Associations Between Play and Welfare in Domestic Cats and the Modifying Factor of Human Perceptions

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BSc. (Animal Behaviour) (Hons)

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Declaration

I certify that this work contains no material which has been accepted for the award of any other degree or diploma in my name, in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

In addition, I certify that no part of this work will, in the future, be used in a submission in my name, for any other degree or diploma in any university or other tertiary institution without the prior approval of the University of Adelaide and where applicable, any partner institution responsible for the joint award of this degree.

The author acknowledges that copyright of published works contained within the thesis resides with the copyright holder(s) of those works. I also give permission for the digital version of my thesis to be made available on the web, via the University's digital research repository, the Library Search and also through web search engines, unless permission has been granted by the University to restrict access for a period of time.

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Abstract

Human-cat play interactions represent an important, yet understudied, component of the human-cat relationship, with potential implications for domestic cat welfare. This thesis investigates associations between human-cat play interactions and cat welfare outcomes, while examining how human perspectives and beliefs may shape these interactions. Through a mixed-methods approach, this research investigates associations between human-cat play components and measures of cat welfare and human-cat relationships. Additionally, this thesis examines human experiences, beliefs and knowledge that may be associated with behaviours within, and attitudes towards, play with cats. Findings suggest that play interactions may be associated with higher cat quality of life and closer human-cat bonds. However, human beliefs and misconceptions about cat behavioural signals, what constitutes an appropriate play interaction, and failure to respond to cat dissent during play may lead to suboptimal, or even harmful, interactions.

The results of this thesis lay essential groundwork for understanding human-cat play interactions, demonstrates the critical need to include human perspectives and experiences in welfare assessments and highlights the bidirectional potential for human-cat play interactions to improve or reduce cat welfare. These findings have implications for educational interventions, animal welfare guidelines, and our broader understanding of how human factors impact animal welfare. Collectively, the Chapters of this thesis contribute to evidence-based recommendations for enhancing cat welfare through optimal human-cat play interactions.

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Chapter 1: Introduction to Thesis

1. Introduction

For over 10,000 years, cats have held a unique place within human populations (Hu et al., 2014; Pennisi, 2004). From early beginnings as functional friends, keeping down pest populations (Ottoni et al., 2017); the humble house cat, *Felis catus*, is now one of the most popular and valued companion animals on a global scale, residing in millions of homes worldwide (FEDIAF 2025; American Pet Products Association 2025). Yet, despite their popularity and long history alongside humans, significant knowledge gaps persist about cat behaviour, human-cat dyad relationships and how human perceptions may impact cat welfare.

Recent shifts in attitude towards cat safety along with increasing environmental concerns have led to arguably the biggest change in cat husbandry of the last several thousand years: keeping cats indoors (Foreman-Worsley & Farnworth, 2019). And with this shift, further questions have emerged over how we can keep an animal, who retains so many of the instincts and behavioural needs of their wild ancestors, happy and healthy within a human-mediated environment, where humans may support or compromise cat welfare (Rault, 2020). With the popularity of cats increasing (Animal Medicines Australia, 2025), and growing numbers of indoor-only cats, research investigating cat behavioural needs, human-cat relationships, and strategies for supporting cat welfare are needed. Human-cat play, a social interaction common between domestic cats and their guardians, may provide an opportunity to investigate these factors and their associations with cat welfare. However, few studies have explored associations between play and welfare in cats and even fewer have specifically examined correlations between cat welfare and human-cat play interactions (Chapter 2). Because the lives and wellbeing of cats are connected to human behaviours and decision

making (Machado et al., 2025), information in this particular area of play research may provide the greatest potential for improving cat welfare in human homes.

1.1 Determining welfare

The definition of animal welfare continues to shift and often differs based on the values of the person or body conceptualising it (Fraser, 2008; Fisher, 2009; Farnworth et al., 2010). However, there are some parameters that are generally agreed upon. These include: (i) the animal's physical health and biological functioning; (ii) the animal's ability to exhibit natural behaviours specific to their species; and (iii) the subjective emotional experience of the animal (Fraser, 2008; Mellor et al., 2020). In combination, these elements may provide a fairly comprehensive picture of an individual animal's welfare (Veit & Browning, 2020).

1.2 Play behaviour definitions

Play in both humans and non-human species is most simply defined as any behaviour that is perceived as play (or 'fun') by the individual performing it (Eberle, 2014; Henricks, 2015). However, when assessing animal play as an external observer, a definition that is operationally functional is needed. For this purpose, the most commonly used definition is the five criteria put forward by Burghardt (2005) and summarised here by Brando & Burghardt in 2019: "Play is repeated, seemingly non-functional behaviour differing from more adaptive versions structurally, contextually, or developmentally, and voluntarily initiated when the animal is in a relaxed, unstimulating, or low stress setting" (Brando & Burghardt, 2019, p. 560).

1.3 Linking play and welfare

Limited studies have investigated the links between play and welfare in cats, especially within the context of human-cat dyad play. However, if we consider the three factors most likely to give a comprehensive overview of a cat's welfare (see paragraph 1.1), play seems likely to provide at least some benefit towards each, i.e., (i) play could provide opportunities for exercise, assisting in maintaining body function and health (Delgado, 2022), (ii) play enables the expression of numerous species-specific behaviours (e.g., wrestling, stalking, ambush) (Delgado et al., 2024) and (iii) play may be indicative of a positive mental state, or may be an enrichment that can assist in shifting a cat from a negative to a positive emotional valence (Bekoff, 2001; Held and Špinka, 2011; Ahloy-Dallaire et al., 2018). Additionally, previous studies into play in animals has linked play to survival (Fagen and Fagen, 2004), the formation of coping strategies and social competencies (Graham and Burghardt, 2010; Pellis et al., 2010; Sgro and Mychasiuk, 2020), positive affective state (Burgdorf & Panksepp, 2006) and social, emotional, cognitive and sensorimotor neural development (van Kerkhof et al., 2013, 2014; Vanderschuren, 2010; Vanderschuren & Trezza, 2014). While no studies, to this author's knowledge, have looked at associations between human-cat play and specific cat welfare outcomes, previous research on human-dog dyads has linked human-dog play to positive welfare outcomes, such as closer human-dog bonds (Bradshaw and Rooney, 2015), social coordination (Horowitz and Hecht, 2016), and suggested that higher play rates may be indicative of a positive welfare state (Rooney and Bradshaw, 2014).

1.4 Human influence on welfare

The relationship cats experience with their guardians and the people they share their home environments with can significantly impact cat welfare (Rault, 2020). As well as companions, human guardians function as gatekeepers, who control access to basic needs, provide general

care, and are responsible for accessing medical attention when needed (Stella & Croney, 2016). Behavioural tools that improve or maintain positive human-cat relationships may therefore be protective of cat welfare. Previous research suggests that play may be an ideal candidate for establishing and maintaining the human-cat bond through shared moments of joy (Birke & Hockenhull, 2012), associative learning (Rault et al., 2020) and providing opportunities for developing and maintaining interspecies communication (Palagi et al., 2016). However, considering the inherent power imbalance in human-animal interactions (Amiot & Santerre-Bélec, 2022) and the complication that play is a largely subjective experience (Henricks, 2015), there is potential for a play interaction to be experienced positively by only one member of the dyad. Further, due to play and aggression having visually overlapping components in cats (Gajdoš Kmecová et al., 2021), and humans (Fry, 2005), any incongruence in play perceptions may result in cat stress and potential human injury (Kizer, 1979; Haywood et al., 2021). As such, the positive or negative welfare outcomes of play interactions may hinge on human perceptions and beliefs, such as recognition of cat needs, and respect for cat autonomy. Understanding the human perspective is therefore a crucial element to consider within any investigations of human-cat play and its potential associations with cat welfare.

1.5 Highlighting the gap

Our understanding of human-cat play, its associations with human-cat relationships and cat welfare is still in its infancy. Foundational questions remain unanswered, such as how guardians define and perceive human-cat play, what amount of play human-cat dyads engage in, what communication signals are used during play, what human-cat play factors are associated with positive or negative cat welfare and how humans interpret and respond to cat

behaviour during positive and negative play interactions. Considering play interactions are currently encouraged as enrichment for cats (Delgado & Hecht, 2019; Ellis et al., 2013), it is imperative these questions are explored to ensure these interactions are optimised to improve cat welfare and do not inadvertently place cats at added risk.

1.6 Thesis Aims

The overarching Aim of this thesis was to: Investigate whether, and in what ways, human-cat play interactions are associated with cat welfare.

To explore this, we employed two specific Aims to:

1. Investigate associations between human-cat play interactions and welfare in cats.
2. Assess human perceptions and experiences of human-cat play and how these may impact human-cat play interactions.

The individual Aims of each research Chapter and the general structure of the thesis is shown in Figure 1.1.

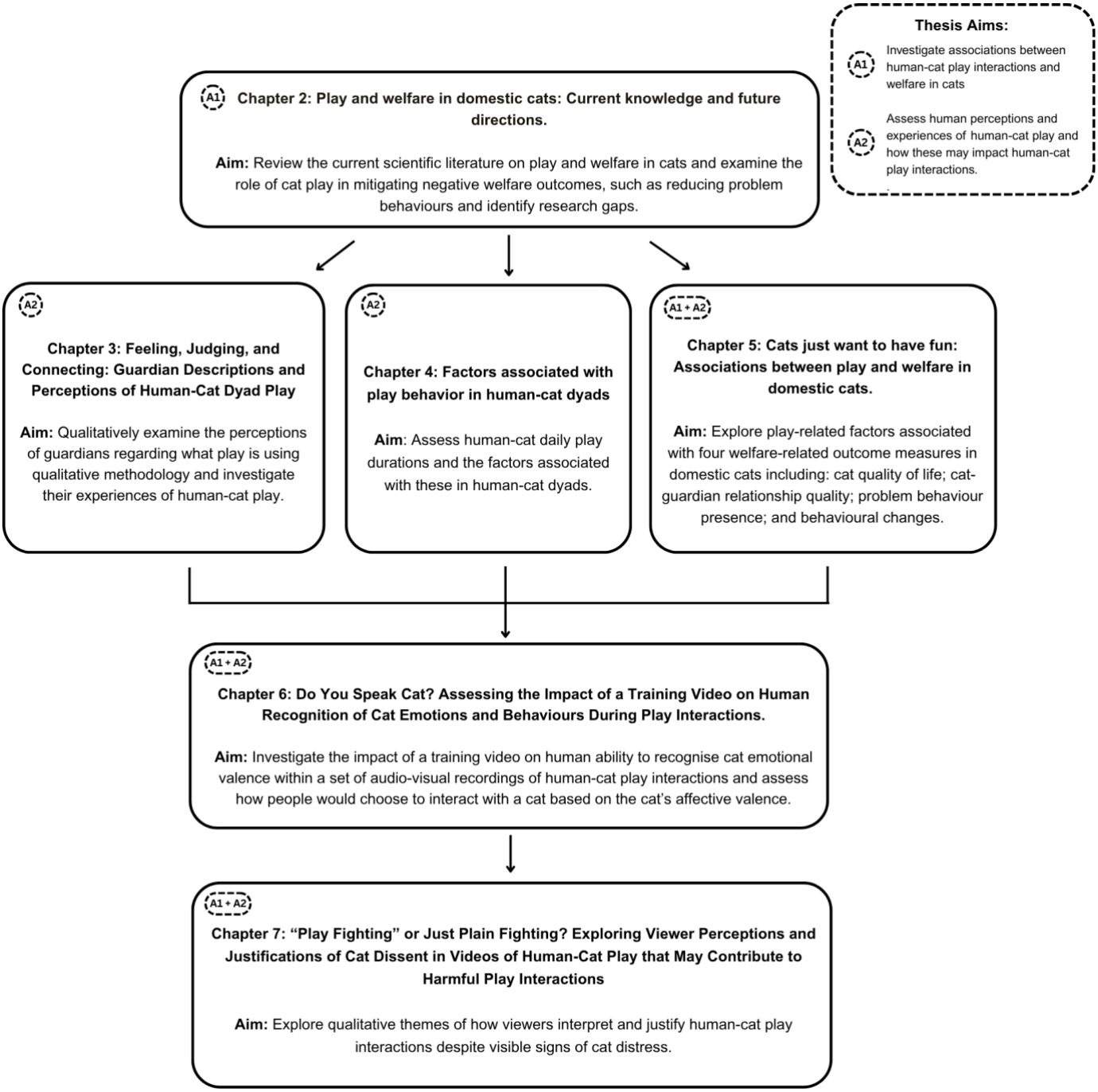


Figure 1.1 Structure and Aims of the thesis: Associations Between Play and Welfare in Domestic Cats and the Modulating Factor of Human Perceptions

1.7 Thesis structure

This thesis argues that human-cat play interactions may be beneficial to the welfare of the individuals participating in it. However, it cautions that play interactions may pose a welfare

risk in and of themselves if care is not taken to ensure the interaction is mutually assented to and cat dissent at any stage is respected. Consisting of eight Chapters, this thesis comprises an introduction (Chapter 1), a published literature review (Chapter 2), five research chapters, of which four are currently published (Chapters 3-6), and one has been submitted for publication (Chapter 7), and a concluding discussion (Chapter 8).

Chapter 2: Orients the reader within the current literature on play and welfare in cats, initially establishing definitions for the elements at the core of this association (play and welfare) before delving into cat-specific play and welfare associations and their implications for future research.

Chapter 3: Investigates guardian perceptions and experiences of human-cat play; an area identified in Chapter 2 as under-researched within the current literature. Using reflexive thematic qualitative analysis, the overarching objective of this Chapter is to provide a foundational, qualitative investigation into guardian perceptions of human-cat play and to identify guardian perceptions or observations that may inform future research. Specifically, this Chapter focuses on guardian perceptions of what constitutes a play interaction, explores guardian reports of human-cat communication cues during play, perceived benefits of play for cat socialisation, anthropomorphism in guardian interpretation of cat behaviour, and guardian observations of how factors such as cat age, disability and household dynamics impact cat play.

Chapter 4: This Chapter establishes an initial understanding of components inherent to human-cat play interactions and investigates factors that may influence play availability. This

study considers guardian and cat demographic data, relationship quality, time and resource availability, who initiates play and potential reasons for guardians avoiding play, and models how these factors may impact opportunities for play and subsequent play durations in human-cat dyads.

Chapter 5: Previous literature has often neglected to use specific welfare measurements when assessing the links between play and welfare in cats. To begin to bridge this gap, this Chapter utilises four welfare-related outcomes to assess correlations between play factors and welfare, including cat quality of life, human-cat relationship quality, problem behaviour presence and observable behaviour changes. The study generates initial information about whether meaningful associations between play and cat welfare exist, and what factors may contribute to this association, such as play quantity, quality and its correlation with human-cat relationship quality.

Chapter 6: Within Chapters 3 through 5, a common thread emerged regarding the importance of mutual initiation, inter-species communication and guardian concerns around injury risk during play and outcomes such as play times, cat quality of life and cat-guardian relationships. Chapter 6 further explores these elements using videos of both positive and negative human-cat 'play' interactions, investigating participant ability to recognise and respond to cat communication cues indicative of these valences and explores human perceptions of cat emotions during play.

Chapter 7: Findings of Chapter 6 revealed a concerning gap between recognition of a cat's negative state and subsequent appropriate response choices. Chapter 7 narrows the focus to

investigate human perceptions that may contribute to this gap. Using viewer comments on online videos as a natural study of human perceptions, this Chapter explores themes in how viewers interpret, normalise and justify human-cat play interactions despite visible signs of cat dissent, and discusses implications for interventions aimed at reducing unwanted interactions.

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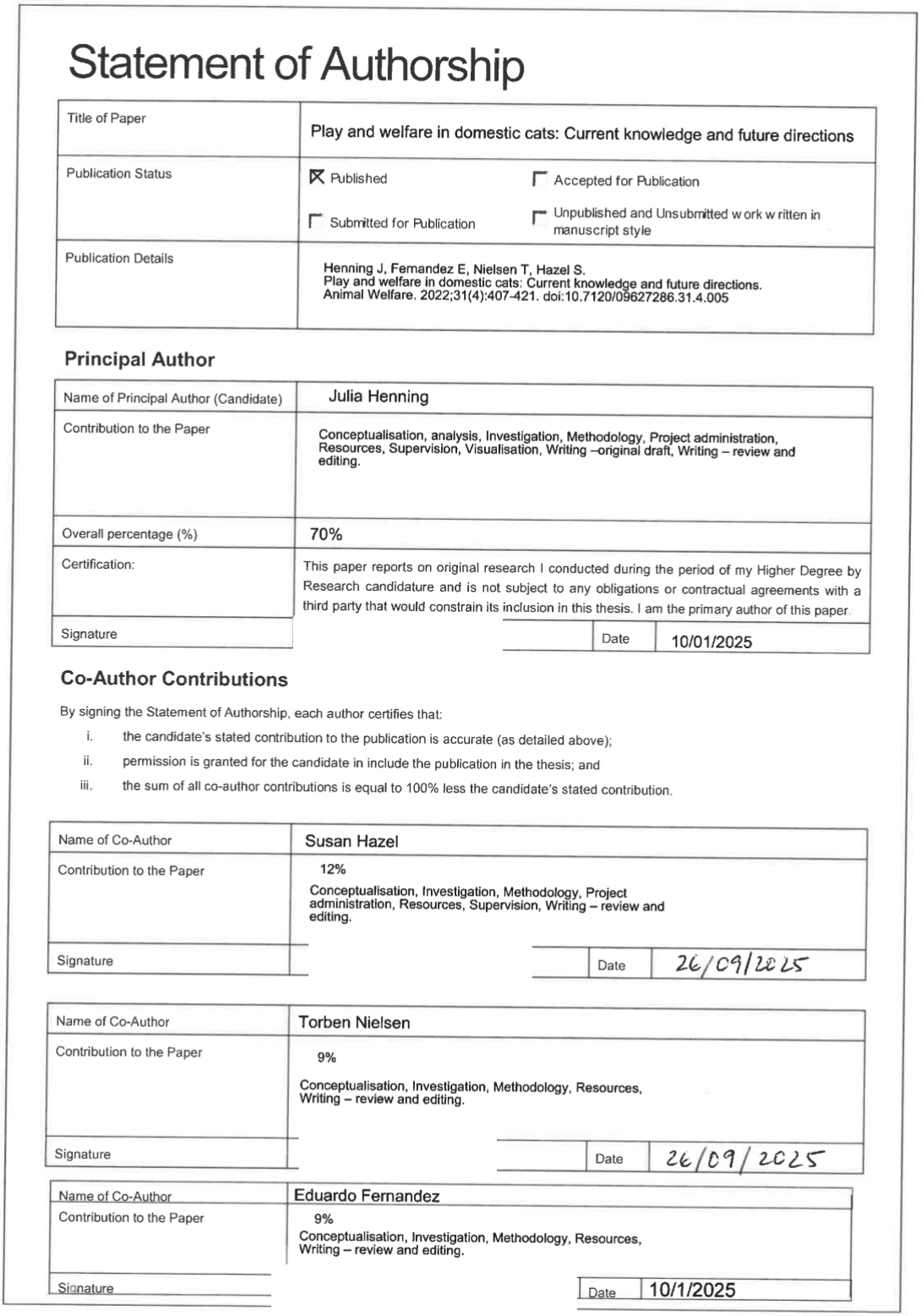
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Chapter 2: Play and welfare in domestic cats: Current knowledge and future directions.

Context Statement

This Chapter addresses Aim 1: To assess associations between human-cat play interactions and welfare in cats. A review of the current literature is used to establish foundational knowledge on correlations between play and welfare in cats and identify areas for future research. The review discusses how human-cat play may be useful as both an indicator and promotor of welfare in cats and raises concerns that inadequate understanding of play requirements may contribute to cat stress, problem behaviours and compromised welfare outcomes in domestic cats. Recognising that play behaviour in domestic cats has historically been viewed through a narrow lens of predatory skill development, the Chapter challenges this assumption, provides evidence for the necessity of play in cat social skill development and advocates for a more comprehensive view of the function of play in cat behavioural development, discussing the implications of this for cat welfare. The review highlights considerable gaps in the empirical knowledge of human-cat play, particularly regarding optimal play needs, cat play preferences, and the mechanisms through which play may affect cat welfare and human-cat relationships. The Chapter stresses the link between quality of human-cat relationships and cat welfare outcomes, highlighting that cats are entirely reliant on guardians for resource provisioning, companionship, health care, and critical life decisions including surrender and euthanasia. This dependency underscores the need for addressing human-cat play factors that may mitigate negative welfare outcomes. Finally, this Chapter identifies areas for future research including understanding guardian perceptions of cat play behaviours and cat play needs, investigating human-cat play communication and examining how human-cat play affects the human-cat bond.

