are you?

☐ Below 16 years of age

☐ 16-24 years of age

☐ 25-34 years of age

☐ 35-44 years of age

☐ 45-54 years of age

☐ 55-64 years of age

☐ 65 years of age and older

5. What country do you live in?

______________________________________________________________

6. What gender is your dog?

- ☐ Entire female
- ☐ Neutered female
- ☐ Entire male
- ☐ Castrated male

7. What breed is your dog?

_______________________________________________

8. How old is your dog?

- ☐ Less than 6 months of age
- ☐ 6-12 months of age
- ☐ 1-2 years
- ☐ 2-6 years
- ☐ 6-10 years
- ☐ 10-14 years

☐ 14 years and older

8. How long have you owned your dog?

☐ Less than 2 months

☐ 2 months- 1 year

☐ 1 – 2 years

☐ 2 – 4 years

☐ 4 – 6 years

☐ 6 – 10 years

☐ 10 – 14 years

☐ 14 years’ plus

9. Has your dog been hip scored?

☐ Yes

☐ No

☐ Not sure

If yes, what is your dog's hip score?

-------------------------------------------------------

10. Has your dog received a diagnosis of hip problems from your veterinarian?

☐ Yes

☐ No

☐ Not sure

If your dog does NOT have a hip problem, please skip to question 15. If your dog DOES have a hip problem, please complete all the questions.

11. Is your dog undergoing, or has your dog undergone treatment for their hip problems?

☐ Yes

☐ No

☐ Not sure

12. Please indicate the type of treatment your dog has received for their hip problems.

| | Tried previously | Current treatment being used | Never tried before |
|---|---|---|---|
| Surgery | | | |
| Joint supplements | | | |
| Steroidal anti-inflammatory drugs | | | |
| Nonsteroidal anti-inflammatory drugs | | | |
| Opioid pain relief | | | |
| Amitriptyline | | | |
| Radiotherapy | | | |
| Physiotherapy | | | |
| Hydrotherapy | | | |
| Acupuncture | | | |

| | | | |
|---|---|---|---|
| Homeopathy | | | |
| Massage | | | |

Other

________________________________________________________________

13. Since your dog has had hip problems...

| | More than before | Less than before | Same as before | N/A |
|---|---|---|---|---|
| Do you exercise your dog… | | | | |
| Help your dog onto the bed… | | | | |
| Help your dog into the car… | | | | |

14. Which of these best describes your dog's hip problems?

- ☐ My dog has had a short isolated bout, but has now returned to normal
- ☐ My dog has had an isolated medium bout, or several short bouts, but has returned to normal
- ☐ My dog has constant chronic illness
- ☐ I have seriously thought about the possibility of euthanasia for my dog because of their hip problems

15. Please indicate if your dog has had any of these health problems and how long they lasted

| | Previously but resolved | On-going with no treatment | On-going with a treatment plan | N/A |
|---|---|---|---|---|
| Gastrointestinal problems | | | | |
| Respiratory problems | | | | |
| Skin complaints | | | | |
| Dental problems | | | | |
| Eye problems | | | | |
| Musculoskeletal problems | | | | |

| | | | | |
|---|---|---|---|---|
| Gland problems (such as anal gland) | | | | |
| Urinary tract issues | | | | |
| Ear problems | | | | |

Other___________________________________________________________

**16. Personality questionnaire one**

For each of the statements below, please place a cross in the box which most accurately describes your level of agreement with how your dog behaves in general in this situation. Please consider whether your dog's behaviour is of similar intensity and occurs as frequently as described. For example, if in item 2 you dog **always** becomes **a little** excited when it is about to go for a walk, you would mainly agree with the statement.

