The Old School, Brewhouse Hill, Wheathampstead,
Hertfordshire AL4 8AN, UK
www.ufaw.org.uk

Animal Welfare 2021, 30: 431-440
ISSN 0962-7286
doi: 10.7120/09627286.30.4.006

The effect of animal shelter sound on cat behaviour and welfare

BH Eagan*†, E Gordon‡ and D Fraser†

† Animal Welfare Program, Faculty of Land and Food Systems, University of British Columbia, 2357 Main Mall, Vancouver BC V6T 1Z4, Canada
‡ British Columbia Society for the Prevention of Cruelty to Animals, 1245 East 7th Avenue, Vancouver BC V5T 1R1, Canada
* Contact for correspondence: Baileyhe@mail.ubc.ca

Abstract

*This study assessed how sound affected fear- and maintenance-related behaviour in singly housed cats (*Felis silvestris catus*) in an animal shelter. Two daily 30-min observation sessions (morning and evening) were made for 98 cats from admittance for ten days or until the cat was removed. Cat behaviour and presence of sound (classified by the source) were recorded by instantaneous and one-zero sampling with 15-s intervals. Each 30-min observation session was classified as 'quiet' or 'noisy' if the one-zero score for presence of sound was above or below the median of sessions at that time of day. To ensure that cats had at least two complete days of comparable observations, statistical analysis was restricted to the 70 cats (30 females, 40 males) present for two or more weekdays. Cats varied widely in the amount of fear and maintenance behaviour they performed. Males showed less fear and maintenance behaviour than females. Morning sessions consistently had much more sound than evenings, and cats showed more fear behaviour and less maintenance behaviour in the mornings. Cats showed more fear behaviour in noisy morning sessions than quiet ones, with no comparable difference in maintenance behaviour. Where sessions included a pronounced transition in sound, fear-related behaviour was more common after a transition from quiet to noisy and less common after a transition from noisy to quiet. The results show that shelter cats vary greatly in their responses and suggest that sound in shelter environments can substantially affect their behaviour. Lowering sound levels in shelters may help improve cat welfare.*

Keywords: *animal welfare, cat, fear, noise, shelter, stress*

Introduction

Admittance into an animal shelter can be a stressful experience for cats (*Felis silvestris catus*) since they are sensitive to environmental changes (Wagner *et al* 2018a). Chronic stress in shelters can lead to severe health consequences, such as upper respiratory infection (Dinnage *et al* 2009), plus behavioural changes, such as fearfulness toward humans that may reduce adoptability and increase the risk of euthanasia (Gourkow & Fraser 2006; Dybdall *et al* 2007; Fantuzzi *et al* 2010). Hence, recognising and minimising negative experiences by cats in shelters is an ongoing challenge for shelter management.

A cat's posture and behaviour appear to offer indicators as to how it is coping with stressors (Kessler & Turner 1999; McCune 1994; Rochlitz *et al* 1998). As noted by Stanton *et al* (2015), behaviours classified in categories such as affiliative, maintenance, agonistic, avoidant, vigilant or fear can offer an insight into a cat's affective state.

One behaviour linked to fear by Stanton *et al* (2015) is hiding which is often seen in presumably fear-inducing situations, such as veterinary hospitals, laboratory settings, and shelters (Carlstead *et al* 1993; Gourkow & Fraser 2006). Hiding appears to decrease cat stress in shelters (Kry & Casey 2007), has been demonstrated to correlate with higher cortisol-to-creatinine ratios (Rochlitz *et al* 1998), and been used as a measure of stress in shelters (Stella *et al* 2014). When not provided the opportunity to hide, cats have been observed to create a hiding place by turning litter-boxes upside down (Gourkow & Fraser 2006; Vinke *et al* 2014) or hiding under towels (Hirsch 2011).

Other fear-related behaviours detailed by Stanton *et al* (2015) are also observed in situations likely to cause fear and stress. Holding the ears back and/or flat has been observed during a mock veterinary exam (Moody *et al* 2018); cats sometimes freeze when exposed to an unfamiliar dog (Tsyrlin *et al* 1983); and Carlstead *et al* (1993) found that when cats were presented with an irregular caretaking routine and manipulations, they spent more time alert or hiding and less time playing. Upon stimulation of the amygdala, a range of behavioural responses of cats have been observed including hissing, fixed staring, flattened ears and flight (de Molina & Hunsperger 1959). Further, Ursin and Kaada (1960) observed an alert response from cats followed by cowering and ultimately flight and hiding upon amygdala stimulation.

Behaviours that do not address a near-term need or threat (eg behaviours like playing and grooming) have been proposed as indicators of positive affect (Fraser & Duncan 1998). Consistent with this view, Carlstead *et al* (1993) and Gourkow *et al* (2014a) found that behaviours likely indicative of a positive affective state, such as play, grooming and feeding, are often negatively correlated with fear behaviours. Behaviours classified as 'maintenance' or 'affiliative' were also used as evidence of a positive affective state by Stella *et al* (2014). While most cat welfare research focuses on behaviours that indicate negative affective states, a more comprehensive approach would include indicators thought to reflect positive affect (Fraser & Duncan 1998; Boissy *et al* 2007; Mellor & Beausoleil 2015).

Shelter environments often involve high levels of noise in a wide range of frequencies (Morgan & Tromborg 2007). Noise can lead to adverse changes in behaviour and physiology, and even hearing damage (Spreng 2000; Coppola *et al* 2006; Scheifele *et al* 2012; Fullagar *et al* 2015). Cats are significantly more sensitive to sounds than humans, and have one of the broadest known hearing ranges among mammals, extending from 48 Hz to 85 kHz (at 60 dB sound pressure level) (Heffner & Heffner 2007). While the range of audible frequencies at various dB levels has not been extensively tested in cats, cats do have a very broad range of 'good hearing', as indicated by their ability to detect a wide range of frequencies even at a low 10 dB sound pressure level (Heffner & Heffner 2007). Based on human hearing, a noise over 70 dB is considered 'loud' (Baker 1998). Damage can be caused to hearing with prolonged exposure to 70 dB sounds or immediately with exposure to sounds above 120 dB (Centres for Disease Control and Prevention [CDC] 2019). While the impact of precise dB level on shelter animal welfare is not known, there is some evidence of negative effects. For example, sound over 73 dB results in a stress response in rats (*Rattus norvegicus*) (Baldwin *et al* 2007); dogs (*Canis familiaris*) in kennels exposed to sounds of 100–108 dB over six months demonstrated a decline in hearing ability (Scheifele *et al* 2012); and sound in the 50–70 dB range is considered detrimental to the hearing of rodents and rabbits (*Oryctolagus cuniculus*) (Canadian Council on Animal Care [CCAC] 1993).