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Play and welfare in domestic cats: Current knowledge and future directions

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Abstract

*Play and welfare have long been linked within animal research literature, with play considered as both a potential indicator and promoter of welfare. An indicator due to observations that play is exhibited most frequently in times when an animal's fitness is not under threat and when immediate needs such as food, water and adequate space are met. And a promoter, because of observations that animals who play more also have better welfare outcomes. However, limited research has been undertaken to investigate this link, especially in companion animals. The domestic cat (*Felis catus*) is one of the most popular companion animals in the world, yet little is known about the impact of play behaviour on cat welfare. We review the current literature on play and welfare in cats. This includes examining the role of cat play in mitigating negative welfare outcomes, such as reducing problem behaviours, one of the leading reasons for guardian dissatisfaction and cat relinquishment to shelters. Play is also discussed as a potential tool to provide environmental enrichment and to improve cat-human relationships. Future areas for research are suggested. We find that further research is needed that uses a multi-faceted approach to assess how quantity, type and quality of play impact subsequent cat behaviour and welfare. Future research could also assess cat play needs and preferences as well as investigate the role of play in mitigating threats to cat welfare such as reducing problem behaviour and improving human-cat relationships. If play is an indicator and promoter of welfare, studies into the impact of play may offer an accessible approach for monitoring and improving domestic cat welfare.*

Keywords: *affective state, animal welfare, behaviour, cat, enrichment, play*

Introduction

As humans learn more about the animals we share our lives with, we have become increasingly concerned about how animals are treated within society and how we can protect and promote their welfare (Broom 1991; Fraser 2009b; Widmar *et al* 2018). While no consensus on what defines animal welfare exists, for many the concept of welfare includes both freedom from pain and suffering, as well as the presence of positive experiences that make life worth living (Fraser 2009a; Broom & Fraser 2015; Mellor 2016). Previous studies into welfare often focused on avoiding negative outcomes. Only recently has positive welfare begun to be explored. This is especially true regarding affective state, a term that describes the sentient underlying experience of emotions, feelings, or moods such as joy, anger, pain, or hunger (Russell 2003; Fraser 2008; Ahloy-Dallaire *et al* 2018), and a core component of what many believe constitues good animal welfare. One class of behaviour within the animal behaviour toolbox that may offer a unique opportunity to both investigate and improve welfare is play, a behaviour that has now been recognised for its role in processes key to surviving and thriving, such as social, emotional, cognitive, and sensorimotor development (Vanderschuren & Trezza 2013). As a result of this, and the common observation that play is only observed in times when all basic needs have been met (Ahloy-Dallaire *et al* 2018), play is considered both an indicator and promoter of welfare in many species (Held & Špinka 2011). Limited research has investigated this concept or researched the associations between play and welfare, including play associations with positive affective state, especially in companion animal species (Oliveira *et al* 2010; Held & Špinka 2011; Hausberger *et al* 2012; Mintline *et al* 2013; Sommerville *et al* 2017; Ahloy-Dallaire *et al* 2018).

The domestic cat (*Felis catus*) is the second most common companion animal in the world (Growth from Knowledge 2016). Despite this popularity, few studies have investigated the impact of play on cat welfare (Strickler & Shull 2014; Loberg & Lundmark 2016; Duffy *et al* 2017). If play is an indicator and promoter of welfare and affective state, studies into the impact of play may offer an accessible approach for guardians, veterinarians, and shelters to monitor and improve domestic cat welfare. Currently, little is known about how much play is available to cats, what factors are associated

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with play availability, or how play duration, type or quality differ in their ability to impact cat welfare or affective state. One previous study suggests that play may decrease incidence of problem behaviour, a common issue in domestic cats that leads to negative welfare outcomes such as surrender and euthanasia (Strickler & Shull 2014). Here, we review the current literature on play and welfare (with a focus on affective state) in cats, as well as the role of cat play in problem behaviour mitigation and environmental enrichment and suggest areas for future research.

Methods

To establish the current level of knowledge within the literature on cat play and welfare we examined peer-reviewed studies and surveys which included aspects of cat play behaviour and welfare outcomes. Since, to date, no studies have tested play against a specific welfare measure, welfare outcomes were defined as outcomes strongly linked to welfare such as decrease in problem behaviour, development of social skills or evidence of poor environmental conditions associated with changes in play.

Searches were conducted on Google Scholar™, Scopus and Web of Science. Search terms included ['cat play' OR 'feline play' OR 'kitten play' OR 'juvenile cat'] AND ['play' OR 'behaviour' OR 'welfare']. Searches were limited to papers published in English. No limitation was made based on year of publication. The literature search yielded 471 results. Publications that were book chapters, literature reviews, conference proceedings, abstracts, unpublished theses, or case studies were excluded. Inclusions were limited to peer-reviewed journal publications. A review of titles and abstracts further excluded any papers that were not about play, welfare, or domestic cats. Reference snowballing was used to identify any further relevant papers. After exclusion, the search resulted in 23 papers that had empirically investigated the association between cat play and welfare outcomes.

Play

Defining play

Play is a behaviour that, until the last few decades, had been relegated to the sidelines of behavioural research (Burghardt 2005). Much debate still exists over exactly how to define play and its various subcategories, partly because play varies between and within species and encompasses several behavioural categories (Held & Špinka 2011). Perhaps the most defining characteristic of play is not how it is observed, but how it is experienced. That is, play is anything that is perceived as play (or 'fun') by the person or animal performing it (Blanche 2002; Scarlett *et al* 2004; Brown 2009; Henricks 2015). This definition has mostly been explored in the realms of human psychology and philosophy but also resonates within the realm of non-human animals (Ahloy-Dallaire 2015). While this definition is likely the best for broadly distinguishing play from other behaviours, it is difficult to utilise operationally in observing, analysing, or optimising play, especially in animals. For this purpose, Burghardt (2005) suggested an operational definition of play, utilising five criteria to differentiate play behaviour from non-play behaviours. According to Burghardt: "Play is repeated, seemingly non-functional behaviour differing from more adaptive versions structurally, contextually, or developmentally, and voluntarily initiated when the animal is in a relaxed, unstimulating, or low stress setting" (Brando & Burghardt 2019; p 560). Within this framework, Burghardt focuses on proximate mechanisms for play, related to the life and experience of the individual, rather than ultimate functions related to why play has evolved within a species context. This focus is important and useful, encouraging consistency within play research and providing a user-friendly framework for recognising play within observations. However, while proximate mechanisms may assist us in observing and quantifying play, play may have important adaptive value, particularly in social, cognitive, and physical development during juvenile periods (Himmler *et al* 2016; Siviy 2016). Further research into ultimate causes for the presence and continuation of play behaviour among species may eventually expand and alter our current definitions of play.

Play types

Definitions of the types of play vary between and within disciplines (Marsh *et al* 2016). Multiple taxonomies and classifications of play types have been proposed for human play (Bishop & Curtis 2001; Broadhead 2003; Bird & Edwards 2015) with as many as 16 types of play identified in human children (Hughes 2002). This richness of play classification is currently lacking in classifications of non-human animal behaviour. Instead, three broad types of play are utilised (Ahloy-Dallaire *et al* 2018). These are: object play; locomotor play; and social play (see Table 1). While these play types are the most used, unfortunately their names and definitions are not consistent within the literature. Additionally, many specific instances of play can (and often do) fit within multiple classifications. A cat may be engaging with a toy, solo, but if another cat joins in, is this object or social play? Moreover, if the two cats begin to chase the toy, is this social, object or locomotor play? Two alternative schemes for play types have been proposed to solve this issue (Mitchell 1990; Fagen 1995), both deploying hierarchical systems of play with higher levels subsuming the lower. However, these schemes are not without their criticisms and neither have been readily adopted in the field (Burghardt 2005). If a hierarchical scheme was to be used, it is likely that the hierarchy would need to change based on the species in question and their social structures. For instance, in Table 1 we list playing with a toy together as social play rather than object play, because the act of socialising is likely to be more impactful and potentially valuable to a cat than playing with a toy solo, however this hierarchy would be inappropriate for a solitary species and may even change within a species. Cats are a likely candidate for this as their degree of sociality can vary distinctly between individuals. It is also important to note that not all animals play and that of those that do, only some engage in all the three typical play types, therefore a

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Table 1 Locomotor, object and social play definitions and examples.

Play type	Definition and characteristics	Example in cats
Locomotor play	Playful activity where an individual moves their body in space, performing sustained or intense locomotor movements, commonly without an apparent reason or stimulus (Martin & Bateson 1985; Burghardt 2005, 2011). Sometimes referred to as movement play or locomotor-rotational (Hausberger *et al* 2012) play due to the head shaking or body twisting movements that often accompany this type of play (Wilson & Kleiman 1974). Usually, the first play behaviour to appear ontogenetically (Burghardt 2005)	A cat running, leaping, prancing, rolling, sliding, jumping in the air etc
Object play	Where an individual manipulates and/or interacts with an object that unlike food or nesting material provides no obvious immediate benefit to the individual (Burghardt 2005). Common in predatory animals though also present in many herbivorous species. Sometimes referred to as exploratory play or solitary play, solitary object play or sensorimotor play (Burghardt 2011). The most common form of play used for enrichment in captive animals through the addition of toys and other novel objects to a captive animal's environment (Burghardt 2005)	A cat batting a crinkled piece of paper with their paw, mouthing or carrying around a toy mouse, stalking and/or pouncing on a toy, knocking an item off of a surface etc
Social play	Play directed at one or multiple conspecific(s) or other animal(s) playing the role of a conspecific. According to Burghardt (2005) the five criteria need to be applied to both or all participants involved in the social play in order show that the behaviour is playful from the perspective of all participants. Social play often involves behaviours such as head shaking, biting and growling that are otherwise associated with aggression. Because of this, social play requires participants to show an ability to communicate and co-operate with each other that they are 'playing' (Bekoff & Allen 1997). In some species a known play signal is used, such as play bows in dogs or vocalisations in squirrel monkeys (Burghardt 2005). In cats, there is a suggestion that a half-open mouth position known as 'play face' may be a play signal (Bradshaw 2012; Delgado & Hecht 2019). These play signals have been described by some as constituting metacommunication. That is, secondary communication about how a communication should be interpreted (Bekoff & Allen 1997)	Generally, a cat playing with another cat, dog, human or other animal. Play includes chasing, play fighting, wrestling, stalking, biting, playing with a toy together etc. Play can include elements of deception, role-reversal across bouts and self-handicapping

species-specific approach is needed (Pellis *et al* 2019). Within this paper, we have focused on social play as any play, including locomotor or object, that involves social elements while object play is any play, including locomotor that involves an object, without any social element, and locomotor play is any play that involves movement of the body, without any object or social elements. Gajdoš Kmecová *et al* (2021a) suggest that future studies consider moving away from contextual or purely functional classifications of cat play towards a psychobiological approach, which concentrates on the motivational and emotional state of the cat(s) combined with a consideration of the underlying functional behavioural system involved. For example, within this conceptualisation, conspecific or heterospecific social play would be classified as 'learning about social manipulation.' While this paper begins to move the needle forward in generating more detailed classification of play type, it still focuses mostly on the three play types specified above, moving them into five categories instead of three. Alternatively, work by Pellis *et al* (2019) investigates play as a behaviour system within an evolutionary context.

It is possible that cat play involves even more types and distinct patterns of play than are currently described scientifically. Richer classification of play types in cats could improve our understanding of cat play, its evolutionary history and allow for comparisons across the species while also enabling greater depth of analysis of play, its functions, and impacts. However, care needs to be taken to ensure that any play classifications are created in a consistent and user-friendly way to avoid any confusion which may hinder progress in our understanding of cat play. Further research into the behavioural patterns and breadth of play in cats would be useful in beginning to establish further classifications of cat play types.

Play in cats

A common concept in early play research into cats, and other predatory species, was that play was 'practice' for later, more serious, versions of the behaviour such as catching prey (Egan 1967). This concept was studied in kittens who were separated from their mother, and littermates, and raised in isolation for eleven weeks while either being made to wear frosted plastic goggles or raised in a dim, visually barren environment (Thomas & Schaller 1954). At eleven weeks of age, these isolated kittens showed similar prey-catching abilities to kittens reared normally. This finding was further supported by Caro (1980) who found that kittens deprived of opportunities to play with objects showed similar ability to catch four types of live prey as kittens who had access to toys during development. Further, a 1988 study of adult cats by Pellis *et al* investigated the link between 'predatory play' and predation by experimentally dosing cats with benzodiazepines, oxazepam or diazepam, which have previously been shown to enhance predation in mammalian carnivores (Leaf *et al* 1984). Results found that benzodiazepines increased attack patterns in cats along a gradient that escalated from avoiding to killing prey. With the administration of benzodiazepines, cats that previously avoided mice during obser-

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vation now began to interact with the mice in what could be perceived as a 'playful' manner. Cats that previously had 'played' with the mice were now more likely to kill them. And cats who had previously killed the mice now did so with less latency or preliminary contact. Pellis *et al* concluded that the previously proposed dichotomy of predation and predatory play is a misnomer and that the impression given of playfulness towards prey was instead a misinterpretation of repeated physical contact with the prey in preparation for a kill. What is often observed during predation to be 'play' is instead suggested to be a blend of attacking behaviour and defensive action taken by the cat to avoid injury. This blend of attacking and defending may be what makes the cat *look* as if it is playing. Injection of benzodiazepines significantly decreased the number of defensive behaviours shown by the cat and, without these defensive elements, the similarities between predatory 'play' and 'play' ceased. Predatory play may therefore not be play at all and, instead, part of a predation pattern which sits along a gradient (Pellis *et al* 1988).

These findings suggest that the development of play, at least in cats, does not function to develop predatory skills (Martin & Caro 1985). Instead, play, especially social play, may at least partly function in establishing another skill entirely. Guyot *et al* (1980) showed that kittens experimentally isolated from their mother and littermates developed object play normally, though at a lower frequency than kittens raised with a mother and/or littermates. However, these socially deprived kittens did not engage normally in social play, appeared to lack social communication skills, and struggled to cope with exposure to novel stimuli into adulthood compared to kittens reared with a mother and/or littermates who engaged regularly in socialisation and social play. These findings suggest that social play may be important for developing and maintaining social skills in cats. It is important to note that experiments involving isolation are limited in their ability to provide information we can draw adequate conclusions from. Isolation itself is a traumatic experience which may confound results and is often harmful long term to the animals involved. Kittens experimentally isolated from their mother at two weeks of age by Seitz (1959) were shown to exhibit a "greater proneness to anxiety" in adulthood (Seitz 1959; p 356) when exposed to novel or stressful situations than kittens allowed to stay with their mother until 12 weeks of age, while kittens who remained with their mother until 12 weeks exhibited greater amounts of play behaviour and general playfulness than kittens who had been isolated. Therefore, a potential confound in studies that involve isolation may be the negative impacts of isolation itself on the welfare of the kitten which, in turn, may have affected levels of play and socialisation proficiency. An experience which may confound results and is often harmful long term to the animals involved. Further, isolated animals are deprived generally of all forms of social contact, including but not limited to play. Therefore, any developmental effects observed may be due to play or could also be due to the lack of any number of other social deprivations.

Optimal play

Little is known about the play needs of domestic cats. It is probable that needs for play change with age and differ depending on many factors including environmental conditions, housing, early life experiences, personality etc. However, to date, no studies have investigated play in cats beyond the juvenile period nor have these factors been studied. Results of a survey undertaken by Strickler and Shull (2014), of 277 veterinary clients in Tennessee, showed that 64% of guardians reported playing with their cat more than twice a day in bouts lasting between 5–10 min. This is less time than reported in a previous survey of 550 guardians in Germany by Heidenberger (1997) in which most guardians reported playing with their cats three times across the day with average play times for each individual session reported to be between 20–40 min. Differences between these studies could be due to variances between countries, in survey participants, number of responses, disparities in the wording of questions or may reflect changes in human behaviour over time.

Only a few studies have looked at play preferences in cats. Within these studies, cats preferred toys similar in size to a mouse (Hall *et al* 2002), toys that moved (Shreve *et al* 2017) and toys that were novel (Hall *et al* 2002). Habituation to toys has been associated with decreased play or engagement with the toy in both cats (Hall *et al* 2002) and dogs (*Canis familiaris*) (Pullen *et al* 2012). Habituation and dishabituation to toys in cats has also been associated with post-inhibitory rebound, where play is inhibited due to habituation and then rebounds when a novel toy is presented (Hall *et al* 2002). This phenomenon has been previously proposed as an indicator of frustration and therefore diminished welfare in farm animals (Freire *et al* 2009). Rotation and replacement of toys has therefore been suggested to assist in encouraging continued cat play behaviour (Alho *et al* 2016). In one survey by Strickler and Shull (2014), only 22% of cat guardians reported that they rotate availability of their cat's toys.

Currently, studies into the play needs of cats have focused on human-cat play. However, it is important to acknowledge that cats engage in play in many ways, not just with humans but also with other cats and non-human heterospecifics such as dogs, as well as by themselves. Further studies into solo cat play, multi-cat play, cat-heterospecific play, differences between indoor and outdoor cat play needs, solo-housed and multi-animal housed play needs as well as when and how to rotate toys, how much play is available to cats, what factors impact how much a guardian plays with their cat, what toy and play preferences cats have and, what amount, and quality of play is ideal for a cat's physical and mental well-being are needed.

Play and welfare

Play and welfare: Defining welfare

The definition of animal welfare does not currently have a consensus. This is due, in part, to defining animal welfare being a value-based endeavour. Current animal welfare definitions and parameters differ greatly depending on the under-

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lying values of the individual conceptualising it, what audience the individual is talking to (such as public, scientific or industry) and what level of suffering is deemed reasonable or justified (Fisher 2009). The Brambell Report (1965) states that "welfare is a wide term that embraces both the physical and mental well-being of the animal" (Brambell 1965). Webster (2016) surmises that "The welfare of any sentient animal is determined by its individual perception of its own physical and emotional state" (Webster 2016; p 1).

While previous definitions of welfare focused on an absence of pain and suffering, this thinking has been updated to incorporate the three pillars of physical health, ability to express natural behaviours and a presence of positive affective states (Mellor & Beausoleil 2015; Heath 2020).

Play and welfare: Measuring welfare

Measurements of welfare differ greatly. It is currently suggested that a multifaceted approach that relies upon multiple measures is necessary for proper welfare assessment (Broom & Johnson 2019). Three of the most used factors in welfare assessments include: (i) the animal's physical health and biological functioning; (ii) the animal's ability to exhibit natural behaviours specific to their species; and (iii) the subjective emotional experience of the animal (Fraser 2008, 2009a,b). Each of these factors is often explored individually when measuring welfare. However, the authors of this paper agree with the suggestion by Veit and Browning (2021), that an integration of these three perspectives and their associated measures is necessary to illuminate a comprehensive picture of an animal's welfare.

Affective state and welfare

Affective states can be broken down into three broad categories: (i) homeostatic affects, internal bodily states such as hunger and thirst; (ii) sensory affects: states that result from sensory imputs such as taste or touch; and (iii) emotional affects: states that "arise from the same neural circuits that integrate and orchestrate the emotional action and autonomic responses of the brain-body continuum" (Panksepp 2011; p 1796) and comprise behavioural, physiological, and subjective components (Paul *et al* 2005). Further, each of these affective states can be described as being valanced, that is they have a value that is either positive/preferred (eg joy) or negative/aversive (eg pain) (Russell 2003; Ahloy-Dallaire *et al* 2018). Affective states also differ in their degree of valence (eg very negative or mildly positive), their duration (from acute pain reactions to short-term emotional responses and long-term mood alterations) and their level of stimulation or arousal (Russell 2003; Harmon-Jones *et al* 2013; Ahloy-Dallaire *et al* 2018).

Within an affective state welfare model, an animal's welfare is considered 'good', when an animal experiences mostly positive affective state. 'Bad' welfare would be considered when an animal experiences a surplus of negative affective state and 'neutral' welfare would exist when an animal's affect was mostly neutral or roughly equitable in both positive and negative affective states (Mendl *et al* 2017; Ahloy-Dallaire *et al* 2018). Welfare is often seen as a composite of both physical and mental health with emphasis sometimes placed more on one or the other depending on value-based judgements. Mendl *et al* (2017) asserts that animal welfare can be measured operationally through observations of affective state, especially of valence and that an animal's emotional state is a key determinant of their welfare.

Observations of affective state, when combined with physical health information and environmental quality, could offer a multifaceted and robust approach to assessing overall welfare (Veit & Browning 2021).

Play has been suggested as both an indicator and promoter of positive affective state and, therefore, good welfare. This is again because play is most observed in animals when their immediate needs such as food, water, and adequate space are met and during times when their fitness is not threatened (Fagen 1978; Ahloy-Dallaire *et al* 2018). Therefore, high amounts of play are thought to indicate that an animal is experiencing a positive affective state while low levels of play are thought to indicate a poor negative affective state (Burghardt 2005; Held & Špinka 2011; Ahloy-Dallaire *et al* 2018). However, what constitutes a high or low amount of play, in cats or other species, is currently undefined. Prospective cohort studies, surveys and detailed observational studies may be able to begin to answer this question.

Some research into human children suggests that play frequency may not always be indicative of positive affective state and can instead sometimes indicate negative affective state (Ahloy-Dallaire *et al* 2018). In several studies of children with medical conditions or in negative circumstances, social play was reduced, while solitary or object play was unaffected or, in some cases, increased (Altmann & Gotlib 1988; Fantuzzo *et al* 1996; Gariépy & Howe 2003; Ahloy-Dallaire *et al* 2018). Gariépy and Howe (2003) studied play in hospitalised children with leukaemia compared to a control of healthy children. While children with leukaemia did play less than the healthy controls, they also showed distinct differences in type of play. Within the study, children with leukaemia spent a far greater proportion of their play time engaging in solitary play than did healthy children within the control group (67 vs 35%). In another study on children, depressed children engaged in social interactions significantly less than non-depressed controls, while engaging in solitary play as much as eight times more than non-depressed controls (Altmann & Gotlib 1988). The findings of these studies suggest *type* of play may have an important role in detailing whether play is indicative of positive or negative affect. It is important to note that these findings were all within human studies, and it remains unclear if the findings are universal across mammal species. It is likely, for instance, that a less social animal like a cat may have very different welfare associations with social play than a human. Future research into the associations between play type and welfare and/or affective state conducted specifically in cats would provide much needed clarity on how observations of play type may indicate levels of welfare.

Another factor that may be key to successful analysis of play and its purported welfare implications is the quality of the

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play. Very little is known about how quality of play affects animal behaviour, affective state or welfare or what factors affect the perceived quality of a play session for an animal. Currently, there is no definition of quality when it comes to play. Previous studies have utilised play type as a proxy for quality, such as in the study by Barrett *et al* (1992) where, in a population of gelada baboons (*Theropithecus gelada*), lack of rainfall reduced both general quantity of play and limited the amount of 'high quality', high energy play behaviours, such as wrestling, that the animals engaged in. While increasing 'lower quality' but less physically demanding, more solitary play types (Barrett *et al* 1992). Within this study and others (Altmann & Gotlib 1988; Fantuzzo *et al* 1996; Gariépy & Howe 2003; Ahloy-Dallaire *et al* 2018) play quality is represented by quantitative changes in play type. In these instances, play quality and quantity are distinguished from each other by changes in overall amounts of play (quantity) verses changes in the amount of each play type exhibited (quality). Similarly, Smaldino *et al* (2019) makes an argument for the importance of play complexity in gauging play quality, observing that while complex play requires higher degrees of investment than more simple forms of play, it may also yield greater potential benefit to the animal, especially with regards to socio-cognitive development. However, in both scenarios, a particular quality (aspect of/characteristic) of play is being used to assume the quality (high or low value) of the play. It remains unclear whether this method is useful or whether play type, quantity or complexity are adequate proxies for ascertaining quality of play. It is likely that quality of play is more multifaceted than simply type or complexity and may also involve individual preference, species-typical behaviours, play partners, environment, seasonal or time relevant factors etc. As such, we maintain a distinction between play quality and play quantity, type or complexity and suggest that consideration of play quality will likely require analysing multiple factors, including context.

