A preliminary investigation into personality and pain in dogs

James Lush[1] & Carrie Ijichi[1]*

[1] *University Centre Hartpury, Hartpury, Gloucester, UK, GL19 3BE*

**carrie.ijichi@hartpury.ac.uk*

ABSTRACT

Adherence to basic animal welfare standards involves effective monitoring and control of pain, especially in a veterinary setting. Assessment relies on behavioural and physiological indicators. However, individual differences in physiology mediate consistent individual differences in behaviour, referred to as personality (Koolhaas et al., 1999). Therefore, personality may confound measurements of pain (Ijichi et al., 2014). The current work is a preliminary investigation into whether Extraversion and Neuroticism are associated with differences in individual behavioural and physiological responses to pain. Twenty dogs were observed during recovery from routine castration in a clinical setting. Core temperature was recorded using Infrared Thermography (IRT) (Stewart et al., 2008) upon admission, 15 minutes post-extubation and every 30 minutes thereafter, until the subject was collected by their owner. Behaviour during recovery was scored using Short Form Glasgow Composite Measure Pain Scale (Reid et al., 2007) at the same intervals as IRT readings. Personality was measured using Monash Canine Personality Questionnaire-Revised (Ley et al., 2009) and owners rated their dog's tolerance to pain on a five-point Likert scale. Pain score did not have an association with eye temperature discrepancy or core temperature changes from control, indicating it may not predict affective response to pain. More highly extravert subjects had significantly higher pain scores ($p = 0.031$), despite experiencing similar tissue damage. More extravert subjects showed significantly greater right eye temperature ($p = 0.035$), suggesting hemispheric dominance. Neuroticism had no association with physiological or behavioural responses to pain. Finally, owners were not able to predict their dog's behavioural or physiological response to pain. These results indicate that personality may be a useful clinical tool for assessing individual differences in response to pain, whilst owner ratings of their dog's response is not reliable.

KEYWORDS: personality, pain, extroversion, neuroticism, dogs, castration

INTRODUCTION

Animals are unable to verbally convey their emotions to human care-givers, which makes the measurement of pain difficult (Reid et al., 2013). Therefore, behaviour-based scales are utilised to quantify pain levels in animals, assisting the administration of the correct dosage of analgesic drugs and informing decisions on humane end-points (Ashley et al., 2005). Consequently, it is vital that these scales are both sensitive and valid, to reduce the welfare implications that could occur through the incorrect assessment of pain (Rutherford, 2002). However, personality - defined as individual differences in behaviour which are stable over time and across contexts (Koolhaas et al., 1999) - may confound this. For example, human subjects scoring more highly for Extraversion express their experiences of pain more clearly (Harkins et al., 1989), though they may experience pain less intensively (Ramírez-Maestre et al., 2004; Soriano et al., 2012). Extraversion is characterised by traits such as energetic behaviour, assertiveness and the tendency to seek stimulation (Costa and McCrae, 1985). Further, highly neurotic people have a higher emotional stress response to pain when compared to those who have a low score for neuroticism (Goubert et al., 2004; Koenig et al., 2015). Neuroticism is associated with the tendency to experience unpleasant emotions easily and a low degree of emotional stability (Costa and McCrae, 1985).

The association between personality and pain response has recently been investigated in animals in a clinical setting (Ijichi et al., 2014). This study provides preliminary evidence that extraversion correlates with behavioural expressions of pain in horses, whilst neuroticism is associated with reduced tolerance to pain. However, it is not known whether personality affects the emotional experience of pain, as well as its behavioural expression in animals, as it does in humans (e.g.

Asghari & Nicholas 2006). Further, this study used a variety of naturally occurring tissue damage, making comparison across individuals more complex. In addition, it is not known whether the link between personality and pain is a species-specific phenomenon or whether it is seen in other non-human mammals.

In dogs, personality and pain can be measured using validated questionnaires. The Monash Canine Personality Questionnaire-Revised (MCPQ-R) has been validated as having good inter-rater and test-retest reliability for five factors which include Extraversion and Neuroticism (Ley et al., 2009b). On this scale, extravert dogs are typically active, excitable and restless, whilst neurotic dogs are characterised as fearful, submissive and timid. Canine pain can be measured using the Short Form Glasgow Composite Measure Pain Scale (CMPS-SF) (Reid et al., 2007) as it has been shown to be both more sensitive and have less inter-observer variability when compared to other tests (Guillot et al., 2011). It is designed as a clinical tool for dogs in acute pain and uses 30 descriptors within six categories to inform decisions about pain management (Reid et al., 2007).