If your dog has never encountered the situation and you are unable to predict the behaviour, please use the not applicable option

| | | Agree strongly | Mainly agree | Partly agree, partly disagree | Mainly disagree | strongly | Not applicable | | Office use only |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Your dog is rarely frightened | | | | | | | | |
| 2 | Your dog becomes very excited when it is about to go for a walk (e.g. when it sees its lead, or when it hears "walkies", etc.) | | | | | | | | |
| 3 | Your dog is easily startled by noises and / or movements | | | | | | | | |
| 4 | Your dog is very persistent in its efforts to get you to play | | | | | | | | |
| 5 | Your dog shows little interest in its surroundings | | | | | | | | |
| 6 | Your dog appears nervous and / or jumpy for several minutes after it has been startled | | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 7 | Your dog is easily excited | | | | | | | |
| 8 | Your dog has a specific fear or phobia | | | | | | | |
| 9 | Your dog tries to escape from the garden | | | | | | | |
| 10 | Your dog appears calm in noisy, crowded places | | | | | | | |
| 11 | Your dog is full of energy | | | | | | | |
| 12 | Your dog is frightened by noises from the television or radio | | | | | | | |

| | | Agree strongly | Mainly agree | Partly agree, partly disagree | Mainly disagree | strongly | Not applicable | Office use only |
|---|---|---|---|---|---|---|---|---|
| 13 | Your dog usually appears relaxed | | | | | | | |
| 14 | Your dog is lazy | | | | | | | |
| 15 | Your dog adapts quickly to changes in its environment (eg. being cared for by different people, moving house or a family member leaving home) | | | | | | | |
| 16 | Your dog appears afraid of the vacuum cleaner or any other familiar household appliance | | | | | | | |
| 17 | Your dog requires a great deal of encouragement to take part in energetic activities | | | | | | | |
| 18 | Your dog persists in being naughty despite being told off for the behaviour | | | | | | | |
| 19 | Your dog appears calm in unfamiliar | | | | | | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | environments | | | | | | | | |
| 20 | Your dog is very boisterous | | | | | | | | |
| 21 | Your dog appears unsettled by changes to its routine (e.g. if it is not fed at the usual time, if it is left alone for longer than usual) | | | | | | | | |

**17. Personality questionnaire two**

Please rate how well each word describes your dog's personality by marking the appropriate number.

Consider how your dog behaves overall. For example, if your dog is friendly to most people, some dogs but not others, you may rate them as a 3 or 4. A dog that is friendly to every person and every dog they meet is a 5 or a 6 on the scale.

**1= really does not describe my dog, 6= really describes my dog**

| | **1** | **2** | **3** | **4** | **5** | **6** |
|---|---|---|---|---|---|---|
| **Friendly** | | | | | | |
| **Persevering** | | | | | | |
| **Nervous** | | | | | | |
| **Energetic** | | | | | | |
| **Attentive** | | | | | | |
| **Easy going** | | | | | | |
| **Independent** | | | | | | |
| **Trainable** | | | | | | |
| **Non-aggressive** | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Hyperactive** | | | | | | |
| **Submissive** | | | | | | |
| **Determined** | | | | | | |
| **Relaxed** | | | | | | |
| **Tenacious** | | | | | | |
| **Timid** | | | | | | |
| **Biddable** | | | | | | |
| **Active** | | | | | | |
| **Intelligent** | | | | | | |
| **Sociable** | | | | | | |
| **Restless** | | | | | | |
| **Fearful** | | | | | | |
| **Obedient** | | | | | | |
| **Lively** | | | | | | |
| **Reliable** | | | | | | |
| **Assertive** | | | | | | |
| **Excitable** | | | | | | |

**18. Behaviour questionnaire one**

Please choose the answer that best describes your dog's behaviour over the last seven days.