Further research is needed to investigate what factors are associated with play quality and how play quality can be assessed. The association between play and welfare is likely more complicated than initial conceptualisation suggests. It is therefore important to analyse multiple facets of play including quantity, quality, complexity and play type when investigating play as an indicator and/or promoter of affective state and welfare.

Evidence for the association between play and welfare

Play has also been suggested as a non-invasive indicator that an animal's welfare needs are being met (Held & Špinka 2011). Certainly, play is quickly abandoned when interrupted by an immediate fitness threat and has been closely associated with favourable environmental conditions such as ample resources (Martin & Caro 1985; Burghardt 2005). Studies show that play behaviours decrease in conditions of overcrowding (Leyhausen & Tonkin 1979; Tacconi & Palagi 2009; Loberg & Lundmark 2016), where environmental hazards are present (Berger 1979), during food deprivation (Lee 1984; Siviy & Panksepp 1985) and when an animal is in poor health or recovering from an injury (Fagen 1978). Conversely, play behaviour increases when food is supplemented experimentally (Sharpe *et al* 2002) and once an animal has recovered from injury or poor health (Fagen 1978). Play has also been linked to survival. Fagen and Fagen (2004, 2009) observed that juvenile brown bears (*Ursus arctos*) who played more had greater survival during the first year of life and to independence. While these studies show promising associations between play and welfare, more play may not always equal greater welfare. Play behaviour is influenced by various emotional and physiological factors and may not always be an indicator of a positive or pleasant affective state.

In studies of cats, kittens showed increases in object play behaviour when experiencing a restriction in milk provisions through separation from their mother (Bateson & Young 1981), through induced onset of early weaning through bromocriptine injection (Bateson *et al* 1981), or when their mother was malnourished (Bateson *et al* 1990). Object play also increased in kittens as their mother decreased her care of them (Bateson *et al* 1981, 1990). These findings contrast with more recent observations of dairy calves that found early weaning and low-energy intake to be associated with decreases in locomotor play (Krachun *et al* 2010; Rushen *et al* 2016). It is possible that these differences may be due to differences between predatory and prey species, specific differences in cats or flaws in the methodology used. While we do not suggest repeating the previous methods, it may be possible to formulate an observational study of shelter kittens to establish and investigate the effects of malnourishment or early weaning on play behaviour.

In addition, play has been suggested as a measure of welfare due to its rewarding nature and involvement in increasing opioid-mediated pleasurable experiences (Boissy *et al* 2007). A lack of play and, by association, pleasure and reward, is therefore thought to be indicative of poor welfare or a life lacking in quality (Boissy *et al* 2007; Held & Špinka 2011). The endogenous opioid system appears to play an important role in modulating social play behaviour in rats (*Rattus norvegicus*), with studies experimentally stimulating opioid neurotransmission through administration of an opioid receptor agonist (morphine) increasing or prolonging social play behaviour (Panksepp *et al* 1980, 1985; Normansell & Panksepp 1990; Vanderschuren *et al* 1995; Trezza & Vanderschuren 2008; Manduca *et al* 2014). Conversely, administration of opioid receptor antagonists (eg naloxone and naltrexone), reduced social play behaviour in rats (Beatty & Costello 1982; Panksepp *et al* 1985; Siegel *et al* 1985; Niesink & Van Ree 1989; Trezza & Vanderschuren 2009). Play also shows evidence for being integral to normal social, emotional, cognitive and sensorimotor neural development in rats. Social play is mediated by co-ordinated activity in the limbic corticostriatal network and neural circuits underlying social, emotional, cognitive and, reward processes (Pascual *et al* 2006; Leussis *et al* 2008; Bell *et al* 2010; Baarendse *et al* 2013; Van Kerkhof *et al* 2013, 2014). Further, these studies suggest that social play may be important for stimulating development and maintenance of these circuits. Limbic regions, such as the habenula and

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amygdala, play a role in social play behaviour in rats. The habenula is involved in mediating the negative affective aspects of social isolation. Studies show that this mediation may be mitigated by opportunities for social play, and that play may help to promote normal amygdala development (Meaney *et al* 1981; Daenen *et al* 2002; Kurian *et al* 2008; Leussis & Andersen 2008; Van Kerkhof *et al* 2013, 2014). However, it is important to note that, although the animals involved in these studies exhibited substantial amounts of social play behaviour during testing, it is not yet possible to determine whether the opportunity for social contact in and of itself may have contributed to these findings.

While many studies have investigated the relationship between play, pleasure and, neural development in rats, there are limited studies in other species, including cats. Without specific studies, it is unclear if these systems work similarly in cats.

Finally, welfare benefits of play may be furthered by its socially contagious nature (Varlinskaya *et al* 1999). Simply observing other animals playing can stimulate play in an observer (Bekoff 2001). In this way, if even one animal is exhibiting playfulness in a group-housing setting, this playful mood may be able to initiate a similar play mood in other animals within the household, extending the benefits of play to the whole group (Held & Špinka 2011). However, play contagion may not be as straightforward as previously thought. A recent study into this phenomenon in calves experimentally altered play through deprivation or supplementation of calf milk allowance (Größbacher *et al* 2020). Cows (*Bos taurus*) were housed uniformly within their milk allowance *or* housed in a mixed grouping with calves in the same housing receiving either a high or low milk allowance. It was expected that, within these mixed housings, calves on a low milk allowance would exhibit more play behaviour due to play contagion from the more playful high milk allowance calves. However, contrary to this, within mixed housing, play was instead suppressed in calves on the high milk allowance. While further studies are needed, the findings highlight the possibility of conspecific suppression of play behaviour, a greater complexity to play contagion and that play may be impacted by the social environment of the animal more so than available energy (Größbacher *et al* 2020). Whether these findings in a prey species apply to a predatory species, such as cats, has yet to be investigated. Studies into play contagion in multi-cat households may be a useful first step.

The study of play in cats has changed considerably over the last 60+ years, in line with our changing understanding of cats and how we relate to them. Early research into play often employed isolation within study designs. This type of study is limited in its experimental value and involves major ethical concerns for the animals subjected to them. It is unlikely that studies such as these would receive ethical approval today and while current research can take what it will from them, with an understanding of their limitations, these studies, and studies like them, should not be repeated. More recent studies into play have tended to focus on play in home environments and within human-cat dyads and generally take a much less invasive approach to their subjects with an emphasis on outcomes for both cat and guardian.

Previous studies into the link between play and welfare in cats have found associations between changes in play behaviour and social isolation, rearing history, consistency of husbandry, attachment to guardian, hunger level, problem behaviour, habituation, and space availability (see Table S2 in Supplementary material). Of these studies, few specifically set out to investigate the links between play and welfare and only three used a specific welfare measure within their study design. Welfare measures that were used included the cat's physical condition (Arhant *et al* 2015), occurrence of abnormal, repetitive behaviours (Kogan & Grigg 2021) and only one took a multifaceted approach utilising both physiological and behavioural signs of stress (Carlstead *et al* 1993). Further, most studies utilised only one type or sub-type of play within their observations or interventions with only one paper specifically investigating all three general types of play. Most of the studies utilised small group sizes. These small sizes may have led to issues with low statistical power, increased false discoveries, an overestimated size estimation and difficulties with reproducibility. Finally, observation techniques, ethograms and analysis were often not detailed enough for reproduction or to adequately show that observations were objective and free from bias, especially in earlier studies. Future research that specifically investigates play and welfare, uses a specified welfare measure, accounts for multiple play types, adequately reports and defines behaviours and utilises larger group sizes is needed. In particular, research into how play frequency, quality or type differ in their ability to predict or optimise welfare, how play impacts affective state, what mechanisms increase or decrease play in cats, cat play preferences, and the impact of human-cat dyad relationships, multi-cat homes and indoor or outdoor housing on cat play and welfare is suggested.

Cat-specific welfare

Cat-specific welfare: Environment and enrichment

In 2013, the American Association of Feline Practitioners and the International Society of Feline Medicine released a set of guidelines for meeting the environmental needs of cats (Ellis *et al* 2013). Within these guidelines, they employed a set of standards they called the Five Pillars of a Healthy Feline Environment. Pillar three of this five-pillar model focuses on providing opportunities for play and predatory behaviour. While predatory behaviour on actual prey species is not encouraged, enabling cats to engage in the strongly instinctual sequence of stalking and catching prey-like toys through play and playful feeding devices has been suggested as a way of allowing cats to safely express their natural behaviours (Ellis *et al* 2013). However, debate currently exists as to the relevance and benefits of playful feeding devices such as food puzzles (Delgado *et al* 2021). Pillar four highlights the importance of providing consistent and predictable positive human-cat social interactions. This pillar can be supported by engaging in regular, cat-centric play bouts that prioritise cat preferences for play length and type.

Provision of toys and other resources for play can be referred to as environmental enrichments. Previously used

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in settings such as zoos and laboratories, the concept of environmental enrichment has only recently been applied to domestic house pets (Ellis 2007). While what constitutes enrichment is still being refined within the literature, within this paper enrichment is defined as the positive or enriching interaction between a response and an event, such as the delivery of a feeding device or interactable item (Newberry 1995; Mellen & Sevenich MacPhee 2001; Hoy *et al* 2010; Fernandez *et al* 2021). That is, enrichment is defined here as an interaction (ie contingency) between an object or event, not simply the object or event itself. In other words, the emphasis is placed on demonstrating an observable, measurable interaction, rather than simply calling an arbitrary stimulus 'enrichment' (Fernandez *et al* 2021; Fernandez 2022). Play as potential enrichment has previously been discussed with respect to forming social bonds in wild lemurs (*Propithecus verreauxi*) (Antonacci *et al* 2010) and experiencing pleasure in humans (Vanderschuren 2010). Play may be enriching for cats in a multitude of ways. Some of the benefits of using play as enrichment include encouraging physical activity, which is especially important for cats who live in confined spaces (Wall *et al* 2019), and for increasing emotional resilience (Delgado & Hecht 2019). The level to which guardians may need to supplement environmental enrichments may depend on the individual cat and the degree to which the cat is kept indoors. Outdoor cats may require less play or enrichment as they are more readily able to meet their own needs outside of the home.

Threats to cat welfare: Problem behaviour

As a result of their near identical morphology and genetics to their closest wild relative, domestic cats still exhibit many natural wild behaviours. Exhibiting these normal behaviours is imperative to cat welfare, yet these behaviours are often at odds with human desires for their home, causing problems between guardians and cats (Bradshaw 2018). 'Problem behaviour' is a term used to describe any behaviour expressed by an animal that is unacceptable to a guardian (Amat *et al* 2009). This often includes behaviours such as scratching furniture, aggression towards heterospecifics and/or conspecifics and, urinating or defaecating outside of the litter tray (Bradshaw 2018). It is important to note that while many problem behaviours may not be problematic for the animal themselves, some can be indicative of a deficiency in the animal's environment and some problem behaviours may be an indicator of an underlying medical issue (Bowen & Heath 2005).

Research in cats indicates that lack of play may be associated with occurrence of problem behaviour (Strickler & Shull 2014; Foreman-Worsley & Farnworth 2019). Problem behaviour is the leading cause of euthanasia in otherwise healthy pet cats (Carney *et al* 2014) and the major reason cats are surrendered to shelters (McCabe & Ecker 1996). Due to major cat overpopulation problems, shelters struggle to provide enough resources and space to cope with the multitude of animals surrendered into their care (Stavisky 2014; Janke *et al* 2017). Empowering guardians to provide their cat with adequate enrichment may improve guardian satisfaction and reduce the number of cats surrendered due to problem behaviour, ultimately easing the strain of cat overpopulation in shelters and increasing general cat welfare (McCabe & Ecker 1996). One issue that may exacerbate the occurrence of problem behaviours is the perception by some guardians that cats only require minimal investment in terms of hands-on care and environmental enrichment and a general lack of understanding about cat behavioural requirements (Grigg & Kogan 2019). If behavioural needs are not met, behaviours associated with poor welfare can arise (Broom 1986). A previous survey by Strickler and Shull (2014) suggested that play may reduce problem behaviours in cats, with guardians who reported play bouts of 5 min or more also reporting fewer problem behaviours compared to guardians with play bouts of 1 min. If play can assist in reducing problem behaviour it may also lead to positive welfare outcomes by increasing guardian satisfaction and decreasing risk of surrender or euthanasia.

Hunting behaviour: A problem for cat and wildlife

Outdoor roaming cats are a recognised threat to biodiversity (Medina *et al* 2011), though debate remains as to how best to control this threat (Crowley *et al* 2020). For owned cats, the current recommendations from the American Veterinary Medical Association (AVMA) are to house cats indoors (AVMA 2019). Indoor-only living has previously been suggested as a potential risk factor linked to increased risk of developing urinary tract issues (Lund *et al* 2016; Longstaff *et al* 2017), diabetes (Slingerland *et al* 2009) or problem behaviours (Amat *et al* 2009). However, if supplied with adequate living conditions (Herron & Buffington 2010), cats adapt well to indoor living, especially when habituated from a young age (Jongman 2007). Indoor-housed cats may also gain from a number of welfare benefits. Previous studies indicate that cats kept exclusively indoors show lower levels of inter-cat aggression (Levine *et al* 2005; O'Hanley *et al* 2021), are at lowered risk from parasitic infection (Chalkowski *et al* 2019), road traffic accidents (Wilson *et al* 2017), trauma and predation by other animals (Tan *et al* 2020). However, many cat guardians push back against indoor confinement due to beliefs around how it will impact their cat's quality of life or physical health, struggles to implement confinement, guardian aversion to indoor litter trays or because of a perceived association between indoor confinement and incidence of problem behaviour (McLeod *et al* 2015; Foreman-Worsley *et al* 2021). Public perceptions of cat predatory behaviour directly impact both cat housing and risk of mortality (Riley 2019). Reducing cat impacts on wildlife is therefore integral to improving cat welfare. While indoor confinement may eliminate predation, for the time being, it is unlikely that all homes will be willing or able to confine their cats. Opportunities to reduce predation that are more likely to be widely adopted are needed (Cecchetti *et al* 2021). This research by Cecchetti *et al* showed that a play intervention of just 5–10 min a day reduced guardian-reported wildlife predation by 25% in a

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study of cats with known regular hunting behaviour. On top of this, 76% of guardians in the play treatment indicated that they would be happy to continue with the intervention. An intervention, such as play, may be more likely to be implemented by cat guardians than indoor confinement and has the added incentive of providing enrichment for their cat. While these results are promising, so far only Cecchetti *et al* (2021) have investigated the impact of play on predation and their study design relied heavily on guardian-report, which may mean that some predations that did not occur at or were not brought back to the home were missed.

The mitigating role of human-cat relationships on welfare

While domestication has arguably come with many benefits to cats, it has also left many cats subject to the care and lifestyle decisions of the people with whom they co-habitate. Personality differences in guardians are associated with welfare outcomes for cats, with guardian neuroticism, in particular, being associated with increased likelihood of problem behaviour, stress-related behaviour and ongoing medical conditions (Finka *et al* 2019). Co-habitation impacts humans and animals alike, providing potential benefits for both human and cat physical and mental health (Friedmann & Son 2009; Gillum & Obisesan 2010; Stella & Croney 2016; Brooks *et al* 2018). The degree to which these benefits are associated with co-habitation is likely influenced by the quality of the relationship between guardian and cat. In a study of guardians of cats with epilepsy, closer cat-guardian relationships were associated with both reduced burden of care in guardians and higher quality of life in cats (Henning *et al* 2021). It follows that improving cat-guardian relationships is likely to be a pivotal step to take in improving both cat and owner welfare and well-being. Play may be a key element to this step. Encouraging play between guardian and cat offers an opportunity for guardians to establish and improve social bonds with their feline companions. In a stimuli preference study by Shreve *et al* (2017), both pet and shelter cats showed distinct preference for human social interaction over toys, novel scents and food. Similarly, humans have shown preference for cats that are interactive (Brown & Stephan 2020). It is important that future research investigates how play impacts cat-human relationships and whether play positively impacts guardian satisfaction.

Communication in human-cat dyads

One element of play that may be important in establishing and improving human-cat relationships is communication (Palagi *et al* 2016). Communication is a vital element of understanding the needs, desires, and state of another individual. Through communication, we may learn what a cat enjoys, what they dislike, whether they require assistance or feeding, if they are stressed or relaxed and if they require medical intervention. Communication is also an integral part of social play. Social play between humans and animals is generally observed within the category of free play, a type of play where the participants are continually creating, following, and changing the 'rules' of the game as they go (Pellegrini 2009). Free play often requires a great deal of complex communication as players navigate the changing rules or boundaries while exhibiting actions that, in different contexts, may be interpreted as aggressive or threatening behaviour (Bekoff & Allen 1997). As a result of this, play may provide a platform for guardians to improve their understanding of their cat's communication signals and, through this, improve their ability to meet and understand their cat's needs.

Animal welfare implications and conclusion

Play may be a formidable tool in the pursuit of improved animal care as both an indicator and promoter of welfare, with a strong emphasis on affective state. However, little is known about how play in cats, or how quantity or quality of play, impact subsequent behaviour and welfare. Research is needed to further define play, its types and quality in cats, to quantify optimal play needs and cat play preferences as well as to investigate the role of play in mitigating threats to cat welfare, such as reducing problem behaviour and improving human-cat relationships. Understanding these factors may provide an opportunity to recognise and optimise cat welfare and may illuminate concepts that also relate to humans and the complexities of how human and animal welfare intertwine. While more research is needed to fully comprehend play and its usability as a welfare indicator or promoter, implications from the current body of research in cats suggest that play may be important for the formation of adequate social skills, ability to cope with novel or stressful situations and maintenance of physical health. Species-specific research into play and welfare may provide promising areas for future research.

Declaration of interest

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Table S2 Studies and surveys linking play and welfare outcomes in domestic cats and kittens.

Object play	Experimental Design	Measures	Cat age during study	Sample size	Outcomes
Caro (1980)	11 kittens assigned object play (OP) group and given opportunities to play with 2 toys: a black table tennis ball and an elliptical black woollen ball filled with sand. 8 control kittens not given opportunities or exposure to object play with toys. Kittens in both groups reared normally with mothers and littermates.	At 6 mnths of age, kittens from both OP and Control groups individually tested on ability to catch and kill 4 types of live prey (rat, mouse, canary, and goldfish). Behaviours recorded and analysed for differences in predatory motor patterns, frequencies, and latencies between the groups.	4 weeks – 6 months	19 kittens n=11 for OP, n= 8 for C	Small differences in latency with prey between the OP and control group. OP kittens slower in some circumstances to paw at or initiate behaviour pattens with prey. No differences between no of prey killed and eaten between groups. Within this study, object play did not show any quantitative difference in the development of adult predatory skills.
Bateson & Young (1981) Bateson et al. (1981) Bateson et al. (1990)	Bateson and Young (1981): Kittens raised with mothers until 31-35 days of age when 2 kittens from each litter gradually separated to create 2 groups: Control: kittens raised with mother Early weaned: kittens raised separated from mother and minimal human handling.	Checklist of 9 play behaviours and 2 non-play behaviours every 2-3 days for 30 mins (presented with a tennis ball, a stuffed toy dog and a stuffed piece of rabbit skin)	Birth – 9 weeks	28 kittens. for each condition n=14	Separated, early weaned kittens showed significantly higher play frequencies than control kittens. Similar results through induced onset of early weaning using bromocriptine injection (Bateson et al. 1981), or malnourishment of the mother (Bateson et al. 1990). Play increased in kittens as their mother decreased her care of them (Bateson et al. 1981; Bateson et al. 1990).
Hall & Bradshaw (1998)	To study the impact of hunger on play, cats presented with a large or small toy, immediately after, or 16 hrs after their last meal.	24 behavioural patterns observation through video footage.	5-6 years	9 cats	Cats played more with the small toy and generally avoided the large toy. Avoidance of large toy decreased and play intensity and frequency of close-contact behaviours with the small toy (such as a 'kill bite') increased when cats had been fasted for 16 hours. The authors compare these results to a study on predatory behaviour in cats which showed that the probability of a kill was able to be predicted by the hunger level of the cat and the size of the prey (Biben 1979). These findings could suggest that predatory behaviour and object play may have a shared motivational basis. If this is correct, this information may provide cat guardians with an opportunity to satisfy predatory instincts with play. However, these findings may instead indicate that as hunger levels increased, inhibition levels may have decreased as per Pellis et al., 1988.
Hall et al. (2002)	Experiment 1: Effects of colour and sensory contact in cats with no hunting history. *Treatments:* white or black ellipsoidal fake-fur covered toy. Experiment 2: Effects of interval length between play sessions on magnitude of disinhibition. *Treatments:* inter-session interval of 5, 15 or 45 minutes. Experiment 3: Replication of part of experiment 2 on a population of cats with hunting experience. *Treatment:* 5 min inter-session interval with toy either changed or kept same for 4th session. Experiments 1 and 2 conducted in a walled cubicle and experiment 3 conducted within the cat's home.	Analysis conducted on play intensity using: Clutch: cat holds the toy close to the body with one or both front paws Kill-bite: cat delivers a forceful bite to the toy	Experiment 1 and 2: 5-8 years Experiment 3: 13 months – 7 years	21 cats, for experiments 1 and 2: n =8 for experiment 3: n=8	Play intensity declined in both group-housed and pet cats by 3rd play session. When a contrasting new toy was presented in the 4th session, play response intensified and became disinhibited. This intensity in the 4th session associated with inter-session interval duration. When durations between sessions were longer (25-45min) play not observed to recover its initial intensity. Shorter durations between sessions showed a higher intensity of play response, roughly equal to its initial level when duration was 15 mins and even higher than 1st session when inter-session was 5 mins. This finding of heightened intensity vs even the first session is indicative of post-inhibitory rebound, proposed as an indicator of frustration and therefore diminished welfare in farm animals (Freire et al., 2009). Since this study was published many sources have recommended regular rotation and replacement of toys to reduce habituation, including: Alho et al. (2016) and Ellis (2009).
Arhant et al (2015)	30 animal shelters visited twice, 50-76 days apart.	Shelter management questionnaire plus number of toys available, cat physical condition, behaviour and housing environment	Adults (Ages unreported)	30 animal shelters, mean of 63 cats per shelter (range, 3-583)	Poor physical condition of the cats significantly associated with low provision of toys. The authors suggest providing toys to stimulate object play might be important for shelter cat welfare. However, they caution that because 20-31% of agonistic encounters occur around re- sources such as toys, toys need to be provisioned in adequate numbers for all cats and disinfected to avoid transmission of disease.
Kogan & Grigg (2021)	Online survey	Questions on demographics, cat problem behaviours, environmental conditions, daily play times, toy use, use of laser light pointers and a measure for guardian-cat relationship called the Pet Relationship Scale (Kafer et al. 1992).	Adult cats (range 1 year to 10+ years)	618 cat guardians	Significant associations between higher frequency of laser light play and occurrence of abnormal repetitive behaviours such as spinning on the spot, tail chasing, staring 'obsessively' at lights or reflections or fixating on a specific toy. These findings suggest that laser light play may be associated with abnormal repetitive behaviour development in cats.
Object and Social Play	**Experimental design**	**Measures**	**Cat age during study**	**Sample size**	**Outcomes**
West (1974)	Fourteen kittens were observed within laboratory settings. Fourteen kittens were observed within a rural home with access to the outdoors. All kittens were kept with their mothers.	Observations of development of motor patterns, motor patters during social play, frequency of play and observations of object play were reported daily.	14 days – 7 months	28 kittens, for each condition n=14	Motor patterns associated with social play appeared to provide an opportunity for exercise. Social play may function to develop and maintain friendly social relations as well as allow cats to identify friendly or threatening approaches by other cats.