Sound in shelters, kennels, and veterinary intensive care units regularly exceeds 100 dB (Sales *et al* 1997; Coppola *et al* 2006; Scheifele *et al* 2012; Stella & Croney 2016), often corresponding to caretaker activity, such as cleaning (Morgan & Tromborg 2007), plus dog barking (Sales *et al* 1997) and factors such as ventilation, gating of kennels, and reverberation of materials used in a shelter environment (Wagner *et al* 2018b). Such levels of sound contrast with sound levels in natural environments, such as in savannah habitats where noise levels range from 20 to 36 dB (Morgan & Tromborg 2007), and may be problematic for cat welfare.

There is little policy and limited research on controlling sound levels in shelters for the benefit of the animals. Attard *et al* (2013; p 11) state that "maintaining an appropriate acoustic environment is essential for good animal health and welfare", and Stella and Croney (2016; p 3) note that "it is likely that reducing noise levels and maintaining sound intensity around 60 dB (quiet conversational level) may be beneficial to cats." Other studies also suggest that noise is a likely contributor to stress and warrants further investigation (McCobb *et al* 2005; Stella *et al* 2014).

This study aimed to understand how shelter cats differing in age, source, sex, health status, and time in the shelter express fear- and maintenance-related behaviour during louder and quieter times, and what sources of sound are commonly present.

Materials and methods

Study animals and housing

This study received ethical approval from the University of British Columbia's Animal Care Committee (A17-0336) and was conducted in the British Columbia Society for the Prevention of Cruelty to Animals (BC SPCA) Vancouver shelter between March and July 2018 in a high-traffic room housing cats. The 12 stainless steel cat enclosures in the room were arranged into three tiers. Eight of these enclosures were triple-compartment enclosures measuring 1.5 × 0.7 × 0.6 m (length × width × height); one of these was used for each cat in the study. Each enclosure consisted of a BC SPCA Hide, Perch & Go™ box (British Columbia Society for the Prevention of Cruelty to Animals, Vancouver, BC, Canada), a litter-box, food, water and a bed. Enclosure configuration remained mostly consistent between cats except that provision of toys varied between individuals, and staff occasionally draped a pillowcase over the front of one section of the enclosure to allow a degree of concealment.

The shelter schedule followed a consistent daily routine. At 0700h shelter staff conducted welfare checks of all animals in care, began shelter and enclosure cleaning, and provided food, water and medications where applicable. The shelter was open to the public for adoptions daily (excluding statutory holidays) during 1200–1700h on Monday to Friday and 1200–1600h on Saturday and Sunday. After the shelter was closed to the public at the end of day, volunteers would frequently interact with cats before the shelter closed at 1900h on weekdays or 1800h on weekends.

The study involved 98 singly housed cats (40 females, 58 males) that had been previously spayed or neutered. Based on age estimated by staff, the cats were classified as 24 young adults (1–3 years), 66 adults (4–7 years), and eight seniors (8+ years). As per standard BC SPCA protocol, each cat received a complete physical examination conducted by trained shelter staff, at which time all source and health information were collected. Cats entering the shelter were classified by their origin as stray (n = 44), owner-surrendered (n = 42), returned (n = 10), or brought by a Humane Officer (n = 2). Health status of each cat was classified by assigning an Asilomar Accords and Adoptability Guidelines category (Armstrong *et al* 2004; Gordon 2016) (an in-shelter evaluation matrix based on health and behaviour of animals on intake for data collection and reporting purposes). Study cats were clas-

https://doi.org/10.7120/09627286.30.4.006 Published online by Cambridge University Press

Table 1 The ethogram used for this study, adapted from the Standardised Ethogram for Felidae (Stanton *et al* 2015).

Behaviour category	Behaviour	Definition
Fear	Hide (or attempt to hide)	Part or all of the cat is behind or under something in the cage. Locations classified as 'hide' include in the hide-box, behind the hide-box, under the bed and behind the litter-box
	Crouch	Cat is alert with the body close to the floor, all four legs bent, and the belly touching or raised slightly above the floor
	Ears back	Ears are held at the rear of the head
	Ears flat	Ears are flattened to its head so they tend to lie flush with the top of the head
	Alert	Cat is vigilant and attentive to surroundings, with eyes open, ears forward, mouth closed or slightly open, and head up. Cat's eyes may be focused in a specific direction, or scanning the area accompanied by head and possibly ear movement
	Freeze	Cat suddenly becomes immobile with body tensed
Maintenance, affiliative and/or calm	Groom	Cat cleans itself by licking, scratching, biting or chewing its fur. May also include licking a front paw and wiping it over the head
	Play	Cat interacts with something in a playful manner
	Stretch	Cat extends its forelegs while curving its back inwards
	Urinate	Cat releases urine while in a squatting position
	Defaecate	Cat releases faeces while in a squatting position
	Eat	Cat ingests, chews and swallows food
	Drink	Cat ingests water by lapping with the tongue
	Scratch	Cat scratches its body using hind-feet claws
	Yawn	Cat opens its mouth widely while inhaling, then closes mouth while exhaling deeply

sified as healthy (n = 36), treatable-rehabilitatable (n = 54), or treatable-manageable (n = 8) (Gordon 2016). After admission to the shelter, cats were assigned unsystematically by staff to any available enclosure in the cat adoption room.

Behavioural observations and records of sounds

Cats' behaviour was observed daily from admittance for ten days or until the cat was removed because it was adopted, transferred, redeemed or euthanased (the four possible 'outcomes'). The first study day was defined as the first complete day after admittance. At the time when cats were removed from the study, the outcome was noted, and the number of days in the shelter was recorded.

Behavioural observations consisted of a twice daily 30-min observation session: AM (1000–1030h on weekdays or 0730–0800h on weekends) and PM (2000–2030h on weekdays or 1900–1930h on weekends). Timing of observations was scheduled around the shelter routine to allow a session unaffected by other in-room activity, such as cleaning, feeding and interaction with cats. Hence, the weekday AM session was timed to coincide with the daily staff meeting immediately after morning cleaning, but as there were no uninterrupted sessions on weekends, weekend AM sessions were conducted earlier in the day.

Behaviour was recorded by both one-zero and instantaneous methods (Martin & Bateson 2007) with 15-s intervals. In each 30-min recording, the observer observed the cat in the upper left cage for 15 s, then the cat in the upper right, and then the others to a maximum of six cats, always in the same order, giving 300 s of recording for each cat in each 30-min session. If there were fewer than six cats available, the observer simply paused for the corresponding 15 s so that the timing remained consistent. Cats were recorded daily until they were removed from the study room due to standard shelter operations; therefore, the number of observation sessions per cat varied (median [M] = 5, interquartile range [IQR] = 7). The same observer recorded all cats for all sessions.