The current investigation aims to investigate whether personality affects emotional and behavioural response to pain in dogs in a clinical setting. Castration was selected as it is a common routine procedure which causes moderate post-operative pain (Wagner et al., 2008) and is often conducted on healthy, young animals. In addition, the ability of owners to predict their dog’s response to pain was measured, as horse owner ratings have been shown to have high predictive accuracy (Ijichi et al., 2014). Canine Extraversion and Neuroticism was measured using the MCPQ-R (Ley et al., 2009a) and compared with pain behaviour using the CMPS-SF (Reid et al., 2007). Emotional response to pain was measured using Infrared Thermography (IRT) as core temperature increases with arousal (Stewart et al., 2005; Travain et al., 2015) and decreases with pain in cattle (Stewart et al., 2008). Tympanic differences in temperature relate to lateralised cerebral blood flow (Riemer et al., 2016), reflecting emotional valence. Therefore, discrepancy between the right and left eye was explored as this may indicate lateralised cerebral blood flow.

Based on human and equine research, it was hypothesised that 1) Extraversion will correlate positively with behavioural indicators of pain and may correlate with changes in physiology; 2) Neuroticism will correlate negatively with owner rating of the subject’s tolerance and positively with emotional response to pain; 3) Owner Tolerance ratings will correlate negatively with behavioural indicators of pain and emotional response. In addition, the association between behavioural and emotional response to castration will be investigated to determine if behaviour is an accurate indicators of the emotional state of subjects.

MATERIALS AND METHODS

Subjects were assessed between 24th October 2016 and 17th January 2017 at two veterinary surgeries based in Gloucester and Surrey (UK). Subjects were admitted and treated as per standard protocol for each veterinary practice. Patients were pre-medicated with acepromazine and sub-cutaneous buprenorphine. General anaesthesia was induced by intravenous propofol and maintained using inhaled isoflurane. Subjects were observed whilst pain was caused by a routine, voluntary procedure conducted in normal veterinary practices. This procedure would cause dogs’ moderate pain regardless if the dogs were part of this study, allowing for an ethical means of testing the aims of this study, as additional pain infliction is not needed. Where the subject’s medical needs conflicted with those of the study, medical needs were prioritised and the subject withdrawn from data analysis.

Twenty dogs of mixed breed were assessed as limiting subjects to a single breed would reduce personality variance to an unacceptable degree, as personality is known to differ between breeds (Starling et al., 2013). The age of subjects could not be specified as the sample included re-homed dogs without clear histories. To reduce confounding effects, subjects were not included in the study if they: had pre-existing conditions that might cause pain; underwent any additional treatment; required a different anaesthetic drug or had recently been administered pain relieving medicine for a separate condition.

Of 20 original subjects, three dogs were excluded. One dog received a different anaesthetic drug and one slept throughout the study, preventing ocular temperatures and behavioural pain scores from being measured. An additional dog was excluded due to the subject being paired with another dog, which was likely to confound results. Two dogs were removed from part of the study, as tissue damage and analgesic drug dosage were not controlled. One of these dogs was administered a lower dose of the pre-operative drugs due to their older age. The other subject had juvenile teeth and two dew claws removed, which was elected during the castration operation. Data from these dogs was used only when assessing whether eye temperatures correlates with behavioural pain scores, as different treatment would not affect within-individual correlations.

Personality and Owner Ratings

Upon admission, owners were informed of the nature and purpose of the study and written consent to use their dog was obtained. Subsequently, owners were asked to complete the Monash Canine Personality Questionnaire-Revised (MCPQ-R) (Ley et al., 2009a). This ensured owners were blind to the subject's post-operative pain response when they completed the questionnaire. Extraversion and Neuroticism were the only personality factors used for further analysis, as these relate to the hypothesis of the study, based on previous literature. An additional five-point Likert scale was added to the MCPQ-R to assess the owner's rating of subject's tolerance to pain (Ijichi et al., 2014). This score will be referred to as "Tolerance".