Guyot (1980)	Kittens experimentally assigned to the following rearing conditions: [1] biological mother and 1 littermate [2] biological mother only [3] brooder device and 1 littermate (brooder provided constant warmth of 32-38°C, a shag carpet for contact and milk through a nipple) [4] brooder device only	Kittens tested weekly in an open field to determine separation distress (not a measure of play so might have to move this to the outcomes section) and then in a playroom from 8 to 20 wks of age for social and individual behaviours against a checklist.	Birth - 20 weeks	32 kittens, for each condition n=8	Kittens in brooder only condition developed object play normally, though at a lower frequency than kittens raised with a mother and/or littermates. Socially deprived kittens did not engage normally in social play, appeared to lack social communication skills, and struggled to cope with exposure to novel stimuli or environments well into adulthood (it is not clear when or how this was checked by the researchers). These findings suggest that socialisation, and in particular social play, may be important in developing and maintaining social skills in cats.
Carlstead et al. (1993)	Laboratory born and reared cats randomly assigned to: STR: Altered caretaking including irregular cleaning and feeding times, no talking or petting by caretakers and unpredictable daily manipulations. CON: Standard caretaking schedule.	Measures included 24 hr video of behaviour, daily urine samples for cortisol and pre- and post-trial testing of hormone stimulation with adrenocorticotropic hormone (ACTH) and luteinizing hormone-releasing hormone (LHRH).	9 months-6 years	16 cats, for each condition n=8	Cats in STR group showed consistently elevated urinary cortisol concentrations, enhanced adrenal sensitivity to ACTH and reduced pituitary sensitivity to LHRH throughout 3-week trial period. Play and exploratory behaviour was suppressed. This study showed that irregular or poor caretaking is a strong psychological stressor in domestic cats. These results connect physiological and behavioural signs of stress in cats and provide evidence for the reduction or absence of play behaviour during times of stress in cats.
Edwards et al. (2007)	Cats underwent an adapted version of the Ainsworth Strange Situation Test (Ainsworth et al. 2015).	Cat behaviour when alone, with their guardian or with a stranger were compared.	1-7 years	28 cat and guardian pairings, n=28.	Cats reported to show play behaviour only when with their guardian, not with the stranger or alone. This study showed initial evidence for the presence of attachment or social bonds between guardians and cats. Further, it illustrates that this attachment may impact a cat's behaviour, including play. This study was repeated by Potter and Mills (Potter & Mills 2015) with slightly changed experimental procedures and analysis. Their version of the study indicated that though cats vocalised more when their guardian left compared to when the stranger left, there was no further evidence for a secure attachment bond between cat and guardian.
Loberg & Lundmark (2016)	Cats exposed to large group living (15 or 14 cats at a time) in varying floor areas, per cat, of $1m^2$, $2m^2$ and $4m^2$.	Cats tested in a balanced order between the three flooring sizes for 3 days at a time with acclimation periods between treatments for a total of 54 days. Stress measured using the Cat-Stress-Score (Kessler & Turner 1997) and observations of behaviours recorded.	1-12 years	89 cats, in groups of 15 or 14	As space increased, cats showed more solitary play with significant differences in solitary play frequency between the $1m^2$ and $4m^2$ treatments. The study argues these results indicate that increased space was associated with increased welfare in cats. No difference was found in social play, however the definition of social play used relied on social-object play and did not include rough and tumble play or chasing (social-locomotor) play.
Shreve et al. (2017)	Free operant preference assessment. Cats from 2 populations (shelter and pet) presented with 3 stimuli within 4 categories: food, human social interaction, scent and toy.	The proportion of time each cat spent interacting with each stimulus recorded and analysed. In a final assessment, the most-preferred stimulus from each of the 4 categories presented to determine the cat's most-preferred stimulus overall on both a population and individual level.	1-20 years	38 cats, for each condition n=19	The largest no of cats (n=25) selected playing as their most preferred social interaction. However statistically, there was no difference in preference between playing and petting so both were used randomly in the final between-category assessment. When presented with their most-preferred selections from all four categories, cats generally preferred social interaction (playing or petting) to food, scent, or a toy. The study also highlights that there is significant individual variability in cat preferences, and these differences should be considered when seeking to improve cat welfare.
Cecchetti et al. (2021)	Cats with known hunting history. 6 interventions to decrease predatory behaviour tested. A before-after-control-impact design was utilised with: bell collars, Birdsbesafe collar cover, food in a puzzle feeder, provision of high quality, grain free food or 5-10 minutes of daily social-object play.	Guardians reported the total no of prey animals, as well as a breakdown of the no of mammals or birds, captured and brought home by cats living in the same household.	Juveniles and adults (exact ages unreported)	355 cats, n per intervention is unclear	When compared to pre-treatment period, total nos of predation per cat were significantly reduced by the play (-25%). However, food puzzles increased predation (+33%). Though food was the most successful intervention overall (-35%), only 33% of participants in the food treatment indicated they would be happy to continue with the intervention, compared to 76% of participants in the play intervention, suggesting that play may be an accessible and easy to implement intervention for the general public.
Social Play	**Experimental design**	**Measures**	**Cat age during study**	**Sample size**	**Key findings**
Collard (1967)	Kittens divided into groups of 10 and randomly assigned to: [1] 5-person group - kittens handled and played with by a different person each day for 5 consecutive days per wk. [2] 1-person group - kittens were handled and played with the same as group 1 but by one experimenter. [3] No-person group - kittens received no handling or play from any experimenters.	Observations were recorded ad hoc of through tabulation of behaviour occurrences.	5 weeks – 9 weeks	30 kittens, for each condition n=10	Kittens in 5-person group showed less fear of strangers than kittens in other groups. Kittens in 5-person group approached a novel string toy more often than kittens in other groups however kittens in the 1-person group showed greater success and motivation in string catching than the other groups. Kittens in no-person treatment showed decreased play behaviour compared to the other groups. Kittens in 1-person group showed twice as many playful or affectionate contacts (climbing on, rubbing against, playful mouthing of fingers) with their experimenter vs kittens in other groups. When called, one-person kittens were more likely to approach the tester than kittens in the other groups. The experimenters noted individual differences in kittens regardless of their assigned experimental condition.
Caro (1981)	Kittens assigned to:	During exposures observations of cat	Birth – 12 weeks	7 litters of 3	Prey presence had an inhibiting effect on social play with kittens playing less while prey was alive and in the room.

	Mice group: exposure to live white laboratory mice Canary group: exposure to live canaries. All kittens exposed to prey 34 times for 30 or 40 mins, 17 exposures with their mother present.	behaviour scored and recorded continuously while observations of mother cat or kitten behaviour towards prey or other cats recorded on a focal-animal basis for 30 seconds at a time per individual.		kittens each, 21 kittens total. Mice group n = 9, canary group n=12	Play behaviours increased significantly following the prey being killed and consumed. This finding is in line with current concepts that play is most commonly present in situations where all other needs have been met and no intense competing systems are present (Burghardt, 2005).
Mendl (1988)	14 laboratory reared litters of kittens from 10 different mothers culled within 2-3 days of birth to litters of 1 or 2. Only male kittens were used.	Each litter observed for 40 minutes three times a day within home pen from 22 to 83 days of age. Data recorded continuously using the Madingley Interactive Computer for Recording Observations ('MICRO', Styles 1980).	Birth -12 weeks	21 kittens, 7 litters of n=2 and 7 litters of n=1	Single kittens played more with their mother than kittens reared with a litter mate. Mother cats of single kittens played more with their kitten than mothers of 2 kittens. However total play was higher for kittens reared with a litter mate and mother due to the kitten also playing with the litter mate. Mothers of single kittens were observed to show more aggressive behaviours towards their kitten that kittens reared with a litter mate. The study's author suggests that kittens may prefer playing with a littermate over a mother cat and that differences in size, skill, and willingness to play between a mother cat and a litter mate may lead to quantitative differences between single reared and litter reared kittens in early and later life.
Heidenberger (1997)	Online survey	Demographics, questions about the animal's history, problem behaviours, food, housing conditions, veterinary care and quality of the human-animal relationship.	2 weeks-27 years	550 guardians, 1177 cats	86% of guardians reported play to be their favourite way of handling their cat. On average 3 periods of play were spread over the entire day, with each play session lasting 20-40 minutes. Most guardians reported their cat preferred to play with other cats within the household over play with their guardian. Greater time available to interact with the cat was associated with less problem behaviour.
Strickler & Shull (2014)	Online survey	Frequency and duration of guardian daily interactions with their indoor cat and no of toys and activities provided for cat.These factors were assessed alongside measures for the prevalence of : aggression to guardian, aggression to visitors, inappropriate urination, inappropriate defecation, inter-household cat aggression, and inter-cat aggression to outdoor cats.	6 weeks - 18 years with a mean age of 5 years	277 cat guardians	Guardians who reported play bout times of 5 mins or more also reported fewer behavioural problems than guardians with play bout times of 1 min.
Gajdoš Kmecová et al. (2021b).	Online survey	Demographic information, items about cat behaviour, including 85 from the Fe-BARQ questionnaire (Duffy et al., 2017) and a further 15 miscellaneous items.	6 months – 11+ years	1,805 cats	Social play with other household cats was negatively correlated with aggression in cats. Playfulness scores reduced with an increase in age of the cat and an increase in the age the cat was obtained. Play also decreased as fearfulness scores increased. Finally, playfulness increased with increased reports of social play with other household cats. These findings suggest that social play with other household cats may reduce issues with aggression that may be an indicator of, or in turn impact, a cat's welfare or the welfare of humans and other animals within the home. Findings on fearfulness and age may further support the concept that play reduces or disappears in time when welfare is compromised either due to the ill effects of age or issues coping in their environment as indicated by fearfulness.

Object, Social and Locomotor Play	**Experimental design**	**Measures**	**Cat age during study**	**Sample size**	**Key findings**
Duffy et al. (2017)	Online survey	The Fe-BARQ, a questionnaire instrument for quantitative guardian-reported assessment of pet cat behaviour was developed and validated.	7 months -20 years with a mean age of 6 years	2788 cat guardians	Responses showed associations between play and potential welfare factors. Declawed cats reported to show less playfulness than cats with intact claws while reports of playfulness declined with age.

Social-object Play	**Experimental design**	**Measures**	**Cat age during study**	**Sample size**	**Key findings**
Pyari et al. (2021)	Cats underwent 3 tests within their own homes. Test 1 'play with ball' tested whether the cats chose to interact with varying sizes of balls rolled towards them. Test 2 'play with chaser wand' tested the cat's interactions with a bird shaped soft toy attached to a stick via a string. Test 3 'sound playback' tested the cats' reaction to pre-recorded sounds of a bird chirping, a mouse squeaking, a sheet of paper being crumpled or a rustling bag, respectively.	Tests were recorded for subsequent analysis.	Adults (exact ages unreported)	31 cats, Outdoor n=13, Indoor only n=18	Indoor only cats showed greater interest in toys and sounds that showed closer resemblance to prey, and more interest in most stimuli overall, than outdoor cats. The results of this study may indicate that indoor cats, who do not have access to real prey show more intense reactions towards 'replacement stimuli'. This may indicate that play could fulfill a role in enabling a cat's natural behaviours within a setting where predation is not possible such as indoor-only housing.

Unspecified play type	Experimental design	Measures	Cat age during study	Sample size	Key findings
Seitz (1959)	Pregnant mother cats brought into the lab 2 weeks before birth. After birth, litters culled to 3 kittens per litter and randomly assigned to. [1] separated from mother at 2 wks of age [2] separated at the age the kittens spontaneously began to wean themselves by lapping from a saucer [3] kept with mother until 12 weeks of age.	Behavioural testing at 9 months of age, an age that the study considered to constitute adulthood.	Birth – 9 months	18 kittens, for each condition n=6	Kittens experimentally separated from mothers at 2 wks showed a "greater proneness to anxiety" (Seitz 1959, p.356) when exposed to novel or stressful situations. Kittens allowed to stay with their mother until 12 wks exhibited more play behaviour and general playfulness vs kittens separated early from their mother.
Martin (1984)	Kittens were born and observed in laboratory settings with their mothers present.	Instantaneous observations were collected every 10 minutes for 14 hours. Mean metabolic rates during play were calculated from measures of oxygen consumption rate, running velocity during play and food intake.	10-12 weeks of age	Unclear. Minimum 16 kittens.	Kittens spent less than 10% of their day engaging in play behaviours. Additional energy expenditure associated with play accounted for less than 10% of total expenditure. The authors conclude that play is not a 'costly' activity.

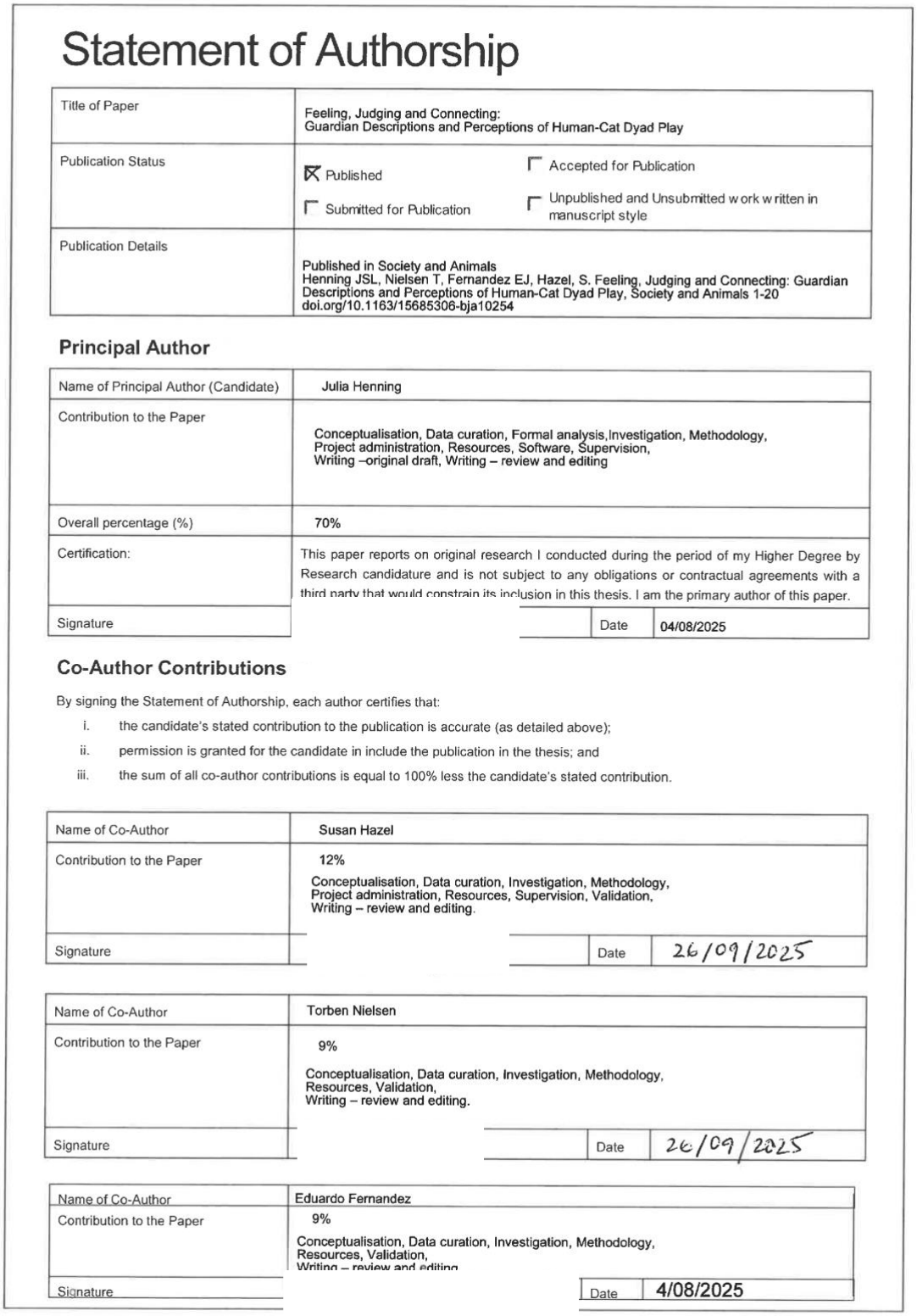
Chapter 3: Feeling, Judging, and Connecting: Guardian Descriptions and Perceptions of Human-Cat Dyad Play

Context Statement

This Chapter addresses Aim 2: Investigating guardian perceptions and experiences of human-cat play. Play behaviour between humans and cats has received limited attention, with previous research generally focused on inter-cat play. This Chapter addresses the human component of human-cat play by exploring human perspectives and experiences of human-cat play interactions. Importantly, this Chapter is the first to report on guardian descriptions of what human-cat 'play' is and what it entails. Data was collected through a global online survey, which also served as the data collection for the following two Chapters of this thesis (Chapters 4 and 5).

Responses from 1,591 participants across 55 countries were collected. Reflexive thematic analysis was conducted on two open-ended questions about 1) guardian feelings during play and 2) guardian perceptions of how they play with their cat. Findings showed considerable variability in guardian concepts of human-cat 'play', from traditional toy-based interactions and complex multi-step games to shared experiences such as going for a drive and tactile interactions including snuggling and petting. Guardians reported observing differences in cat play due to factors such as household dynamics, changes in cat housing style (indoor vs outdoor), and cat age. Play was perceived by guardians as beneficial for human-cat bonding and cat socialisation. Guardians reported using a range of behaviours, vocalisations and context cues when assessing cat desire to play. When describing feelings during play sessions, many guardians reported positive emotions, such as joy, or a sense of being present in the moment. However, guardians also reported experiencing negative emotions, such as confusion or fear, with concerns often specifically related to a fear of injury. The findings of this Chapter provide important insights for informing future studies. Overall, the themes described within this Chapter demonstrate the importance of including guardian perspectives when undertaking research or developing materials to promote cat welfare through play.

Statement of Authorship



Statement of Authorship

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Contribution to the Paper	Conceptualisation, Data curation, Formal analysis,Investigation, Methodology, Project administration, Resources, Software, Supervision, Writing –original draft, Writing – review and editing
Overall percentage (%)	70%
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.
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By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate in include the publication in the thesis; and

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Feeling, Judging, and Connecting: Guardian Descriptions and Perceptions of Human-Cat Dyad Play

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Abstract

Humans and domestic cats have a unique relationship that has changed progressively over 10,000 years. This dyad's play behavior is especially interesting due to its potential role in fostering interspecies communication and bonding. However, human-cat play and guardians' perceptions of its benefits and detriments may not be well understood. This study used a global online survey which included answers to open-text questions. Responses were analyzed using reflexive thematic analysis. A total of 1591 responses were analyzed and six major themes were identified. These themes provide insight

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into guardians' perceptions of human-cat play and illuminate several diverse and complex concepts of what play entails, its benefits, and how it impacts guardians' perceptions of cats. Considering growing numbers of cats in human homes and increasing numbers of guardians wishing to keep cats indoors, further research into play, its role in facilitating healthy cat-human relationships, and its ability to provide enrichment is needed.

Keywords

human-animal interactions – human-cat dyad – play – behavior

Play is fundamental in social intraspecies relationships (Burghardt, 2005; Palagi et al., 2004). Considering close social associations between cats and humans, who often share a home, it is likely that play is also important in human-cat interspecies relationships. Social play relies on complex communication between individuals and helps in establishing and reinforcing social bonds (Bekoff & Allen, 1998; Vanderschuren & Trezza, 2013). Considering cats' reliance on human counterparts for enrichment, resources, protection, and health management, any behavior, including play, that may create, maintain, or improve social bonds between individuals is highly likely to impact cats' welfare outcomes.

Until recently, little research has been conducted specifically regarding play between humans and cats (Heidenberger, 1997; Henning, Fernandez et al., 2022; Henning, Nielsen et al., 2023; Strickler & Schull, 2014). Lack of standardized definitions makes play difficult to qualify: Some define play functionally for research purposes (Burghardt, 2005; Held & Špinka, 2011); others concentrate on philosophical experiences of play (Eberle, 2014). In its broadest sense, play may be defined by how it is experienced by an individual (Henricks, 2015) or by the intention of the individual approaching the behavior (Bekoff & Allen, 1998; Irvine, 2008). Experiencing play as "fun" may be most connected to positive outcomes (Henning, Nielsen et al., 2023).