In each observation session, cat body positions and location in the enclosure were recorded by instantaneous sampling at the beginning of the 15-s interval, and any behavioural events occurring in the 15-s interval were recorded by one-zero sampling (a method of sampling that records whether a behaviour occurred within a defined interval; Martin & Bateson 2007). The ethogram used for this study (Table 1) was based on the Standardised Ethogram for Felidae of Stanton *et al* (2015). 'Fear behaviours' included hide, crouch, ears back or flat, alert, and startle. Eat, drink, defaecate, urinate, groom, stretch, and scratch were classified as 'maintenance behaviours', and for convenience this category also included play, yawn and knead. Thus, 'maintenance behaviour' included behaviours from the maintenance, calm, and affiliative categories of Stanton *et al* (2015).

Behaviour was recorded in person by the investigator standing 2.5 m from the enclosures with a 1.5-m high, two-sided, foam-core barrier between the observer and the cats. Before beginning the behavioural observations, the investigator stood silently for 5 min to allow cats to adjust to human presence, apart from a few occasions (fewer than 5% of sessions) when the shelter schedule prevented this.

In addition to the behavioural observations, codes were also used to record distinct sounds, if any, that were present during each 15-s interval. Sounds were classified as dog barking, human voices, distinct outdoor traffic sounds, cat movement sounds, small animal sounds, and the remainder were classed as shelter operational sounds. By watching a SPLnFFT Sound Meter iOS app (determined to have high accuracy for measurement of true noise levels by Murphy & King 2016) situated on a table in front of the observer, it became clear that an increase in intensity of 15 dB, above the 45–50 dB of ambient sound that was always present, signalled a subjectively distinct sound. Hence, the observer confirmed an increase of about 15 dB in the rare cases where there was any doubt over whether to record a sound as present. With this criterion, faint sounds such as a car passing quietly outside were not included.

Inter-observer reliability was assessed by having a second observer, who was trained on behavioural and sound measurements but naïve to the purpose of the study, simultaneously record behaviour and sound alongside the primary investigator for a total of 22 individual cats over seven observation sessions. As these sessions were spread over the duration of the study, different cats were recorded during each of the seven different sessions.

Statistical analysis

Weekend observations were not strictly comparable to weekday observations because operational requirements caused them to be carried out at different times of the day. Therefore, the analysis was restricted to weekday records. In addition, observations on some cats were very limited because the animals were adopted or transferred after very little time in the shelter. To ensure that every cat had at least two complete days of comparable observations, all statistical analysis (unless otherwise specified) was restricted to weekday recordings for the 70 cats that were present for two or more weekdays (called the 'analysis sample'). SAS Studio 3.8 was used for all statistical analyses.

For each of the 70 cats, a 'fear score' and a 'maintenance score' were calculated for each 30-min observation session. These were the number of 15-s observation intervals in the 30-min session in which fear and/or maintenance behaviours (defined above) were observed. A 'sound score' was determined for each observation session by calculating the number of 15-s intervals when sound was scored as present as detailed above.

Shapiro Wilk tests and Q-Q plots were used to assess normality of the fear and maintenance scores (n = 70). As the scores showed very pronounced non-normality that could not be resolved through transformations, non-parametric tests were used for all analysis. The non-parametric Wilcoxon signed-rank test was used to assess differences between AM and PM observations in fear scores and in maintenance scores (n = 70). A non-parametric Mann-Whitney *U* test was used to assess differences between the 40 male and 30 female cats in fear scores and in maintenance scores. Non-parametric Kruskal-Wallis tests were used to assess differences in fear and maintenance scores between different sources, between age groups, and between Asilomar Accords categories (n = 70).

To assess how fear and maintenance behaviours were related to each other, a mean fear score and a mean maintenance score were calculated for each cat based on its AM weekday observations (because of the limited expression of fear behaviour in the PM sessions). To express the relationship between fear and maintenance scores, a Spearman rank correlation (n = 70) was calculated between the mean fear and mean maintenance score of each cat.

To test the relationship between sound level and behaviour, each AM session was classified as 'quiet' if the sound score for that session was below the median of all AM sessions, or 'noisy' if above the median. The analysis was restricted to AM sessions as PM sessions were more uniformly quiet. The Wilcoxon signed-rank test was used to assess the difference between quiet and noisy AM sessions in fear scores and in maintenance scores of the cats. Cats were included (n = 38) if they were present for at least one noisy and one quiet AM session. If they were present for more than one noisy or quiet AM session, the analysis was based on the mean fear score of the different sessions.

To test whether the scoring criteria for fear, maintenance and sound could be assessed consistently by different observers, Spearman rank correlations were calculated between scores of the two observers for the seven 30-min observation sessions. As a sound score was calculated for each observation session, the seven sound scores were used for this calculation. As fear and maintenance scores were calculated for each cat, the 22 individual cats were used for this calculation.

A minority of the 30-min observation sessions included a noticeable change from quiet to more noisy conditions or from noisy to more quiet. To ensure a clear contrast, a quiet-to-noisy transition was defined as occurring when a 5-min period had at least three-fold more sound present than the immediately preceding 5 min, where presence of sound was quantified by the number of 15-s intervals when sound was scored as present in the 5 min. For a noisy-to-quiet transition, a 5-min period had at least three-fold less sound present than the immediately preceding 5 min. The point between the initial 5 min and the subsequent 5 min was termed the 'transition point.' The type of sound present during each transition was also noted. The behaviour of study cats present was noted for the 5 min before and after the transition point, and a fear score and a maintenance score were calculated for each cat. If more than one cat was present during a transition, the mean score for all study cats present was used for analysis. Wilcoxon signed-rank tests were then used to assess whether fear scores differed before versus after the transition point.

To test whether the amount of hiding influenced adoption or other outcomes, outcome and days until outcome were recorded for each cat. Mean days until outcome was then calculated for: (i) all adopted cats; (ii) cats that spent more

https://doi.org/10.7120/09627286.30.4.006 Published online by Cambridge University Press

than 90% of their observation sessions hiding; (iii) cats that spent less than 10% of their observation sessions hiding; (iv) cats that spent time hiding in highly concealed locations in the enclosure (under the bed, and behind the hide-box); and (v) cats that did not occupy highly concealed locations.

