The association between infrared thermal imagery of core eye temperature, personality, age and housing in cats

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Abstract

Understanding individual responses to stress is a key aspect of maintaining optimal animal welfare. This is especially important where animals are being kept in sub-optimal environments or where the species may not clearly demonstrate stress. Therefore, the aim of this study was to investigate how stress varies in cats in a cattery environment in association with personality, age and housing. Stress was measured using Infrared Thermal Imaging (IRT) of core eye temperature and compared with scores from the Feline Temperament Profile (FTP), age and single or group housing (n=34). It was predicted that higher eye temperature would be inversely correlated with acceptable scores and directly correlated with questionable scores calculated from the FTP as these are suggested to indicate a stress sensitive cat. As predicted, eye temperature correlated significantly with acceptable FTP scores ($r_s = -0.377$, $p = 0.028$). Eye temperature was also higher in older cats ($r_s = 0.417$, $p = 0.014$) and those singly-housed compared with group housed ($U = 37$, $N1 = 12$, $N2 = 22$, $P = 0.001$). This provides preliminary evidence that personality may predict stress sensitivity in cats and that older and singly housed cats may find the cattery environment more aversive. These findings may improve adoption rates as unresolved stress can cause avoidance and aggressive behaviour, both of which are undesirable in companion animals. Further, they may increase adoption success rates if owners have more knowledge of the personality and likely stress sensitivity of the cat before adopting. In addition, educating owners that the cat they have adopted is stress sensitive will encourage greater vigilance and awareness of subtle indicators of stress, thus improving welfare.

Key Words: coping; feline; stress; temperament; thermography; welfare; personality

1. Introduction

Understanding stress is key to enable effective management and improvement of the welfare of animals in our care. There are many potential challenges that cause stress such as artificial lighting, loud noises, arousing odours, uncomfortable temperatures, confined spaces, restricted movement, and forced proximity to humans and other animals (Morgan and Tromborg 2007). However, an individual's response to such stressors can also be affected by individual differences such as personality, and how well the individual copes within its environment (Biro and Stamps, 2008; Koski, 2011). Personality can have implications on the behaviour and coping ability of an animal (Ijichi et al., 2013a, 2013b) and tolerance to pain (Ijichi et al., 2014). It has also been shown that different personality coping styles correlate with different physiological responses as well as health implications such as immunodeficiency (Koolhaas, 2008; Koolhaas et al., 1999). Therefore, it is crucial that methods of welfare assessment take accurate indicators of the welfare state of the individual whilst taking into consideration individual personality.

The welfare of domestic cats is an area of concern for several reasons. First, estimates of numbers of household cats suggest 26% of households have a cat accounting for approximately 10,332,955 individuals in the UK (Murray et al., 2010) without considering feral populations. Therefore, if welfare is not measured accurately in this species, there is the potential for a large number of individuals to suffer. Second, it is suggested that accurate stress assessment in cats is difficult using behavioural indicators (Morgan and Tromborg, 2007; Ottway and Hawkins, 2003). Many cats will display hiding behaviours instead of vocalisations when confronted with a stressful situation (Nibblett, Ketzis and Grigg, 2015). Finally, there are a large number of shelter centres which function to re-home and house unwanted animals. This environment may cause stress, especially for feral or older individuals who may be less flexible in response to this environmental change. Stress is associated with avoidance and aggressive behaviour (Amat, Camps and Manteca, 2015; Siegford et al., 2003) which are considered undesirable to potential new owners. This may impact on adoption rates if this behaviour is not resolved. This may result in long term housing of unwanted animals and potentially euthanisation. Therefore, accurate identification of stress sensitive individuals that may

not cope adequately with sub-optimal environments is crucial for the welfare of a large number of individuals. Feline personality assessment may play an important role in this.

The Feline Temperament Profile (FTP) is a non-invasive objective questionnaire based approach to categorise the temperament of cats based on how they react to human actions (Lee et al, 1983). The FTP has been validated as a measure of temperament in regards to responses to human presence and it has been proposed to relate to stress sensitivity by Siegford et al (2003). In addition, this study indicated that the test is stable across time and, importantly, before and after adoption has taken place. However, previous studies were not able to validate this method against salivary cortisol levels (Iki et al., 2011; Siegford et al., 2003). This may be because accurate measurements of cortisol are notably difficult as levels may be rapidly metabolized (Schatz and Palme, 2001). Therefore, the current study will compare FTP scores with Infrared thermography.