Thus, it is pertinent to investigate how guardians and cats perceive play. Guardian perceptions are important in determining welfare outcomes for animals in their care (Bouma et al., 2022; Grigg & Kogan, 2019; Henning, Costa et al., 2023). For instance, if guardians perceive their cat to be "aggressive" or "disinterested" in play, or feel negatively about their cat, they may be reluctant to engage in play and/or provide playful enrichment. This may reduce cats' access to enrichment, exercise, and bonding opportunities. On a direct physical health level, lack of play opportunities could reduce physical activity and

decrease occasions for guardians to monitor physicality (e.g., a guardian is more likely to notice a cat's ailment if they are not playing in their usual manner). On a mental and behavioral level, lack of play could increase potential for frustration and subsequent "problem" behaviors. And on a social welfare level, limited or absent play sessions could impact connection and communication opportunities between human and cat, preventing — or even undoing — relationship growth and maintenance. This, combined with any "problem" behaviors from the cat impacting the guardian's life or environment, could potentially lead to an exacerbation of a cat's health and/or mental needs not being met and, in serious cases, an increased risk of surrender and/or euthanasia.

While previous research has investigated cat-guardian play in various contexts including within cat shelters (Algar & Algar, 2003), in the context of companion animals (Irvine, 2008), through a lens of intersubjectivity (Jerolmack, 2009), as part of cat-human relationships (Ines et al., 2021) and within the expanding modern family unit (Laurent-Simpson, 2021), limited specific qualitative analysis of cat guardians' perceptions of play, play communication, and its impact on guardians' perceptions of cats has been undertaken (Henning, Fernandez et al., 2022). We aimed to establish foundational qualitative information on guardians' perceptions of play, identify areas of opportunity to better establish and improve guardians' perceptions of their cats, and consider how qualitative data regarding these perceptions may inform our understanding of interspecies communication and cat welfare.

Materials and Methods

An online survey was developed and distributed globally through social media. A short summary is included here, as well as details relevant to areas of the questionnaire analyzed within this paper. (For analysis of other survey sections, please see Henning, Fernandez et al., 2022; Henning, Nielsen et al., 2022; Henning, Nielsen et al., 2023.) This study was conducted with approval from the Human Research Ethics Committee at the University of Adelaide, Australia (#H-2021-091). Participants were recruited using passive snowballing via Animal Behaviour Welfare and Anthrozoology Laboratory's (ABWAL) social media pages. Inclusion criteria required participants to be 18+ years old and the primary caregiver of a cat 1+ years old. If participants had multiple cats, they were asked to respond specifically about the cat with whom they spent the most time. Participation was voluntary. Informed consent comprised participant notification of survey length, investigator name, study purpose, and particulars of data storage. No identifying information was collected or stored.

Survey

The survey was developed in consultation with veterinarians and animal behaviorists from The University of Adelaide, and further piloted for question clarity, completion time, and errors by a group of six cat guardians. The 107-question survey was hosted on Qualtrics XM® and took approximately 20–30 minutes. Questions included demographic information; play questions including durations, types, and guardian experiences of play; and three validated measures: the feline Quality of Life Measure (Tatlock et al., 2017), Cat Owner Relationship Scale (Howell et al., 2017) and Adult Playfulness Trait Scale (Shen et al., 2014). The survey was active June 22–July 17, 2021.

We specifically and exclusively analyzed answers to two open-ended questions: "When I am playing with my cat I feel …" (Q1) and "Is there anything else you would like to tell us about your cat, how you play together or how they play?" (Q2). Only free-text answers of participants who completed 98% of the survey overall were included in the final analysis.

Analysis

To gather insight into perceptions and attitudes of guardians toward play with their cats, and to develop and summarize common themes regarding guardian perceptions, a reflexive thematic analysis method was used. We adopted Braun and Clarke's (2021, 2022) six-phase analytical process of reflexive thematic analysis, moving back and forth through phases as needed. First, a period of data familiarization was undertaken with responses actively read and then transcribed, compiled by hand, printed, displayed, and moved around as researchers acquainted themselves with the responses. During this time, initial observations of early trends and responses of interest were noted. Following this initial phase, shorthand codes were generated and assigned identifying colors to efficiently code and recognize the large dataset in Excel. To avoid limiting qualitative analysis through imposition of pre-existing frameworks, an inductive method was used for analyzing responses (Braun et al., 2017). Free-text responses were coded as semantic or latent using a fine coding approach that utilized constructionist epistemologies and experiential orientation. Answers for Q1 were analyzed separately from answers for Q2. As coding evolved, tracked changes and copies of previous code iterations were kept and periodically examined. Once coding was completed, themes were generated and revised through collapsing or splitting and active construing of conceptual codes and thematic mapping. The resulting initial themes were then reviewed by the research team alongside members of ABWAL, including 14 members with qualifications in veterinary science, animal behavior, and psychology, to cross-check and further identify and develop accurate themes. Inter-code

relationships and whether the proposed themes suitably interpreted the dataset were reviewed and cross-checked by the research team and ABWAL. In cases of disagreement or emergence of a new/altered theme, the research team and ABWAL backtracked through the six phases until full agreement was reached. Responses to Q2 resulted in the establishment of five themes while responses to Q1 resulted in one.

Results and Discussion

We received 1,591 complete responses from 55 different countries. Nearly half (49.3%) of participants lived in Australia, 90.3% identified as female, and 47.8% lived in a two-person household. Most participants' cats were mixed-breed (76%); 51.4% were neutered and 47.5% were spayed. Cats 3–5 years old comprised 28.8% of the sample, 67% were housed exclusively indoors with 38.9% living in a single cat home, and 42% had lived with their guardian for 2–5 years.

Six themes emerged relating to guardian perceptions and attitudes toward play and their cat (see Table 1).

TABLE 1 Themes and their definitions for guardian perceptions of human-cat dyad play

Theme	Description
Play is whatever you make it	The nature of human-cat dyad play is subject to the perceptions and preferences of both cat and guardian.
Social benefits of play	The perceived role of play in promoting cat socialization and increased tolerance of other animals, including humans, in cats.
Playing the variables	How external and internal factors influence cat play behavior.
Anthropomorphism, labels, and moral judgements of cat play behaviors	Guardian judgements about cat play behavior using an anthropomorphic lens.
Mutual understandings	Guardian perceptions of play communication.
Playing with your feelings	Investigating the impact play can have on guardian feelings toward themselves and their cat.

Note: As reported by 1,591 cat guardians in a global survey, available online between June 22 and July 17, 2021.

Themes

Play Is Whatever You Make It

Participants reported a broad range of behaviors and interactions as play, from simple exchanges — "We 'stalk' each other around the house" (1455) — to complex, multi-step games:

> "[Cat] is addicted to "Who's Queen," a game of her own invention. This involves me gently throwing her on the bed whilst she is slightly spinning in the air, so she lands on all four paws … emits a gentle prrrrr whilst airborne then leaps onto her cat gym … and makes her way to various heights whilst I vigorously rub her back and tell her "You're the queen." She sometimes hides in one of the boxes and then I will leave her. She immediately runs out, meows, and we repeat the game. When she gets to the very top of the cat gym, the game is over." (7)

This broad concept of play is unsurprising considering the wide-ranging nature of play in humans (Hughes, 2002) and ongoing scientific discourse as to what defines "play" (Ahloy-Dallaire et al., 2018; Held & Špinka, 2011). The most widely used definition of play within animal research defines play as "repeated, seemingly non-functional behaviour differing from more adaptive versions structurally, contextually, or developmentally, and voluntarily initiated when the animal is in a relaxed, unstimulating, or low-stress setting" (Brando & Burghardt, 2019, p. 560). Another proposed conceptualization defines play not by the actions involved but by the experience of the "player" (Henricks, 2015). Both definitions could be applied to the participants' descriptions.

Certainly, guardians' responses indicate that play involves action, but it is also the mindset one brings to the action which makes it play. Previous research considered intentionality as a qualifier for play (Bekoff & Allen, 1998; Irvine, 2008) but emphasized the need for empirical investigation prior to it being used as such. Irvine (2008) discusses play as an activity that showcases shared intentions. Highlighting this perspective of play as a mindset or intention, several guardians within this study considered shared experiences, such as yardwork or a drive in the car, to be play. While participants' examples here do not include specific "play" actions with objects or between individuals, they do involve novel, shared experiences or intentions that may include playful feelings. For example: "Her favourite thing is to go on adventures together. She is harness-trained and we go for outdoor adventures" (610), and "We go for car rides" (1399). Engaging in shared experiences or interactions is a prerequisite for relationship formation and maintenance within and between species

(Busia & Griggio, 2020). Considering the current proposal of play as an intention or experience and the benefits of shared experiences/interactions for social bonding, we can reasonably suggest that shared experiences fall within the definitions of "play."

Similarly, guardians' descriptions included tactile actions not necessarily traditionally thought of as interspecies play, such as snuggling. Though these actions may not be classically defined as play, they do involve elements of shared experiences and physical behaviors: "His way of 'playing' is rubbing his face up against me and having me love on him" (1039).

Guardians also reported that these types of tactile play were perceived as affectionate or loving: "My cat prefers cuddle time to activity-style play. He loses interest in game play very quickly, but we spend hours every night snuggling and face-booping, with him kneading … and climbing me to get more pets" (276). Although guardians report their cats as perceiving these interactions as play, it is possible they are biased by their own perceptions. Previous research indicates that guardians' self-reported affection toward their cats is strongly correlated with how much the guardian perceives their cat to be affectionate toward them (Turner & Stammbach-Geering, 1990). However, it is also possible that some cats do perceive tactile and/or affectionate behavior as playful, and this may sit as a tactile sub-category of "shared experiences" as play.

Guardians' play descriptions commonly included actions with and without toys and often reported play preferences differing based on play partner: "She plays differently depending on who she plays with; rougher with my husband (chasing hands under a blanket etc.) than with me (wands, mice, etc.). Chase play more with the dogs and our daughter" (533). Guardians also frequently referenced making play from everyday chores or experiences using household items such as paper, ice, bedsheets, and hair ties: "Loves to be involved when we change the bed sheets on our bed … as well as pouncing on a hand/foot moving under a blanket" (580). These responses suggest that toys may add variety and interest but are not fundamental to play — indeed reflective of the range of intraspecies play behaviors with which cats engage (Delgado & Hecht, 2019).

Most studies of play or other human-cat interactions focus on guardians' experiences (Bolstad et al., 2021; Currin-McCulloch et al., 2021; Ratschen et al., 2020), likely due to human perceptions being more easily gathered, with cat studies typically more focused on overt behaviors (Behnke et al., 2021; Vitale Shreve et al., 2017). Although cat perceptions are harder to quantify, interactions that cats willingly repeat are likely to be enjoyable for them (Rault et al., 2020; Vitale Shreve et al., 2017). Future research into domestic cat experiences

and/or perceptions of such interactions is necessary to further elucidate what cats experience as play.

Social Benefits of Play

Guardians reported several social benefits from playing with their cats. These were noted both in how cats related socially to their guardian or other people as well as other cats:

> "I play with her every opportunity I get. … Whether that's playing chasey around the car when I get home, hide-and-seek while making dinner, she jumps in the shower with me. … I'll pick her up and sling her over my shoulder whenever she's around. It's been harder with the extra cats, but I realized that playing with them all helped them settle and reduced anxiety. [Cat] became quite distressed with change/new cats but has settled and our strong bond remains … but I had to give her a lot of … individual play for her to know that she was still important to me." (704)

Previous studies have also found improvements in intraspecies social relationships due to play (Nunes & Montemayor, 2023; Palagi et al., 2004).

Play may also help establish and improve relationships in human-cat dyads (Heidenberger, 1997; Henning, Costa et al., 2023; Henning, Nielsen et al., 2022, 2023). Within this study, several participants emphasized play in establishing or maintaining their relationship with their cat: "Play is essential for bonding" (868); "We encourage social play as a way of bonding" (53). These observations align with previous studies of humans (Tahmores, 2011), rats (Stark & Pellis, 2020), and cats (Henning, Nielsen et al., 2023) among others, which reported play as an important feature of developing, sustaining, and enhancing social skills and bonds.

Notably, participants mentioned improvements in their cats' coping abilities around unfamiliar people: "She is a super anxious cat, a rescue that was separated from her mother too early. She is heavily bonded to me and can be scared around new people … play has helped her socialise with new people" (211). This may benefit those working in a veterinary or shelter setting, as in these fields, timid or human-averse cats are most likely to face welfare challenges when undergoing handling for medical treatments or being exposed to interactions with unfamiliar people and prospective adopters (Alger & Alger, 2003; Bollen, 2015; Mariti et al., 2017). If play can increase sociability, even in cats past the sensitive phase for human socialization (Casey & Bradshaw, 2008) it may be an accessible intervention for lowering cat stress levels in veterinary and adoption settings.

Playing the Variables

Guardians reported differences in play behavior depending on external and internal factors such as aging, medical conditions, changes in household dynamics, indoor or outdoor housing, and their cat's life history.

Commonly, cats' play behavior changed significantly as they aged (Henning, Nielsen et al., 2022): "He's getting older and seems to be 'slowing down' and playing less" (97). Others observed distinct differences in their cats' play preferences: "As she is getting older her play patterns change, she used to play a lot more and locomotor play was a big part of play. Now especially when it's cold she doesn't want to play, but rather cuddle" (1354).

Another factor repeatedly impacting cat play behavior was medical conditions, including chronic pain — "Her play is limited by chronic pain; I think she would play more if she was healthier" (1343); congenital conditions — "She has cerebellar hypoplasia, so she doesn't play how most cats do. She flops about a lot and usually only runs in short bursts" (132); and disabilities — "[Cat] is blind, she likes noisy toys and ones on wands" (169). Surgery recovery or medication use also impacted play: "About the only time he is not interested in play is when he has recently visited the vet … and you can tell he just wants to sleep it off" (520).

Guardians reported changing their play styles to accommodate disabilities or differences (e.g., using loud toys when playing with a blind cat). Little research has examined animal disabilities or how their needs may differ (Birke & Gruen, 2022; Carr, 2022; Fashing & Nguyen, 2011). Within this study, 415 animals were reported to have some form of ongoing medical condition or disability, indicating a need for further research in this area.

Household dynamic shifts also resulted in play behavior changes. Changes, both positive and negative, were often noted when a new animal was introduced. In some instances, a new addition resulted in increased play, especially when a kitten was introduced to an older cat: "He mostly stopped playing, but then we got two kittens a year ago. He plays much more now" (77). In other instances, new additions caused increased stress and, in turn, a lack of play: "We have recently gotten a new cat which has caused her anxiety. So, her social play is only just starting to get back to normal amounts" (713).

Previous observations highlight differences in play behavior during times of stress or relative calm (Ahloy-Dallaire et al., 2018; Burghardt, 2005; Held & Spinka, 2011). When animals are stressed, play behavior often stops; when stress is minimal or absent, play is often abundant (Burghardt, 2005). Conversely, some cats exhibited increased play when a new animal was introduced. This may be partially explained by play contagion, a phenomenon where

watching an individual play increases playful feelings within the observer (Held & Spinka, 2011).

Animal loss was commonly reported to impact behavior in the cat left behind. Some reported negative changes to play, with behavioral indicators of stress and grief — "My cat and I lost two other cats in the last year, including another male he was bonded with. [Cat] has become more anxious, and louder since their deaths and his play has changed" (1277). Other participants reported positive changes in play and sociality after the loss of another animal:

> "Initially she was not highly engaged with us (first 6 years). When the other cat died … her behaviour dramatically changed, she started coming to us for affection for the first time. Since then, her play time has gradually just kept increasing and increasing, like she is coming out of her shell." (977)

Reaction differences in response to the loss of another household animal may be due to relationship quality between animals, individual animal differences, or how grief is experienced. While animal grief is not yet fully understood (King, 2013; Uccheddu et al., 2022), its existence is generally accepted. Considering animal individuality, it is likely that, like human grief, nonhuman-animal grief may take many forms (Bonanno & Kaltman, 2001).

Guardians also reported changes due to the presence of children. While many guardians reported that their cat had a high tolerance for playing with children — "My toddler plays with [Cat] all the time. [Cat] is always gentle in spite of sometimes rough treatment. Never bites or scratches" (70) — several reported play stopped entirely when children joined the household: "This cat never instigates play and often attempts to entice him fail. I think he is fearful of our 4yo son (loud)" (592).

Dogs were also commonly reported as influencing cats' behavior. A dog's introduction could reduce play — "Doesn't play when the dog is in the house. Dog leaves at the weekend and cat then plays with me. Used to play every day when there was no dog!" (1111) — as well as increase play: "The cat often initiates play behaviour with the dog, and they play together until we separate them. We played with the cat more often before we got the dog, but now they have found each other" (1398).

Whether these changes in household members and dynamics have positive or negative impacts on cats and their behavior is likely determined by cats' individual personality and preferences, and how the guardians introduce the change. Indeed, some factors such as teaching children to respect cats' boundaries and understand signals (Meints et al., 2018), slowly introducing new animals (Kinsman et al., 2022), and offering extra companionship after the loss

of a household member (Walker et al., 2016) may reduce the risk of adverse reactions to changes in household makeup.

Play behavior also seemed to be influenced by the cats' physical environments. Cats played differently depending on whether they had outdoor access or were housed exclusively indoors. Indoor cats appeared more interested in play than their outdoor counterparts, with several guardians noting significant changes in play interest after moving their cat indoors: "[Cat] has recently been transitioned from an indoor-outdoor cat to only indoor. It took him a few weeks to want to engage in play however is doing it much more often" (1258). Conversely, allowing cats outdoor access reportedly led to less play: "We play together less often now that she goes outdoors" (857). Guardians also reported that access to enclosed outdoor areas improved cats' welfare and playfulness: "He used to be extremely needy and almost nothing would console him, even if I took him outside for an hour or more. Now with the outdoor cat run, he's much happier and can have safe outdoor time" (718). Some past studies found differences in play behavior between indoor and outdoor cats (Foreman-Worsley et al., 2021; Henning, Costa et al., 2023; Henning, Nielsen et al., 2022, 2023); however, differences between indoor and outdoor cat behavior and welfare are still under-studied and require deeper investigation. This is especially important as policies begin to restrict cats' outside movements (Foreman-Worsley & Farnworth, 2019).

Cat life history was commonly reported as a factor which altered or predetermined play behavior. Life histories impacting play included previously being "street cats" — "[Cat] was a street cat, so she seems to like to explore (frequently patrols and sniffs) rather than play" (403); being orphaned or hand-raised (Martínez-Byer et al., 2023) — "[Cat] was a 3-week-old bottle baby. He has a noticeably high play drive" (706); and having experienced abuse — "[Cat] came from a physically abusive house, so I am careful when playing so he does not think I will hit him. Even a string hitting him in the face can make him panic a little" (793). Similar patterns have been noted in children, with children's play behavior being differentially impacted depending on experience of abuse (Ahloy-Dallaire et al., 2018; Harper, 1991). Animal life histories remain under-researched and may provide interesting and worthwhile findings for better understanding animal cognition, behavior, and welfare.

Anthropomorphism, Labels, and Moral Judgements of Cat Play Behaviors

Participants often used anthropomorphic language with implicit moral judgments when describing cat attitudes toward, or behavior during, play: "My cat likes to drown her toys" (893); "She's lazy and thinks I'm the pet, her idea of play

is sitting still and hitting the ball and making me kick it back to her" (395); "She has never been a fan of toys of any kind. It's almost as if she thinks she is above them" (988); and "[Cat] likes to drag toys around and present them to us as her 'kills'" (971). Conclusions about behavior based on human morals and perspectives are problematic in research, by individuals regarding their animals, or by society at large (Timberlake, 2007). This is especially evident in human judgements of cat behavior, which often creates inaccurate narratives of cats as morally corrupt (Lynn et al., 2019): "He's kind of a dick" (1330); "Absolute lunatic. Is very naughty if she's not given enough attention" (455); "[Cat] is a spoiled brat" (534). Projection of human morals onto cat behavior has resulted in some highly questionable research. For instance, Evans et al. (2021) investigated cat psychopathy using human measures and constructs, while other research incited moral panic over cats' threat to biodiversity and human health (Hill, 2022; Lynn et al., 2019). Consequences of such anthropomorphic moral judgements can be seen in how free-ranging cats are represented in media and, in turn, culled in large numbers (Hill, 2022), as well as in how individual cats are treated by their guardians, often with negative consequences to animal welfare (Bradshaw & Casey, 2007; Mota-Rojas et al., 2021). For example, guardians who assume inappropriate urination is an act of spite may fail to explore the more likely possibility that their cat is stressed or requires veterinary assistance (Mariti et al., 2017). If cats continue to display this behavior and guardians continue to assume malicious intent, it may lead to a compromise of cat welfare and ultimately surrender or euthanasia (Bradshaw & Casey, 2007; Mota-Rojas et al., 2021).

Mutual Understandings

Guardians reported interpreting specific body language, vocalizations, or actions as their cats' desire to play and/or communications during play. Participants mentioned using their cats' vocalizations to make inferences about desires or needs and several participants noted using consistent vocal cues to communicate with their cats: "He is very talkative about playing and uses specific vocalizations. I know when he is playing because he only makes those vocalizations during play" (630); "I use specific noises or words to communicate with him which helps with play and other things" (1227). Other participants noticed their cats' body language. This was often mentioned as a communication method during play which gave information about whether their cat wished to keep playing or stop. In some instances, body cues were used due to hearing difficulties in human or cat: "Gives warnings of 'had enough' by raising paw" (65); "My cat is deaf, so his means of instigating play is very physical — he stares at me, then arches and skuttles or crouches and sprints to engage me in his game!" (557).

Along with body language cues, participants also described cats using physical touch via paws or heads to communicate a desire for play: "She will often seek me out, reach up with her front paws to pat at my hand to show me she either wants to be stroked or played with and will persistently do this until she has my attention" (84).