1. My dog's mood has been

- ☐ Very alert
- ☐ Alert
- ☐ Neither alert nor indifferent
- ☐ Indifferent
- ☐ Very indifferent

2. My dog has played

- ☐ Very willingly
- ☐ Willingly
- ☐ Reluctantly
- ☐ Very reluctantly
- ☐ Does not play at all

3. Rate how often your dog has vocalised pain (audible complaining, whining, crying out etc)

- ☐ Never
- ☐ Hardly ever
- ☐ Sometimes
- ☐ Often
- ☐ Very often

4. My dog has walked

- ☐ With great ease
- ☐ With ease
- ☐ Neither with ease nor with difficulty
- ☐ With difficulty
- ☐ With great difficulty

5. My dog has trotted (moving diagonal limbs at the same time; "jogging")

-  With great ease
-  With ease
-  With some difficulty
-  With great difficulty
-  Does not trot at all

6. My dog has galloped ("high speed running")

-  With great ease
-  With ease
-  With some difficulty
-  With great difficulty
-  Does not gallop at all

7. My dog has jumped (eg. into car, onto sofa...)

-  With great ease
-  With ease
-  With some difficulty

- ☐ With great difficulty
- ☐ Does not jump at all

8. My dog has lain down…

- ☐ With great ease
- ☐ With ease
- ☐ Neither with ease nor with difficulty
- ☐ With difficulty
- ☐ With great difficulty

9. My dog has risen from a lying position…

- ☐ With great ease
- ☐ With ease
- ☐ Neither with ease nor with difficulty
- ☐ With difficulty
- ☐ With great difficulty

10. My dog has moved after long rest…

- ☐ With great ease
- ☐ With ease
- ☐ Neither with ease or with difficulty
- ☐ With difficulty
- ☐ With great difficulty

11. My dog has moved after major activity or exercise…

- ☐ With great ease
- ☐ With ease
- ☐ Neither with ease nor with difficulty
- ☐ With difficulty
- ☐ With great difficulty

12. Do you think your dog has been in any pain over the last seven days?

- ☐ Yes

- [ ] No
- [ ] Not sure

**19. Behaviour questionnaire two**

Please choose a number to rate your dog's pain over the past seven days

0= No pain 10= Worst pain possible

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Tick the one number that best describes the pain at its worse in the last 7 days | | | | | | | | | | |
| Tick the one number that best describes the pain at its least in the last 7 days | | | | | | | | | | |
| Tick the one number that best describes the pain at its average in the last 7 days | | | | | | | | | | |
| Tick the one number that best describes the pain as it is right now | | | | | | | | | | |

Choose the one number that describes how during the past 7 days pain has interfered with your dog's:

0= No interference 10= Most interference

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| General activity | | | | | | | | | | |
| Enjoyment of life | | | | | | | | | | |
| Ability to rise to standing from lying down | | | | | | | | | | |
| Ability to walk | | | | | | | | | | |
| Ability to run | | | | | | | | | | |
| Ability to climb up (for example, stairs or curbs) | | | | | | | | | | |

20. How do you view your dog?

- ☐ Like a member of the family.
- ☐ Like a child.
- ☐ As a working, functional dog.
- ☐ As just a dog.

21. Here are a number of characteristics that may or may not apply to you. For example, do you agree that you are someone who *likes to spend time with others*? Please write a number next to each statement to indicate the extent to which **<u>you agree or disagree with that statement.</u>**

| **1** | **2** | **3** | **4** | **5** |
|---|---|---|---|---|
| Disagree<br><br>Strongly | Disagree<br><br>a little | Neither agree<br><br>nor disagree | Agree<br><br>a little | Agree<br><br>strongly |

**I am someone who is**

1. ______ Is talkative

2. ______ Tends to find fault with others

3. ______ Does a thorough job

4. ______ Is depressed, blue

5. ______ Is original, comes up with new ideas

6. ______ Is reserved

7. ______ Is helpful and unselfish with others

8. ______ Can be somewhat careless

9. ______ Is relaxed, handles stress well.