Pain Scores

Behavioural expression of pain was assessed using the Short Form Glasgow Composite Measure Pain Scale (CMPS-SF) (Reid et al., 2007). Section B (analysis of mobility) and section C (pain on palpitation of wound) of the CMPS-SF were deemed unethical for the purposes of this study, potentially causing dogs unnecessary pain and stress, and so were omitted from the current study procedure.

Post-extubation, veterinary nurses were asked to orientate the subjects' face towards the video camera during recovery. This allowed for easier observations of the dogs' behaviour without disturbing the subject during recovery. Scoring was conducted retrospectively from 3-minute video recordings of the subjects taken using a Canon 60D® with a Canon® 28-105mm EF-S lens, to reduce the effect of observer presence. The first minute was disregarded due to the influence the observer may have had on entering the room. Pain scores were taken 15 minutes post-extubation and every 30 minutes thereafter, totalling a maximum of twelve recordings of two minutes per dog, dependant on how long the subject remained in recovery. These timings were recommended and used by previous studies looking at post-operative pain in dogs (e.g. Wagner et al., 2008). The scoring observer (J.L.) was blind to subject's personality scores at the time of scoring. For each subject, the peak pain score recorded from the first four recordings was used for analysis of individual differences. This is referred to as Peak Pain Score. Four recordings were used because dogs remained in the recovery kennel for different amounts of time but all subjects were present during at least the first four time periods. Recordings of behaviour between the 5^{th} and 12^{th} observation were discarded for comparison across individuals. These reading were use to explore how pain changed over time.

Infrared Thermography

Eye temperature readings were taken with an infrared camera (FLIR® One™ for android). A mobile device was used as it is considerably smaller than hand-held devices with a similar specification, which have been shown to causes stress in canine subjects (Travain et al., 2015). Images were taken from a distance of 0.5m - 1.0m and an angle of 90˚ from each eye (Stewart et al., 2007), calibrating the camera after each photo was taken. A control measurement was taken 15 minutes after the dogs were placed into the recovery cage prior to surgery or the administration of medication to measure the stress caused by being in a veterinary practice, as opposed to that caused by pain. This will be referred to as Control Temperature. During recovery, images were taken immediately after video recording stopped (15 minutes post-extubation and every 30 minutes thereafter) for each behaviour assessment time point. This was to prevent IRT recording altering the subject's behaviour and confounding CMPS-SF behavioural results.

Temperatures were analysed retrospectively using the FLIR® One™ app by identifying the palpebral fissure, including the lacrimal caruncle and taking the maximum temperature from this area (Yarnell et al., 2013). This reduced the stress-inducing effects of prolonged IRT measurement required to take accurate readings of such a small area (Travain et al., 2015). The observer (J.L) was blind to personality scores at the time of taking and assessing IRT images.

The mean for both eyes at each time point was calculated to indicate Core Temperature. Core temperature at each time point was subtracted from Control Temperature, separating the stress inducing effects of being in a veterinary practice from pain-induced stress post-castration. This gave a score for how much core temperature had changed at each time point and whether it had increased or decreased. This is referred to as Temperature Change from Control.

Only recordings from the first four time periods were used for analysis of individual differences, as per pain scoring. The maximum increase from Control Temperature was used for analysis of individual differences as previous research used peak temperature (Stewart et al., 2008). This is referred to as Peak Temperature Increase. The discrepancy between eyes was calculated by subtracting the left eye temperature from the right to indicate the extent of right hemispheric dominance. This is referred to as Eye Temperature Discrepancy. A positive score indicates the right eye was hotter, and a negative score indicates the left was. The greatest discrepancy recorded from the four measurements was used for analysis of individual differences. This is referred to as Peak Discrepancy.

Analysis

Analysis was conducted using “R” (R Development Core Team, 2017) and IBM® SPSS® Statistics 23. Shapiro-Wilks tests were used to test for normality of variables and residuals for tests of difference (Field, 2009). Paired T-tests were used to analyse for differences in core temperature between the control measurement and each observation post-castration. Paired T-test and Wilcoxon Signed-Rank tests were used, as appropriate for normality, to analyse whether eye temperature discrepancy was significantly different between control and post-castration readings. Shapiro-Wilks tests were used to determine the normality of variables. Where each variable was normally distributed, a Levene test (Fox and Wiesberg, 2011) assessed the homogeneity of variance on paired variables (Field, 2009). To determine whether behaviour correlated with emotional response, pain scores were compared with matched Temperature Change from Control and eye temperature discrepancy, using Pearson or Spearman-Rank correlations as appropriate for normality and homoscedasticity. Relationships between personality factors and Peak Pain Score, Peak Discrepancy and Peak Temperature Increase were explored using Pearson or Spearman-Rank correlations, as appropriate. Correlations were stated as weak where the coefficient was less than ±0.1, moderate for ±0.3 and strong for ±0.5 (Field, 2009).

RESULTS

Post-castration behaviour and changes in physiology

Paired T-Tests indicated significant differences in core temperature from control in observations 1,2,3,5,6 and 7 (Table 1; Figure 1). Paired T-tests and Wilcoxon Signed-Rank tests did not detect significant differences from control for eye temperature discrepancy (Table 2). The change in pain scores across observations can be seen in Figure 2.

Relationship between behavioural and physiological responses to pain

Spearmans correlation revealed Pain Score did not have an association with Eye Temperature Discrepancy (r_s = -0.091, N = 164, P = 0.246) or Temperature Change from Control (r_s = 0.131, N = 164, P = 0.095).

Personality and response to pain

Extraversion had a strong positive correlation with Peak Pain Score (Spearman: r_s = 0.558, n = 15, p = 0.031). Control Temperature did not correlate with Extraversion (Pearson: r_s = -0.390, n = 17, p = 0.15). Post-surgery, Extraversion had a moderate positive relationship with Peak Temperature Increase which can be seen through visual inspection (Figure 3). However, this was not statistically significant (Spearman: r_s = 0.438, n = 15, p = 0.101). Extraversion correlated strongly and positively with Peak Discrepancy post-surgery (Pearson: r_s= 0.546, n = 14, p = 0.035; Figure 4).

Control Temperature did not correlate with Neuroticism (Pearson: r_s = -0.078, n = 17, p = 0.78). There was no significant correlation between Neuroticism and Peak

Discrepancy (Spearman: r_s = -0.401, n = 15, p = 0.138), Peak Pain Score (Spearman: r_s = 0.107, n = 15, p = 0.703), Peak Temperature Increase (Pearson: r_s = -0.124, n = 15, p = 0.660), or Peak Discrepancy (r_s = -0.011, n = 15, p = 0.970).

Owner Predictions

There was no significant correlation between Tolerance and Peak Pain Score (Spearman: r_s = 0.372, n = 15, p = 0.172), Peak Temperature Increase (Spearman: r_s = 0.029, n = 15, p = 0.917), Peak Discrepancy (Spearman: r_s = 0.101, n = 15, p = 0.720), Extraversion (Spearman: r_s = 0.431, n = 15, p = 0.109) or Neuroticism (Spearman: r_s = -0.016, n = 15, p = 0.956).

DISCUSSION

Accurate pain assessment is essential for animal welfare and vital for correct pain management (Rutherford, 2002). Ijichi et al. (2014) provided preliminary evidence to suggest behavioural indicators of pain in horses may not accurately indicate the level of damage sustained. Instead, this study found the behavioural response to damage is associated with personality. This indicates behaviour based pain assessment tools may not be accurate and the subsequent management of pain among animals may not be appropriate. The over estimation of pain could increase analgesic drug dosage - causing adverse pharmaceutical effects - or contribute to an unnecessary euthanasia (Ashley et al., 2005). Underestimation could result in inadequate pain relief and subsequent suffering (Reid et al., 2007). Both of these result in welfare implications, highlighting the need for accuracy in these assessment tools. In the present study, post-operative behaviour was assessed after castration and compared with personality and core temperature. The results provide further evidence that there may be a relationship between personality and behavioural pain scores, as well as physiological measures.