An interesting cue not yet researched within cats is context cues, or cues based on location or object interaction. Many guardians may recognize their cat wants dinner when they begin pawing or meowing next to their bowl and participants within this study noted using similar context cues when identifying their cats' play communications: "He very much lets me know he wants to play by bringing me his favourite toy" (135), and "To say 'play' she sits on her special chair and looks at me to get her bouncy ball" (17).

Commonly, communication involved more than one type of cue. In keeping with findings of Mouzon and Leboucher (2023), these bimodal cues mostly consisted of visual and vocal cues used together: "Sometimes he gets the cat wand and walks around vocalising" (144); "When he wants to play, he'll get up and go sit next to the wand handle, meow at me, and slowly pat the handle of the wand" (864).

Several participants mentioned respecting their cats' cues, understanding when their cat communicated a desire to stop playing (e.g., by hissing or removing themselves from the area) and appreciating that this meant play was over: "[Cat] likes things on her terms. She walks off when she's had enough" (1106), and "We have a very peer-peer relationship as I treat him as an equal and we both 'train' each other and communicate well … our relationship is force-free and I'm very respectful of him when he wants to stop playing or training" (255). This understanding and respect for cat autonomy likely contributes to better cat-guardian relationships and allows cats to feel comfortable and self-governed within human homes (Haywood et al., 2021; Henning, Nielsen et al., 2023).

Recent studies have highlighted cats' communication styles (Koyasu et al., 2020; Merloa et al., 2015), with a study by Mouzon and Leboucher (2023) investigating cats' communication preferences. Results indicated that cats prefer communication that is visual or visual *and* vocal (bimodal) and found supporting evidence for human-compatible sociocognitive skills in cats. Several studies have also found that humans and cats have limited ability to correctly read cues from a stranger but score above-chance when interpreting communications from their personal cat or guardian (Ellis et al., 2015; Mertens & Turner, 1988). Research into cat-human communication is still in its early stages but shows a promising avenue for further research (Turner, 2021).

Playing with Your Feelings

Guardians reported experiencing a range of feelings during play. Some guardians felt vicarious joy, or joy derived from watching another individual experience joy, when observing their cat's happiness while playing: "I get much joy from playing fetch with him and having him return things to me to throw again, he is an endless source of entertainment" (196). Others noted that play made them feel more present: "I feel grounded, brought back to the present moment" (1052). While participants did report feelings of joy, relaxation, and love — "When I play with my cat, I feel loved" (1352) — play did not exclusively elicit positive feelings. Several guardians reported negative feelings: "I feel guilty that I don't play more" (1232); "Playing makes me melancholy (she's getting old and slow)" (644); "I'm confused — what does he want to do?" (1446); and "I'm fearful he is going to bite me" (254).

Such feelings may impact how often or in what ways guardians play with their cats. Henning, Nielsen et al. (2022) indicated that guardians who were fearful of their cat hurting them were less likely to engage in play and would actively avoid it. In turn, this is likely to impact their cat's social enrichment and welfare.

Limitations

The population used in this study is self-selected and may not reflect the wider population. Additionally, self-report surveys are prone to response and recall bias. Participants may have chosen to provide socially desirable responses, potentially influencing data validity (Paulhus & Vazire, 2007). The method of data collection may have a limited ability to capture nuanced perspectives or complex experiences, potentially resulting in certain perspectives or themes not being adequately captured or explored. Additionally, once-off surveys lack the ability to gain further insight or clarification, limiting depth of understanding.

Furthermore, despite employing a reflexive approach, interpretation and analysis of data are subject to researchers' subjective lenses, potentially influencing theme identification and interpretation (Clarke & Braun, 2017).

Conclusion

Cats have long been members of our social circles. However, relatively little has been studied regarding the interactions between our two species. Research into these relationships is crucial for providing insights into effective communication, optimal care, and enhanced cat welfare and guardian wellbeing. The

present study aimed to illuminate guardian perspectives of play in human-cat dyads. Play is a particularly promising behavior to study within human-animal relationships as it relies on interspecies communication and requires exhibition of social behaviors. The present study revealed interesting perspectives from participants through the establishment of six themes. Play descriptions provided by participants were diverse, encompassing various interactions and shared experiences, and highlighting that it is not just the action of play, but also the mindset brought to the action, that is important. Guardians' reports of play improving both intra- and interspecies social cohesion support previous findings that play may function partly to create and maintain social skills and bonds. Participants often used anthropomorphic language and moral judgments when describing their cats' behavior during play, reflecting a problematic tendency to project human experiences and morals onto animals, which can have negative consequences for both research and individual animal welfare. Several factors such as life history, housing type, and disability were perceived by guardians to influence cat play behaviors, which may be important considerations in future cat play research. Participants reported using various cues to interpret their cat's desire to play and to communicate during play, often emphasizing multi-modal cues in cat-human communication — a promising area for further investigation. A range of emotions were perceived by participants during play, including feelings of love and being present in the moment, but also feelings of guilt and fear, which could impact the frequency and nature of play interactions and subsequently affect cats' social enrichment and welfare. These findings identify several areas for future research into human-cat relationships and highlight the possibilities of play behavior as a tool for exploration.

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Chapter 4: Factors associated with play behaviour in human-cat dyads

Context Statement

Continuing to explore Aim 2, Chapter 4 sought to establish a foundational understanding of play session durations, daily play times, and to assess factors associated with play availability in human-cat dyads. This research employed the same global online survey from Chapter 3, utilising guardian reported play durations, demographic information and validated measures including cat quality of life (QOL), the Cat Owner Relationship Scale (CORS), and the Adult Playfulness Trait Scale (APTS) to examine play times and the factors associated with them. Results showed a guardian-reported median daily play time of 45 minutes, in sessions averaging 15 minutes each. However, play times varied considerably depending on the dyad, ranging from 0 minutes to 5 hours per day, in sessions ranging from 0 minutes to 2.5 hours each. It is probable that the extended play times reported here may be partially explained by the broad concepts of play demonstrated by guardians, as described in Chapter 3, including shared experiences and petting. Closer human-cat relationships (CORS) and a greater number of games played between the dyad were both significantly associated with longer daily play times and longer play session lengths. Additionally, total daily play times were significantly associated with mutual initiation of play interactions (where both cat and human initiate play). These findings demonstrate potential links between successful human-cat communication (e.g., mutual initiation, ability to negotiate a greater diversity of games), closer human-cat bonds (e.g., higher CORS scores) and the amount of human-cat play performed by the dyad. While it is not possible from these findings to determine whether better communication and a closer bond results in more play or if more play leads to greater bonds and communication, it highlights an important area for future research. Notably, over one-third of guardians reported avoiding play, primarily due to being busy or fearing injury from their cat. This Chapter provides important baseline information on human-cat play dynamics and suggests that play may serve an important role in establishing and maintaining social bonds between cats and their guardians.

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By signing the Statement of Authorship, each author certifies that:

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Factors associated with play behavior in human-cat dyads

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ABSTRACT

Play is a common behavior, often exhibited within human-cat dyads. Play is a behavior that may have numerous benefits to both cat and human, including within the realms of social cooperation and inter-species communication. However, little is known about human-cat play and foundational information is needed. The current study aimed to investigate total daily play durations, play session lengths, and the factors associated with play times in human-cat dyads.

An online survey was developed using demographic information, questions related to play times, resources available to the cat, "games" played with the cat, free text sections and the following validated measures: cat quality of life (QOL), the cat owner relationship scale (CORS) and the human adult playfulness trait scale (APTS). Regression analysis was conducted using SPSS 26.

Responses were completed by 1,591 cat guardians from 55 countries. Total daily play times and play session lengths were both significantly higher in human-cat dyads where the cat was younger in age, the guardian reported playing a larger diversity of "games" with the cat, and the guardian reported experiencing a closer relationship with their cat. Some guardians reported avoiding play during times when they were too busy or due to fears over incurring injuries.

The amount of play available in human-cat dyads may have an effect on establishing and maintaining social bonds between cats and their humans. Further research into understanding play within human-cat dyads and how it affects inter-species relationships is needed.

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Introduction

Domestic cats are one of the most popular pets in the world, residing in approximately 25%-29% of homes in the UK, USA, and Australia (American Veterinary Medical Association, 2022; Animal Medicines Australia, 2019; Cats Protection, 2021). However, despite their popularity and proximity to humans, there is still much to learn about how cats and humans interact as well as how these interactions affect both human and cat wellbeing (Turner, 2021). A commonly observed interaction within human-cat relationships is play. Play is a behavior that has been shown to aid the development of social skills (Guyot et al., 1980; Vanderschuren and Trezza, 2013) and constitutes an ability to communicate and recognize communication (Bekoff and Allen, 2011; Palagi et al., 2016). These 2 features of play may make it an important part of establishing and maintaining healthy human-cat dyad communication and relationships.

Play is often considered an indicator and promotor of good welfare in many species, including in cats and humans (Held and Špinka, 2011; Ahloy-Dallaire et al., 2018; Yogman et al., 2018; Vojtkovská et al., 2020). This is because play is most often observed in times of good health, where there are ample resources, and when fitness threats (such as predators) are absent (Fagen, 1978). Play is also regarded as being fundamental to development in animal juvenile periods, especially in the development of cognitive-behavioral, emotional, and neurological/physiological skills (Vanderschuren and Trezza, 2013). Play may also be vital to maintaining these skills and functions well into and throughout adulthood (Burghardt, 2005; Vanderschuren and Trezza, 2013). In human literature, play between children and parents has been shown to improve a child's ability to cope with stress, promote healthy child development, and is integral to creating and maintaining strong parent-child bonds (Ginsburg, 2007). It is possible that some of these benefits may be transferrable to guardian-cat relationships.

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The dynamic between cats and their guardians has substantially changed over the past several decades. For instance, research suggests that a growing number of guardians envision themselves as a surrogate parent to their pets (Cohen, 2002; Greenebaum, 2004; Finka et al., 2019; Bouma et al., 2022). A recent study by Bouma et al. (2022) found that this perception of a parental-type relationship was associated with living environment outcomes for the cat, including high-quality care. While this may be an over-simplification of what is a complex relationship between 2 species, there are certain similarities between parent-child relationships and human-cat relationships. In both cases, the core "family" relationships are important for behavioral development and the well-being or welfare of the individuals involved (Finka et al., 2019). In both scenarios, children and cats are reliant on the provision of resources, care, and social interaction from their parent or human guardian, and the quality of these provisions and interactions will have marked differences on the well-being of the child or cat experiencing them.

Previous investigations into the amount of time people spend playing with their cats have reported conflicting results. In a study of 550 guardians, participants reported playing with their cat 3 times across the day with average play times for each individual play session reported between 20 and 40 minutes (Heidenberger, 1997). However, in a more recent survey of 277 guardians by Strickler and Shull (2014) most participants reported playing less with their cat; playing twice or more times a day for 5-10 minutes per play session bout. These inconsistencies between studies could be due to inherent problems with survey methodology, disparities in the number of responses, different guardian-play expectations between countries, variances in survey populations or participants, or may reflect changes in human behavior over time. There is a gap in knowledge of how much play is routinely experienced between cats and guardians, how long the play sessions last, and guardian attitudes to playing with their cat. Further research is warranted considering the importance of play for welfare, juvenile development, maintenance of executive skills, coping, and normal functioning as well as its role in supporting social bonds in both humans and cats.

The present study aimed to investigate the factors associated with guardian-reported play behavior in human-cat dyads. Questions included: what is the total daily length of human-cat dyad play reported by guardians? What is the length of individual play sessions between human-cat dyads? And what are the factors associated with these reported times, such as the amount of time the cat was left home alone or the age of guardian, as well as guardian-reported reasons for avoiding human-cat dyad play. It is hoped that this information may inform future studies into human-cat dyad play and assist in identifying factors that may help facilitate human-cat dyad play in human homes.

Materials and Methods

The protocol for this study was conducted with approval from the Human Research Ethics Committee at the University of Adelaide, approval code: H-2021-091. Participants were recruited through passive snowballing from posts on the research team's laboratory social media sites such as Twitter, Facebook, and Instagram. Inclusion criteria required participants to be 18 years of age or older at the time of the survey and to be the primary caregiver for a cat of at least 1 year in age. Where participants had multiple cats, they were asked to select the cat they spend the most amount of time with and answer all questions as if they were about this cat specifically. Participation was voluntary. Informed consent included notifying participants of survey length, investigator name, study purpose, and details of data storage including what data would be kept and for how long. No identifying information was collected or stored.

Development of survey

The survey was developed in consultation with veterinarians, animal behaviorists, and cat guardians. The survey was hosted on Qualtrics XM® and comprised 107 questions, with completion time estimated between 20 and 30 minutes. Questions for the survey included demographic information (N = 21), questions regarding play (N = 24) including play durations, play types, guardian experience of play, and play times, and 3 validated measures (see 3.2-3.4). The survey was open for participation between June 22 and July 17, 2021.

Feline Quality of life (QOL) measure

A 16-item feline quality of life (QOL) measure (Tatlock et al., 2017) was used to assess the quality of life of cats included in the study. The measure included items relating to healthy behaviors and clinical signs within the following sub-concepts: general health and wellbeing, pain, grooming/appearance, interest/interaction with surroundings, gastrointestinal symptoms, metabolism, and physical activity level. Responses were collected on a 5-point Likert scale with answers ranging from "not at all" to "very much." Possible scores range from 16 to 80, with higher scores indicating higher quality of life. Reverse coding measures were undertaken prior to analysis. Cronbach's alpha for this measure within the current study was acceptable (0.76).

Cat owner relationship scale (CORS)

The cat owner relationship scale (CORS) (Howell et al., 2017) was used to measure the closeness of the relationship between guardians and their cat. The measure was adapted for use in cats from the Monash Dog-Owner Relationship Scale (MDORS) and consisted of 26 items from the full 33-item survey. Responses ranged from "strongly agree" to "strongly disagree" or "once a day" to "never" depending on the question. For example, "how often do you talk to your cat?" CORS measures the quality of the cat-owner relationship on 3 components or subscales: Cat-Owner Interactions, Perceived Emotional Closeness, and Perceived Costs. Possible scores range from 26 to 130, with higher scores indicating a closer owner-cat relationship. Reverse coding measures were undertaken before analysis. Cronbach's alpha for this instrument within the current study was good (0.84).

Adult playfulness trait scale (APTS)

The adult playfulness trait scale (APTS) (Shen et al., 2014) was used to measure the playfulness of guardians within the survey. The measure consists of 19 items that include 3 subscales for fun-seeking motivation, uninhibitedness, and spontaneity. Responses were collected on a 7-point Likert scale with possible answers ranging from "strongly disagree" to "strongly agree." Possible scores ranged from 19 to 133 with higher scores indicating higher levels of playfulness in a guardian. Cronbach's alpha for APTS within this study was good (0.88).

Data management

Duplicate entries from the same user were identified through an IP check. Where an IP address was used twice, the more completed form was kept and the other eliminated from the data set.

Table 1
Demographic information from an online survey of guardians and their cats between June 22 and July 17, 2021; N = 1590 for all items, except for items: Guardian sex (N = 1582), People in household (N = 1588), Relationship status (N = 1567), Cat breed (N = 1584), Cat age (N = 1584) and length of guardianship (N = 1587).

Country	Australia 49.3% (784)	USA 32.4% (515)	UK 4.2% (66)	Canada 3.7% (59)	Other 10.4% (166)*
Guardian sex	Female 90.3% (1429)	Male 6.4% (101)	Non-Binary 3.3% (52)		
Guardian age	18-24 yr. 11.3% (179)	25-34 yr. 38.7% (616)	35-44 yr. 24.9% (396)	45-54 yr. 15.4% (245)	55+ yr. 9.7% (154)
People in household	1-person 18.3% (291)	2-person 47.8% (760)	3-person 17% (269).	4+ person 16.7% (268)	
Relationship status	Single 28.8% (458)	Partnered 47% (747)	Single with child(ren) 4% (65)	Partnered with child(ren) 18.8% (297)	
Cat sex	Intact Male 0.6% (9)	Neutered Male 51.4% (817)	Intact Female 0.5% (8)	Spayed Female 47.5% (756)	
Cat breed	Purebred 24% (380)	Mixed-Breed 76% (1204)			
Cat age	1-2 yr. 22.4% (354)	3-5 yr. 28.8% (457)	6-9 yr. 23.8% (377)	10+ yr. 25% (395)	
Cat housing	Indoor Only 67% (1066)	Outdoor Access 33% (524)			
Number of cats in home	1 cat 38.9% (618)	2 cats 33.6% (534)	3 cats 13.6% (217)	4+ cats 13.9% (221)	
Length of guardianship	0-1 yr. 19.6% (311)	2-5 yr. 42% (667)	6-9 yr. 20.2% (321)	10+ yr. 18.2% (288)	

* Other = Germany, Slovakia, Israel, Netherlands, Poland, Greece, France, Bahamas, Spain, Italy, Sweden, Japan, United Arab Emirates, Belgium, Portugal, Jordan, Romania, Switzerland, Colombia, Denmark, Hong Kong (S.A.R.), Argentina, India, Iceland, Finland, New Zealand, Mexico, Angola, Indonesia, Luxembourg, Norway, Czech Republic, Chile, Lebanon, Serbia, South Africa, Fiji, Singapore, Philippines, Sri Lanka, Myanmar, Taiwan, Ireland, Uruguay, Malaysia, Austria, Brazil, Turkey, Lithuania, South Korea and Bulgaria.

Only participants who completed 98% of the survey including completing all measures for cat QOL and CORS were used in analysis. Any inconsistent or unrealistic answers were identified (e.g., reporting they play with their cat for 30 hours a day) and removed from the data set. The variables for total number of resources and total number of games were created from a series of yes/no questions that asked about the presence of different resources in the house or games played by the guardian and cat. These yes/no answers were then given a number (Yes- 1, No- 0) and collated into the 2 variables of "total resources available" and "total games played." Resources included: post, cat bed, hiding place, water fountain, wand toy, food puzzle, food treats, motorized toy, wall or window perch, harness walks, outdoor cat enclosure, cat grass, self-cleaning litter tray, Feliway™, and automatic feeder. Games included: fetch, playing with catnip toys, playing with noisy toys, playing with boxes, playing with hands, playing with digital devices, playing with wand toys, playing with laser pointers, playing with food, playing with motorized toys, chasing each other and training.

Descriptive statistics

Descriptive statistics were used to describe the study population. The main outcomes of the current study were total daily cat play time and play session length. Descriptive statistics for each variable were performed by univariate linear regression (continuous variables) or ANOVA (categorical variables).

Statistical analyses

Two multivariate general linear models were created with total daily cat play time and play session length as dependent variables respectively. All variables from the descriptive regressions or ANOVAs with a $P < 0.2$ were included in initial modelling. Non-significant factors were removed using backwards elimination. Relevant interactions were checked for significance, but none were found. Statistical analyses were completed using SPSS® Statistics 27. A P-value of <0.05 was considered significant.

Results

Demographics

A total of 2,501 responses were recorded, of which 910 were excluded from analysis due to duplicate attempts as identified by IP address, or because the response was incomplete. One thousand five hundred and ninety-one participants who had completed at least 98% of the survey were included in the final analysis. Most participants were based in Australia, identified as female, reported currently being in a relationship and living in a 2-person household (see Table 1). Most cats in the study were mixed breed while cat sex was split almost equally between male and female. Cat age ranged between 1 year and 22 years of age with most cats 3-5 years of age at the time of the study. Most cats were housed exclusively indoors, resided within a single cat home and had been living with their current guardian for 2-5 years (Table 1).

Daily play time and play session length

Guardians reported a median total daily play time of 45 minutes and a range of 0-300 minutes per day (Figure 1a). Play session length ranged from 0 to 150 minutes (median 15 minutes) (Figure 1b).

Guardian avoidance of play

A total of 36.9% (N = 1,580) of guardians reported that they sometimes avoided playing with their cat. Of those who reported a reason for avoiding play (N = 572), the most common reason was being busy with another task, followed by fear of injury/the cat becoming too aggressive or excitable during play (Table 2).

Most guardians reported that they avoided play due to being busy.

"When I'm busy working and if I'm honest, when I can't be bothered"

"I work from home right now and when I'm working, I can't play with him. It can be a little frustrating because he's very needy and won't let up."

Many guardians reported avoiding play due to fear of sustaining an injury such as a bite or scratch from their cat.

"She can be aggressive mid-play and bite/kick, if her pupils dilate, I'm out of there!"

"My cat gets overstimulated very easily and will start to bite and scratch so I move away, but sometimes he chases me and hunts me down"

Multiple guardians also made moral judgments about their cat because of this "aggressive" behavior.

"He has anger issues"

"When he's being naughty and biting me to get me to play"

Some guardians also reported avoiding play as a punishment for guardian-perceived poor behavior by the cat.

"If he does naughty things on purpose over and over"

"As a punishment when she bites me"

Some guardians reported that they experienced chronic or acute illness that prevented them from playing with their cat or

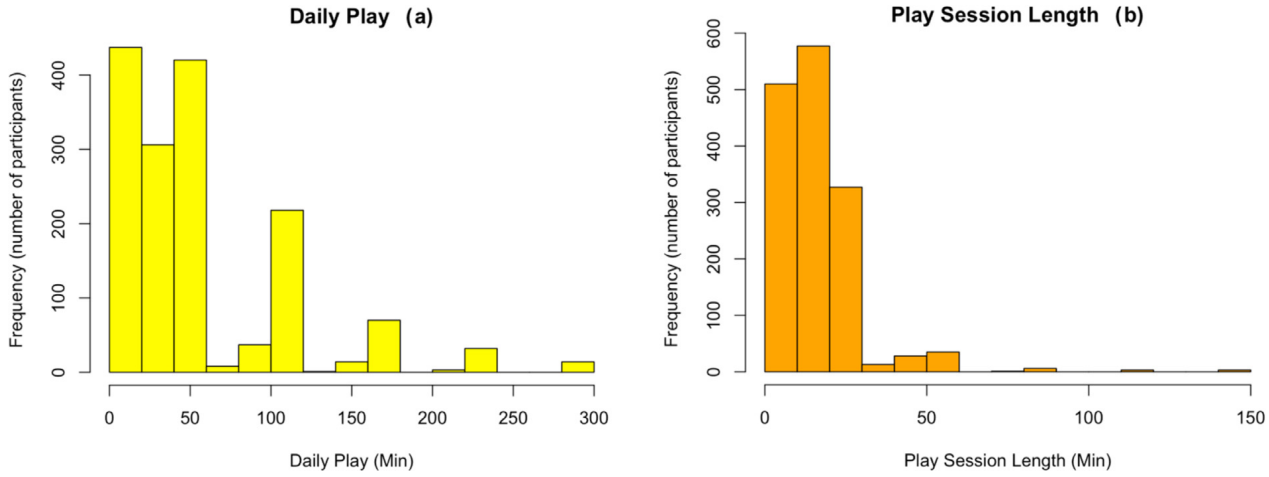


Figure 1. Frequency (number of participants; y-axis) reporting total length of play (minutes; x-axis) based on: (a) total daily play, and (b) play session length.