Results

The analysis sample consisted of 30 females and 40 males, all previously spayed or neutered. The sources of the cats were owner-surrender (n = 32), stray (n = 29), return (n = 7) and humane-officer surrender (n = 2). Suspected breeds were domestic longhair (n = 10), domestic medium hair (n = 10), domestic shorthair (n = 46) or exotic (n = 4). Estimated age groups were 14 young adults (1–3 years), 51 adults (4–7 years), and five seniors. Asilomar Accords categories were healthy (n = 23), treatable-rehabilitatable (n = 41) or treatable-manageable (n = 6). The median length of stay in the study enclosures was four days (IQR = 5) before reaching an outcome. All cats were ultimately adopted (n = 66), redeemed by their owner (n = 3) or euthanased (n = 1). Of all 221 AM and PM observation sessions, sound scores (representing the number of 15-s intervals when sound was recorded as present) had a median of 42 (IQR = 47).

Inter-rater reliability tests showed a strong positive correlation for fear scores (r_s [22] = 0.994; P = 0.001), maintenance scores (r_s[22] = 0.941; P = 0.001), and sound scores (r_s[7] = 0.964; $P < 0.005$) by Spearman rank correlation.

Study cats differed widely in the amount of fear and maintenance behaviour that they performed. Of the ten cats with the highest fear scores, the most common fear behaviour was hiding. Eight of these cats hid for the entire observation session on every day of observation, while the two others hid 90 and 78% of the time, respectively. None of these cats showed any maintenance behaviour during either AM or PM observation sessions. In contrast, for the ten cats with the highest average maintenance scores, grooming was the most common maintenance behaviour observed, and these cats spent only 0–5.1% of their observation sessions showing hiding or other fear behaviour. Among all 70 cats, those with high mean fear scores tended to have low mean maintenance scores and *vice versa* (r_s [70] = –0.353; P = 0.002 by Spearman rank correlation).

During AM sessions (when fear behaviour was more common), females had higher fear scores (M = 11.58, IQR = 15.79) than males (M = 3, IQR = 15.83; P = 0.047 by Mann Whitney U test). In PM recordings (when maintenance behaviour was more common) maintenance scores tended to be higher for females (M = 2, IQR = 2.34) than males (M = 1, IQR = 1.67; P = 0.128 by Mann Whitney U test), but there was no apparent sex difference in AM recordings. No significant difference in fear behaviour was observed between age group, Asilomar Accords category, or source. However, of the two most common source categories, stray cats tended to have higher fear scores (M = 7.46, IQR = 11.65) than owner surrender (M = 2.12, IQR = 8.95; P = 0.060 by Mann-Whitney U test). No significant difference was observed in maintenance scores between age groups, Asilomar Accords categories, or source.

There was no consistent tendency for fear behaviour to decline over days in the shelter. Of the 47 cats that were scored for both AM and PM on their first day in the cat adoption room and at least one additional day, 12 (26%) had a higher fear score on day one than on any other day. However, fear scores were highly variable over days.

Adoption records provided no evidence that hiding decreased the likelihood of, or time taken before, adoption. Mean time until adoption for all cats in the study was four days. Of the nine cats that spent over 90% of their observation sessions hiding, mean time to adoption was 3.5 days versus 4.5 days for the 26 cats that spent less than 10% of their total time hiding. Of the 16 cats that were observed to hide under the bed, all were ultimately adopted. Of the ten cats that were observed hiding behind the box, nine were ultimately adopted. Of the eleven cats that were observed hiding under the bed and were adopted while still in the cat adoption room, the mean number of days until adoption was four. Of the four cats that hid behind the box and were adopted from the cat adoption room, the mean number of days until adoption was five.

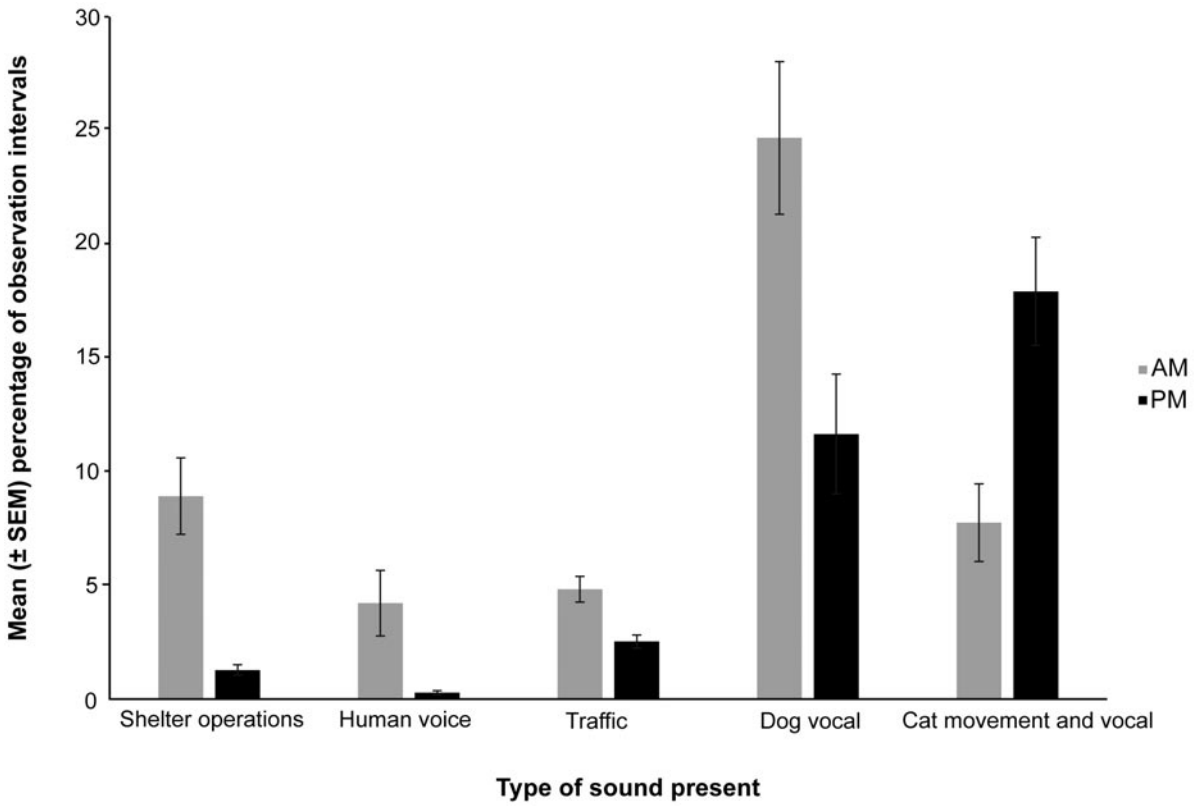
Sound levels in the shelter followed similar patterns each day because of the consistent daily shelter schedule. AM sessions consistently had much more sound than PM sessions. Shelter operations, human voices, traffic, dogs barking, and animal sounds from the small-animal room were consistently present more in the AM even though these observations were made during morning staff meetings. The only sound category that was more common in the PM was cat movement and cat vocal sounds; these included sounds from cats meowing, playing and litter-box use, sounds commonly associated with maintenance behaviours (Figure 1).

Cats showed higher fear scores in AM (M = 5.83, IQR = 17.3) than for PM observations (M = 1.75, IQR = 7.125; $P < 0.001$ by Wilcoxon signed-rank test). In contrast, maintenance scores were higher in PM observations (M = 1.67, IQR = 1.41) than AM (M = 0.66, IQR = 1.41; P = 0.02).

Sound scores for AM sessions ranged from 5 to 269 (out of a maximum of 300) with a median of 52. AM sessions were classified as 'noisy' if they were above the median score and as 'quiet' if below the median. Of the 38 cats that were present for at least one noisy and one quiet AM session, 23 had higher fear scores in noisy AM sessions compared to quiet AM sessions, nine showed no difference between noisy and quiet, and seven showed higher fear scores in quiet sessions (P = 0.001 by Wilcoxon signed-rank test; Figure 2). There was no comparable difference in maintenance scores (P = 0.501).

Of the total 221 observation sessions, 13 (7 AM, 6 PM) met the criterion for quiet-to-noisy transitions, and behavioural records were available for 47 cats during these transitions. Wilcoxon signed-rank tests showed that fear scores were significantly higher after sound transitions from quiet (M = 1, IQR = 3) to noisy (M = 3, IQR = 2.5; P = 0.002). Of the

Figure 1



Mean (± SEM) % of 15-s intervals when different sound types were present, for the 99 AM and 91 PM observation sessions. Sound was considered present if it was audible to the investigator at any point in the 15-s interval, and if it appeared to make the decibel meter increase approximately 15 dB.

47 cats, 37 showed no fear behaviour before the noisy 5-min period began; 16 of these began to show fear behaviour during the noisy period and 21 did not. The remaining ten cats showed fear behaviour before the noisy 5-min period began, and all continued to do so after. The most common types of sound present for quiet-to-noisy transitions were dogs barking (64% of transitions), shelter operational sounds (29%), cat movement sounds (21%), and human voices (7%). Opportunistic observations suggested that fear behaviour was most likely to begin after the onset of dog barking and shelter operational noises.

Additionally, nine sessions (3 AM, 6 PM) met the criterion for noisy-to-quiet transitions. In four of these sessions, cats showed less fear behaviour after the transition while there was no change in the other five sessions (but $P = 0.125$ by Wilcoxon signed-rank tests). Behavioural records were available for 26 cats during these transitions. Of these, 14 cats showed fear behaviour during the initial noisy period, and half of these stopped showing fear when the room became quiet, whereas 12 cats showed no fear behaviour in the noisy period and continued to show no fear behaviour in the quiet. The types of sound present for quiet-to-noisy transitions included dogs barking (67% of transitions), cat movement sounds (44%), shelter operational sounds (22%), and traffic sounds (22%). Fear behaviour seemed most likely to stop with the cessation of dog barking.

Discussion

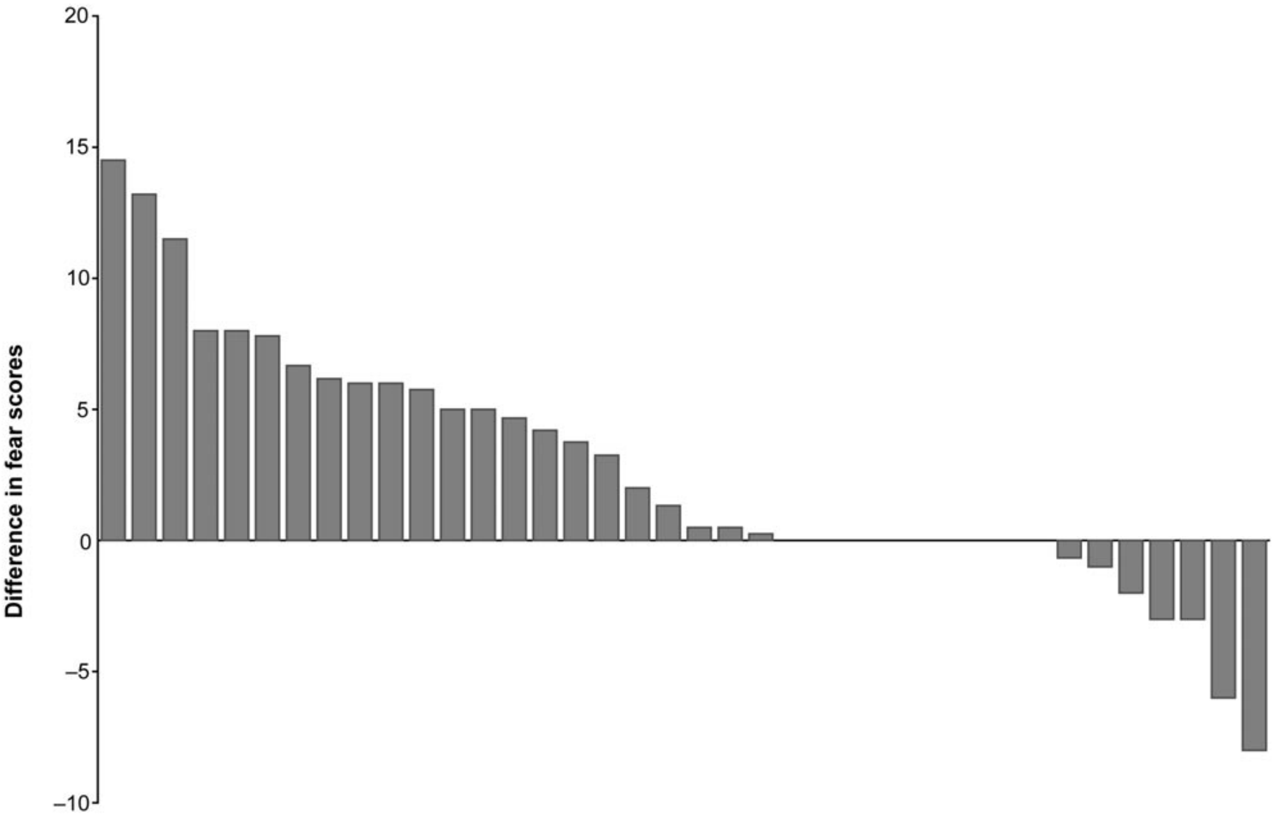
Individual differences in fear and maintenance behaviour

The negative correlation between the fear and maintenance scores found in this study is consistent with previous research by Carlstead *et al* (1993) who showed that cats in stressful situations will decrease play and increase hiding and alert behaviours, and by Gourkow *et al* (2014b) who found that behaviours consistent with our fear category did not occur often in cats showing behaviours consistent with our maintenance category, and *vice versa*.

When hiding (the most commonly observed fear behaviour in this study), cats primarily occupied the hide-box, but also used the space behind the hide-box, and under and behind the bed where they could make themselves even more unseen. The extensive hiding observed in this study supports the increasingly common conclusion that hiding is an important coping mechanism for cats entering new, unpredictable and potentially aversive environments, and is important for cat welfare (Rochlitz *et al* 1998; Gourkow & Fraser 2006; Kry & Casey 2007; Vinke *et al* 2014).

https://doi.org/10.7120/09627286.30.4.006 Published online by Cambridge University Press

Figure 2



Difference in fear scores between noisy AM sessions and quiet AM sessions for 38 cats, where difference is the mean fear score for the noisy sessions minus the mean fear score for the quiet sessions. Cats were included if they were present for at least one noisy and quiet AM session. If they were present for more than one noisy or quiet AM session, the calculation was based on the mean fear score of the different sessions. Each bar represents one cat.

On average, the cats spent 28.7% of observation sessions in the hide-box. While substantial, this usage is notably less than the 77% reported in two other shelter studies (Kry & Casey 2007; Stella *et al* 2014). While the dimensions of the cat enclosures were not specified by Kry and Casey (2007), the enclosures used by Stella *et al* (2014) were 0.55 m^2 in area compared to 1.05 m^2 in the present study. The difference in behaviour could be due to different data collection methods and the fact that cats in smaller enclosures simply have less space outside the hide-box. However, the much lower level of hiding in the present study might also be due to more positive welfare created by the larger and more diverse enclosure. This is consistent with Wagner *et al* (2018c) who found that cage size over 0.74 m^2 was associated with significantly lower rates of stress-associated upper respiratory infections in shelter cats compared to cage sizes of 0.56 m^2 or less.

Use of the hide-box has not been reported to decrease approach to unfamiliar humans by cats or to decrease the likelihood of adoption (Kry & Casey 2007; Stella *et al* 2017). This is consistent with our study as cats occupying other hiding locations appeared to be adopted as often and as quickly as cats that did not occupy these locations. However, further studies are needed to correct for factors known to affect adoptability (activity level, age, sex, and coat colour; Fantuzzi *et al* 2010), and the possible effect of cage location which was assigned by convenience rather than randomly in our study.

Shelter sound and cat behaviour scores

Owing to daily shelter schedules, the AM sessions consistently exposed cats to more sound than PM sessions. The exception was sounds created by cat movement and vocalisations which occurred more in the PM and are commonly associated with cat maintenance behaviour. The sounds in this study were similar to those that previous reports have described as prominent sounds in shelters, including dogs barking (McCobb *et al* 2005), loud voices, and shelter operational sounds, such as metal-on-metal, and door sounds (Sales *et al* 1997; Wagner *et al* 2018b).

The higher level of fear behaviour in the AM and maintenance behaviour in the PM is consistent with the hypothesis that cats demonstrate more fear behaviour when the shelter is noisy, and more maintenance behaviour when the shelter is quiet. These findings align with those of Stella *et al* (2014) who found that cats housed with consistent schedules and minimal sound disturbances exhibited less sickness behaviour, less hiding, and more affiliative and maintenance behaviour than cats in an environment with an inconsistent schedule and more sound.

doi: 10.7120/09627286.30.4.006

https://doi.org/10.7120/09627286.30.4.006 Published online by Cambridge University Press

The behavioural differences between the AM and PM sessions could, of course, reflect diurnal variation rather than the effect of sound itself. As stronger evidence of the effect of sound, cats also showed more fear behaviour in the relatively noisy AM sessions compared to the relatively quiet ones. This further supports the findings of Stella *et al* (2014) that lack of sound disturbances (combined with a consistent schedule) resulted in apparently positive behaviour (eg maintenance behaviours), and of McCobb *et al* (2005) who found that levels of sound and exposure to dogs contribute to stress in shelter cats. The lack of a difference in maintenance behaviour may be explained by the limited amount of maintenance behaviour observed overall, or the presence of the observer in the room. While the observer was partially concealed behind a structure, the observer's presence may have altered the amount of fear and maintenance behaviour exhibited by some cats.

The changes in fear behaviour during sound transitions further reinforce a relationship between fear behaviour and sound. Fear behaviour was observed to increase after ten of the 13 transitions from quiet to noisy, with no change in the remaining three cases; and fear behaviour became less common after four of the nine transitions from noisy to quiet, again with no difference in the remaining five cases. Hence, although some cats showed no change in behaviour during these transitions, the changes that occurred were consistent with the hypothesis that sound was a cause of fear behaviour. Moreover, opportunistic observations of cases where only one type of sound was present during transitions suggested that dog barking and shelter operational noise were particularly effective in eliciting fear behaviour.

More quantitative measures of sound (dB levels, systematic classification of sound type) could allow for more specific exploration of how sound affects cat behaviour.

Individual cat characteristics

The considerable individual behavioural differences observed in our study are consistent with Stella and Croney (2019) who similarly found individual differences in the behavioural responses and coping styles of cats in confinement. The large individual differences were not strongly related to source, health status or age of the cats. The stray cats tended to show higher fear scores than owner-surrender cats; this is consistent with Dinnage *et al* (2009) who found that stray cats were more likely to develop stress-associated upper respiratory infection symptoms, but it conflicts with Dybdall *et al* (2007) who found higher stress scores in owner-surrendered cats. These differences are likely a reflection of the fact that many additional factors may affect the behaviour of cats, such as breed (Dinnage *et al* 2009), being from a single- or multi-cat home (Broadley *et al* 2014), or other historical information (eg experience as a stray in a rural environment compared to an urban environment), most of which is often not known in shelter populations. While senior and geriatric cats are generally considered to experience a higher degree of stress (Dinnage *et al* 2009; Pittari *et al* 2009), we found no comparable difference but only had eight cats in the senior category. Similarly, there were no significant differences in fear or maintenance scores between cats in different Asilomar Accords categories, but these involve broad categories that include different health conditions which may affect behaviour in different ways. In our study, males tended to show less fear behaviour and less maintenance behaviour than females, contrary to the study of Dybdall *et al* (2007) who found no sex differences in stress scores.