10. ______ Is curious about many different things

11. ______ Is full of energy

12. ______ Starts quarrels with others

13. ______ Is a reliable worker

14. ______ Can be tense

15. ______ Is ingenious, a deep thinker

16. ______ Generates a lot of enthusiasm

17. ______ Has a forgiving nature

18. ______ Tends to be disorganized

19. ______ Worries a lot

20. ______ Has an active imagination

21. ______ Tends to be quiet

22. ______ Is generally trusting

23. ______ Tends to be lazy

24. ______ Is emotionally stable, not easily upset

25. ______ Is inventive

26. ______ Has an assertive personality

27. ______ Can be cold and aloof

28. ______ Perseveres until the task is finished

29. ______ Can be moody

30. ______ Values artistic, aesthetic experiences

31. ______ Is sometimes shy, inhibited

32. ______ Is considerate and kind to almost everyone

33. ______ Does things efficiently

34. ______ Remains calm in tense situations

35. ______ Prefers work that is routine

36. ______ Is outgoing, sociable

37. ______ Is sometimes rude to others

38. ______ Makes plans and follows through with them

39. ______ Gets nervous easily

40. ______ Likes to reflect, play with ideas

41. ______ Has few artistic interests

42. ______ Likes to cooperate with others

43. ______ Is easily distracted

44. ______ Is sophisticated in art, music, or literature

**Your pain experiences**

22. Which statement best describes your experience of a pain condition?

- ☐ I have never experienced a condition causing pain.
- ☐ I have experienced a single incident of short lived pain, such as; a minor break, minor muscle injury etc.
- ☐ I have experienced several bouts of short lived pain.
- ☐ I experience a single condition which causes me long term pain.
- ☐ I experience more than one condition which causes me long term pain.

23. Which statement best describes your knowledge about medical issues?

- ☐ I know very little about medical issues.
- ☐ I know as much as most people about medical issues.
- ☐ I know more than most people about medical issues.
- ☐ I have an extensive knowledge of medical issues.
- ☐ I have a medical degree.

If you have any comments about any aspect of the questionnaire (content or problems with design) then please detail them below.

Please leave your email address and/or phone number if you are happy to be contacted about this research. Please do NOT leave a name, but do realise that your contact details will mean that your data is not received totally anonymously. However, all data will be anonymised prior to publication.

-------------------------------------------------------------------------------------------

You have now reached the end of the questionnaire.

Thank you for taking the time to fill in this survey.  Your participation is really appreciated.

Should you have any further questions about this study then please contact the primary researcher on sreaney@lincoln.ac.uk.

## Appendix 4.2 MONASH scoring system.

Please rate your dog's personality using the Monash Canine Personality Questionnaire.

Please rate how well each word describes your dog's personality by marking the appropriate number.

Consider how your dog behaves overall. For example if your dog is friendly to most people, some dogs but not others, you may rate them as a 3 or 4. A dog that is friendly to every person and every dog they meet would be a 5 or a 6 on the scale.
**1 = really does not describe my dog, 6 = really describes my dog**

| | Really does not describe my dog | | | | | Really describes my dog |
|---|---|---|---|---|---|---|
| friendly | 1 | 2 | 3 | 4 | 5 | 6 |
| persevering | 1 | 2 | 3 | 4 | 5 | 6 |
| nervous | 1 | 2 | 3 | 4 | 5 | 6 |
| energetic | 1 | 2 | 3 | 4 | 5 | 6 |
| attentive | 1 | 2 | 3 | 4 | 5 | 6 |
| easy going | 1 | 2 | 3 | 4 | 5 | 6 |
| independent | 1 | 2 | 3 | 4 | 5 | 6 |
| trainable | 1 | 2 | 3 | 4 | 5 | 6 |
| non-aggressive | 1 | 2 | 3 | 4 | 5 | 6 |
| hyperactive | 1 | 2 | 3 | 4 | 5 | 6 |
| submissive | 1 | 2 | 3 | 4 | 5 | 6 |
| determined | 1 | 2 | 3 | 4 | 5 | 6 |
| relaxed | 1 | 2 | 3 | 4 | 5 | 6 |
| tenacious | 1 | 2 | 3 | 4 | 5 | 6 |
| timid | 1 | 2 | 3 | 4 | 5 | 6 |
| biddable | 1 | 2 | 3 | 4 | 5 | 6 |
| active | 1 | 2 | 3 | 4 | 5 | 6 |
| intelligent | 1 | 2 | 3 | 4 | 5 | 6 |
| sociable | 1 | 2 | 3 | 4 | 5 | 6 |
| restless | 1 | 2 | 3 | 4 | 5 | 6 |
| fearful | 1 | 2 | 3 | 4 | 5 | 6 |
| obedient | 1 | 2 | 3 | 4 | 5 | 6 |
| lively | 1 | 2 | 3 | 4 | 5 | 6 |
| reliable | 1 | 2 | 3 | 4 | 5 | 6 |
| assertive | 1 | 2 | 3 | 4 | 5 | 6 |
| excitable | 1 | 2 | 3 | 4 | 5 | 6 |

Scoring:

Add scores for each of the five dimensions together and divide by the maximum for each dimension (see below). Multiply by 100. This gives one score as a percentage for each dimension.

| Extraversion | Motivation | Training Focus | Amicability | Neuroticism |
|---|---|---|---|---|
| Active | Assertive | Attentive | Easy going | Fearful |
| Energetic | Determined | Biddable | Friendly | Nervous |
| Excitable | Independent | Intelligent | Non-aggressive | Submissive |
| Hyperactive | Persevering | Obedient | Relaxed | Timid |
| Lively | Tenacious | Reliable | Sociable | |
| Restless | | Trainable | | |
| Max Score: 36 | Max Score: 30 | Max Score: 36 | Max Score: 30 | Max Score: 24 |
| Score | Score | Score | Score | Score |

## Appendix 4.3. Canine Brief Pain Inventory (CBPI) questionnaire

Description of Pain:

Rate your dog’s pain.

1. Fill in the oval next to the one number that best describes the pain at its worst in the last 7 days.

2. Fill in the oval next to the one number that best describes the pain at its least in the last 7 days.

3. Fill in the oval next to the one number that best describes the pain at its average in the last 7 days.

4. Fill in the oval next to the one number that best describes the pain as it is right now.

Description of Function:

Fill in the oval next to the one number that describes how during the past 7 days pain has interfered with your

dog’s:

5. General Activity

6. Enjoyment of Life

Description of Function (continued):

Fill in the oval next to the one number that describes how during the past 7 days pain has interfered with your

dog’s:

7. Ability to Rise to Standing From Lying Down

8. Ability to Walk

9. Ability to Run

10. Ability to Climb Up (for example Stairs or Curbs)

Overall Impression:

11. Fill in the oval next to the one response best describes your dog’s overall quality of life over the last 7

days?

## Appendix 4.4. Helsinki Chronic Pain Index questionnaire

Please choose the answer that best describes your dog's behaviour over the last seven days.

1. My dog's mood has been

- ☐ Very alert
- ☐ Alert
- ☐ Neither alert nor indifferent
- ☐ Indifferent
- ☐ Very indifferent

2. My dog has played

- ☐ Very willingly
- ☐ Willingly
- ☐ Reluctantly
- ☐ Very reluctantly
- ☐ Does not play at all

3. Rate how often your dog has vocalised pain (audible complaining, whining, crying out etc)

- ☐ Never
- ☐ Hardly ever
- ☐ Sometimes
- ☐ Often
- ☐ Very often

4. My dog has walked

- ☐ With great ease
- ☐ With ease
- ☐ Neither with ease nor with difficulty
- ☐ With difficulty
- ☐ With great difficulty

5. My dog has trotted (moving diagonal limbs at the same time; "jogging")

- ☐ With great ease
- ☐ With ease

- With some difficulty
- With great difficulty
- Does not trot at all

6. My dog has galloped ("high speed running")

- With great ease
- With ease
- With some difficulty
- With great difficulty
- Does not gallop at all

. 7. My dog has jumped (eg. into car, onto sofa...)