Table 2
Reasons given by guardians for avoiding human-cat dyad play (N = 572). Based on online survey responses between June 22 and July 17, 2021.

Reason for avoiding play	n	%
Guardian is busy with another task	139	24.3%
Fear of injury/cat becomes too aggressive or excitable during play	105	18.3%
Guardian feels time poor	75	13.1%
Cat is trying to play during sleep hours	71	12.4%
Guardian is too tired	59	10.3%
Cat tries to initiate play when their guardian is leaving for work	29	5.1%
Guardian is experiencing a physical ailment	25	4.4%
Cat is sick or recovering	25	4.3%
Punishment of the cat for perceived poor behavior	12	2.1%
At times when the guardian is experiencing depression or stress	9	1.6%
Other*	23	4.0%

* Other: Guardian wishes to avoid getting cat hair on their clothing, Guardian does not enjoy playing with their cat, Guardian reports that their children are a higher priority.

that their cat was chronically ill or recovering from an illness and could not play.

"I have arthritis, and he has diabetes. Sometimes we both have to take it easy."

Being protective of their sleep times was also a common reason for avoiding play.

"If it's the middle of the night and (Cat 1) wants to play, it's a solid no!"

"Obsessed with fetch. He drops toys on my face in the middle of the night. I don't want to encourage that as I value my sleep!"

Guardians also reported bouts of depression or stress impeding their ability to play with their cat as they would ordinarily wish to.

"I suffer from depression, and it is sometimes difficult to want to play with her because she just wants to keep going forever. There's never really a natural end to the play session and I feel bad I can't fulfill her the way she wants so sometimes, when especially down, I avoid starting altogether."

"When I am feeling stressed, I struggle to give her the energy she demands to engage in play"

Factors associated with daily play time

One-way analyses showed that total daily play time was longer in human-cat dyads where the guardian and cat were both younger in age, the guardian identified as non-binary, the cat was housed exclusively indoors, the guardian reported their cat to be playful, there was a history of significant injury from the cat during play, both cat and guardian-initiated play, there were more resources available to the cat and the guardian reported playing a greater diversity of "games" (Table 3).

A general linear model analysis of factors associated with total daily play showed longer daily play times in human-cat dyads where the guardian and cat were both younger in age, the guardian reported their cat to be playful, there was a history of significant injury during play, both cat and guardian initiated play, there were more resources available to the cat, the guardian reported playing a greater diversity of "games" with their cat and the guardian reported having a closer relationship with their cat (Table 4).

Play session length

Play session length was longer in human-cat dyads where the guardian identified as non-binary, the cat was younger in age, the cat was left alone for fewer hours each week and the guardian reported playing a greater diversity of "games" with their cat. (Table 5).

Results of a general linear model showed that longer play sessions lengths were present in human-cat dyads where the cat was left alone for fewer hours each week, the guardian reported playing a greater diversity of "games" with their cat, the cat was younger in age, the guardian scored higher on the adult playfulness trait scale and the guardian reported having a closer relationship with their cat (Table 6).

Discussion

Almost a third of homes in the USA, UK and Australia now share their homes with at least 1 cat (Animal Medicines Australia, 2019; American Veterinary Medical Association, 2022; Cats Protection, 2021). The dynamic of how these people interact within and

Table 3
Results of one-way analysis of variance (ANOVA) for each factor associated with total daily play times in human-cat dyads, N = 1590 except for: guardian sex N = 1552, housing and number of cats in home N = 1560, cat playfulness N = 1589, history of injury from cat during play N = 1583, who initiates play? N =1580, number of children in home N = 1559 and cat age N = 1584. Based on online survey responses between June 22 and July 17, 2021.

Factor:	Daily Play TimeMean (Min)	Daily Play TimeRange (Min)	CI (95%)	*P*-value
Guardian Age	87.9	0-300	77.7-98.3	<0.001
18-24 (170)	65.5	0-300	60.8-70.2	
25-34 (606)	55.3	0-300	50.1-60.7	
35-44 (389)	55.8	0-240	49.5-62.1	
45-54 (242)	46.1	0-240	38.4-54.1	
55+ (153)				
Guardian Sex	61.1	0-300	58.1-64.1	0.001
Female (1404)	92.6	0-300	74.8-110.3	
Non-binary (50)	62.3	0-240	50.9-73.5	
Male (98)				
Cat Age				<0.001
1-2 years (340)	84.4	0-300	77.3-91.5	
3-5 years (445)	67.4	0-300	61.9-72.8	
6-9 years (373)	53.4	0-300	48.4-58.4	
10+ years (396)	45.2	0-240	40.5-49.8	
Housing*	55.5	0-300	50.6-60.4	0.002
Outdoor access (511)	65.2	0-300	61.7-68.7	
Exclusively Indoors (1049)				
Cat Playfulness				<0.001
Not very playful, only plays occasionally (478)	39.7	0-240	28.3-35.8	
Neither playful nor not playful (274)	52.2	0-300	36.8-44.8	
Playful, often wants to play (807)	78.6	0-300	46.6-57.6	
Who initiates play?				<0.001
Cat (268)	55.1	0-300	48.5-61.6	
Guardian (311)	43.9	0-240	38.9-49.1	
Both (843)	74.2	0-300	70.1-78.4	
History of injury from cat during play				<0.0001
No injury (435)	52.2	0-300	47.3-56.9	
minor injury (1027)	65.4	0-300	61.7-68.9	
significant injury (91)	71.2	0-300	58.1-84.2	
Total resources available**				<0.001
0-3 resources (93)	32.8	0-180	25.3-40.4	
4-6 resources (552)	52.3	0-300	48.1-56.5	
7-9 resources (686)	68.7	0-300	64.2-73.2	
10-14 resources (229)	77.4	0-300	69.3-85.5	
Total “games” played***				<0.001
0-1 games (155)	34.2	0-300	26.3-42.2	
2-4 games (845)	53.1	0-300	49.8-56.3	
5-6 games (384)	78.6	0-300	72.4 -84.8	
7+ games (176)	93.6	0-300	82.3-103.9	
Number of cats in home				0.003
Solo cat (609)	55.9	0-300	51.6-60.3	
2 cats (526)	64.5	0-300	59.6-69.3	
3 cats (214)	64.2	0-300	56.4 -72.1	
4+ cats (211)	71.4	0-300	62.7-80.1	
Number of children (under 18) in home				0.002
None (1229)	64.7	0-300	61.4-67.9	
1 child (175)	49.9	0-240	43.4-56.6	
2+ children (155)	55.1	0-240	46.1-64.0	

* Housing: Outdoor access was defined as any access to the outdoors without a harness, lead and not within a fully enclosed cat enclosure. Exclusively indoors was defined as cats who were never outdoors unless on a harness, lead or in a fully enclosed cat enclosure.

** Total resources available included: scratching post, cat bed, hiding place, water fountain, wand toy, food puzzle, food treats, motorized toy, wall or window perch, harness walks, outdoor cat enclosure, cat grass, self-cleaning litter tray, Feliway™ and automatic feeder.

*** Total “games” played included: Fetch, playing with catnip toys, playing with noisy toys, playing with boxes, playing with hands, playing with digital devices, playing with wand toys, playing with laser pointers, playing with food, playing with motorized toys, chasing each other and training.A linear regression showed significant association between total daily play times and cat owner relationship (CORS) scores ($P = < 0.001$). The correlation coefficient for CORS and total daily play time was R = 0.271 indicating a moderate correlation (standard error = 0.139).

Table 4
General Linear Model parameter estimates of factors associated with daily play times in human-cat dyads (N = 1413), based on online survey responses between June 22 and July 17, 2021.

Factor:	Coefficient	Std. Error	Significance
Guardian Age	19.7	6.4	0.003
18-24	3.5	5.2	
25-34	2.4	5.4	
35-44	-.65	5.8	
45-54	**		
55+			
Cat playfulness			<0.001
Not very playful, only plays occasionally	-18.9	3.8	
Neither playful nor not playful	-14.6	4.1	
Playful, often wants to play	**		
History of injury during play			0.017
No injury	-16.4	6.5	
Minor injury	-9.2	6.2	
Significant injury	**		
Who initiates play?	-7.1	3.8	0.010
Cat	-10.9	3.8	
Guardian	**		
Both			
Total resources available***			0.041
0-3 resources	-8.5	7.8	
4-6 resources	-8.8	4.6	
7-9 resources	.126	4.3	
10-14 resources	**		
Total “games” played****			<0.001
0-1 games	-22.1	7.1	
2-4 games	-19.1	4.9	
5-6 games	-5.9	5.1	
7+ games	**		
Cat Age			0.001
1-2 years	17.6	4.6	
3-5 years	8.9	4.2	
6-9 years	1.8	4.2	
10+ years	**		
Cat Owner Relationship Scale (CORS)	.95	.15	<0.001

** Reference category

*** Total resources available included: scratching post, cat bed, hiding place, water fountain, wand toy, food puzzle, food treats, motorized toy, wall or window perch, harness walks, outdoor cat enclosure, cat grass, self-cleaning litter tray, Feliway™ and automatic feeder.

**** Total “games” played included: Fetch, playing with catnip toys, playing with noisy toys, playing with boxes, playing with hands, playing with digital devices, playing with wand toys, playing with laser pointers, playing with food, playing with motorized toys, chasing each other and training.

conceptualize their relationship with their cat is changing. The objective of the present study was to investigate how guardians play with their cats, to assess what factors are associated with daily play times and play session durations, and what guardian attitudes are towards play in human-cat dyads. Results indicated that most guardians play with their cats for 45 minutes per day in play sessions lasting an average of 15 minutes. Significant associations were found between cat age, number of games played, and closeness of cat guardian relationships with both total daily play time and play session length. Guardian age, cat playfulness, history of injury during play, who initiates play and total resources available to the cat were solely associated with total daily play times while the number of hours the cat was left home alone, and guardian playfulness scores were exclusively associated with play session lengths. Guardians most reported avoiding play during times when they were busy or because they were afraid of receiving an injury from their cat during play.

Total daily play times and play session lengths

Play time findings in this study differ from 2 previous studies that investigated play times in cats. Heidenberger (1997) found that guardians reported engaging in 3 play bouts with their cat over a day, with each play bout lasting between 20 and 40 minutes, while in a survey by Strickler and Shull (2014), guardians reported engaging in 2 play bouts per day, lasting approximately 5-10 minutes each. Differences between previous results and the ones reported in the current study may be due to the sample populations used, changes in human-cat play over time, or maybe due to differing ideas from participants about what play entails. For some guardians play may encompass cuddling and petting as well as chasing or throwing or moving objects around for their cat, while other guardians may view play as strictly playing with a toy with their cat. Future surveys would benefit from providing a specific definition of the play they wish to investigate to their participants. It is also probable that the global Covid-19 pandemic has

Table 5
Results of 1-way analysis of variance (ANOVA) for each factor associated with play session lengths in human-cat dyads, guardian sex N = 1495, total "games" played N = 1503, cat age N = 1498, number of hours left home alone N = 1503, based on online survey responses between June 22 and July 17, 2021.

Factor:	Play Session Length Mean	Play Session Length Range	CI (95%)	*P*-value
Guardian Sex	19.2	0-150	18.3-19.8	0.007
Female (1353)	25.0	0-90	19.2-30.8	
Non-binary (48)	16.9	0-60	14.8-19.2	
Male (94)				
Cat age				<0.001
1-2 years (323)	22.3	0-120	20.6-23.9	
3-5 years (434)	20.5	0-150	18.9-21.9	
6-9 years (359)	18.4	0-150	16.8-19.9	
10+ years (382)	15.4	0 - 60	14.3-16.5	
Total "games" played*	11.7	0-45	10.2-13.4	<0.001
0-1 games (142)	17.5	0-150	16.6-18.3	
2-4 games (811)	22.2	0-150	20.5-23.7	
5-6 games (374)	25.9	0-150	22.8-28.9	
7+ games (176)				
Number of hours left home alone				<0.001
0-10 hours (488)	17.5	0-45	16.6-18.5	
11-25 hours (417)	23.2	0-150	21.2-25.3	
26-39 hours (386)	18.5	0-90	17.4-19.5	
40+ hours (212)	15.5	0-45	14.4-16.8	
Number of children (under 18) in home	19.6	0-150	18.7-20.4	0.007
None (1186)	18.7	0-150	16.1-21.4	
1 child (170)	15.6	0-75	13.5-17.6	
2+ children (146)				

* Total "games" played included: Fetch, playing with catnip toys, playing with noisy toys, playing with boxes, playing with hands, playing with digital devices, playing with wand toys, playing with laser pointers, playing with food, playing with motorized toys, chasing each other and training.A linear regression of play session length showed significant correlations between play session length and cat owner relationship (CORS) scores (N = 1502), R = 0.221, standard error = 0.036, *P* = <0.001. Play session length also showed significant correlations with adult playfulness trait scale (APTS) scores (N = 1490), R = 0.093, standard error = 0.25, *P* = <0.001).

Table 6
General Linear Model parameter estimates of factors associated with play session lengths in human-cat dyads (N = 1485), based on online survey responses between June 22 and July 17, 2021.

Factor:	Coefficient	Std. Error	Significance
Cat Age			<0.001
1-2 years	4.2	1.1	
3-5 years	3.9	1.1	
6-9 years	2.1	1.1	
10+ years	**		
Total "games" played***			<0.001
0-1 games	-9.8	1.7	
2-4 games	-6.8	1.2	
5-6 games	-2.7	1.3	
7+ games	**		
Number of hours left alone			<0.001
0-10 hours	1.5	1.2	
11-25 hours	7.3	1.2	
26-39 hours	2.4	1.3	
40+ hours	**		
Cat Owner Relationship Scale (CORS)	0.22	0.04	0.021
Adult Playfulness Trait Scale (APTS)	0.05	0.03	0.017

** Reference category
*** Total "games" played included: Fetch, playing with catnip toys, playing with noisy toys, playing with boxes, playing with hands, playing with digital devices, playing with wand toys, playing with laser pointers, playing with food, playing with motorized toys, chasing each other and training.

affected the reported play times of guardians, with many guardians noting within the free text sections of the study that they are now working from home. Previous studies have shown that changes due to the current Covid-19 pandemic have had effects on human-animal relationships (Bowen et al., 2020; Ratschen et al., 2020; Jezierski et al., 2021).

Factors affecting daily play: guardian and cat age

Age of both the guardian and cat was significantly associated with daily play times. Where guardians and cats were younger in age, longer daily play times were observed. Guardians of younger cats also reported longer play session durations. While all cats and

humans in this study were adults, it is likely that play decreases along a gradient as animals (including humans) get older. Certainly, this is the pattern observed within the play times reported in this survey and supported by findings in Duffy et al. (2017) and Gajdoš Kmecová et al., (2021). Guardians in the 55+ category may be more likely to suffer from adverse health effects of aging that may be prohibitive to play sessions with a cat, such as limited energy, mobility, pain, arthritis, or thin skin that may make them more prone to injury (Leventhal et al., 1993; Elders, 2000; Gibson and Lussier, 2012; Calleja-Agius et al., 2013; Rantakokko et al., 2013). Similarly, older cats may suffer from the adverse effects of aging and may be less inclined to play due to pain, joint stiffness, reduction in mobility, or decrease in available energy (Benito et al., 2013; Bellows et al., 2016). Previous studies into cats have focused on play behavior in juvenile periods due to the observation that play is more common during this life stage (Delgado and Hecht, 2019).

Factors affecting play: cat and guardian playfulness

Whether a cat was considered playful by their guardian or not was significantly correlated with longer total daily play times, though not with longer play session lengths. Individual differences in temperament have long been acknowledged in cats (Durr and Smith, 1997; Martínez-Byer et al., 2020). It is likely that some cats are inherently more playful than other cats or prefer more social and energetic play. Highly playful cats may initiate play more than less playful cats, therefore increasing the number of opportunities for play.

While cat playfulness was significantly associated with total daily play time, guardian playfulness, as measured by the adult playfulness trait scale, was significantly correlated with play session length. Where guardians scored higher on the adult playfulness trait scale, they also reported longer play session durations. The adult playfulness scale includes a subscale of fun-belief, that is the belief that fun is valuable to their lives (Shen et al., 2014). Guardians who recognize and believe in the value of play may be more inclined to fully engage with play and may have more stamina for playing due to their belief that what they are doing is good for them, rewarding, or valuable to their life and their cat's life.

Factors affecting play: who initiates play

Where guardians reported that both guardian and cat-initiated play, higher total daily play times were observed, though not longer play session durations. This suggests that people report play behavior to be more frequent in human-cat dyads where both parties are invested in playing together. It may also indicate that play is more frequent where both cat and human are better able to understand each other's communications about, and bids for, instigating play behavior. Where guardians are better able to understand their cat's communications and body language, they are also likely better at identifying and meeting their cat's needs and may have more realistic expectations of their cat's behavior (Heath, 2007). It is likely important to recognize and respect cat choice in whether they engage in an activity such as play or not. In doing so, the cat and guardian are likely to both increase their benefit from feeling safe and personally engaged in an activity they have both chosen to participate in. Recent guidelines suggested by Haywood et al. (2021) highlight the importance of providing cats with choice and control within human-cat interactions. Previous studies have also found that cats prefer to interact with humans who leave them alone while resting, who do not follow them if they choose to retreat from an interaction (Mertens and Turner, 1988) and that cats will respond more enthusiastically to humans who are more responsive to the cat's bids for interaction (Turner, 1991).

Factors affecting play: number of "games"

Where the guardian reported a higher number of games played with their cat, they also reported longer daily play times and longer play session durations. Diversity and variation in play may be important for keeping the interest of both guardian and cat. Previous research has shown that cats can easily become habituated to toys (Hall et al., 2002), decreasing their interest in the toy and their engagement in play behaviors with it. It may be that cats can also become habituated to the sorts of social games presented to them by their guardians. If multiple games are available to a guardian and cat, this variability in game play may keep both parties interested and therefore be reflected in the higher play times and play durations observed within this study. A greater variability in games may also indicate that the guardian and cat are more capable of communicating to each other different cues for different types of play and potentially different "rules" for each game. This ability to better communicate and understand one another may also lead to establishing new games and therefore lead to longer play times and durations. Similar processes of communicating and creating play are observed in parent-child relationships. Fogel et al. (1993) states that "Parent-child play is a creative process, emergent from the dynamics of social discourse between 2 different individuals in a particular cultural and physical context." (Fogel et al., 1993, p. 45). Human-cat dyad play is also likely to be a creative, social process and the better at this process a human-cat dyad is, the more game variability and the longer the associated play times.

Factors affecting play: number of hours cat is left alone

Where a guardian is home more often, more human-cat interactions have the opportunity to take place (Mertens, 1991). Such interactions include play, as in the current study. Guardians who work full time may simply have less opportunity to play due to limited time at home with their cat. Guardians who work full time may also be too tired or busy with other life admin tasks when they get home to be able to prioritize time playing. Of the reasons guardians reported for avoiding play, 3 of the most common were that the guardian was too busy, too tired, or was feeling too time poor to play with their cat. It is worth noting that this survey was conducted during a global pandemic where many people were working from home in some capacity. It is probable that many guardians may have been working from home due to the pandemic and therefore, while not absent from the house, were still too busy with other tasks to play.

Factors affecting play: cat-guardian relationships

Closeness of cat-guardian relationships was significantly associated with both higher daily play times and longer play sessions. Where cat-guardian relationships, as measured by the cat owner relationship scale, were reported to be closer, human-cat daily play times and play session durations were also reported to be longer. Previous research indicates that human-cat relationships affect both human and cat (Turner, 2017; Finka et al., 2019; Henning et al., 2021), though this relationship may affect the cat more than the human due to the cat's reliance on their guardian for care, resources, and social interactions (Finka et al., 2019). The findings of this study may indicate that guardians who are more attached to, or enamored of, their cat are more willing to spend time playing

with them or it could suggest that play is an activity that strengthens the human-cat bond. Further research is needed to investigate this association.

Factors affecting play: why guardians avoid play

Within this study, 572 guardians reported that they sometimes avoid playing with their cat. Reasons for wishing to avoid play ranged from the guardian being busy with another task or to the guardian reporting difficulty engaging with play due to depression (Table 2).

These guardian-reported reasons for avoiding play may indicate areas in which improvements can be made to assist in increasing or improving the quality of human-cat dyad play. It is especially concerning how many participants reported having been injured during human-cat dyad play in the past and how many respondents now report avoiding play due to fear of an injury. It is worth noting that while reports of avoiding play due to injury related fears were common among participants, the relationship between total daily play times and history of injury showed that participants with a history of significant injury also reported longer total daily play times. However, it may be that those who play with their cats more also have more opportunity to experience injury. Teaching guardians about reading cat body language and how to avoid injury may help guardians feel more confident about engaging in play with their cat and may reduce incidence of injury.