Infrared thermography is an alternative non-invasive stress assessment method (Stewart et al., 2005). Stress causes an increase in core body temperature (Bouwknecht et al., 2007; Ogata et al., 2006) and eye temperature reliably correlates with the core body temperature taken from the rectum (Cook et al., 2001; Johnson et al., 2011; Ogata et al., 2006). Travain et al (2015) measured dog eye and rectal temperature before, during and after a veterinarian visit. Both measurements were consistently similar when the core body temperature rose during the clinical examination, indicating a stress response (Bouwknecht et al., 2007) . Several studies have also specifically assessed an area of the eye called the lacrimal caruncle which is the hottest point of the eye and most representative of the core body temperature (Stewart et al., 2008, 2005; Valera et al., 2012).

The current study aims to assess the FTP as a method of predicting stress sensitivity in cats as measured by thermal imagery. To do this, core eye temperature, as measured from the lacrimal caruncle, was compared against acceptable and questionable scores from the FTP in an applied cattery setting. It is hypothesised that individuals scoring low on acceptable and high on questionable traits will have higher eye temperatures as both are expected to indicate stress levels. As a secondary aim, the welfare states of cats housed singly or in groups will be explored as well as variation across ages. This was to determine the possible impact of these facts on tolerance to a cattery environment.

2. Materials & Methods

2.1 Animals and Housing

The research was carried out at three separate cat rehoming centres on thirty-four cats using opportunistic sampling. The centres were located in Newbury, West Berkshire, England (n=12); Newent, Gloucestershire, England (n=18); and Great Shefford, West Berkshire, England (n=4). All cats were neutered, mixed breed (domestic short and long haired) and ranged in age from six months to fifteen years old (mean = 6.10 ± 4.69). All cats studied has been in the centres at least two days to allow them to habituate to their surroundings (Skånberg, 2014).

The Newbury site consisted of individual cat pens which were all equally sized at 1x2m. The exception to this was one pair grouping. The pens consisted of a ground level and a higher shelf cabin unit with a ramp. All pens are laid out the same in terms of bedding, litter tray, toys and water bowl.

The Newent site had four main pens which consisted of two groups of four and two group of five cats. Pens were 2x4m in size and had an inner section with a cat flap that led to the bigger roaming section. The inner section had one litter tray and beds for the cats on shelves. The outer section had more litter trays, toys, water bowls and a chair.

Great Shefford used three slightly different rooms containing four cats. Two rooms were similar and laid out to resemble a living room with a sofa, television, blankets, litter tray and food area. These were $4m^2$ in size. The room with the two cats was $5m^2$ and had an extra chair and double the litter trays and cat beds. All rooms also had a number of toys.

The authors have read policy relating to animal ethics and can confirm that methods used for the purpose of this study comply. Permission was also obtained from the college ethics committee and written informed consent was recorded from each shelter participating in the study.

2.2 Study Design

Observations occurred in the cat's home pens in the morning after subjects had been fed and routine cleaning was complete. After cleaning finished, fifteen minutes were allowed for the cats to settle into their pens (Ellis et al., 2014). Data was collected on days where the sanctuaries were closed to the public, to avoid the confounding effects of multiple people in close proximity to the pens.

Temperament was measured using Lee et al, (1983) Feline Temperament Profile (FTP) which is an objective questionnaire approach to categorise cats based on how well they react to human actions. This test has been validated as an acceptable measure of temperament in cats (Siegford et al 2003). The temperament profile was carried out noting acceptable and questionable responses to each of the ten situations which were totalled to give the number of questionable and acceptable responses. Since the feline temperament profile is objective, the person performing it did not need to already know the cats. The assessor (SF) was not familiar to any of the subjects.

Thermographic measurements measured temperature (^{o}C) in the lacrimal caruncle of each eye (Figure 1), since this has been shown to represent the core body temperature in dogs (Travain et al., 2015). Temperature was recorded using a portable infrared thermal imaging camera (FLIR E5 Compact Thermal Imaging Camera, USA, FLIR™). This device uses electronic stabilization circuitry to maintain calibration as temperature varies and has a resolution of $<0.15\,^{o}$C. Images were captured from directly in front of the focal subject and at a distance of approximately 1m where possible within the pen constraints (Figure 1). As subjects were free within the pen and had individual differences in responses to the presence of the assessor it was not possible to precisely control either angle or distance of image for all subjects.

Thermal image readings took place at three intervals and took measurements of both left and right eyes which were then averaged each time. The first reading occurred when the cat was neutral in its pen immediately before the tester had conducted the FTP. The second took place straight after the FTP profiling and the third reading occurred an hour after the first, when the cat had time to return to its neutral state. These measurements were repeated for each cat and were designed to ensure the

assessor entered the pen the minimum number of times to reduce any disturbance this may have caused the subjects.

Regarding the cats in group housing, it was important not to test cats in the same pen consecutively since they could habituate to the tester's presence. Therefore, in the Newent centre, no more than one cat was tested in each pen at a time. The experimenter returned to pens containing a previously tested cat after approximately sixty minutes. All measurements were carried out within one day at each centre with all the available healthy animals. A random number generator (The Random Number Generator, Apple App Store) was used to pick the order of the cats studied to prevent a biased testing order (Martin and Bateson, 2007).

2.3 Statistical Analysis

Data was analysed using the programme IBM SPSS Statistics 22. A Kolmogorov-Smirnov test was used to assess if variables had a normal distribution. As data was not normally distributed, non-parametric tests were used to test for correlations. Spearman's rank correlations were used to test for correlations between core eye temperature, FTP scores, and age. A Mann-Whitney U test was used to test for differences in core eye temperature and FTP scores across the housing categories. A p-value less than 0.05 was considered significant.

3. Results

Spearman's rank correlation showed a significant negative correlation existed between acceptable and questionable FTP scores (r_s= -0.825, N =34, $p < 0.000$). Spearman's rank correlation showed a significant negative correlation between eye temperature and acceptable FTP scores (r_s = -0.377, N =34, p = 0.028; Figure 1). There was no significant correlation between eye temperature and questionable scores (r_s = 0.324, N =34, p = 0.061; Figure 2).

Spearman's rank correlation revealed a significant positive correlation between eye temperature and age (r_s = 0.417, N =34, p = 0.014). Spearman's rank correlation revealed no significant difference

between age and either acceptable FTP scores (r_s = -0.223, N = 34, p = 0.205) or questionable FTP Scores (r_s = 0.204, N = 34, p = 0.248).

Mann-Whitney U test revealed a significant difference between average eye temperature in single-housed and group-housed cats (U = 37, N_1 = 12, N_2 = 22, P = 0.001). Single housed cats had higher eye temperature (mean = 25.42) than group housed cats (mean= 13.18). Mann-Whitney U test revealed no significant difference between single and group-housed cats for either acceptable (U=125.5, N_1 = 12, N_2 = 22, P = 0.828) or Questionable scores (U=153, N_1 = 12, N_2 = 22, P = 0.453).

4. Discussion

The current study aimed to assess the Feline Temperament Profile as a predictor of stress sensitivity in cats. Eye temperature readings were compared to a validated Feline Temperament Profile (FTP) which had previously been shown to accurately predict behavioural indicators of temperament in cats (Lee et al., 1983; Siegford et al., 2003). Using eye temperature readings, results suggest that this FTP may be a valid predictor of stress sensitivity in cats. In addition, it was noted that stress levels differ in relation to age and housing factors.

In the current study, there was a significant negative correlation between eye temperature and acceptable FTP scores. Thus the FTP accurately predicted those individuals showing increased stress responses in a cattery environment. In a cat rehoming environment, individuals are affected by stress differently and it is important to put management strategies in place to improve the welfare of these cats (Gourkow and Fraser, 2006). The ability to accurately predict and understand individual differences in stress sensitivity and response may allow us to understand responses to pain and sub-optimal welfare conditions (Ijichi et al., 2013b; Ijichi et al., 2013; Koolhaas et al., 2010). If used in cat rehoming centres, the FTP may indicate which cats could need intervention such as environmental enrichment or the use of pheromones (Amat, Camps and Manteca, 2015) to reduce their stress levels (Vainionpää et al., 2013).

Improved welfare can also have an indirect benefit in rescue facilities by increasing the chances of adoption. Stress can cause avoidance behaviour such as hiding but can also result in aggressive behaviour (Amat, Camps and Manteca, 2015; Siegford et al., 2003) both of which are undesirable traits in a companion animals. In addition, studies have shown that barren environments with less active cats have lower adoptions levels (Gourkow and Fraser, 2006). Owners often look for cats with traits such as playful, relaxed and 'happy' to adopt and these behaviours are displayed more frequently in enriched environments (Blackshaw, 2001). Therefore, improving welfare of stress sensitive cats will likely have a positive effect on rehoming rates.

Whilst measures of stress such as IRT can be used regularly to assess fluctuations in stress levels, the FTP can predict reliable and consistent long term personality traits associated with stress responses. It could therefore increase adoption success rates if owners have more knowledge of the personality and likely stress level of the cat before adopting (Siegford et al., 2003). In addition, as cats may not show clear behavioural indicators of stress, (Morgan and Tromborg, 2007; Ottway and Hawkins, 2003), educating owners that the cat they have adopted is stress sensitive will encourage greater vigilance and awareness of subtle indicators. This could be paired with basic education on behavioural indicators that should be considered as indicators of potential stress.

Whilst the FTP may be of use in predicting long-term stress sensitivity, it is not appropriate for measuring fluctuations in stress or response to potentially stressful contexts. For example, whilst FTP scores did not differ with age, eye temperature showed a significant positive correlation with age which suggests that older cats may be more stressed in rehoming centres. FTP scores would not be expected to change with age as personality is relatively stable across time (Koolhaas et al., 1999). IRT readings may be explained because as cats age they may be less tolerant to stress and change such as being relinquished and the presence of irregular handlers (Gourkow and Fraser, 2006). Loud noises and high activity around them may cause more stress in older cats (Gunn-Moore, 2006). Increased stress may also be due to older cats spending longer in rehoming centres (Gouveia, Magalhaes and de Sousa, 2011).

In addition, it was noted that eye temperature differed significantly between single and group housing but again this was not reflected in FTP scores. This is expected as personality is also stable across contexts (Koolhaas et al., 1999) and so a measure of personality should not be affected by differing contexts. Here, cats that were singly housed showed significantly higher eye temperatures than those that were in group housing. This contradicts findings that indicate domestic cats seem to prefer solitary living (Ottway and Hawkins, 2003) and that cats will actively plan their activity budgets to avoid other cats (Crowell-Davis, 2007). Group housing in rehoming centres forces cats into unnatural social arrangements which, under free choice paradigms, would take time to slowly establish (Crowell-Davis, 2007). However, Gourkow and Fraser (2006) used the Cat-Stress-Score developed by Kessler and Turner (1997) and found reduced stress levels in social groups compared to singly housed cats. Kessler and Turner (1999) also found that after a period of two weeks stress levels decreased in groups that were non-changing. Furthermore, cats that are either related or have spent time together previously to group housing do show more signs of affiliative behaviour (Bradshaw and Hall, 1999). A limitation of the current study is that only six groups of multiple housed cats were available and may not be a valid representation of group cat behaviour. In addition, four groups were from a single sanctuary and it is possible that a confounding factor present at this site reduced stress more than group housing per se. Therefore, a longitudinal study of stress levels from initial grouping through to long-term, established groups in a larger sample population may be worthwhile.

5. Conclusion

The current study compared a validated feline temperament profile with thermal imagery to assess stress levels of cats in a rehoming centre. Eye temperature was higher in cats with low acceptable FTP scores, suggesting that these personality types might be more sensitive to stress. This study provides preliminary data indicating that the Feline Temperament Profile is a valid, non-invasive and cost effective means of predicting stress sensitivity in cats in real-world scenarios. FTP would be a simple, non-invasive procedure that can be used in rehoming centres to improve the welfare of cats. In addition, older cats, and singly housed cats, had significantly higher eye temperature readings,

suggesting they may be more stressed. These findings indicate that older cats and those in single housing may need more consideration in terms of welfare.

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Authorship

The idea for the paper was conceived by CI; The study was designed by CI & SF; Data was collected by SF; Data was analysed by SF & CI; The paper was written by SF & CI.

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