The second observation post-castration showed a peak in mean pain score across subjects of 3.13 out of a possible 15 and this steadily declined throughout the observation period. This indicates that, on average, adequate pain relief was administered and pain was successfully managed during recovery (Reid et al., 2007). However, core temperature was significantly lower than control readings from the first observation and this was still seen in observation seven, more than three hours after surgery. Lowered core temperature is associated with pain in cattle (Stewart et al., 2008), however, it may also have been influenced by general anaesthetic and post-castration medication (Raffe et al., 1980). Unlike the study by Stewart et al. (2008), temperature did not rapidly increase after an initial drop. This may be due to differences between the species, procedure, pain-relief or context between the two studies and requires further investigation.

The discrepancy in temperature between left and right eye did not change significantly from control in any observation post-castration and this may indicate that eye temperature discrepancy does not reflect response to pain as originally suggested. This supports the findings of Riemer et al. (2016), which did not indicate a lateralised cerebral blood-flow as a result of separation anxiety. Interestingly, there was noticeable individual variation in both behavioural and physiological responses to pain triggered by the same procedure. Further, behavioural indicators did not correlate with physiological responses. Yarnell et al. (2013) also found ocular temperatures and behavioural measures of stress also did not correlate in horses when exposed to a stressor. Taken together, this indicates behaviour may not accurately indicate when an animal was experiencing poor welfare and that individuals respond differently to the same procedure, supporting previous findings in horses (Ijichi et al., 2014).

Subjects scoring more highly for Extraversion had higher Peak Pain Scores, despite experiencing relatively standardised tissue damage. This indicates behavioural response may differ between subjects due to specific personality factors. This supports Ijichi et al. (2014) in their finding that extravert animals score more highly for behavioural expression of pain, regardless of the severity of their injury. In this previous study, tissue damage was not standardised for severity and constituted both skeletal and soft tissue damage. The current study goes some way to correct this by using pain caused by a standardised procedure under more controlled conditions. The relationship between Peak Pain Score and Extraversion suggests that more introvert subjects are less likely to exhibit pain related behaviours. Intriguingly, human introverts are less physically active and less likely to adopt active coping responses (Soriano Pastor et al., 2010), a behavioural pattern similar to that seen here and supported by evidence that Extraversion may be associated with passive strategies with less apparent behaviour indicators of stress (Ijichi et al., 2013). It is therefore important to investigate whether more introvert animals express fewer behavioural indicators of pain because they have a lower emotional response to pain or because they experience pain to the same degree as extraverts but have inhibited expression, as is the case in human subjects (Harkins et al., 1989).

To investigate whether personality may be associated with differing emotional responses to pain, core temperature was measured using IRT (Stewart et al., 2008). A moderate positive correlation between Extraversion and Peak Temperature Increase was noted in the current study (Figure 3). However, this was not statistically significant, possibly due to the modest sample here. Therefore, the relationship between Extroversion and core temperature should be investigated further. This relationship was not observed before surgery, which may mean that personality correlates with core temperature under painful conditions. It appears that subjects scoring more highly for Extraversion had an increase in core temperature, whilst those with a low score for Extraversion had a decrease in temperature. If arousal results in an increase (dogs: Travain et al., 2015), and pain results in a decrease (cattle: Stewart et al., 2008) in temperature, this may suggest more extravert individuals have increased arousal in response to the same tissue damage whilst introvert individuals experience pain induced depression of core temperature. In human studies, more introvert people have stronger emotional responses to injury (Paine et al., 2009), and have reduced quality of life associated with poor coping mechanisms (Soriano Pastor et al., 2010). However, different species may have differing core temperature responses to pain. Further research will be needed to confirm or reject this novel finding using veterinary practices with larger caseloads of castration.

It is possible that differences in core temperature are the result of variation in hypothermic response to medication. However, it was also observed that the personality extraversion was associated with discrepancy in eye temperature, which might suggest hemispheric dominance. For peak discrepancy readings, more extravert individuals displayed higher temperatures in the right eye, whilst more introvert subjects displayed greater temperature in the left eye. If eye temperature reflects lateralised cerebral blood flow, this suggests that more extravert subjects had increased activity in the right hemisphere and more introvert subjects had increased activity in the left. Whilst this subject is complex, there is evidence to suggest that the right hemisphere processes emotional responses (Borod et al., 1998) and is associated with the tendency to express emotions (Nestor and Safer, 1990). This may explain the higher scores for behavioural expression of pain in these subjects. However, it is suggested that right hemispheric activity is an indicator of increased pain sensitivity and negative affect in humans (Pauli et al., 1999). If this were the case, it would suggest that more extravert subjects expressed more pain due to increased sensitivity, in which case, behavioural indicators may provide valuable information on the affective state of subjects. Further validation of core temperature as an indicator of pain, and ocular temperature discrepancy as an indicator of lateralised cerebral blood flow, is required to fully understand these findings. Heart Rate Variability (Rietmann et al., 2004) and salivary cortisol (Hekman et al., 2012) in a larger sample may clarify this relationship.

Neuroticism did not correlate with Peak Pain Scores. This is not unexpected if this personality factor is more associated with the experience of pain, rather than its expression (Ijichi et al., 2014; Paine et al., 2009). However, in the current study, Neuroticism did not correlate with any physiological indicators taken, which suggests it was not associated with the subjective experience of pain. There are several reasons this may be the case. First, there are species-specific responses to pain (Anil et al., 2002), which may affect behaviour and emotional processing. Second, personality factors measured by different subjective questionnaires may be similar constructs but not identical due to either species or trait differences. Therefore, what is referred to as “Neuroticism” by one assessment method may not be identical to that measured by another. The traits measured by the original equine questionnaire (Ijichi et al., 2013) are not species-specific and may be appropriate for application to canine subjects. Further work on canine pain using this questionnaire could identify whether the differences seen here are the result of species specific responses to pain or differences in the measurement of Neuroticism.

Owner ratings of Tolerance did not correlate with Neuroticism or behavioural and physiological indicators of pain. Ijichi et al. (2014) found that horse owner’s subjective opinion accurately predicted their horses objectively scored response to pain. Owner rated Tolerance also closely correlated with Neuroticism in the previous study. The distinct uses of dogs and horses may have caused this unexpected difference in results. Horses are regularly worked or ridden, which may be negatively impacted upon if the animal is in pain. Typically, the animals are also of much higher financial, though not necessarily sentimental, value. Therefore, horse owners may be more attuned to behavioural indicators of pain. Function may be much less important with companion dogs, as they are mainly household pets, and therefore the same attentiveness to pain might not exist. By contrast, dog owners have the benefit of increased contact time due to sharing their home with their pets which should promote sensitivity to changes in behaviour.

It was noted during collection that owners regularly commenting on the difficulty of remembering a time their dog was in pain. Results by Brown et al. (2013) showed that behavioural pain scales conducted by owners did not correlate with vertical force produced by arthritic dogs. This indicates dog owners may not be good at detecting when their pet is in pain. Hielm-Björkman et al. (2011) discovered owners were only accurate with pain scales when they were ‘self-trained’. In this previous study, once owners had seen the difference in their dogs’ expression of pain after pain medication, they were able to recognise behaviours caused by pain. Taken together, this suggests that dog owners may not offer the same clinical opportunities in understanding individual differences in pain response, as compared to equine owners.

CONCLUSION

The current study provides preliminary evidence for individual variation in behavioural and physiological response to a moderately painful procedure. Further, these individual differences were associated with personality. As predicted, Extraversion was associated with differences in response to pain post-castration as those scoring more highly for this factor presented with more prominent behavioural indicators of pain. The relationship between Extroversion and emotional response to pain was more complex. More extrovert subjects had possible greater increases in core temperature and increased temperature in the right eye compared to the left. To understand the association between extraversion and emotional responses to pain, further physiological tests beyond the scope of the current study should be investigated. Neuroticism was not associated with behavioural or physiological response to pain. This contradicts the prediction of the current study that more neurotic subjects would show more pronounced changes in core temperature. Owner ratings of Tolerance were not associated with any indicator of pain, which suggests that limited value should be placed on using this information in assessing canine pain.

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ETHICAL CONSIDERATIONS

No ethical permission is needed for non-invasive observations of dogs within a clinical setting in the United Kingdom. The veterinary practices and all individual owners were informed about the nature and intent of the research and their written consent was obtained prior to any data collection. Participants were permitted to withdraw up until the point of data analysis, which was conducted using anonymised data.

REFERENCE LIST

Anil, S., Anil, L., Deen, J., 2002. Challenges of pain assessment in domestic animals.

J. Am. Vet. Assoc. 220, 313–319.

Asghari, A., Nicholas, M.K., 2006. Personality and pain-related beliefs/coping strategies: a prospective study. Clin. J. Pain 22, 10–8.

Ashley, F.H., Watermen-Pearson, A.E., Whay, H.R., 2005. Behavioural assessment of pain in horses and donkeys: applications to clinical practice and future studies. Equine Vet. J. 37, 565–575. doi:10.2746/042516405775314826

Borod, J., Cicero, B., Obler, L., 1998. Right hemisphere emotional perception: Evidence across multiple channels. Neuropsychology 12, 446–458.

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. J. Vet. Intern. Med. 27, 22–30. doi:10.1111/jvim.12004

Costa, R.T., McCrae, R.R., 1985. The NEO personality inventory manual. Psychological Assessment Resources., Odessa, FL.

Field, A., 2009. Discovering Statistics using SPSS, Third. ed. SAGE Publications Ltd, London.

Fox, J., Wiesberg, S., 2011. An R Companion to Applied Regression.

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, 234–241. doi:http://dx.doi.org/10.1016/j.pain.2003.11.005

Guillot, M., Rialland, P., Nadeau, M.È., Del Castillo, J.R.E., Gauvin, D., Troncy, E., 2011. Pain Induced by a Minor Medical Procedure (Bone Marrow Aspiration) in Dogs: Comparison of Pain Scales in a Pilot Study. J. Vet. Intern. Med. 25, 1050–

1056. doi:10.1111/j.1939-1676.2011.00786.x

Harkins, S.W., Price, D.D., Braith, J., 1989. Effects of extraversion and neuroticism on experimental pain, clinical pain, and illness behavior. Pain 36, 209–218. doi:10.1016/0304-3959(89)90025-0

Hekman, J.P., Karas, A.Z., Dreschel, N.A., 2012. Salivary cortisol concentrations and behavior in a population of healthy dogs hospitalized for elective procedures. Appl. Anim. Behav. Sci. 141, 149–157. doi:10.1016/j.applanim.2012.08.007

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. Am. J. Vet. Res. 72, 601–607. doi:10.2460/ajvr.72.5.601

Ijichi, C., Collins, L.M., Creighton, E., Elwood, R.W., 2013. Harnessing the power of personality assessment: Subjective assessment predicts behaviour in horses. Behav. Processes 96, 47–52. doi:10.1016/j.beproc.2013.02.017

Ijichi, C., Collins, L.M., Elwood, R.W., 2014. Pain expression is linked to personality in horses. Appl. Anim. Behav. Sci. 152, 38–43. doi:10.1016/j.applanim.2013.12.007

Koenig, J., Gillie, B., Bernardi, A., Williams, D., Hillecke, T., Thayer, J., 2015. Neuroticism influences affective but not sensory ratings of experimentally induced pain. J. Pain 16, S16. doi:10.1016/j.jpain.2015.01.076

Koolhaas, J.M., Korte, S.M., De Boer, S.F., Van Der Vegt, B.J., Van Reenen, C.G., Hopster, H., De Jong, I.C., Ruis, M.A.W., Blokhuis, H.J., 1999. Coping styles in animals: current status in behavior and stress-physiology. Neurosci. Biobehav. Rev. 23, 925–935.

Ley, J.M., Bennett, P.C., Coleman, G.J., 2009a. A refinement and validation of the Monash Canine Personality Questionnaire (MCPQ). Appl. Anim. Behav. Sci. 116, 220–227.

Ley, J.M., McGreevy, P., Bennett, P.C., 2009b. Inter-rater and test–retest reliability of the Monash Canine Personality Questionnaire-Revised (MCPQ-R). Appl. Anim. Behav. Sci. 119, 85–90.

Nestor, P.G., Safer, M.A., 1990. A multi-method investigation of individual differences in hemisphericity. Cortex 26, 409–421. doi:10.1016/S0010-9452(13)80090-1

Paine, P., Kishor, J., Worthen, S.F., Gregory, L.J., Aziz, Q., 2009. Exploring relationships for visceral and somatic pain with autonomic control and personality. Pain 144, 236–244.

Pauli, P., Wiedemann, G., Nickola, M., 1999. Pain sensitivity, cerebral laterality, and negative affect. Pain 80, 359–364. doi:10.1016/S0304-3959(98)00231-0

R Development Core Team, 2017. R: A language and environment for statistical computing.

Raffe, M., Wright, M., McGrath, C., Crimi, A., 1980. Body Temperature changes during general anesthersia in the dog and cat. Vet. Anaesth. 7, 9–15.

Ramírez-Maestre, C., Martínez, A.E.L., Zarazaga, R.E., 2004. Personality Characteristics as Differential Variables of the Pain Experience. J. Behav. Med. 27, 147–165. doi:10.1023/B:JOBM.0000019849.21524.70

Reid, J., Nolan, A.M., Hughes, J.M.L., Lascelles, D., Pawson, P., Scott, E.M., 2007. Development of the short-form Glasgow Composite Measure Pain Scale (CMPS-SF) and derivation of an analgesic intervention score. Anim. Welf. 16, 97–104.

Reid, J., Scott, M., Nolan, A., Wiseman-Orr, L., 2013. Pain assessment in animals Importance of measuring animal pain. In Pract. 34. doi:10.1136/inp

Riemer, S., Assis, L., Pike, T.W., Mills, D.S., 2016. Dynamic changes in ear temperature in relation to separation distress in dogs. Physiol. Behav. 167, 86–91. doi:10.1016/j.physbeh.2016.09.002

Rietmann, T.R., Stuart, A.E.A., Bernasconi, P., Stauffacher, M., Auer, J.A., Weishaupt, M.A., 2004. Assessment of mental stress in warmblood horses: heart rate variability in comparison to heart rate and selected behavioural parameters. Appl. Anim. Behav. Sci. 88, 121–136.

Rutherford, K., 2002. Assessing pain in animals. Anim. Welf. 11, 31–53.

Soriano, J., Monsalve, V., Soriano, J., Monsalve, V., Gomez-Carretero, P., Ibanez, E., 2012. Vulnerable personality profile in patients with chronic pain: relationship with coping, quality of life and adaptation to disease. Int. J. Psychol. Res. 5, 42. doi:10.21500/20112084.748

Soriano Pastor, J.F., Monsalve Dolz, V., Ibáñez Guerra, E., Gómez Carretero, P., 2010. Personality and coping in neuropathic chronic pain: a predictable divorce. Psicothema 22, 537–42.

Starling, M.J., Branson, N., Thomson, P.C., McGreevy, P.D., 2013. “Boldness” in the domestic dog differs among breeds and breed groups. Behav. Processes 97, 53–62. doi:10.1016/j.beproc.2013.04.008

Stewart, M., Stafford, K.J., Dowling, S.K., Schaefer, A.L., Webster, J.R., 2008. Eye temperature and heart rate variability of calves disbudded with or without local anaesthetic. Physiol. Behav. 93, 789–797. doi:10.1016/j.physbeh.2007.11.044

Stewart, M., Webster, J.R., Schaefer, A.L., Cook, N.J., Scott, S.L., 2005. Infrared thermography as a non-invasive tool to study animal welfare. Anim. Welf. 14, 319–325.

Stewart, M., Webster, J.R., Verkerk, G.A., Schaefer, A.L., Colyn, J.J., Stafford, K.J., 2007. Non-invasive measurement of stress in dairy cows using infrared thermography. Physiol. Behav. 92, 520–525. doi:10.1016/j.physbeh.2007.04.034

Travain, T., Colombo, E.S., Heinzl, E., Bellucci, D., Prato Previde, E., Valsecchi, P., 2015. Hot dogs: Thermography in the assessment of stress in dogs (Canis familiaris)-A pilot study. J. Vet. Behav. Clin. Appl. Res. 10, 17–23. doi:10.1016/j.jveb.2014.11.003

Wagner, A.E., Worland, G.A., Glawe, J.C., Hellyer, P.W., 2008. Multicenter, randomized controlled trial of pain-related behaviors following routine neutering in dogs. J. Am. Vet. Med. Assoc. 233, 109–115. doi:10.2460/javma.233.1.109

Yarnell, K., Hall, C., Billett, E., 2013. An assessment of the aversive nature of an animal management procedure (clipping) using behavioral and physiological measures. Physiol. Behav. 118, 32–39. doi:10.1016/j.physbeh.2013.05.013