- With great ease
- With ease
- With some difficulty
- With great difficulty

- ☐ Does not jump at all

8. My dog has lain down…

- ☐ With great ease
- ☐ With ease
- ☐ Neither with ease nor with difficulty
- ☐ With difficulty
- ☐ With great difficulty

9. My dog has risen from a lying position…

- ☐ With great ease
- ☐ With ease
- ☐ Neither with ease nor with difficulty
- ☐ With difficulty
- ☐ With great difficulty

10. My dog has moved after long rest…

- ☐ With great ease
- ☐ With ease
- ☐ Neither with ease or with difficulty
- ☐ With difficulty
- ☐ With great difficulty

11. My dog has moved after major activity or exercise…

- ☐ With great ease
- ☐ With ease
- ☐ Neither with ease nor with difficulty
- ☐ With difficulty
- ☐ With great difficulty

12. Do you think your dog has been in any pain over the last seven days?

- ☐ Yes
- ☐ No

☐ Not sure

## Appendix 5.1. BFI Scoring System

### SCORING INSTRUCTIONS

To score the BFI, you'll first need to **reverse-score** all negatively-keyed items:

Extraversion: 6, 21, 31

Agreeableness: 2, 12, 27, 37

Conscientiousness: 8, 18, 23, 43

Neuroticism: 9, 24, 34

Openness: 35, 41

To recode these items, you should subtract your score for all reverse-scored items from 6. For example, if you gave yourself a 5, compute 6 minus 5 and your recoded score is 1. That is, a score of 1 becomes 5, 2 becomes 4, 3 remains 3, 4 becomes 2, and 5 becomes 1.

Next, you will create scale scores by ***averaging*** the following items for each B5 domain (where R indicates using the reverse-scored item).

Extraversion: 1, 6R 11, 16, 21R, 26, 31R, 36

Agreeableness: 2R, 7, 12R, 17, 22, 27R, 32, 37R, 42

Conscientiousness: 3, 8R, 13, 18R, 23R, 28, 33, 38, 43R

Neuroticism: 4, 9R, 14, 19, 24R, 29, 34R, 39

Openness: 5, 10, 15, 20, 25, 30, 35R, 40, 41R, 44

## SPSS SYNTAX

***** REVERSED ITEMS**

```
RECODE
  bfi2 bfi6 bfi8 bfi9 bfi12 bfi18 bfi21 bfi23 bfi24 bfi27 bfi31 bfi34 bfi35
  bfi37 bfi41 bfi43
  (1=5)  (2=4)  (3=3)  (4=2)  (5=1)  INTO  bfi2r bfi6r bfi8r bfi9r bfi12r bfi18r bfi21r bfi23r bfi24r
  bfi27r bfi31r bfi34r bfi35r bfi37r bfi41r bfi43r.
EXECUTE .
```

***** SCALE SCORES**

```
COMPUTE bfie = mean(bfi1,bfi6r,bfi11,bfi16,bfi21r,bfi26,bfi31r,bfi36) .
VARIABLE LABELS bfie 'BFI Extraversion scale score.
EXECUTE .

COMPUTE bfia = mean(bfi2r,bfi7,bfi12r,bfi17,bfi22,bfi27r,bfi32,bfi37r,bfi42) .
VARIABLE LABELS bfia 'BFI Agreeableness scale score' .
EXECUTE .

COMPUTE bfic = mean(bfi3,bfi8r,bfi13,bfi18r,bfi23r,bfi28,bfi33,bfi38,bfi43r) .
VARIABLE LABELS bfic 'BFI Conscientiousness scale score' .
EXECUTE .

COMPUTE bfin = mean(bfi4,bfi9r,bfi14,bfi19,bfi24r,bfi29,bfi34r,bfi39) .
VARIABLE LABELS bfin 'BFI Neuroticism scale score' .
EXECUTE .

COMPUTE bfio = mean(bfi5,bfi10,bfi15,bfi20,bfi25,bfi30,bfi35r,bfi40,bfi41r,bfi44) .
```

```
VARIABLE LABELS bfio 'BFI Openness scale score' .

EXECUTE .
```

## Appendix 6.1. Experimental set up for force plate and accelerometer study

## Appendix 6.2. X-Ray Example Unhealthy Dog

## Appendix 7.1 Accelerometer placement for forelimbs and hindlimbs

(Forelimbs)

(Hind limbs)