Limitations and future research

Potential limitations of this study include the following. First, our survey population may be biased. Respondents overwhelmingly identified themselves as female. It is possible that woman-cat dyad behavior differs compared to man- or non-binary-cat dyad behavior. Previous research has indicated that woman-cat dyads show greater reciprocity of interactions compared to male-cat dyads (Mertens, 1991). Univariate analysis within our study indicated that non-binary- cat dyad participants reported significantly longer play times than male-cat or female-cat dyad participants. However, this may be limited due to the low number of non-binary and male participants included in the survey. Participants prepared to volunteer for a survey of this length may also be more invested in their cat's care than the average cat guardian and therefore survey respondents may not be an accurate representation of the general population. Further, due to the self-reporting nature of surveys, responses may be vulnerable to respondent and recall bias. This survey was also conducted during a global pandemic so responses may be different to those collected during a more normal year. A major limitation of this study was a lack of a refined definition of what play encompasses. Though detailed descriptions of different play types were given within the survey, "play" in general was not defined and so participant responses appear to vary in their understanding of what play entails. Some participants made a point to explain that they had not included their regular cuddle sessions as play while others described their play within free text as including cuddling. Future studies would benefit from stating their definition of play clearly upfront to respondents and potentially giving examples prior to data collection. Future studies should investigate how play affects cat-guardian relationships, whether there are benefits to cat and/or guardian from engaging in play behavior together and what the role of play is in establishing and maintaining human-cat dyad communication and socialization.

Conclusion

Play is a behavior that may assist in establishing and maintaining healthy human-cat relationships. The present study aimed to assess the factors associated with the amount of play exhibited in human-cat dyads. Results showed significant associations between cat age, diversity of "games" and, closer cat-guardian relationships with both total daily play times and play session lengths. Further investigations into how guardians and cats experience and are affected by human-cat dyad play are needed. In particular, future research should focus on play as a tool for social cohesion and communication in human-cat relationships.

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Ethical considerations

The protocol for this study was conducted with approval from the Human Research Ethics Committee at the University of Adelaide, approval code: H-2021-091.

Conflict of Interest

The author declares no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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Authorship statement

All authors conceived of the idea and provided research and editing. J.H., took the lead on data management, analysis and writing the manuscript with input and contributions from all authors.

Data Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request. The data are not publicly available due to privacy or ethical restrictions.

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Chapter 5: Cats just want to have fun: associations between play and welfare in domestic cats

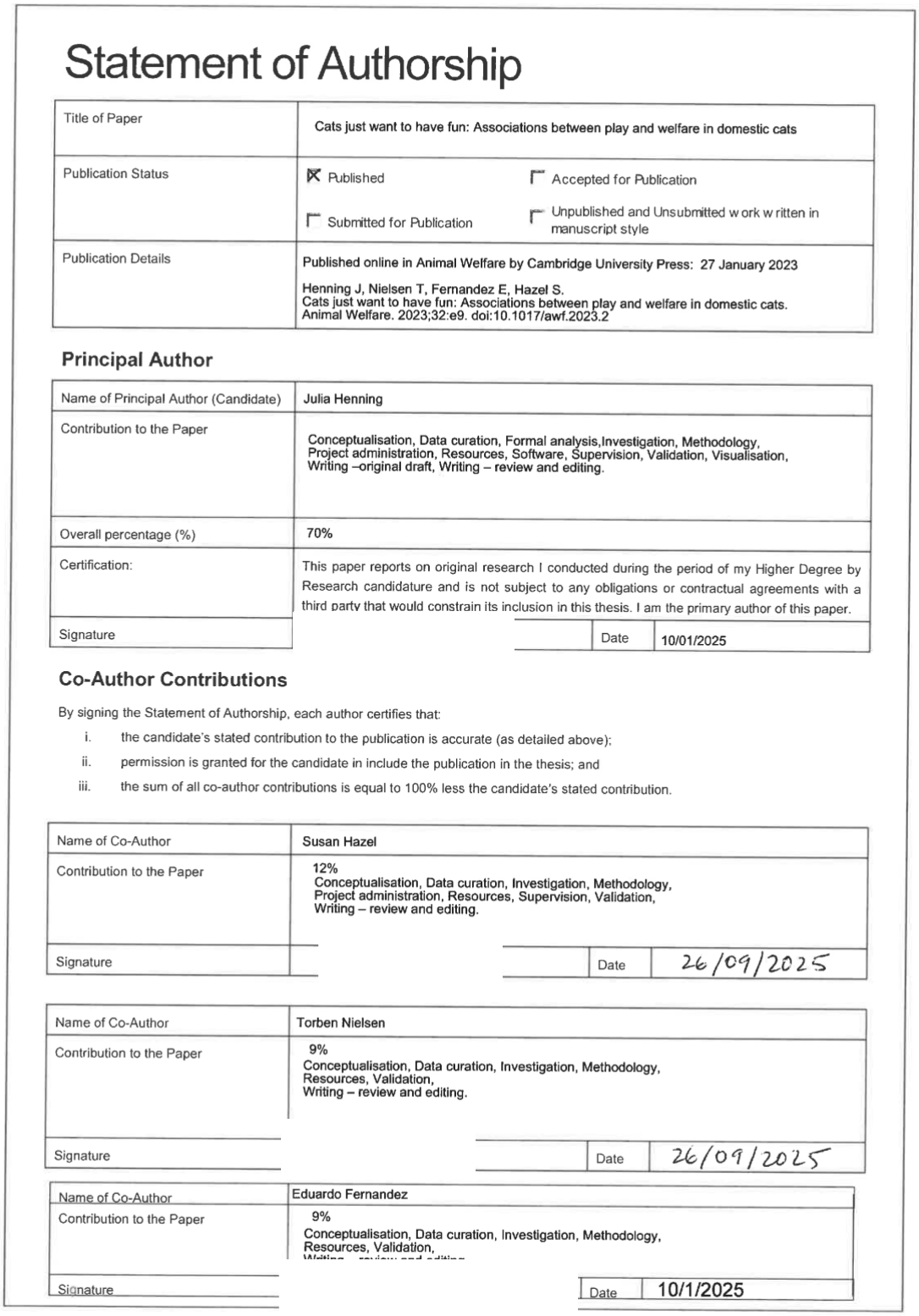
Context Statement

Building on from the findings of Chapters 2, 3 and 4, and further exploring Aims 1 and 2, Chapter 5 empirically investigates the association between human-cat play and welfare utilising four welfare-related outcome measures: a validated cat quality of life (QOL) scale, a validated cat-guardian relationship scale (CORS), and guardian reports of problem behaviour presence and behavioural changes observed in the absence of human-cat play. This Chapter utilised the same global online survey as in Chapters 3 and 4. Findings demonstrated initial support for human-cat play as both an indicator and promotor of cat welfare. As a promotor: cat playfulness and a greater diversity of games played between cat and guardian were associated with higher cat QOL scores while greater diversity of games, mutual initiation and no avoidance of play was significantly associated with higher cat guardian relationship scores (CORS). As an indicator: behavioural changes that indicated stress, frustration or unease were reported during times when play had been absent or withheld.

No play variables (e.g., daily play times, number of games etc) were associated with presence of problem behaviours. However, 40.2% of participants reported play aggression as a problem behaviour in their cat. Of participants who reported cat behaviour changes when play had been absent, 9% reported that their cat's aggression increased. These results provide further insights into some of the findings from earlier Chapters. Notably, a fear of injury during play was evident in Chapter 3, where guardians reported negative emotions including fear and concerns about being injured during play interactions and, in Chapter 4, 18% of guardians reported avoiding play with their cats due to or fearing an injury. Chapter 5 identifies play aggression as a common behaviour problem, reported by 40.2% of participants and demonstrates that avoidance of play (as reported in Chapter 4) may further exacerbate this problem, with increased aggression reported by participants when play was absent. Further, Chapter 5 demonstrates potential welfare implications of avoiding play, with avoidance of play associated with significantly lower cat-guardian relationship scores (CORS). Additionally, following on from Chapter 4's findings of an association between mutual initiation of play and longer play times, the results of Chapter 5 included a correlation between mutual initiation of play and higher CORS scores. Mutual initiation may suggest that the dyad is able to recognise each other's communications. The association between mutual initiation and higher relationship scores may therefore be indicative of potential avenues for investigating the role

of communication in human-cat bonding. This Chapter represents an important expansion of our understanding of human-cat play, human-cat relationships and their links to welfare, providing the first empirical evidence linking specific human-cat play variables to measurable welfare outcomes and identifying potential areas, such as communication recognition and injury mitigation, for increasing play availability and improving human-cat play quality.

Statement of Authorship



Statement of Authorship

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Contribution to the Paper	Conceptualisation, Data curation, Formal analysis,Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualisation, Writing –original draft, Writing – review and editing.
Overall percentage (%)	70%
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.
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By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate in include the publication in the thesis; and

iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

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Cats just want to have fun: Associations between play and welfare in domestic cats

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Abstract

Play is often considered an indicator and promotor of animal welfare and may facilitate closer cat-human relationships. However, few studies have empirically investigated these associations. The current study aimed to investigate play-related factors associated with four welfare outcome measures in cats (*Felis catus*) including: cat quality of life; cat-guardian relationship quality; problem behaviour prevalence; and behavioural changes. An online survey was developed using demographic information, questions related to play and resources, free text sections and the following validated measures: cat quality of life (QOL), the cat owner relationship scale, and the adult playfulness trait scale. Responses were completed by 1,591 cat guardians from 55 countries. Higher cat playfulness scores and a greater number of games played were significantly associated with higher cat QOL scores while longer amounts of daily play, greater number of games, both cat and guardian initiating play and higher guardian playfulness scores were all significantly associated with higher cat-guardian relationship scores. Exclusively indoor housing was significantly associated with both higher cat QOL and higher cat-guardian relationships scores compared to cats with outdoor access. Behavioural changes associated with distress in cats were reported when play was absent. Play may be an important factor in assessing and maintaining cat welfare. Further research into the mechanisms of how play impacts welfare and cat-guardian relationships is needed.

Introduction

The potential of play as a behavioural tool to both identify and increase animal welfare has been a recent topic of interest for applied animal behaviour researchers (Held & Špinka 2011; Ahloy-Dallaire *et al.* 2018). This link between play and welfare is most often observed when animals are experiencing good health, have adequate resources and are free from fitness threats such as predation (Fagen 1978; Oliveira *et al.* 2010). In addition, research links play to juvenile development and long-term maintenance of neurological/physiological, cognitive-behavioural, and emotional skills (Burghardt 2005; Graham & Burghardt 2010; Vanderschuren & Trezza 2013; Pellis *et al.* 2015).

Play may be especially useful in managing the welfare of animals in human care such as cats (*Felis catus*), an increasingly popular pet choice within human homes (PDSA Animal Wellbeing Report 2022). Previous studies into play in cats have found associations between welfare issues such as social isolation, inconsistent husbandry, space availability, problem behaviours and changes in play behaviour (Seitz 1959; West 1974; Guyot *et al.* 1980; Carlstead *et al.* 1993; Strickler & Shull 2014; Loberg & Lundmark 2016). Of the previous studies that assessed play and welfare associations in cats, only a few used a specific welfare metric within their study. For instance, measures of cat physical condition (Arhant *et al.* 2015), occurrence of abnormal, repetitive behaviours (Kogan & Grigg 2021) or physiological and behavioural signs of stress (Carlstead *et al.* 1993). In a recent review of the current literature, we highlighted the lack of specific welfare measures used in studies of play in cats (Henning *et al.* 2022a).

Cat welfare encompasses many elements, from the cats' physical state and the quality of their environment as well as the resources available to them, to their mental state and social relationships (Ellis *et al.* 2013; Foreman-Worsley & Farnworth 2019; Henning *et al.* 2022a). For cats in human homes, all these elements rely heavily on their guardian and their relationship with that guardian. It is therefore important to consider guardian perceptions about their cat, their cat's behaviour and their relationship with their cat when assessing cat welfare within a human home. Human-animal interactions, such as play, are likely to impact the dynamic and quality of relationships between cat and guardian. Considering play may be integral to forming and maintaining social skills and communication intra-specifically in animals (Guyot *et al.* 1980, Bekoff & Allen 2011; Vanderschuren & Trezza 2013; Palagi *et al.* 2016), play may also be capable of assisting in establishing and maintaining healthy cat-guardian relationships (Henning *et al.* 2022b).

Guardians are responsible for making homing and medical choices for their cats which may have serious welfare outcomes, such as surrender or euthanasia. How guardians perceive their

cats may impact how they treat them and even what decisions they make concerning their lives. What guardians perceive as 'problem behaviours', such as scratching furniture or inappropriate urination are often the result of species-typical behaviours that are natural and functional within their usual environment but become problematic when viewed through the lens of a guardian who wishes to have a neat and undamaged home. Regardless of whether the behaviours are problematic for the cat or not, problem behaviours are the leading cat-related factor for surrender to shelters (Patronek *et al.* 1996; Jensen *et al.* 2020) and the foremost cause of euthanasia in otherwise healthy pet cats (Carney *et al.* 2014). Studies suggest that play may have a role in mitigating the occurrence of problem behaviours in cats, with a lack of play associated with greater occurrence of problem behaviours (Strickler & Shull 2014; Foreman-Worsley & Farnworth 2019).

While previous studies show promise for some association between play and welfare in cats, there is still much to be understood about whether play is an adequate indicator of welfare, whether play can be used to promote welfare and how much or what kind of play is best suited to achieving these aims. A previous study by Henning *et al.* (2022b) investigated the factors associated with how much play occurs within human-cat dyads. Here, the present study follows on from this paper and aims to identify and assess whether play itself, its quantity or quality or its role in cat-guardian relationships, is associated with welfare outcomes in cats. To achieve this, four different potential welfare measures were used within a global online survey. These were: cat quality of life (QOL) scores; quality of the cat-guardian relationship scores; reported behavioural problems; and guardian observations of behavioural changes in times when play was absent. It was expected that higher play times would be positively associated with welfare measures.

Materials and methods

The survey development, validated measures, data management and study population have been described in more detail in Henning *et al.* (2022b). A short summary is included here as well as details relevant to the areas of the questionnaire analysed within this paper. The protocol for this study was conducted with approval from the Human Research Ethics Committee at the University of Adelaide, approval code: H-2021-091.

Survey

The survey was developed in consultation with veterinarians, animal behaviourists, and cat guardians. Participants were required to be over 18 years of age and the primary caregiver of a cat over one year of age. If the participant had multiple cats, they were asked to think of the cat they spent the most time with and answer questions as if they had been asked about that cat specifically, so that the survey was only answered for one cat per respondent. The resulting open survey comprised 105 questions and was hosted on Qualtrics XM®. The survey included demographic information, questions regarding duration and time of play, play type, guardian experiences of play, cat medical history, guardian perceptions of changes in behaviour, and three validated measures which included: the Feline Quality of Life Measure (QOL) (Tatlock *et al.* 2017); the Cat Owner Relationship Scale (CORS) (Howell *et al.* 2017); and the Adult Playfulness Trait Scale (APTS) (Shen *et al.* 2014). All included measures had previously been validated (Shen *et al.* 2014; Howell *et al.* 2017; Tatlock *et al.* 2017). Participants were asked to rate whether their cat exhibited certain problem behaviours on a 5-point Likert scale from 'never' to 'most of the time.' Only participants who completed every question of the cat QOL and CORS validated measures, and completed at least 98% of the survey overall, were included in final analysis (Henning *et al.* 2022b). The survey was open for participation between the 22nd of June and the 17th of July 2021.

Analysis

A Kolmogorov-Smirnov test was undertaken to assess normality. The data set were found not to be normally distributed. However, as the data set were large, and thus robust enough, to be tested using standard parametric inferential statistics, these were used (Ghasemi & Zahediasl 2012; Hector 2021). Eighteen reported problem behaviours were reduced to seven components using a Principal Component Analysis (PCA). After viewing the matrix, one component and one item were removed due to low loading, leaving six components and seventeen items. Components were then included in analyses, including ANOVAs, regression, and general linear models. Two general linear models were created with cat QOL and CORS scores as dependent variables. All variables were tested through two-way ANOVA against QOL and CORS scores, respectively, and all variables from regressions or ANOVAs with a $P < 0.2$ were included in subsequent modelling. Non-significant factors were removed using backwards elimination. Interactions that were relevant were checked for significance and included in the model where found. Statistical analyses were completed using SPSS® Statistics 27. A P-value of < 0.05 was considered significant. Descriptive and qualitative analyses of behaviour changes during times play was withheld were undertaken. Free text responses were collected and grouped into types of behaviour. Where quotes have been shortened a '[…]' is used. Quotes were only shortened where necessary while maintaining and respecting the original meaning.

Results

A total of 1,591 completed responses were recorded from 55 different countries. Most participants were currently living in Australia (49.3%), identified as female (90.3%) and reported living in a two-person household at the time of the survey (47.8%). Most cats in the study were of mixed breed (76%) and almost equally reported to be male or female. Most cats were reported to be housed exclusively indoors (67%), between 3–5 years of age (28.8%), within a single cat home (38.9%), and had been living with their current guardian for 2–5 years at the time of the survey (42%). For further information on demographics of this study see Henning *et al.* (2022b).

Factors associated with problem behaviours

A list of problem behaviours and a free text option were presented to respondents along with a five-point Likert scale with options from 'never' to 'most of the time.' Answers above a three on the Likert scale were included in the following tallies and percentages. The most reported problem behaviour by participants was scratching furniture (47.5%), followed by aggression during play (40.2%), excessive vocalisation (37.6%), aggression towards unfamiliar cats (36.6%) and being overly active at night (35.8%) (Table 1).

Eighteen items of reported problem behaviours were reduced using a PCA. Six components presented with an eigenvalue exceeding 1, explaining 51.6% of variance. Sucking on material did not

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Table 1. Problem behaviours reported by cat guardians (n = 1,591). Guardians were able to report multiple behaviours. Based on online survey responses of guardians between June 22nd and July 17th, 2021

Problem behaviours reported	*n*	%
Scratching furniture	755	47.5%
Aggression during play (play aggression)	639	40.2%
Excessive vocalisation	598	37.6%
Aggression towards unknown cats	583	36.6%
Overly active at night	570	35.8%
Anxiety	424	26.6%
Aggression towards familiar household cats	424	26.6%
Aggression towards unknown animals	358	22.5%
Urinating outside of the litter-box	311	19.5%
Sucking on material	244	15.4%
Aggression towards other household animals	217	13.6%
Pica	206	12.9%
Overgrooming	186	11.7%
Aggression towards human household members	171	10.7%
Defaecating outside the litter-box	153	9.6%
Aggression towards unknown people	129	8.1%
Spraying	67	4.2%
Urinating and/or defaecating on furniture	59	3.7%

present with a high enough value in any component and was removed from the analysis, leaving seventeen items. These summary indices included the following components: inappropriate excretion subset, aggression towards unknown animals' subset, annoyance behaviour subset, aggression towards people subset, stress behaviour subset, and aggression towards known animals' subset (Table 2).

Analysis of the PCA components showed no significant results between play and problem behaviour components. Analysis of PCA components and cat QOL scores showed only the component for stress behaviours (e.g., overgrooming, pica, anxiety) as significantly negatively associated with cat QOL scores (see Tables 3 and 4).

Factors associated with cat quality of life

One-way ANOVAs showed that cat QOL scores were higher in cats who were younger, had no health issues, were housed exclusively indoors, were more playful, had access to a greater number of games, had lower stress behaviour PCA component scores, and higher CORS scores (Table 3).

A univariate linear regression showed a significant association between cat QOL and CORS scores ($P < 0.001$). The correlation coefficient for CORS and cat QOL scores was $R = 0.375$, indicating a moderate correlation (standard error = 0.015). A linear regression also showed a significant association between cat QOL scores and stress behaviour PCA component scores ($P < 0.001$). The correlation coefficient for stress behaviours and cat QOL scores was $R = 0.154$ indicating a weak correlation (standard error = 0.08).

Table 2. Loading for 18 problem behaviours reported by cat guardians, generated by means of a Principal Component Analysis

	Summary indices					
Problem behaviour	Inappropriate excretion	Aggression towards unknown animals'	Annoyance behaviour	Aggression towards people	Stress behaviour	Aggression towards known animals
Urinating outside of the litter-box	0.795					
Defaecating outside the litter-box	0.480					
Spraying	0.663					
Urinating and/or defaecating on furniture	0.788					
Aggression towards unknown cats		0.865				
Aggression towards unknown animals		0.865				
Scratching furniture			0.633			
Overly active at night			0.761			
Excessive vocalisation			0.586			
Aggression to household members				0.838		
Aggression to unknown people				0.744		
Aggression during play (play aggression)				0.349		
Overgrooming					0.606	
Pica					0.374	
Anxiety					0.672	
Sucking*					0.052	
Aggression towards familiar household cats						0.709
Aggression towards other household animals						0.697

*Not included due to low loading

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Table 3. Results of a one-way analysis of variance (ANOVA) for each factor associated with quality of life in cats (n = 1,590) except for: cat age (n = 1,584) and cat playfulness (n = 1,589). Based on online survey responses of cat guardians between June 22nd and July 17th, 2021

Factor	Cat Quality of Life Score	Cat Quality of Life Range	CI (95%)	*P*-value
Cat playfulness				< 0.001
Not very playful, only plays occasionally (478)	68.6	40-80	68.1-69.3	
Neither playful nor not playful (281)	70.8	38-80	70.1-71.5	
Playful, often wants to play (830)	73.3	41-80	72.9-73.7	
Total 'games' played[a]				< 0.001
0-1 games (155)	67.8	38-80	66.6-69.1	
2-4 games (856)	71.2	41-80	70.7-71.5	
5-6 games (390)	72.7	40-80	72.2 -73.3	
7+ games (189)	73.5	51-80	72.7-74.2	
Housing[b]				< 0.001
Outdoor access (524)	70.3	41-80	69.7-70.8	
Exclusively Indoors (1,066)	72.1	38-80	71.2-71.8	
Cat age				< 0.001
1-2 years (354)	73.5	50-80	72.9-74.1	
3-5 years (457)	72.3	56-80	71.8-72.8	
6-9 years (377)	71.7	41-80	71.1-72.3	
10+ years (396)	68.5	38-80	67.7-69.3	
Cat health issues				< 0.001
Yes (415)	68.4	38-80	67.6-69.1	
No (1175)	72.6	48-80	72.2-72.8	

[a]Total 'games' played related to games the guardian regularly played with their cat and included: Fetch, playing with catnip toys, playing with noisy toys, playing with boxes, playing with hands, playing with digital devices, playing with wand toys, playing with laser pointers, playing with food, playing with motorised toys, chasing each other and training.
[b]Housing: Outdoor was defined as regular unsupervised access to the outdoors without a harness, lead and not within a fully enclosed cat enclosure. