THE EFFECT OF ANIMAL SHELTER SOUND ON CAT BEHAVIOUR AND WELFARE

by

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THE EFFECT OF ANIMAL SHELTER SOUND ON CAT BEHAVIOUR AND WELFARE

Submitted by Bailey Eagan in partial fulfillment of the requirements for

the degree of Master of Science

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Abstract

This study assessed how sound in an animal shelter affects cat behaviour. Singly housed cats (n=98) were observed over 5 months. Fear-related and maintenance-related behaviour were recorded for 30-minute periods on weekdays (AM 10:00-10:30, PM 20:00-20:30) or weekends (AM 7:00-7:30, PM 19:00-19:30) daily from admittance for 10 days or until removed. Cats observed both AM and PM on 2 or more weekdays were used for analysis (n=70).

Behaviour, plus presence of sound (classified by the source), was recorded using instantaneous and one-zero sampling with 15-second intervals. Each 30-minute observation period was classified as "quiet" or "loud" if the sound was above or below (respectively) the median for all periods at the same time of day. Data were analyzed by non-parametric Wilcoxon signed-rank tests for differences in behaviour between AM and PM periods. Kruskal-Wallis tests were used to test differences between age groups, source of cats, and Asilomar Accords. Mann-Whitney U tests were used to test differences in fear and maintenance behaviour between males and females.

Cats varied widely in the amount of fear and maintenance behaviour they performed. Some spent all their observed time in fear behaviour (especially hiding) and no maintenance behaviour, while others showed no fear behaviour and spent up to 25% of observation intervals in maintenance behaviours. AM periods consistently had much more sound than PM. Cats showed more fear behaviour ($p<0.001$), and less maintenance behaviour ($p<0.020$) in AM than PM periods. Males showed less fear ($p=0.003$) and maintenance ($p=0.035$) behaviour than females.

Cats showed more fear behaviour in loud AM than quiet AM periods ($p=0.001$) but no comparable difference was seen in maintenance behaviour ($p=0.501$). Where sessions included a pronounced change in sound level, fear-related behaviour was more common after a transition from quiet to loud ($p=0.002$, Wilcoxon signed ranks test) and tended to be less common after a transition from loud to quiet ($p=0.125$).

The results show that cats vary greatly in their response to being moved to a shelter and suggest that sound in shelter environments can substantially affect the behaviour of cats. Lowering sound levels in shelters may help improve cat welfare.

Lay Summary

This thesis analyzes the effect of animal shelter sound on cat behaviour and welfare. Cats were observed in a shelter for fear-related and maintenance-related behaviour, plus the presence of sound. Cats showed a variety of each type of behaviour. During morning observations, when the shelter was louder, cats showed more fear and less maintenance behaviour than in evening observations when the shelter was quiet. When cat behaviour was compared between loud and quiet morning periods, cats showed more fear in loud mornings than quiet, although there was no comparable difference in maintenance behaviour. In sessions that included a transition from quiet to loud or loud to quiet, fear behaviour was more common after a transition from quiet to loud and less common after a transition from loud to quiet. The results suggest that sound in shelter environments is an often-overlooked factor that can affect the behaviour and well-being of cats.

Preface

B.H. Eagan, D. Fraser and E. Gordon designed the study. B.H. Eagan collected and analyzed the data; undergraduate student R. Juan collected data alongside B.E. for inter-rater reliability. D. Fraser supervised and provided feedback on the manuscript. D. Weary and E. Gordon also provided feedback on the manuscript.

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This thesis is dedicated to the cat with no name

Introduction

Cats in Canadian animal shelters

The domestic cat (*Felis catus*) is the most common companion animal in Canada, with an estimated 9.3 million cats living in Canadian households in 2017 (Humane Canada 2017), and 81,000 cats admitted to shelters in 2018 (compared to 30,000 dogs) (Humane Canada 2018). In Canada, cat overpopulation is a pressing issue as indicated by the high number of cats entering shelters each year, 43% of which are juvenile, demonstrating a problem of unwanted litters (Humane Canada 2017, 2018). Cat overpopulation presents many challenges for the cats themselves as well as public health concerns and a loss of wildlife in the communities where they live (Humane Canada 2017). Practices to address cat overpopulation in Canadian communities include animal control, licencing, spay/neuter programs, euthanasia, humane education, and finally adoption, the most available and common practice for addressing the problem (Humane Canada 2017). Shelters also offer an opportunity for cats to receive care and a home. In 2017, cats entered Canadian shelters from a variety of sources including stray (48%), guardian surrender (34%), transfer from another organization (11%), other intakes (3.6%), cases of abuse (1.5%) and born in shelter (1.5%) (Humane Canada 2017). Of cats that entered Canadian shelters in 2018, 62% were adopted, 5% returned to owner, 15% euthanized, 6.3% transferred, 7.6% remained in shelter, 1.7% returned to field, 1.1% died or lost, and 0.8% had "other" live outcome (Humane Canada 2018)

While admittance into a shelter can provide the opportunity for cats to be connected with an adopter and ultimately find a home, it can also lead to compromised welfare, as cats are sensitive to environmental changes (Wagner et al. 2018a). Entry into a shelter may cause negative affective states as a result of transportation, intake procedures, confinement, an inability to express natural behaviours, separation from (or exposure to) people and other animals, altered routines, and introduction to an unfamiliar environment with novel visual, olfactory and auditory stimulus (Stephen & Ledger 2005, Griffin & Hume 2006, Attard et al. 2013, Janeczko 2015).

Hans Selye defined stress as the "nonspecific response of the body" (pg. 27) to scenarios that can be either beneficial or detrimental (Selye 1974). Animals experiencing stress undergo physiological and behavioural changes which involve activation of the sympathetic nervous system and the hypothalamic-pituitary-adrenal (HPA) axis. When the sympathetic nervous system is activated it leads to release of epinephrine and norepinephrine which results in changes including increased respiratory rate, heart rate, blood pressure, and dilated pupils. This response is often called the 'fight or flight response' or 'SAM response' (named SAM due to the sympathetic nervous system and adrenal medulla) (Janeczko 2015, Sapolsky 1992). A more chronic stress response involves activation of the hypothalamic pituitary adrenal (HPA) axis, and the ultimate release of cortisol, which affects "nearly every system in the body" including lowered immunity (Janeczko 2015, pg. 205). However, although chronic activation of these systems is potentially harmful to the health and welfare of animals, short-term activation does not necessarily indicate that the animal is experiencing poor welfare as activities like play or mating can activate the same systems (Selye 1974, Janeczko 2015).

The connection between chronic stress (likely caused by negative affective states such as fear) and severe health consequences for cats is well recognized in shelters, specifically with diseases affecting respiratory and urinary tracts (e.g. upper respiratory infection (URI) caused by stress-triggered feline herpes virus) (Gaskell & Wardley 1978, Westropp et al. 2006, Dybdall et al. 2007, Dinnage et al. 2009, Tanaka et al. 2012, Janeczko 2015). Chronic fear also can lead to behavioural changes that may reduce adoptability and increase the risk of euthanasia (Gourkow & Fraser 2006, Dybdall et al. 2007, Fantuzzi et al. 2010). A cat experiencing chronic stress in a shelter environment is, therefore, at risk of entering a negative feedback loop. It may experience compromised welfare due to living in the shelter, that results in illness or behavioural changes making them less likely to become adopted, leading to more time spent in the shelter environment. For this reason, recognizing, understanding, and minimizing negative affective states experienced by cats in shelters is an identified priority and ongoing challenge for shelter management.

Assessing shelter cat welfare

Both behavioural and physiological measures of stress are used in cat research. Some veterinary and physiological studies measure upper respiratory infection incidence (Wagner et al. 2018d), blood pressure, temperature, heart rate, and respiratory rate (Quimby et al. 2011), although cortisol is the most commonly used measure of physiological stress in cats in shelters (Janeczko 2015). Collection of blood, urinary and faecal cortisol can be challenging and expensive in a shelter setting; therefore, the cortisol-to-creatinine ratio in urine – a relatively non-invasive and validated method (Carlstead 1992, Janeczko 2015) – appears to be the most-used cortisol measure in current cat shelter literature. While studies have found that cortisol is increased in situations that are likely to elicit fear in cats (e.g. when housed in close proximity to dogs (McCobb et al. 2005)), elevated cortisol levels have also been found to coincide with behaviours that may be indicative of a positive affective state in cats, such as being friendly, walking and eating (Gourkow et al. 2014b). This is an important consideration when interpreting physiological findings such as cortisol, as elevated levels may not exclusively be due to negative affective states.

It is generally accepted that behaviour can help provide information about an animal's affective state. Behavioural measures of stress are a relatively quick, non-invasive, and inexpensive approach to assess cat stress in shelter settings (Janeczko 2015). A cat's posture and behaviour likely offer a good indication of how it is coping with potential stressors (Kessler & Turner 1999, McCune 1994, Rochlitz 1998), and may provide a better indicator of long-term stress than physiological measures (Broom and Johnson 1993). One of the most common measures of stress in cats is the "Cat-Stress Score" (CSS) developed by Kessler and Turner (1997), a seven-level behavioural score based on body position and activity, which has remained prevalent in modern cat shelter literature (e.g. Rochlitz et al. 1998, Kessler and Turner 1999, Ottway & Hawkins 2003, Gourkow & Fraser 2006). A limitation of the CSS is that feigned sleep (an indicator of negative welfare in cats (Wagner et al. 2018b)) may be confused with true sleep which is taken to indicate low stress by the CSS. Further, the CSS has been found to not correlate with urine cortisol-to-creatinine ratios in cats (McCobb et al. 2005). Finally, some consider that the CSS is specific to fear, as the highest levels of "stress" on the scale are called "fearful, stiff," "very fearful" and "terrified" (McMillan, 2012) and are classified when the cat exhibits behaviours such as crouching, fast breathing, and being motionless with fast ventilation, eyes fully opened with pupils dilated, ears flattened and back (Kessler & Turner 1997).

Other behavioural measures of stress in cats include the use of detailed ethograms such as Stanton et al. (2015)'s 'Standardized Ethogram for the Felidae', which includes behaviours classified in categories such as affiliative, maintenance, agonistic, avoidant, vigilant, or fear. Behaviours including hide, crouch, ears back/flat, alert and freeze are included in the fear category, while behaviours such as groom, play, stretch, eat, drink, yawn, knead, urinate, defecate, and scratch are included in the maintenance categories. However, while behavioural categories such as "fear" and "maintenance" can help provide information about an animal's affective state, performing these behaviours (e.g. hiding) does not certainly indicate that the animal is indeed experiencing the emotion of fear.

Hiding is an essential coping mechanism for cats, and provision of hiding spaces appears to decrease cat stress in shelters (Kry & Casey 2007). The use of hiding as a measure of cat welfare is supported by observations of hiding behaviour in response to likely fear-inducing scenarios including veterinary hospitals, laboratory settings, and shelters (Carlstead et al. 1993, Gourkow & Fraser 2006). Rochlitz et al. (1998) found that cats exhibiting more hiding behaviour had higher cortisol-to-creatinine ratios, indicating that hiding behaviour is likely related to stress experienced. This approach was also used by Stella et al. (2014), who looked at mean hiding behaviour in cats to understand the environmental factors that affect the behaviour of cats in confinement. The importance of hiding to cats has been demonstrated, as when not provided the opportunity to hide, cats have been observed to create a hiding spot by turning litter boxes upside down (Gourkow & Fraser 2006) or hiding under towels (Hirsch 2011).

As cats are in a shelter for the primary reason of being adopted, there is some concern that allowing hiding opportunities will decrease the likelihood of adoption for a cat, although this does not seem to be true. Cats that are provided hiding places are no less likely (Stella et al. 2017) or more likely to approach a potential adopter (Kry & Casey 2007).

Other fear-related behaviours detailed by Stanton et al. (2015), including crouch, ears back/flat, freeze and startle, are likely indicators of a negative affective state. Ears back and/or flat have been used to assess cat welfare as they are observed in situations likely to cause fear and stress, such as a veterinary hospital (Moody et al. 2018). When exposed to an unfamiliar dog, cats have been observed to freeze (Tsyrlin et al., 1983). Carlstead et al. (1993) found that when cats were presented with an irregular caretaking routine and manipulations, and absence of contact with humans, cats spent more time alert and attempting to hide, and less time playing. Further, Gourkow et al. (2014b) found that hiding, flat postures, freeze, startle, crawl and retreat from humans were negatively correlated with normal patterns of feeding, grooming, sleeping, locomotion and other behaviour.

As demonstrated by Carlstead et al. (1993) and Gourkow et al. (2014b), behaviours likely indicative of a positive affective state, such as play, grooming and feeding, are often negatively correlated to fear behaviours. Behaviours classified as "maintenance" or "affiliative" are used in some studies to demonstrate a positive affective state (Stella et al. 2014). While most cat welfare research focuses on behaviours indicative of negative affective state, a more comprehensive approach may be to also include indicators of positive affective states such as affiliative behaviour and play (Boissy et al 2007). As detailed in Mellor & Beausoleil (2015), extensions to welfare assessments to include both negative and positive experiences can provide a more comprehensive representation of animal welfare.

Individual cat characteristics

How quickly a cat acclimates to a new environment varies greatly. Acclimation can last from a few days to a few weeks, with some cats potentially never acclimating (Kessler & Turner 1997, 1999, Rochlitz et al. 1998, Broadley et al. 2014). The experience of the cat in a shelter and the rate that it acclimates may depend on a variety of factors including source, age, sex, and temperament, although information on these variables and how they affect cats in shelters is limited (Bollen 2015).

Source and source attributes (e.g. from a single-cat home, indoor/outdoor access, exposure to dogs) may affect a cat's response to the shelter. Studies investigating cat stress in shelters from single and multi-cat homes have demonstrated conflicting results. McCobb et al. (2005) found that cats from multi-cat households had slightly higher urine cortisol-to-creatinine ratios compared to cats from single-cat homes, while Broadley et al. (2014) found no difference between CSS of cats from single-cat households and multi-cat households, although those from single-cat households that had been in the shelter less than four days demonstrated higher CSS. Other studies have found that stray cats were more likely to develop upper respiratory infections than owner-surrendered cats (Dinnage et al. 2009), while Dybdall et al. (2007) found that owner-surrendered cats showed more behavioural signs of stress using the CSS, and were likely to develop an upper respiratory infection sooner than stray cats. From these conflicting findings, it is unclear how source and source attributes affect cat welfare when admitted to a shelter.

Senior and geriatric cats (often defined as 11 years or older) are thought to experience a higher degree of stress (Pittari et al. 2009) and have a significantly higher risk of stress-associated upper respiratory infections compared to younger adult cats in shelters (Dinnage et al. 2009). However, studies on how age is related to experience of stress in a shelter are scarce.

The temperament of cats can also affect their behaviour and welfare in a shelter. Cats with bold and friendly temperaments appear to adapt better to novel housing and demonstrate more maintenance behaviour in a shelter environment (McCune 1994, Kessler & Turner 1999). Efforts have been made to create and validate a standardized feline temperament test for cats (McCune 1995, Siegford et al. 2003, Gartner & Weiss 2013, Litchfield et al. 2017), including the commonly used American Society for the Prevention of Cruelty to Animals (ASPCA) Feline-ality Meet Your Match™ Program to assess social behaviour and response to novel stimuli. While this behavioural assessment has been shown to predict certain specific types of post-adoption behaviour successfully (Weiss et al. 2015a), temperament tests in shelters conducted at one point in time are often criticized for lack of validation, reliability, and usefulness, as detailed in Patronek & Bradley (2016) .

In summary, further research is needed to predict and recognize welfare challenges for cats in shelters, to understand how individual characteristics such as source, age, and temperament affect acclimation to a shelter, and to help inform care decisions for diverse individual cats.

Daily activity levels

Cat behaviour may vary depending on the time of day, as cats are generally considered to be nocturnal (Barrat 1997, Tynes et al 2015) or crepuscular (Fitzgerald & Turner 2000, Landsberg et al 2013) in nature. After watching the behaviour of confined cats for 24-hour periods, Rochlitz et al. (1998), excluded evening recordings of cats from future studies because they found cats were inactive during the night. Heidenberger (1997) surveyed indoor cat owners and found that cats in homes spent 7.5 and 7.6 hours resting in the night and day respectively, indicating no notable difference in activity level between different time periods. Owners also reported cats in homes spent most of the day high up or on a windowsill and most of the night on the bed. In a study assessing physical activity level of adult cats with varied feeding frequency, Deng et al. (2011) found no difference in activity between feeding frequency, but that activity level peaked at mealtimes. McCobb et al. (2005) found that CSS levels in shelters were highest in the morning during morning cleaning and decreased throughout the day. These findings demonstrate that time of day, or more likely feeding time, may affect the behaviour of cats, and therefore behavioural measures of cats used to assess stress.

The effect of the macroenvironment on cat welfare

Shelter-cat welfare is affected by housing, as cats are a species that is notably sensitive to changes in their environment (Wagner et al. 2018b). As stated by Wagner et al. (2018a), “the quality of housing can literally be a matter of life or death for a cat entering a shelter” (pg. 635), although a relatively limited amount of scientific evidence is available to inform shelter environment design (Attard et al. 2013, Wagner et al. 2018b). Most research to date on the impact of the environment on cat welfare aims to improve aspects of a cat’s primary enclosure (‘microenvironment’) such as providing adequate housing space or hiding and perching opportunities to improve welfare (Gourkow & Fraser 2006, Wagner et al. 2018b). Decidedly few studies have aimed to assess how the room environment (called the ‘macroenvironment’ by Stella et al. 2014) affects cat welfare in shelters, including aspects such as temperature, humidity, lighting and noise. While research is limited, the macroenvironment of shelters appears at least as essential to a cat’s welfare as the microenvironment (McCobb et al. 2005, Stella et al. 2014).

Sound and cat welfare

In 1859, Florence Nightingale expressed concerns over the effects of noise on human patients stating that “unnecessary noise, then, is the most cruel absence of care which can be inflicted either on sick or well” (Nightingale 1859). Shelter environments that house animals often differ significantly from animal’s natural environments, and include high levels of unnatural noises in a wide range of frequencies (Morgan & Tromborg 2007). Noise can have negative effects on animal welfare, leading to adverse behavioural, physiological, or functional responses (e.g. hearing damage) (Spreng 2000, Coppola et al. 2010, Scheifele et al. 2012, Fullagar et al. 2015).

Few studies directly address how noise affects cat welfare in shelters, although these studies do indicate that noise is a likely contributor to stress and warrants further investigation (McCobb et al. 2005, Stella et al. 2014). Noise and other macroenvironmental factors such as lighting, presence of people, cleanliness, and presence of conspecifics in the room affect eating behaviour in cats (Scott, 1975 as cited in CCAC 1993), a critical maintenance behaviour (Stanton et al. 2015).

To understand the effects of the macro- and microenvironment on cat welfare, Stella et al. (2014) studied cats in environments where both the macroenvironment (including noise disturbances and schedule consistency) and the microenvironment (provision of hiding and perching opportunities) were varied (Stella et al. 2014). Behavioural observations were conducted for 48 hours using an ethogram, followed by a stranger-approach test. Cats housed in the managed macroenvionment with minimal noise disruptions and consistent schedule had a significant decrease in sickness behaviours and hiding behaviour from day 1 to 2. They also showed significantly more affiliative and maintenance behaviours (at the end of day 1), compared to cats housed in the unmanaged macroenvironment with noise disruptions and an inconsistent schedule. Cats in the managed macroenvironment showed a shorter latency to interact in the approach test, longer duration of interaction, and more affiliative behaviours directed to the stranger, compared to cats housed in the unmanaged macroenvironment. From these findings, the authors concluded that the macroenvironment is likely at least as relevant to the cat as the microenvironment and that focusing on improving only the cage environment is insufficient for confined cat welfare (Stella et al. 2014).

McCobb et al. (2005) assessed stress levels in cats in four different shelters using the CSS at three periods throughout the day, and subjectively classified noise levels and dog-exposure levels (as low or high) after the behavioural assessments. The following day, they collected urine samples for analysis of cortisol-to-creatinine ratio. They found that the most significant factor affecting stress levels in different types of shelters as indicated by cortisol-to-creatinine ratios was high exposure to dogs. However, there was no significant relationship with the reported noise levels alone. From these findings, the authors conclude that “levels of noise and exposure to dogs are potential factors that may contribute directly to stress levels in shelter cats; the influence of noise on stress levels in cats could be investigated by use of more objective methods, such as decibel measures of ambient sound” (McCobb et al. 2005, pg. 554).

The hearing range of shelter animals

Much like dogs and other small mammals commonly kept in shelters, cats are significantly more sensitive to sounds than are humans (Heffner & Heffner 2007). Behavioural audiograms of cats demonstrated that (at 70 dB) their hearing range extends from 48 Hz - 85 kHz. In comparison, human hearing frequency range is approximately 20 Hz - 20 kHz; although children can hear higher than 20 kHz, this decreases with age as the average adult has an upper hearing range of 15–17 kHz (Purves et al. 2001). Other animals commonly kept in shelters have broad hearing ranges including: dogs with 40 Hz - 50 kHz (Fay 1988), rabbits with 96 Hz – 49kHz (Masterton & Heffner 1980), rats with 250 Hz – 70 kHz (Heffner et al. 1994), and mice with 2.3 kHz – 85 kHz (Masterton & Heffner 1980). Generally speaking, small mammals such as rats and mice are sensitive to high-frequency noises, but not low-frequency noises (Purves et al. 2001). Cats are unique in that they have one of the broadest known hearing ranges among mammals as they can hear both low- and high-frequency sound (Heffner & Heffner 1985).

Measuring and interpreting sound

The term 'noise' is often used for loud sound that is a product or unintended consequence of an operation and is undesired by the recipient (Holmes 2015). Relative loudness of sound is measured in decibels (dB), while the frequency of sound refers to the number of vibrations or pressure fluctuations per second measured in Hertz (Hz) or Kilohertz (kHz). Low-frequency sound is often classified as any sound below 1000 Hz, and high-frequency sounds are those above 6000 Hz (Holmes 2015). As the perception of the loudness of sound is not only dependant on noise level, but also the frequency, hearing does not respond to noise equally across frequencies. To address hearing changes by frequency, "frequency networks" are commonly used in sound measurement (most commonly: A-weighting, C-weighting and linear or Z-weighting).

The most commonly used A-weighting reflects the human hearing range, although the similar C-weighting may be used for occupational assessments that involve high volumes of noise (Holmes 2015). The Z-weighting network is less common (especially in human assessments), as it does not account for human hearing range and includes sounds of all frequencies. Most reported sounds produced in a hospital environment are within frequencies included in the A-weighted scale (Ryherd et al. 2008). For this reason, A-weighting is the most commonly used in studies assessing impacts of noise on animals in shelters, laboratories, veterinary intensive care units, and kennels (Milligan et al. 1993, Coppola et al. 2006, Ellis & Wells 2010, Scheifele et al. 2012, Fullagar et al. 2015). However, select studies have also used Z-weighting (Milligan et al. 1993, Sales et al. 1999), likely as A-weighting measurements will not include sounds outside the 20 Hz – 20 kHz range. As no frequency network exists to approximate animal hearing, the choice of frequency network should be considered when interpreting animal studies involving noise measurements. Depending on the weighting, it may not include sounds in all ranges audible to the animal (e.g. A-weighting, C-weighting), or it may include sounds beyond what the animal can perceive (Z-weighting).

Sound is reported on a logarithmic scale as the range of intensities and pressures is extensive, and loudness of noise is therefore not linear (Holmes 2015). A 10 dB increase in noise level is a doubling of perceived loudness (Holmes 2015). Common measurements reported for sound include: equivalent continuous sound level (Leq) representing the "average" noise, maximum noise and minimum noise (the highest or lowest level of noise over a given period), and peak (the maximum value reached by sound pressure with no time constant applied) (Holmes 2015).

Sound pressure levels, sound patterns, and acoustic properties in animal shelters

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 or immediately with exposure to sounds above 120 dB (CDC 2019). While the impact of precise dB level on shelter animal welfare is not known, sound over 73 dB results in a stress response in rats (Baldwin et al. 2007); dogs 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 (CCAC 1993).

Sound in shelters regularly exceeds 100 dB (Sales et al. 1997, Coppola et al. 2010, Scheifele et al. 2012, Stella & Croney 2016). Sales et al. (1997) measured sound pressure levels (Z-weighting) and found during the day, Lpeak values (peak level of the sound pressure with no time constant applied) regularly exceeded 100dB (occasionally reaching 125 dBZ), and Leq values ranged between 65 and 100 dB. Coppola et al. (2006) measured sound (A-weighting) within an animal shelter and found that maximum noise levels regularly exceeded measuring capacity (118.9 dBA). Further, when the shelter seemed "quiet" (absence of dogs barking and husbandry procedures), the noise readings remained above 50-60 dBA (Coppola et al. 2010). Scheifele et al. (2012) evaluated sound in kenneled dogs at a veterinary technical college and an animal shelter; they found that noise levels in both sites regularly exceeded 100 dBA, and of 14 dogs that were tested, all demonstrated hearing loss over six months when housed in the veterinary technical college. Studies conducted in kennels, laboratories, and veterinary intensive care units reflect similar noise levels (Milligan et al. 1993, Fullagar et al. 2015). In indoor dog kennels, A-weighted sound levels averaged 90 dB over 15 minutes while visitors were present (Milligan et al. 1993). Sound recorded in two veterinary intensive care units (A-weighted) demonstrated that LAmax reached 78 dBA, and the number of sound spikes >80 dBA to be up to 240 on weekdays (Fullagar et al. 2015).

In shelters and research centres, sound pressure levels often correspond to caretaker activity (Morgan & Tromborg 2007). Sales et al. (1997) found that in shelters, there was a diurnal pattern of sound with levels generally low and constant overnight, gradually increasing in the early morning and once staff arrive, fluctuating throughout the day, and decreasing in the later afternoon to evening. High levels of sound throughout the day appeared to be associated with husbandry and cleaning procedures, and dog barking (Sales et al. 1997). Other suggested sources of noise in shelters include ventilation, gating of kennels, and reverberation due to the non-absorptive nature of many materials (e.g. metal and cement) used in a shelter environment (Wagner et al. 2018b).

Guidelines and recommendations for sound in Canadian animal shelters

Limiting exposure to noise is considered essential for stress management of cats (Attard et al. 2013, Wagner et al. 2018b). While noise levels in shelters reach volumes loud enough to require hearing protection for employees (occupational exposure limits in Canada list maximum permitted noise exposure level as 87 dBA (CCOHS 2020)), no policies are currently in place recommending a maximum volume for shelters for animals. The Canadian Standards of Care in Animal Shelters state that "maintaining an appropriate acoustic environment is essential for good animal health and welfare" (Attard et al. 2013, pg. 11), and Stella & Croney (2016) state that "it is likely that reducing noise levels and maintaining sound intensity around 60 dB (quiet conversational level) may be beneficial to cats" (pg. 3). Due to the sensitivity of cat hearing, unnatural levels, sources and patterns of noise in animal shelter facilities (which contrast with sound levels in natural environments, such as in savannah habitats where noise levels range from 20 dB to 36 dB (Morgan & Tromborg 2007)), it is likely that sound in shelters is problematic to cat welfare.

Some specific recommendations relating to management of sound in animal shelter environments have been presented. Hubrecht (2002) suggests noise-producing equipment be kept as far from animals as possible, and Wagner et al. (2018b) suggest maintaining at least two doors of separation between noisy areas in a shelter, and using sound-blocking doors. Further, they encourage ensuring all doors remain closed and using sound-proofing measures in shelters such as sound-proofing tape on doors and sound-absorbing tiles to improve room acoustics (Wagner et al. 2018c). Shelter design should aim to maintain significant separation between cats and dogs (McCobb et al. 2005), and implement architectural strategies, behaviour modification and enrichment to reduce barking levels that contribute to shelter noise (Griffin 2009; Johnson 2004).

Conclusion and aims of the present research

Although studies to date are limited, it is reasonable to consider that sound may affect the welfare of cats in shelters and may also contribute to adverse effects of the animals' health, welfare and ease of adoption. This study therefore aimed to understand how a population of shelter cats differing in age, source, Asilomar Accords, sex, and day since admission in the shelter behave during louder and quieter times, and what sources of sound are commonly present. Furthermore, this study aimed to quantify the variation of fear-related and maintenance-related behaviours observed in cats, and understand the relationship between the expression of these behaviours. A better understanding of how sound affects cat welfare in shelters could help inform shelter design and guidelines.

Materials and methods

Study site

This study was conducted in the British Columbia Society for the Prevention of Cruelty to Animals (BC SPCA) Vancouver shelter between March and July 2018. The shelter houses cats, dogs and small mammals available for adoption. The facility is a large structure with a series of separate rooms and holding areas. This study was undertaken in the "cat adoption room" a high-traffic room housing cats. The room has doors accessing the rest of the shelter, and is in close proximity to storage, cleaning and laundry rooms, access to the outdoors, and other adoption areas for cats, dogs and rabbits. Connected to the cat adoption room by a Dutch-style door is a small-mammal adoption room which commonly houses rats, mice and/or guinea pigs. The cat adoption room is located in a section of the building near a major roadway and transit hub. The room receives natural light at all times from windows and a skylight (Appendix A: Cat Adoption Room Photo).

Within the cat adoption room are 12 portalized stainless-steel cat enclosures, eight of which are portalized twice, resulting in enclosures of 1.5m x 0.7m x 0.6m composed of three separate sections connected by tunnels that allow free access to all sections. These eight equal-sized enclosures were used in this study for consistency. Each enclosure consisted of a BC SPCA Hide, Perch & Go™ box, a litter box, food, water and a bed. Enclosure configuration remained mostly consistent between cats except that provision of toys varied between cats, and staff occasionally draped a pillowcase over the front of one section of the enclosure for concealment. Common toys included one or more of pipe cleaners, balls, rattles and puzzle-style toys (Appendix B: Cat Enclosure Configuration).

Shelter schedule

The shelter schedule followed a consistent daily routine. At 7:00 shelter staff conducted welfare checks of all animals in care, began shelter and enclosure cleaning, and provided food, water and medications where applicable. Multiple staff members (and occasionally volunteers) conducted animal care duties until approximately 10:00 when some staff members had a morning meeting (10:00-10:30). Animal care activities then continued in the cat adoption room. The shelter was open to the public for adoptions daily except Statutory Holidays during 12:00-17:00 on Monday to Friday and 12:00-16:00 on Saturday and Sunday. After the shelter was closed to the public at the end of day, approximately 1-5 volunteers would frequently interact with cats for approximately 1-2 hours before the shelter closed for the evening. During the night one emergency care worker was present in the administrative office but there was no human presence in the cat adoption room until morning.

Study cats

The study consisted of 98 singly housed cats estimated by shelter staff to be adults over 1 year of age. Upon entry into the shelter, as per standard BC SPCA protocol, each cat received a complete physical exam 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 strays, owner-surrendered, returned (brought back to the shelter after an attempted adoption), brought by a Humane Officer ('Humane Officer Intake'), or transferred from another shelter. With this combination of sources, some cats had experienced a shelter environment previously while others had not. Each cat was assigned an Asilomar Accords category of Healthy, Treatable-Rehabilitatable, Treatable-Manageable, or Unhealthy and Untreatable (Gordon 2016). To minimize variation due to health, only cats designated Healthy, Treatable-Rehabilitatable, or Treatable-Manageable were included in the study.

After admission to the shelter, cats were assigned unsystematically by staff to any available enclosure in the cat adoption room. Cat ID number was recorded by the investigator, and age >1 year was verified from the cat's identification tag on the enclosure door. Additional information about each cat was later retrieved from the BC SPCA ShelterBuddy database including sex, source, age, and Asilomar Accords category (Table 1).

Table 1. Summary of characteristics of the 98 cats. Data are from the ShelterBuddy database.

Characteristic Group	Characteristic	Number of Cats
Sex	Female	40
	Male	58
Source	Humane Officer Intake	2
	Owner Surrender	42
	Return	10
	Stray	44
Breed	Domestic Longhair	11
	Domestic Mediumhair	14
	Domestic Shorthair	68
	Exotic	5
Estimated Age Group	Young Adult (1-3 years)	24
	Adult (4-7 years)	66
	Senior (8+ years)	8
Asilomar Accords category	Healthy	36
	Treatable-Rehabilitatable	54
	Treatable-Manageable	8

Behavioural observations

Behaviour of the cats was observed daily from admittance for 10 days or until the cat was removed because it was adopted, transferred, redeemed by the guardian or euthanized. The first "study day" was defined as the first complete day following admittance into the cat adoption room. At the time of removal from the study, cat outcome was noted, and the number of days until outcome were recorded. Behavioural observations consisted of a 30-min sample at two periods daily: AM (10:00-10:30 on weekdays or 7:30-8:00 on weekends) and PM (20:00-20:30 on weekdays or 19:00-19:30 on weekends). Timing of observations was scheduled around the shelter routine to allow for a period unaffected by other in-room activity such as cleaning, feeding and interaction with cats. Hence, the weekday AM period was timed to coincide with the staff meeting, but as there were no uninterrupted periods on weekends due to continued staff and volunteer activity in the cat adoption room, weekend AM periods were conducted earlier in the day.

Behavioural observations were recorded using both one-zero and instantaneous methods (Martin and Bateson, 2007) with 15-sec intervals. Cats were observed in order from the enclosure on the upper left, to enclosures on the bottom right. In each 30-min sample, the first cat was recorded for 15 sec, then the second cat for 15 sec, and so on until all cats had been observed; then the procedure was repeated until the end of the 30 min. A maximum of six cats were recorded in a given sample, allowing a total of 300 sec of recording for each cat in each 30-min period. If fewer than six cats were present on a selected study day, recording was paused for the 15-sec intervals corresponding to the missing cats, so that the sequence of recording was kept consistent among sessions.

Occasionally, behaviour recordings could not occur because of interruptions in the shelter schedule (e.g. staff needed access to the cat adoption room for cat care) and sessions would be ended and omitted from analysis. Of the 221 attempted observation recordings, 99 complete AM periods and 91 complete PM periods were collected.

Behaviour recordings were conducted in person by the investigator, at a distance of 2.5 m from the study enclosures, from behind a two-sided foam-core barrier 1.5 m high situated between the investigator and the study cats. Before beginning the behavioral observations, the investigator sat silently for 5 min to allow cats to adjust to human presence before recording began, apart from a few occasions when the shelter schedule prevented this.

Behaviour recording included cat body positions, location in the enclosure and any behaviour events occurring within the 15-sec intervals of observation. Body position and location in the enclosure were recorded by instantaneous sampling at the beginning of the 15-sec interval. Behaviour events were recorded by one-zero sampling; that is, each behaviour was scored as occurring or not occurring in the 15-sec interval. The ethogram used (Appendix C Behavioural Ethogram) was developed using the Stanton et al. (2015) Standardized Ethogram for Felidae, and behaviours used for analysis were selected from "Fear," "Maintenance," "Affiliative" and "Calm" categories. Fear behaviours included hide, crouch, ears back or flat, alert, and startle. Maintenance behaviours (which included behaviours from the maintenance, calm, and affiliative categories of Stanton et al., 2015) included groom, play, stretch, eat, drink, yawn, knead, defecate, urinate, and scratch.

Records of sounds in the cat adoption room

In addition to the behavioural observations, sounds in the room were also recorded as present or absent in each 15-sec interval using the same one-zero sampling method. A Decibel X:dB Sound Level Meter app was used, and sound was considered present if it was audible to the investigator within the closed room, and if it appeared to make the decibel meter increase at least 15 dB. If sounds were already occurring before recording began (and therefore an increase from the background noise could not be observed), sounds were included if they were clearly audible to the observer in the cat adoption room. With these criteria, faint sounds, such as a car driving by outside, were not included, nor were background sound (approximately 40-50 dB) that was always present in the shelter. Sounds were classified by type based on the sound recording criteria (Appendix D: Sound recording criteria), and were noted as dog barking, shelter operational sound, human voices, traffic sounds, cat movement sounds, or small animal sounds.

Statistical analysis

Analysis sample

In this study the AM and PM observations occurred at a different time of day on weekends compared to weekdays, and cats were present for variable numbers of days because some were adopted or transferred. To eliminate possible complications from the different recording times on weekends, and from cats with short duration in the shelter, the analysis was restricted to weekday recordings for the 70 cats that were present for 2 or more weekdays. Data from these cats (called the "analysis sample") were used for all statistical analysis unless otherwise indicated. SAS Studio was used for all statistical analysis.

Individual differences in fear and maintenance behaviour

To investigate individual variability among cats in fear and maintenance behaviour, the percentage of observation intervals in which fear behaviours and maintenance behaviours were observed for each cat was calculated. As fear behaviour was observed more in the AM periods, data were restricted to AM weekday observations only. The 10 cats showing the most fear behaviour and the 10 cats showing the most maintenance behaviour in weekday AM periods were selected to illustrate the wide range of individual differences.

To assess how fear and maintenance behaviour are related to each other, a "fear score" and a "maintenance score" were calculated for each cat based on AM weekday observations. These were the mean number of observation intervals per recording period in which fear or maintenance behaviours (respectively) were observed for each cat. Shapiro Wilk tests were used to assess normality of the scores, and a Spearman rank correlation was calculated between the fear and maintenance score of each cat. Inter-rater reliability tests were conducted on fear and maintenance scores by calculating the Spearman rank correlation between 2 observers for 7 30-min recording periods.

Differences in fear and maintenance scores between AM and PM periods

A non-parametric Wilcoxon signed-rank test was used to assess differences between AM and PM observations in fear scores and in maintenance scores. Because differences were found between AM and PM periods, all other tests were done with three different datasets: AM data alone, PM data alone, and AM and PM data combined (AM+PM). A non-parametric Mann Whitney U test was used to assess differences between male and female cats in fear scores and in maintenances scores. Non-parametric Kruskal-Wallis tests were used to assess differences in fear and maintenance scores between different sources (Humane Officer intake, stray, owner surrender, and return), between age group (young adult, adult, senior), and between Asilomar Accords status (Healthy, Treatable-Rehabilitatable, and Treatable-Manageable).

Fear scores and study day

Daily fear scores (AM, PM and AM+PM) were graphed and assessed visually for differences. As cats within the analysis sample were present for a variable number of days, three datasets of cats within this group were selected to look for trends in fear scores over days including: (1) all cats that were scored both AM and PM on their first day in the shelter and both AM and PM on at least one additional day, (2) cats experiencing the shelter for the first time meeting the same criteria (therefore not including cats that were transferred from another shelter or room when entering the cat adoption room), and (3) cats present on at least four complete AM and PM study days. The last group was chosen because it included a reasonable sample size (n=21) and aligns with the timeline of decreasing stress in shelters observed by Broadley et al. (2014).

Fear and maintenance scores in quiet and loud AM periods

A "sound score" was determined for each recording period by calculating the number of 15-sec intervals that included sound (recorded as detailed above). Inter-rater reliability was assessed by calculating the Spearman rank correlation between sound scores of 2 observers for 7 30-min recording periods.

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

Fear responses to sound transitions

A minority of the 30-min recording sessions included a noticeable change from quiet to loud or from loud to quiet and did not include continuous noise throughout. To ensure a clear contrast, a quiet-to-loud transition was defined as occurring when a 5-min period was at least threefold louder than the immediately preceding 5-min period, where loudness was quantified by the number of 15-sec observations when sound was scored as present in the 5-min period. To be considered a loud-to-quiet transition, a 5-min period had to be at least threefold louder than the following 5-min period. The point between the initial 5-min period and the following 5-min period of each transition was labelled 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 period both 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 was used for analysis. Wilcoxon signed-rank tests were then conducted to assess whether fear scores differed before and after the transition point.

Results

Study cats showed a wide range of fear and maintenance behaviours. Of the 10 cats with the highest average fear behaviour (Table 2), the most common fear behaviour was hiding. Most of these cats hid for the entire observation time except Imogen and Sully who hid 90% and 77.5% of the time respectively. None of the 10 most fearful study cats showed any maintenance behaviour during recording periods. In contrast, of the 10 cats with the highest average maintenance behaviour (Table 3), grooming was the most common maintenance behaviour observed, and these cats spent only 0-5.1% of their observation intervals showing fear behaviour.

Cats showing high fear scores tended to show low maintenance scores and vice versa ($r_s(70)=-0.353$, $p<0.05$ by Spearman rank correlation). Inter-rater reliability tests showed a strong positive correlation for fear scores ($r_s(7)=0.994$, $p<0.05$) and maintenance scores ($r_s(7)=0.941$, $p<0.05$) by Spearman rank correlation.

Table 2. The percentage of observation intervals in which fear behaviours and maintenance behaviours were seen in the 10 cats with the highest fear scores in weekday AM periods. As none of these cats showed maintenance behaviour during recording sessions, detailed breakdown of maintenance behaviour is excluded. Behaviours with an asterisk were considered hiding.

Cat Name	**Precious**	**Mesa**	**Lily**	**Kookey**	**Jeramiah**	**Hercules**	**Asia**	**Alex**	**Imogen**	**Sully**
FEAR BEHAVIOURS										
In Hidebox*	33.3	0	20	0	95	80	60	0	0	71.3
Rear of Hidebox*	66.7	0	60	0	0	20	40	0	0	0
Under Bed*	0	50	0	93	0	0	0	0	90	0
Behind Hidebox*	0	50	20	0	5	0	0	0	0	0
Behind Bed*	0	0	0	7	0	0	0	100	0	2.5
Alert	0	0	0	7	0	0	0	0	0	3.8
Crouch	0	0	0	0	0	0	0	0	0	0
Ears Back/Flat	0	0	0	0	0	0	0	0	0	0
Startle	0	0	0	0	0	0	0	0	0	0
Fear Total (%)	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**90**	**77.5**
MAINTENANCE BEHAVIOURS										
Maintenance Total (%)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Table 3. The percentage of observation intervals in which fear behaviours and maintenance behaviours were seen in the 10 cats with the highest maintenance scores in weekday AM periods.

Cat Name	Tuck	Waffles	Ned	Drumstick	Cyclone	Chubby	Boo	Flash	Misty	James
FEAR BEHAVIOURS										
In Hidebox	1.7	0.7	0.8	0	1.7	0.8	0	0	0	0
Rear of Hidebox	0	0	0	0	0	0.8	0	0	0	0
Under Bed	0	0	0	0	0	0	0	0	0	0
Behind Hidebox	0	0	0	0	0	0	0	0	0	0
Behind Bed	0	0	0	0	0	0	0	0	0	0
Alert	0	0	0	0	0	0	0	0	0	0
Crouch	1.7	0.7	0.8	0	1.7	1.7	0	0	0	0
Ears Back/Flat	1.7	0.7	0	0	0.8	0.8	0	0	0	0
Startle	0	0	0	0	0	0	0	0	0	0
Fear Total (%)	**5.1**	**2.1**	**1.6**	**0**	**3.3**	**4.7**	**0**	**0**	**0**	**0**
MAINTENANCE BEHAVIOURS										
Groom	6.7	2.9	7.5	22.5	5.0	7.5	0	0	0	25
Play	0	0.7	0	0	0	0	0	0	0	0
Stretch	1.7	0	0	0	0	1.7	1.7	5.0	2.5	0
Eat	0	0.7	0	2.5	0.8	1.7	0	0	0	0
Drink	0	0	0	0	0.8	2.5	0	0	0	0
Yawn	0	0.7	0	0	0	0	0	0	0	0
Knead	0	0	0	0	0	0.8	0	0	2.5	0
Defecate	0	0	0	0	0	0	0	0	0	0
Urinate	0	0	0	0	0	0	0	0	0	0
Scratch	0	0.7	0	0	0	0.8	0	0	0	0
Maintenance Total (%)	**8.3**	**5.7**	**7.5**	**25.0**	**6.7**	**15.0**	**1.7**	**5.0**	**5.0**	**25.0**

Adoption records provided little evidence that hiding outside the hide box (e.g. under the bed or behind the box) decreased the likelihood of adoption. Of the 16 cats that were observed under the bed, all were ultimately adopted. Of the 10 cats that were observed behind the box, 9 were ultimately adopted. Of the 11 cats that were observed under the bed and were adopted while still in the cat adoption room, the average number of days until adoption was 4. Of the 4 cats that were behind the box, and were adopted from the cat adoption room, the average number of days until adoption was 5. Neither of these differs notably from the overall average days until adoption of 4.

Records of sound in the cat adoption room

Sound levels in the shelter followed similar patterns each day due to the consistent daily shelter schedule. AM periods consistently had much more sound than PM periods. Shelter operations, human voices, traffic, dog 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, which included sounds from cats meowing, playing and litterbox use, sounds commonly associated with maintenance behaviours (Figure 1).

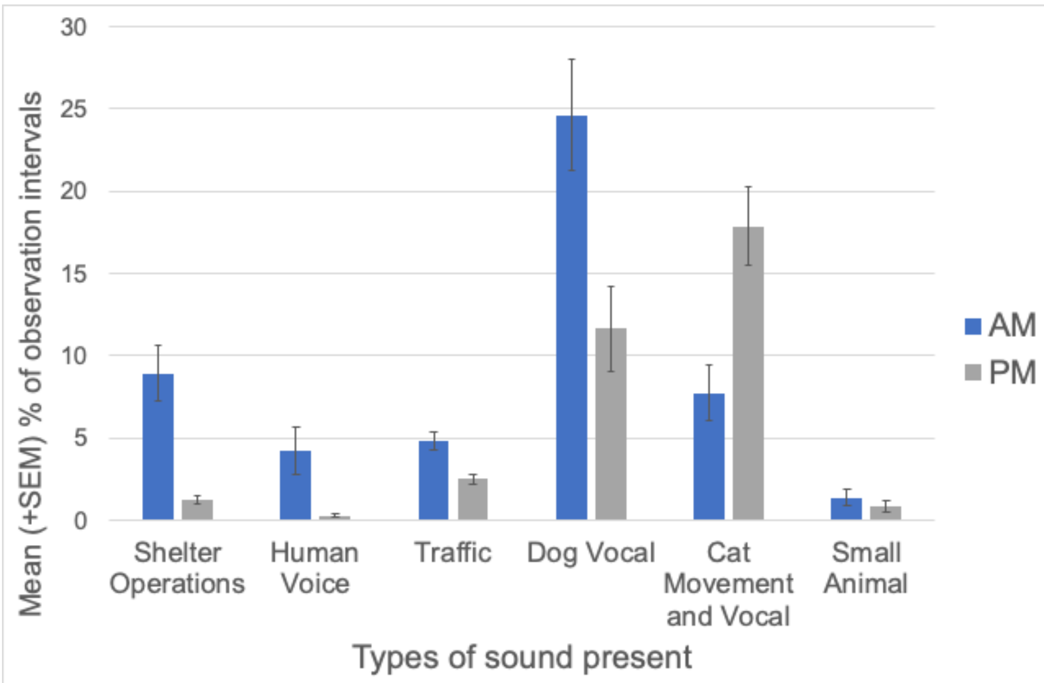

Figure 1. The mean (±SEM) % of observation intervals when different sound types were present in the 99 AM and 91 PM recording periods (mean calculated across recording periods for AM and PM).

Differences in fear and maintenance scores between AM and PM periods

Fear behaviour was observed more often by more cats in the AM weekday periods (Figure 2A), than the PM weekday periods (Figure 2B). Conversely, maintenance behaviour was observed more often by more cats in the PM period (Figure 2D) than the AM period (Figure 2C).

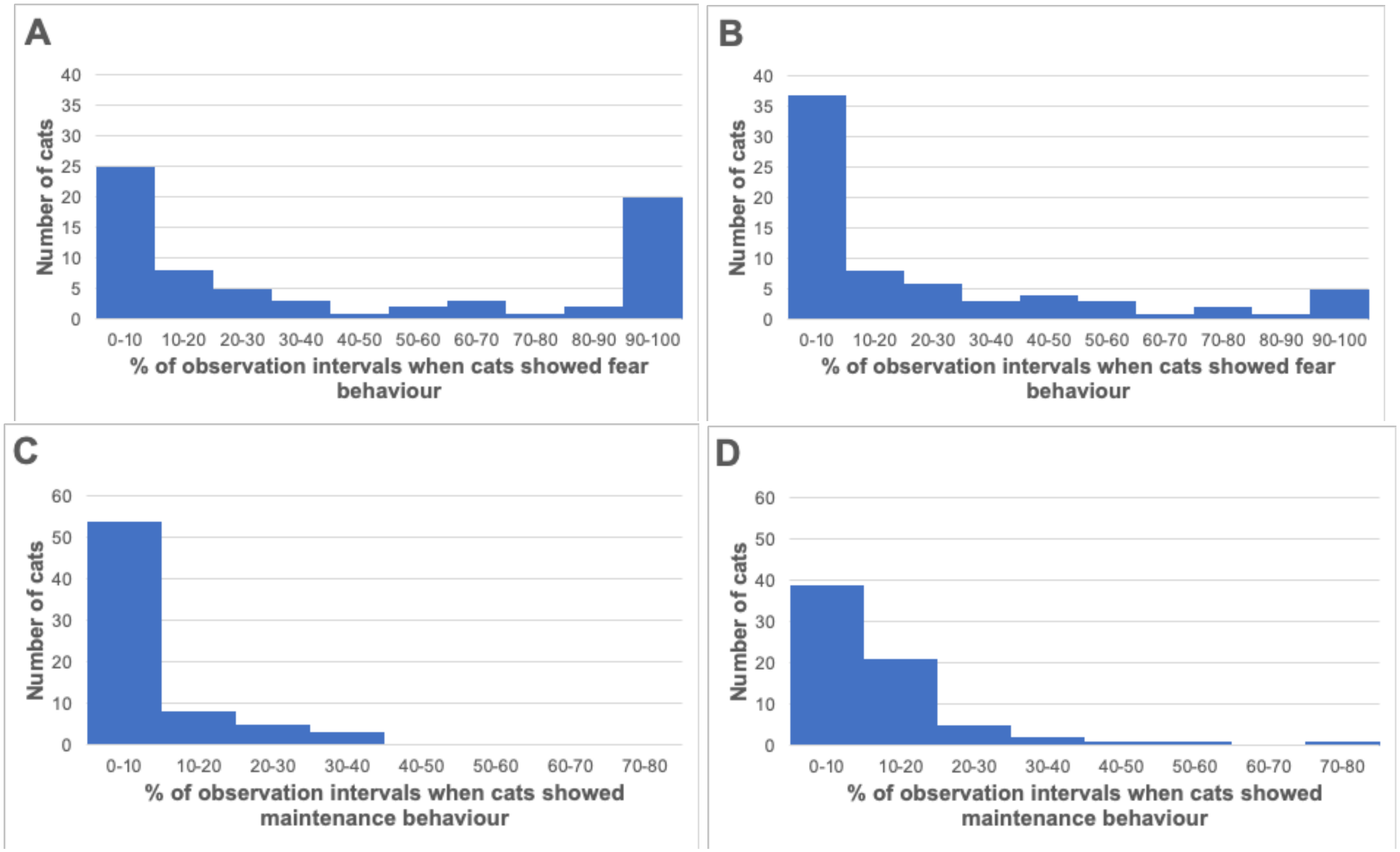

Figure 2. Number of cats showing different amounts of A) fear behaviour in AM observations, B) fear behaviour in PM observations, C) maintenance behaviour in AM observations, and D) maintenance behaviour in PM observations. Amount of fear and maintenance behaviour is the percentage of observation intervals when the cat performed fear or maintenance behaviour averaged over all AM or PM weekday observations for that animal (n=70).

Cats showed higher fear scores in AM than in PM observations (p<0.001) and lower maintenance scores in the AM than in the PM (p = 0.02) by Wilcoxon signed-rank tests.

Females showed higher fear scores than males by Mann Whitney U tests for AM periods (p=0.047, when fear behaviour was more common), and higher maintenance scores than males by Mann Whitney U tests for AM+PM periods (p=0.0359). No significant difference in fear behaviour was observed between age group, Asilomar Accords category, or source (Table 4). However, of the two most common source categories, owner-surrendered cats tended to have higher fear scores than strays (Figure 3). No significant difference was observed in maintenance scores between age group, Asilomar Accords category, or source (Table 5).

Table 4. Summary of non-parametric tests, datasets used, p-values, and direction of difference in fear behaviour for AM vs PM, Age Group, Source, Sex, and Asilomar Accords. The direction of the difference is noted where P< 0.2.

Test	**Dependent Variable(s)**	**Dataset (n=70)**	**P-value**	**Direction**
AM PM				
Wilcoxon signed rank	AM PM	AM + PM	***p<.001**	AM > PM
Age Group				
Kruskal-Wallis	Age (Ya, Ad, Sen)	AM	p=0.969	
Kruskal-Wallis	Age (Ya, Ad, Sen)	PM	p=0.983	
Kruskal-Wallis	Age (Ya, Ad, Sen)	AM + PM	p=0.940	
Source				
Kruskal-Wallis	Source (OS, St, R, HOS)	AM	p=0.562	
Kruskal-Wallis	Source (OS, St, R, HOS)	PM	p=0.090	HOS > St > R > OS
Kruskal-Wallis	Source (OS, St, R, HOS)	AM + PM	p=0.115	HOS > St > OS > R
Sex				
Mann Whitney U	Sex	AM	***p=0.047**	Female > Male
Mann Whitney U	Sex	PM	p=0.412	
Mann Whitney U	Sex	AM + PM	p=0.069	Female > Male
Asilomar Accords				
Kruskal-Wallis	Asilomar Accords (H, TM, TR)	AM	p=0.579	
Kruskal-Wallis	Asilomar Accords (H, TM, TR)	PM	p=0.733	
Kruskal-Wallis	Asilomar Accords (H, TM, TR)	AM + PM	p=0.877	

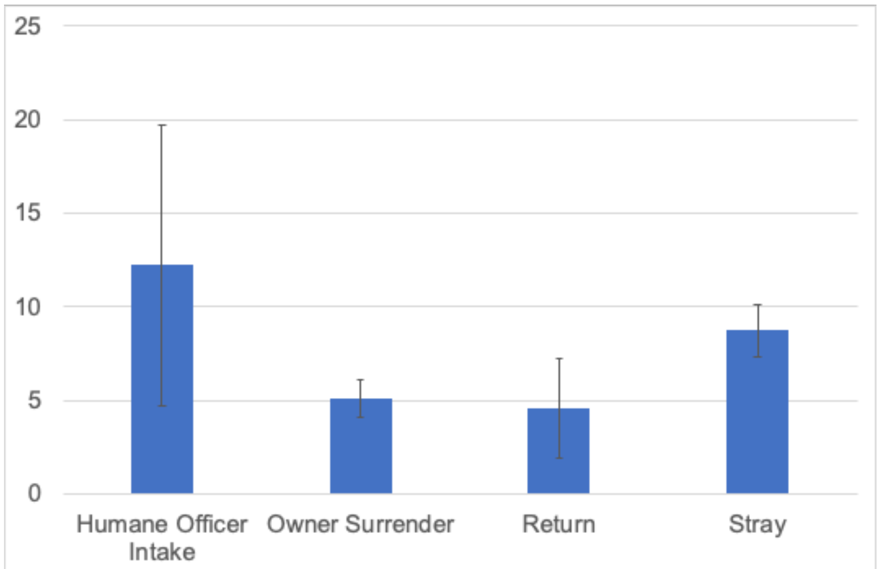

Figure 3. Mean (± SEM) fear scores for Humane officer intake (n=2), owner surrender (n=30), return (n=7) and stray cats (n=31). Fear score was calculated by averaging fear scores for cats from each source for AM+PM data.

Table 5. Summary of non-parametric tests, datasets used, p-values, and direction of difference in maintenance behaviour for AM PM, Age Group, Source, Sex, and Asilomar Accords. The direction of the difference is noted where P< 0.2.

Test	**Dependent Variable(s)**	**Dataset (n=70)**	**P-value**	**Direction**
AM PM				
Wilcoxon signed rank	AM PM	AM + PM	***p=0.020**	PM > AM
Age Group				
Kruskal-Wallis	Age (Ya, Ad, Sen)	AM	p=0.790	
Kruskal-Wallis	Age (Ya, Ad, Sen)	PM	p=0.472	
Kruskal-Wallis	Age (Ya, Ad, Sen)	AM + PM	p=0.572	
Source				
Kruskal-Wallis	Source (OS, St, R, HOS)	AM	p=0.685	
Kruskal-Wallis	Source (OS, St, R, HOS)	PM	p=0.517	
Kruskal-Wallis	Source (OS, St, R, HOS)	AM + PM	p=0.372	
Sex				
Mann Whitney U	Sex	AM	p=0.885	
Mann Whitney U	Sex	PM	p=0.127	Female > Male
Mann Whitney U	Sex	AM + PM	***p= 0.035**	Female > Male
Asilomar Accords				
Kruskal-Wallis	Asilomar Accords (H, TM, TR)	AM	p=0.616	
Kruskal-Wallis	Asilomar Accords (H, TM, TR)	PM	p=0.314	
Kruskal-Wallis	Asilomar Accords (H, TM, TR)	AM + PM	p=0.225	

Fear scores and study day

Some cats had higher fear scores on day 1 than on later days as illustrated by three cats (Grace Kelly, Marlowe and Lily) who showed high fear scores on day 1, followed by lower scores on all consecutive days in the study (Figure 4). Of the 47 cats that were scored for both AM and PM on the first study day and at least one additional day, 12 (26%) followed this pattern by having a higher fear score on day 1 than on any other day. Of these 47 cats, 15 were experiencing the shelter environment for the first time; five of these had a higher fear score on day 1 than any other day (33%). However, fear scores were highly variable over days, with no overall trend for scores to decline over time within the shelter (Figure 5).

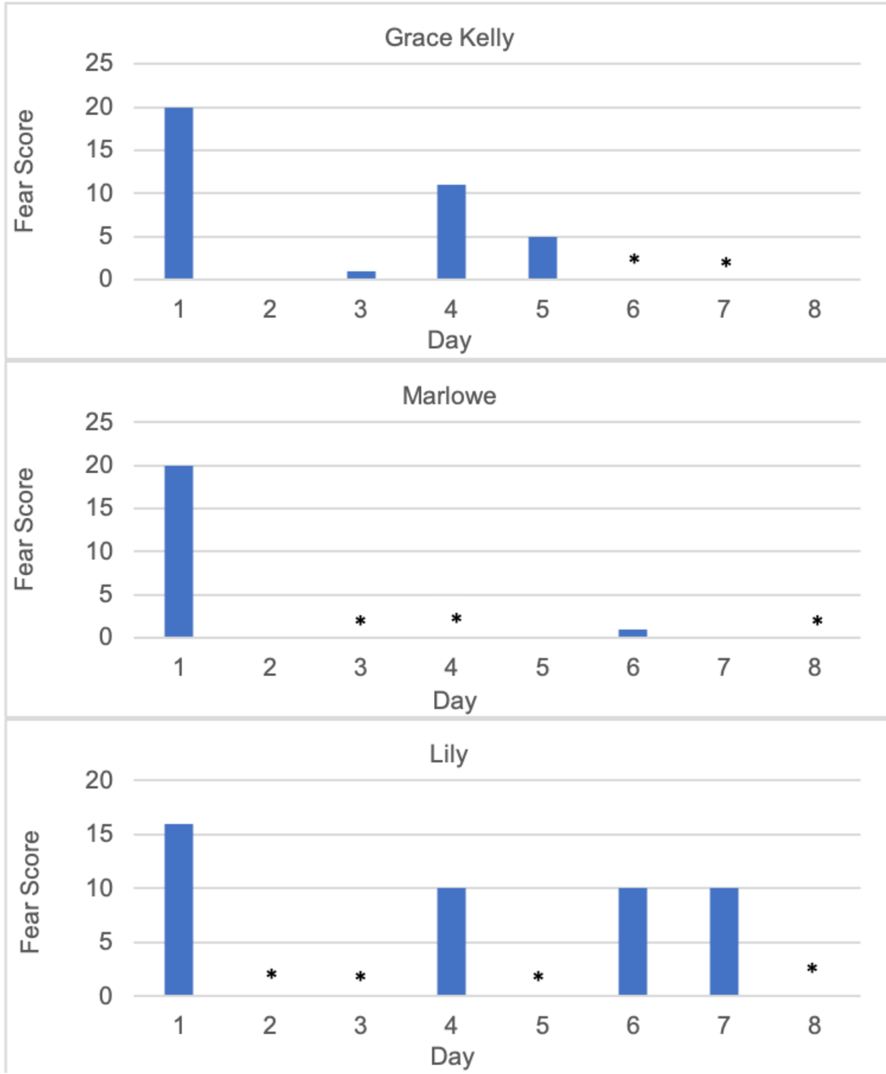

Figure 4. Fear score on study days 1-8 for cats Grace Kelly, Marlowe and Lily. Asterisks indicate a weekend day or a day when complete (AM+PM) data were not available. Fear score was calculated by averaging the AM and PM fear behaviours observed for each study day.

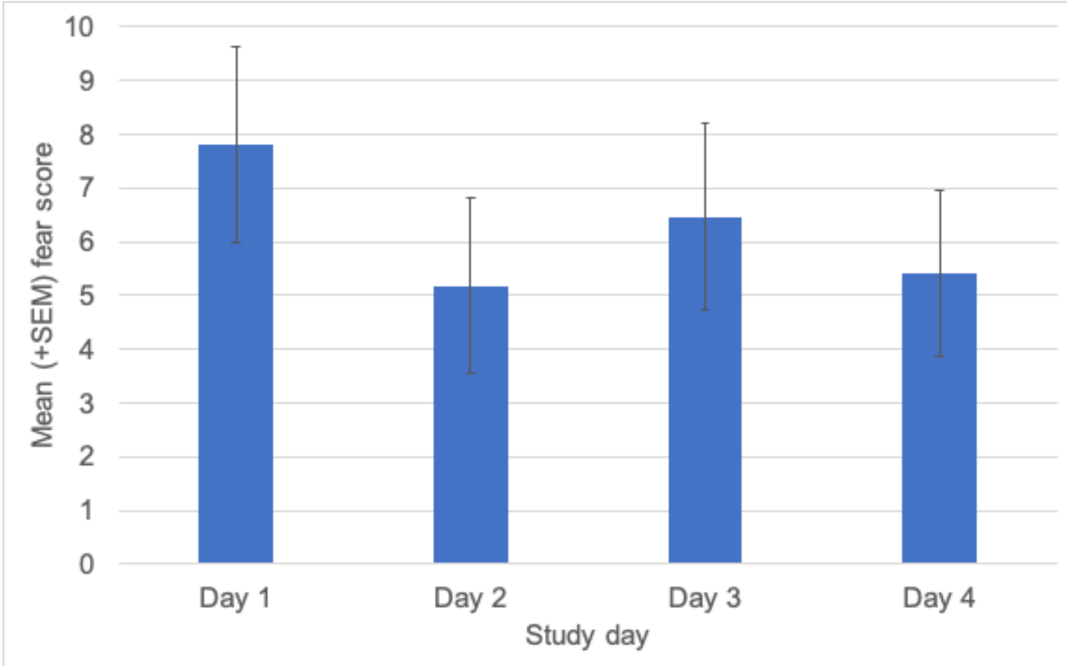

Figure 5. Mean (+ SEM) fear scores on study days 1-4 for cats present for the first 4 complete (AM+PM) weekday study days (n=21). Fear score was calculated by averaging the AM and PM fear behaviours observed for each study day.

Fear and maintenance scores in quiet and loud AM periods

Sound scores for AM periods ranged from 5 to 269 (out of a maximum of 300) with a median of 52. AM periods were considered loud if they were above the median score and quiet if below the median. Cats showed higher fear scores in loud AM periods than in quiet AM periods. Of the 38 cats, 23 had higher fear scores in loud AM periods compared to quiet periods, 9 showed no difference between loud and quiet, and 6 showed higher fear scores in quiet periods ($p=0.001$ by Wilcoxon signed-rank test, Figure 6). There was no comparable difference in maintenance scores ($p=0.501$).

Inter-rater reliability tests showed a strong positive correlation for sound scores (r_s $(7)=0.964$, $p<0.05$) by Spearman rank correlation.

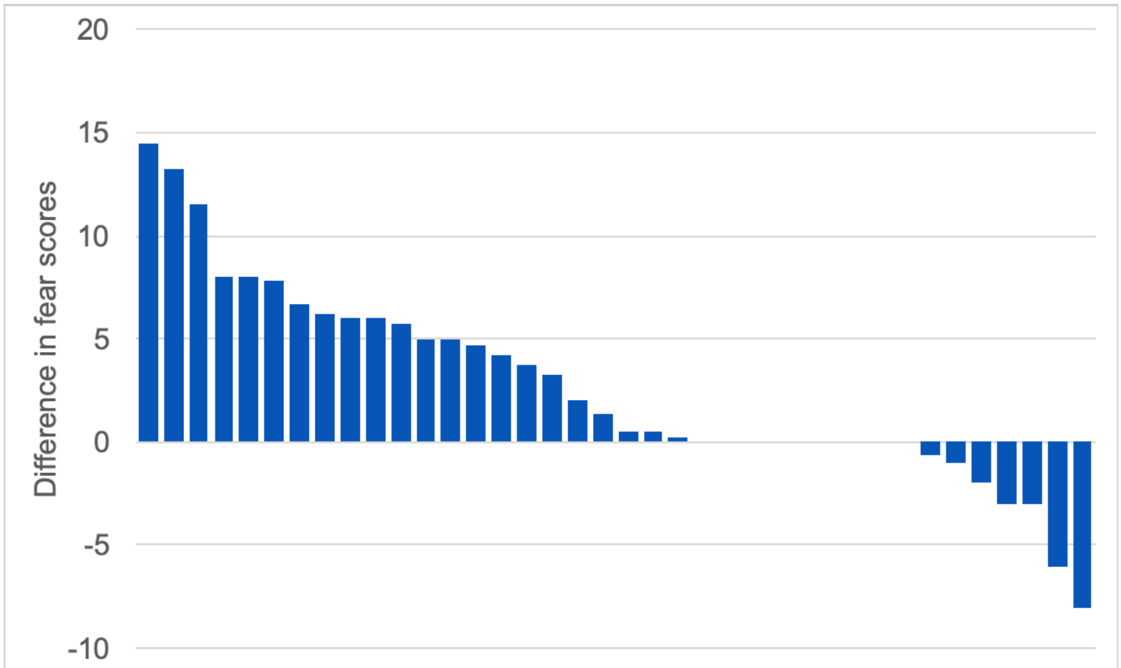

Figure 6. Difference in fear scores between loud AM periods and quiet AM periods for 38 cats, where difference is the mean fear score for the loud periods minus the mean fear score for the quiet. Each bar on x-axis represents one cat.

Fear responses to sound transitions

Of the total 221 observation sessions, 13 met the criterion for quiet-to-loud sound transition (7 AM, 6 PM) 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-to-loud (p=0.002) (Figure 7). Of the 47 cats, 37 showed no fear behaviour before the loud period began; 16 of these began to show fear behaviour during the loud period and 21 did not. The remaining 10 cats showed fear behaviour before the loud period began, and all continued to do so after. The most common types of sound present for quiet-to-loud sound 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, 9 sessions met the criterion for loud-to-quiet sound transitions (3 AM, 6 PM) and behavioural records were available for 26 cats during these transitions. Of these, 14 cats showed fear behaviour during the initial loud period, and half of these stopped showing fear when the room became quiet, whereas 12 cats showed no fear behaviour in the loud and continued to show no fear behaviour in the quiet. Wilcoxon signed-rank tests did not show a significant difference in fear behaviour following loud-to-quiet sound transitions (p=0.125), however the direction of difference indicated cats showing fear more during the period of sound (Figure 8).The types of sound present for quiet to sound 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.

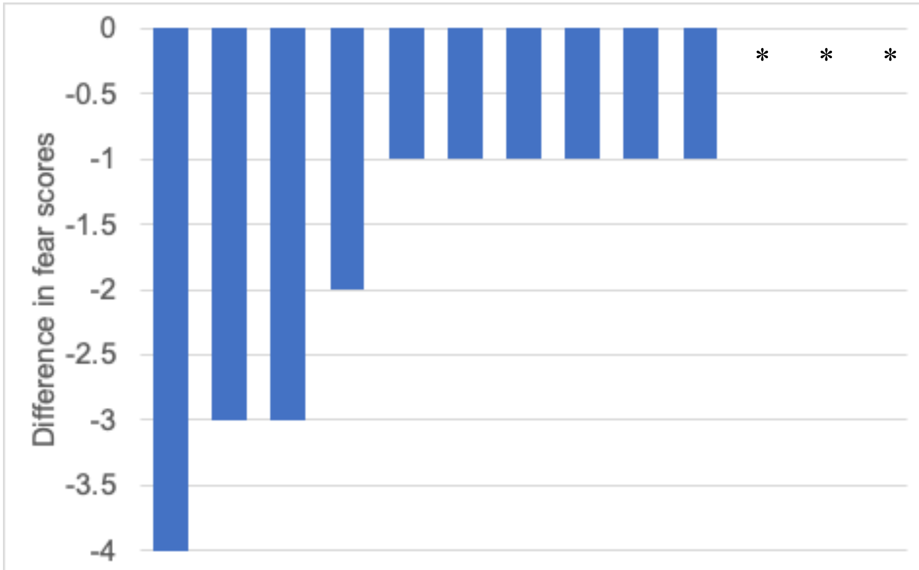

Figure 7. Difference in fear scores before and after quiet-to-loud sound transitions. Difference was calculated by subtracting the summed fear score for all study cats on each day before and after the transition point. Each bar on the x-axis represents 1 of the 13 recording sessions when a quiet-to-loud transition occurred. Asterisk represents a difference of 0.

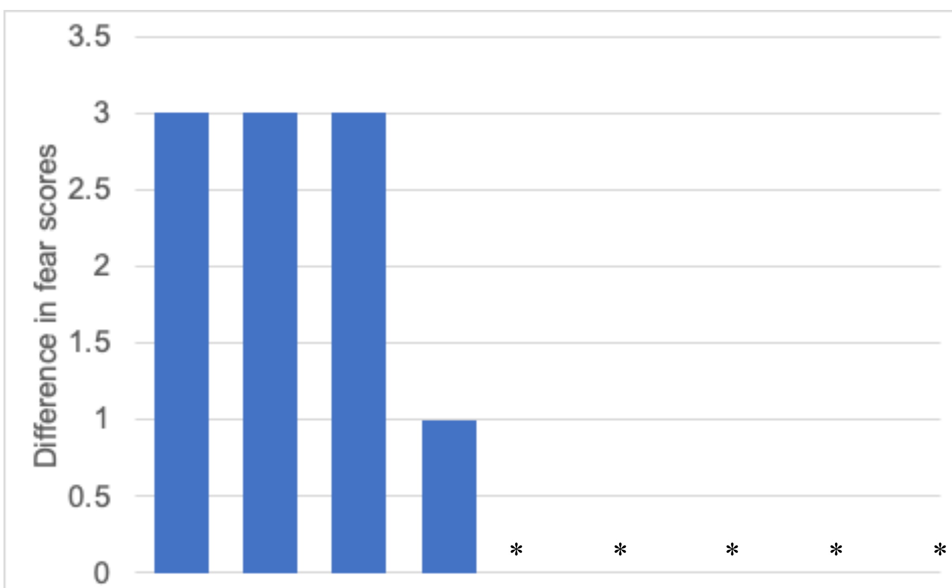

Figure 8. Difference in fear scores before and after loud-to-quiet sound transitions. Difference was calculated by subtracting the summed fear score for all study cats on each day before and after the transition point. Each bar on x-axis represents 1 of the 9 recording sessions when a loud-to-quiet transition occurred. Asterisk represents a difference of 0.

Discussion

Fear and maintenance behaviour

In this study, cats that showed more fear behaviour tended to show less maintenance behaviour and vice versa, as demonstrated by a negative correlation between the fear and maintenance scores. This finding is supported by previous research by Carlstead et al. (1993) showing that cats presented with stressful situations will decrease play and increase hiding and alert behaviours, and Gourkow et al. (2014) where behaviours consistent with the fear category used in this study did not occur often in cats showing behaviours consistent with the maintenance category used (and vice versa).

Cats in this study showed great individual variability in their expression of fear and maintenance behaviours. Some cats spent up to a quarter of their observed time in maintenance behaviours and very little time showing fear behaviours. Other cats showed fear behaviour throughout all the observation periods, with hiding as the major activity of this category, primarily in the hide box, but also in the space behind the hide box, and under and behind the bed. This finding 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).

On average, the cats spent 28.7% of observation intervals in the hide box, confirming that this as an important and well-utilized resource for cats. However, this usage is notably less than the 77% reported in other shelter studies (Kry & Casey 2007, Stella et al. 2014). While dimensions of the enclosure were not specified by Kry & Casey (2007), the enclosures by Stella et al. (2014) were only 0.55 m^2 in area (compared to 1.05 m^2 of the present study). The difference in behaviour could be due to different data collection methods and the fact that cats in a smaller enclosure simply have less space outside the hide box. However, the much lower level of hiding in this study might also be due to more positive welfare created by the larger and more diverse enclosure. This is supported by Wagner et al. (2018) 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.

When not provided the opportunity to hide, cats have been observed creating hiding places by turning litter boxes upside down (Gourkow & Fraser 2006), hiding under towels (Hirsch 2011), or hiding behind the litterbox (Vinke et al. 2014). Even when provided a hide box, a few cats in this study created a more concealed hiding space by pushing the hide box forward and occupying space behind the box or alternatively hiding under or behind the bed. The open sides of the hide box may not have provided enough concealment for these cats.

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), but it is not clear whether more extreme forms of concealment (e.g. under the bed or behind the box) might decrease an animal's adoptability. Although occupying these concealed locations was rare in this study, cats that used such complete concealment were not less likely to be adopted nor to spend more days until adoption, compared to cats that did not occupy these locations. However, further studies that correct for factors known to affect adoptability (activity level, age, sex, and coat colour; Fantuzzi et al. 2010) are needed.

Individual cat characteristics

No significant differences were found between fear or maintenance behaviour between cat sources, although stray cats generally showed higher fear scores than owner-surrender cats. This apparent difference is consistent with Dinnage et al. (2009) who found that stray cats were more likely to develop stress-associated upper respiratory infection symptoms. In contrast, Dybdall et al. (2007) found that owner-surrender cats showed higher behavioural stress scores, and developed upper respiratory infections significantly sooner, than stray cats. These conflicting findings are likely a reflection of the fact that there are many additional factors that may affect the behaviour of cats, such as breed (Dinnage et al. 2009), whether owner-surrendered cats are from a single-cat or multi-cat home (Broadley et al. 2014), or other historical information (e.g. experience as a stray in a rural environment compared to an urban environment), most of which is often not known in shelter populations.

Males showed less fear behaviour than females especially in the AM observations when fear behaviour was more common, and less maintenance behaviour. Behavioural differences between male and female cats are rarely reported in published studies but one study showed no difference in stress scores between male and female cats (Dybdall et al. 2007). However, in behavioural responses to restraint, female cats showed a shorter latency to escape immediately post-handling, which may indicate more fear among females in this situation (Moody et al. 2018). Sex differences in stress- or fear-related behaviour have been observed in other animals such as rats (Windle et al, 1999), and they warrant further study with cats.

No statistically significant difference was found in fear or maintenance behaviours between cats in different age groups. While senior and geriatric cats are generally considered to experience a higher degree of stress (Pittari et al. 2009) and have a significantly higher risk of stress-associated upper respiratory infection than younger adult cats in shelters (Dinnage et al. 2009), no comparable difference was seen in this study. However, our study included only eight cats in the senior category.

No significant differences in fear or maintenance behaviour were found between cats in different Asilomar Accords categories. However, the Asilomar Accords uses broad categories that include different health conditions which may affect behaviour in very different ways. More detailed health information would be needed to explore a relationship between health and welfare challenges in a shelter environment.

Fear scores and study day

Various cats showed different levels of fear behaviour on different study days. Many showed more fear behaviour on day 1 than on later days, but fear scores were highly variable over days, with no overall trend for scores to decline over time. 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 in whether and how quickly fear behaviour changed over time in the shelter environment.

Differences in behaviour between AM and PM recording periods

Owing to the consistent nature of daily shelter schedules, the AM periods consistently exposed cats to a greater amount of sound than PM periods. The exception was sounds created by cat movement and vocalizations which occurred more in the PM and are commonly associated with cat maintenance behaviour. The sounds in this study were similar to those identified in previous reports, including dog barking (McCobb et al. 2005), loud voices, and shelter operational sounds such as metal-on-metal, and door sounds (Wagner et al. 2018a)

The sound patterns observed in the present study are consistent with diurnal patterns observed in other animal care facilities. Sound levels often correspond with caretaker activity (Morgan & Tromborg 2007), being low overnight, gradually increasing in the morning, and fluctuating throughout the remainder of the day before becoming quiet again in the later afternoon and evening (Sales et al. 1997). As found by Sales et al. (1997), high presence of sound in our study appeared to be associated with husbandry and cleaning procedures and with dog barking.

Fear behaviour was more common in the AM and maintenance behaviour in the PM. This is consistent with the hypothesis that cats demonstrate more fear behaviour when the shelter is loud, 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 behaviour, and more affiliative and maintenance behaviour than cats in an environment with an inconsistent schedule and more sound.

Our findings also align with those of McCobb et al. (2005) who found that exposure to dogs and barking sounds had an effect on stress levels in cats. However, McCobb et al. (2005) also found no difference in stress between shelters classified overall as “high” or “low” sound. This null finding might be due in part to the fact that McCobb et al. (2005) simply classified shelters subjectively as high or low sound after behaviour observations. The authors acknowledged this should be investigated using more objective measures of sound. Furthermore, as they classified shelters as loud or quiet not including morning cleaning, their classification may have overlooked some important variation. While our study also involved a subjective aspect to measurement (by the primary investigator determining presence or absence of sound at each interval), the use of the decibel meter to help discern which sounds to include, and the use of systematic one-zero sampling at 15-second intervals, likely provided a more systematic and quantitative measure of presence of sound.

The behavioural differences between the AM and PM period could, of course, reflect an effect of time of day rather than sound itself. Hence, any conclusion linking cat behaviour to sound requires additional evidence as noted below.

Fear and maintenance scores in quiet and loud AM periods

Cats showed more fear behaviour in the AM periods with a high presence of sound, compared to the AM periods with low presence of sound, further supporting the hypothesis that high levels of sound contribute to compromised welfare for shelter cats. This finding further supports the findings of Stella et al. (2014) that lack of sound disturbances (combined with a consistent schedule) resulted in apparently positive behaviour (e.g. 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 small sample size, and the limited amount of maintenance behaviour observed overall by cats in either the AM or PM periods.

Fear responses to noise transitions

The changes in fear behaviour during sound transitions further reinforces a relationship between fear behaviour and sound. Fear behaviour was observed to increase after 10 of the 13 transitions from quiet to loud, with no change in the remaining 3 cases; and fear behaviour became less common after 4 of the 9 transitions from loud to quiet, again with no difference in the remaining 5 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.

Conclusions

Cats in this study showed great individual variability in fear and maintenance behaviours. Animals entering shelters have many different traits, and any cat may be fearful or relaxed, regardless of their source, age, Asilomar Accords category, or sex. In this study owner-surrendered cats tended to show less fear behaviour than stray cats and males showed less than females; however, the small sample of older cats did not show more fear behaviour than younger cats, and health status as indicated by Asilomar Accords category did not influence the behaviour. Given the inconsistent findings in the literature, it seems likely that many other factors such as specifics of the cat's history may affect fear behaviour.

Although many cats showed more fear on the first day than on later days, there was no uniform change in fear scores over days in the shelter. This suggests that there is no consistent pattern of acclimation to shelters.

Finally, there is good evidence that higher amounts of sound in the shelter increase signs of fear in cats. This is reinforced by behavioural differences between AM and PM periods, between loud and quiet AM periods, and by the changes in behaviour after transitions between loud and quiet times within observation periods. The data do not indicate whether certain sources of sound are more important for cat behaviour, as the study used an aggregate measure of sound. Hence, pending further study, it would seem reasonable to reduce all the major sources of sound in the categories of dogs barking, shelter operational noises, human voices, and traffic sounds.

Practical applications

Because some cats in this study sought concealment beyond what was offered by the hide box, it may be beneficial to place the hide box so that cats can move it, and to provide other manipulable features such as towels and beds. Observing which cats occupy these highly concealed areas may help indicate which cats would be best suited for a move to a quieter room or foster-home if available.

The findings of this study support the implementation of sound-proofing infrastructure and materials in a shelter. These 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 dog bark management practices 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 (e.g. cleaning, feeding, visitor or volunteer activities) to help determine the major sources of sound and guide implementation of sound-decreasing measures.

Limitations, and future directions

Observer effects on cat fear and maintenance behaviour possibly affected the results of this study, as observations were made by the observer standing behind a structure. However, because a similar level of partial concealment was used for all periods of observation, the differences detected should be robust.

While measures of negative affective states are more common in cat shelter literature, it appears that behaviours likely indicative of positive affective states (such as maintenance behaviours) are also useful measures of cat welfare and should be explored further, especially considering their negative correlation with fear behaviours. However, while maintenance behaviour appeared to be a beneficial measure of welfare for some aspects of this study, due to its relatively limited expression, it is likely that this contributed to it not being as useful as fear behaviour for determining behavioural differences between cats. Additionally, if maintenance behaviour is used as a measure of welfare, grooming should not be confused with overgrooming, a common displacement behaviour in many species (Weiss et al. 2015b).

Differences in individual cat characteristics were observed including differences between males and females, and possibly between owner-surrender and stray animals. However, the study was limited by a small sample size of senior cats (a group often hypothesized to show higher fear behaviour), and because the Asilomar Accords categories were likely too broad to allow for discernment of meaningful differences in health status.

Results of this study indicate that cat welfare is affected by sound, but the study took place only two times each day. Therefore, the sound sources identified here do not necessarily represent the sounds most present in the shelter. Future research should focus both on identifying the common sources of sound in shelters over the course of an entire day, and on determining which sound sources and decibel levels contribute most to behaviour and welfare in shelter cats to inform further shelter guidelines.

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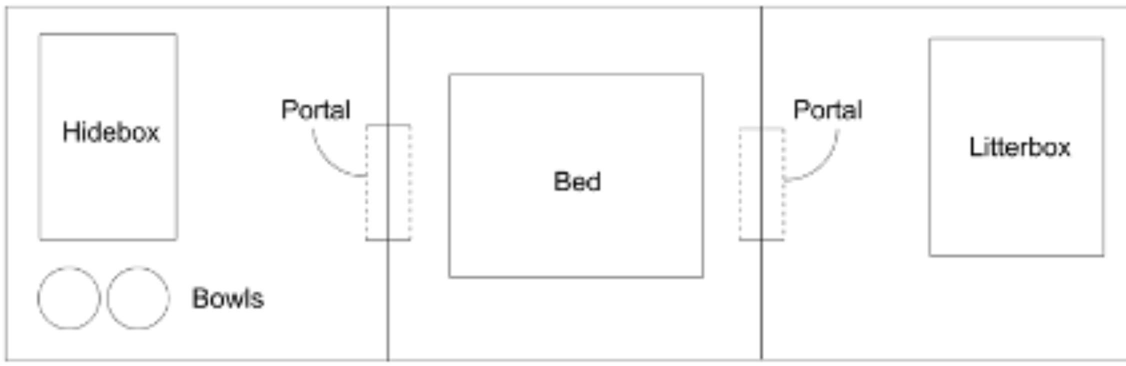
Appendices

Appendix A Cat Adoption Room Photo

Source: Bailey Eagan

Appendix B   Cat Enclosure Configuration



Appendix C Behavioural Ethogram

Behaviour Category	Behavior	Definition
Fear	Hide (or attempt to hide)	Cat occupies a location away from a specific stimulus (or modifier) (Stanton et al 2015); Part of the cat or the entire cat is behind or under something in the cage (Stella 2017). Locations classified as "hide" include in hidebox, behind hidebox, under bed, behind bed, behind litterbox.
	Crouch	Cat is alert and positions the body close to the ground, whereby all four legs are bent, and belly is touching (is raised slightly off ground) (Stanton et al 2015); The cat is positioned with his/her ventrum and legs in contact with the ground, the paws are folded (Stella 2017)
	Ears Back	Ears are held at rear of head (Stanton et al 2015; UKCBWG 1995).
	Ears Flat	Cat flattens its ears to its head, so they tend to lie flush with the top of the head (Stanton et al 2015; UKCBWG 1995).
	Alert	The cat remains generally inactive with eyes fully open and flicks ears occasionally as he/she scans his/her surroundings (Stella 2017)
	Freeze	Cat suddenly becomes immobile with body tensed (UKCBWG 1995).
Maintenance	Groom	Cat cleans itself by licking, scratching, biting or chewing the fur on its body. May also include the licking of a front paw and wiping it over one's head (Stanton et al 2015).
	Play	Cat interacts with something in a "non-serious" manner (i.e. there is no intention of harm) (Stanton et al 2015); Stella (2017 subdivided into object, self, social, roll and knead)
	Stretch	Cat extends its forelegs while curving its back inwards (Stanton et al 2015); The cat extends himself/herself or his/her limbs to full length (Stella 2017)
	Urinate	Cat releases urine on the ground while in a squatting position (Stanton et al 2015)
	Eat	Cat ingests food (or other edible substances) by means of chewing with the teeth and swallowing (Stanton et al 2015); The cat consumes food (Stella 2017)
	Defecate	Cat releases feces on the ground while in a squatting position (Stanton et al 2015)
	Drink	Cat ingests water (or other liquids) by lapping up with the tongue (Stanton et al 2015); The cat laps water or other liquid (Stella 2017)
	Scratch	Cat scratches its body using the claws of its hind feet (Stanton at al 2015).
	Yawn	Cat opens its mouth widely while inhaling, then closes mouth while exhaling deeply (Stanton et al 2015); The cat opens the mouth wide with a deep inhalation, usually involuntarily from drowsiness, fatigue, or boredom (Stella 2017)

Appendix D Sound Type Classifications

Sound Type	Definition
Shelter Operations	Sound approximately over 70dB in Cat Adoption Room due to regular shelter operations including; cleaning, feeding, doors opening/closing.
Human Voice	Sound approximately over 70dB in Cat Adoption Room due to human (staff, volunteer, member of the public) speaking.
Traffic	Sound approximately over 70dB in Cat Adoption Room from vehicles outside (including cars, trains, buses, honking).
Dog Vocal	Sound approximately over 70dB in Cat Adoption Room due to dogs barking.
Cat	Sound approximately over 70 dB in Cat Adoption Room due to cats meowing, or moving within their enclosure (including playing, litterbox use).
Small Animal	Sound approximately over 70dB in Cat Adoption Room due to small animals due to movement within enclosure.