Previous research has demonstrated that how quickly a cat settles into a new environment can vary greatly, with acclimation lasting from a few days to a few weeks, and some animals never acclimating (Kessler & Turner 1997, 1999; Rochlitz *et al* 1998; Dybdall *et al* 2007; Broadley *et al* 2014). This is supported in our study as individual cats appeared highly variable as to whether and how quickly fear behaviour changed over time in the shelter environment. This finding was likely due to the cats in the study entering from a variety of sources and backgrounds, remaining in the shelter for a relatively short time before reaching an outcome, and having varied durations in shelter care before entering the study room.

Animal welfare implications

This study provides evidence that higher amounts of sound in the shelter increase signs of fear in cats; specifically, fear was more common in morning observations (when the shelter was generally noisier) compared to evenings, in mornings that were relatively noisy compared to mornings that were relatively quiet, and after short-term transitions from quiet-to-noisy periods within observation sessions. These findings support the implementation of sound-proofing infrastructure and materials in a shelter. This might include use of non-metal or rubber-coated dishes, quiet toys, acoustic dampeners on enclosures, room door silencers, acoustic panels and baffles, keeping doors closed between rooms, adding cupboard door dampeners, implementing management practices that reduce dog barking, and keeping voices of staff, volunteers, and visitors low. Inexpensive, validated, sound-measuring smartphone applications could allow shelters to measure the sounds of frequent daily activities (eg cleaning, feeding, visitor or volunteer activities) to help determine the major sources of sound and guide implementation of sound-decreasing measures.

Acknowledgements

The authors thank the entire BC SPCA team for their help and use of their facilities for this project, especially Jodi Dunlop and the Vancouver shelter staff and volunteers. Thanks also to our research assistant Rebecca Juan, and to Zoetis Canada and the Mitacs Accelerate Fellowship for very helpful financial support.

References

Armstrong M, Avanizino R, Burns P, Fina P, Goldstein M, Lewis B, Loftus D, McCall J, McHugh-Smith J, McHugh S, McKenney N, Morrison D, Nagy J, Naumann C, Rohde R, Sayres E, Snyder J, Terpstra K, Tiscornia G and Belew Wheatley M 2004 *The Asilomar Accords*. Pacific Grove, California, USA. https://shelteranimalscount.s3.us-east-2.amazonaws.com/2004aaccords5_c97fa2dafd.pdf

Attard E, Duncan K, Firmage T, Flemming S, Mullaly K, Pryor P, Smrdelj M, Cartwright B and Rastogi T 2013 *Canadian Standards of Care in Animal Shelters: Supporting ASV Guidelines*. Association of Shelter Veterinarians: Apex, NC, USA

Baker DE 1998 Equipment decibel levels. *Grounds Maintenance 33(3)*: 73

Baldwin L, Schwartz GE and Hopp DH 2007 Are investigators aware of environmental noise in animal facilities and that this noise may affect experimental data? *Journal of the American Association for Laboratory Animal Science 46*: 45-51

Boissy A, Manteuffel G, Jensen MB, Moe RO, Spruijt B, Keeling LJ, Winckler C, Forkman B, Dimitrov I, Langbein J, Bakken M, Veissier I and Aubert A 2007 Assessment of positive emotions in animals to improve their welfare. *Physiology and Behavior* 92: 375-397. https://doi.org/10.1016/j.physbeh.2007.02.003

Broadley HM, McCobb EC and Slater MR 2014 Effect of single-cat versus multi-cat home history on perceived behavioral stress in domestic cats (*Felis silvestris catus)* in an animal shelter. *Journal of Feline Medicine and Surgery 16*: 137-143. https://doi.org/10.1177/1098612X13502972

Carlstead K, Brown JL and Strawn W 1993 Behavioral and physiological correlates of stress in laboratory cats. *Applied Animal Behaviour Science 38:* 143-158. https://doi.org/10.1016/0168-1591(93)90062-T

CCAC 1993 *Guide to the Care and Use of Experimental Animals*. Canadian Council on Animal Care (CCAC): Ottawa, Canada

CDC 2019 *Loud Noise Can Cause Hearing Loss*. Centers for Disease Control and Prevention (CDC): Atlanta, USA. https://www.cdc.gov/nceh/hearing_loss/what_noises_cause_hearing_loss.html

Coppola CL, Enns RM and Grandin T 2006 Noise in the animal shelter environment: building design and the effects of daily noise exposure. *Journal of Applied Animal Welfare Science 9*: 1-7. https://doi.org/10.1207/s15327604jaws0901_1

De Molina AF and Hunsperger RW 1959 Central representation of affective reactions in forebrain and brain stem: eletrical stimulation of amygdala, stria terminalis, and adjacent structures. *Journal of Physiology 145*: 251-265. https://doi.org/10.1113/jphysiol.1959.sp006140

Dinnage JD, Scarlett JM and Richards JR 2009 Descriptive epidemiology of feline upper respiratory tract disease in an animal shelter. *Journal of Feline Medicine and Surgery 11*: 816-825. https://doi.org/10.1016/j.jfms.2009.03.001

Dybdall K, Strasser R and Katz T 2007 Behavioral differences between owner surrender and stray domestic cats after entering an animal shelter. *Applied Animal Behaviour Science 104*: 85-94. https://doi.org/10.1016/j.applanim.2006.05.002

Fantuzzi JM, Miller KA and Weiss E 2010 Factors relevant to adoption of cats in an animal shelter. *Journal of Applied Animal Welfare Science 13*: 174-179. https://doi.org/10.1080/10888700903583467

Fraser D and Duncan IJH 1998 'Pleasures', 'pains' and animal welfare: toward a natural history of affect. *Animal Welfare 7*: 383-396

Fullagar B, Boysen SR, Toy M, Makwana C and Pang DSJ 2015 Sound pressure levels in 2 veterinary intensive care units. *Journal of Veterinary Internal Medicine 29*: 1013-1021. https://doi.org/10.1111/jvim.13574

Gordon E 2016 *Asilomar Accords and Adoptability Guidelines*. The British Columbia Society for the Prevention of Cruelty to Animals: Vancouver, BC, Canada

Gourkow N and Fraser D 2006 The effect of housing and handling practices on the welfare, behaviour and selection of domestic cats (*Felis silvestris catus*) by adopters in an animal shelter. *Animal Welfare 15*: 371-377

Gourkow N, Hamon SC and Phillips CJC 2014a Effect of gentle stroking and vocalization on behaviour, mucosal immunity and upper respiratory disease in anxious shelter cats. *Preventive Veterinary Medicine 117*: 266-275. https://doi.org/10.1016/j.prevetmed.2014.06.005

