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Published in:

Applied Animal Behaviour Science

Publication date:

2017

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[10.1016/j.applanim.2017.01.004](https://doi.org/10.1016/j.applanim.2017.01.004)

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Citation for published version (APA):

Foster, S., & Ijichi, C. (2017). The association between infrared thermal imagery of core eye temperature, personality, age and housing in cats. *Applied Animal Behaviour Science*, 189, 79-84.
<https://doi.org/10.1016/j.applanim.2017.01.004>

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

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13 **The final version of this article was published in Applied Animal Behaviour Science and can be**
14 **accessed at <https://doi.org/10.1016/j.applanim.2017.01.004>**

15 **Abstract**

16 Understanding individual responses to stress is a key aspect of maintaining optimal animal welfare.
17 This is especially important where animals are being kept in sub-optimal environments or where the
18 species may not clearly demonstrate stress. Therefore, the aim of this study was to investigate how
19 stress varies in cats in a cattery environment in association with personality, age and housing. Stress
20 was measured using Infrared Thermal Imaging (IRT) of core eye temperature and compared with
21 scores from the Feline Temperament Profile (FTP), age and single or group housing (n=34). It was
22 predicted that higher eye temperature would be inversely correlated with acceptable scores and
23 directly correlated with questionable scores calculated from the FTP as these are suggested to indicate
24 a stress sensitive cat. As predicted, eye temperature correlated significantly with acceptable FTP
25 scores ($r_s = -0.377$, $p = 0.028$). Eye temperature was also higher in older cats ($r_s = 0.417$, $p = 0.014$)
26 and those singly-housed compared with group housed ($U = 37$, $N_1 = 12$, $N_2 = 22$, $P = 0.001$). This
27 provides preliminary evidence that personality may predict stress sensitivity in cats and that older and
28 singly housed cats may find the cattery environment more aversive. These findings may improve
29 adoption rates as unresolved stress can cause avoidance and aggressive behaviour, both of which are
30 undesirable in companion animals. Further, they may increase adoption success rates if owners have
31 more knowledge of the personality and likely stress sensitivity of the cat before adopting. In addition,
32 educating owners that the cat they have adopted is stress sensitive will encourage greater vigilance
33 and awareness of subtle indicators of stress, thus improving welfare.

34

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

36 1. Introduction

37 Understanding stress is key to enable effective management and improvement of the welfare of
38 animals in our care. There are many potential challenges that cause stress such as artificial lighting,
39 loud noises, arousing odours, uncomfortable temperatures, confined spaces, restricted movement, and
40 forced proximity to humans and other animals (Morgan and Tromborg 2007). However, an
41 individual's response to such stressors can also be affected by individual differences such as
42 personality, and how well the individual copes within its environment (Biro and Stamps, 2008; Koski,
43 2011). Personality can have implications on the behaviour and coping ability of an animal (Ijichi et
44 al., 2013a, 2013b) and tolerance to pain (Ijichi et al., 2014). It has also been shown that different
45 personality coping styles correlate with different physiological responses as well as health
46 implications such as immunodeficiency (Koolhaas, 2008; Koolhaas et al., 1999). Therefore, it is
47 crucial that methods of welfare assessment take accurate indicators of the welfare state of the
48 individual whilst taking into consideration individual personality.

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

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

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

74 Infrared thermography is an alternative non-invasive stress assessment method (Stewart et al., 2005).
75 Stress causes an increase in core body temperature (Bouwknicht et al., 2007; Ogata et al., 2006) and
76 eye temperature reliably correlates with the core body temperature taken from the rectum (Cook et al.,
77 2001; Johnson et al., 2011; Ogata et al., 2006). Travain et al (2015) measured dog eye and rectal
78 temperature before, during and after a veterinarian visit. Both measurements were consistently similar
79 when the core body temperature rose during the clinical examination, indicating a stress response
80 (Bouwknicht et al., 2007) . Several studies have also specifically assessed an area of the eye called
81 the lacrimal caruncle which is the hottest point of the eye and most representative of the core body
82 temperature (Stewart et al., 2008, 2005; Valera et al., 2012).

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

90 **2. Materials & Methods**

91 *2.1 Animals and Housing*

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

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

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

105 Great Shefford used three slightly different rooms containing four cats. Two rooms were similar and
106 laid out to resemble a living room with a sofa, television, blankets, litter tray and food area. These
107 were 4m² in size. The room with the two cats was 5m² and had an extra chair and double the litter
108 trays and cat beds. All rooms also had a number of toys.

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

112

113

114 *2.2 Study Design*

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

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

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

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

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

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

149 *2.3 Statistical Analysis*

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

156

157 **3. Results**

158 Spearman's rank correlation showed a significant negative correlation existed between acceptable and
159 questionable FTP scores ($r_s = -0.825$, $N = 34$, $p < 0.000$). Spearman's rank correlation showed a
160 significant negative correlation between eye temperature and acceptable FTP scores ($r_s = -0.377$, N
161 $= 34$, $p = 0.028$; Figure 1). There was no significant correlation between eye temperature and
162 questionable scores ($r_s = 0.324$, $N = 34$, $p = 0.061$; Figure 2).

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

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

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

172

173 **4. Discussion**

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

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

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

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

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

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

234

235 **5. Conclusion**

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

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

245 **6. Acknowledgments**

246 We would like to thank the animal centres Newbury Cats Protection, New Start Cat Rescue
247 Gloucester and National Animal Welfare Trust Berkshire for providing the subjects for this study.

248 **Authorship**

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

251

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