Gourkow N, LaVoy A, Dean GA and Phillips CJC 2014b Associations of behaviour with secretory immunoglobulin A and cortisol in domestic cats during their first week in an animal shelter. *Applied Animal Behaviour Science 150*: 55-64. https://doi.org/10.1016/j.applanim.2013.11.006

Heffner HE and Heffner RS 2007 Hearing ranges of laboratory animals. *Journal of the American Association for Laboratory Animal Science 46*: 20-22

Hirsch E 2011 *Feline stress: Methodological Considerations for Non-Invasive Assessment of Cats Housed in Groups and Singly*. Doctoral Thesis, Acta Universitatis Agriculturae Sueciae, Skara, Sweden

Kessler MR and Turner DC 1997 Stress and adaptation of cats (*Felis silvestris catus*) housed singly, in pairs and in groups in boarding catteries. *Animal Welfare 6*: 243-254

Kessler MR and Turner DC 1999 Socialization and stress in cats *(Felis silvestris catus*) housed singly and in groups in animal shelters. *Animal Welfare 8*: 15-26

Kry K and Casey R 2007 The effect of hiding enrichment on stress levels and behaviour of domestic cats (*Felis silvestris catus*) in a shelter setting and the implications for adoption potential. *Animal Welfare 16*: 375-383

Martin P and Bateson P 2007 *Measuring Behaviour: An Introductory Guide*. Cambridge University Press: Cambridge, UK. https://doi.org/10.1017/CBO9780511810893

McCobb EC, Patronek GJ, Marder A, Dinnage JD and Stone MS 2005 Assessment of stress levels among cats in four animal shelters. *Journal of the American Veterinary Medical Association 226*: 548-555. https://doi.org/10.2460/javma.2005.226.548

McCune S 1994 Caged cats: avoiding problems and providing solutions. *Newsletter of the Companion Animal Behaviour Therapy Study Group 7*: 33-40

Mellor D and Beausoleil N 2015 Extending the 'Five Domains' model for animal welfare assessment to incorperate positive welfare states. *Animal Welfare 24*: 241-253. https://doi.org/10.7120/09627286.24.3.241

Moody CM, Picketts VA, Mason GJ, Dewey CE and Niel L 2018 Can you handle it? Validating negative responses to restraint in cats. *Applied Animal Behaviour Science 204*: 94-100. https://doi.org/10.1016/j.applanim.2018.04.012

Morgan KN and Tromborg CT 2007 Sources of stress in captivity. *Applied Animal Behaviour Science 102*: 262-302. https://doi.org/10.1016/j.applanim.2006.05.032

Murphy E and King EA 2016 Testing the accuracy of smartphones and sound level meter applications for measuring environmental noise. *Applied Acoustics 106*: 16-22. https://doi.org/10.1016/j.apacoust.2015.12.012

Pittari J, Rodan I, Beekman G, Gunn-Moore D, Polzin D, Taboada J, Tuzio H and Zoran D 2009 Senior care guidelines: special article. *Journal of Feline Medicine and Surgery 11*: 763-778. https://doi.org/10.1016/j.jfms.2009.07.011

Rochlitz I, Podberscek AL and Broom DM 1998 Welfare of cats in a quarantine cattery. *Veterinary Record 143*: 35-39. https://doi.org/10.1136/vr.143.2.35

Sales GD, Milligan SR and Khirnykh K 1999 Sources of sound in the laboratory animal environment: A survey of the sounds produced by procedures and equipment. *Animal Welfare 8*: 97-115

Scheifele P, Martin D, Clark JG, Kemper D and Wells J 2012 Effect of kennel noise on hearing in dogs. *Journal of American Veterinary Research 73*: 482-489. https://doi.org/10.2460/ajvr.73.4.482

Spreng M 2000 Possible health effects of noise induced cortisol increase. *Noise & Health 2*: 59-64

Stanton LA, Sullivan MS and Fazio JM 2015 A standardized ethogram for the felidae: A tool for behavioral researchers. *Applied Animal Behaviour Science 173*: 3-16. https://doi.org/10.1016/j.applanim.2015.04.001

Stella J and Croney C 2019 Coping styles in the domestic cat (*Felis silvestris catus*) and implications for cat welfare. *Animals 9(6)*: 370. https://doi.org/10.3390/ani9060370

Stella J, Croney C and Buffington T 2014 Environmental factors that affect the behavior and welfare of domestic cats (*Felis silvestris catus*) housed in cages. *Applied Animal Behaviour Science 160*: 94-105. https://doi.org/10.1016/j.applanim.2014.08.006

Stella JL and Croney CC 2016 Environmental aspects of domestic cat care and management: implications for cat welfare. *The Scientific World Journal 2016*: 1-7. https://doi.org/10.1155/2016/6296315

Stella JL, Croney CC and Buffington CT 2017 Behavior and welfare of domestic cats housed in cages larger than U.S. norm. *Journal of Applied Animal Welfare Science 20*: 296-312. https://doi.org/10.1080/10888705.2017.1317252

Tsyrlin VA, Bravkov MF and Bershadsky BG 1983 Possible mechanisms underlying the pressure responses evoked in conscious cats by emotional stress. *European Journal of Physiology 388*: 81-87. https://doi.org/10.1007/BF00581052

Ursin H and Kaada BR 1960 Functional localization within the amygdaloid complex in the cat. *Electroencephalography and Clinical Neurophysiology 12*: 1-20. https://doi.org/10.1016/0013-4694(60)90058-4

Vinke CM, Godijn LM and van der Leij WJR 2014 Will a hiding box provide stress reduction for shelter cats? *Applied Animal Behaviour Science 160*: 86-93. https://doi.org/10.1016/j.applanim.2014.09.002

Wagner D, Hurley K and Stavisky J 2018a 1. Shelter housing for cats: Principles of design for health, welfare and rehoming. *Journal of Feline Medicine and Surgery 20*: 635-642. https://doi.org/10.1177/1098612X18781388

Wagner D, Hurley K and Stavisky J 2018b 2. Shelter housing for cats: Practical aspects of design and construction, and adaptation of existing accommodation. *Journal of Feline Medicine and Surgery 20*: 643-652. https://doi.org/10.1177/1098612X18781390

Wagner DC, Kass PH and Hurley KF 2018c Cage size, movement in and out of housing during daily care, and other environmental and population health risk factors for feline upper respiratory disease in nine North American animal shelters: *PLoS One 13(1)*: e0190140. https://doi.org/10.1371/journal.pone.0190140

https://doi.org/10.7120/09627286.30.4.006 Published online by Cambridge University Press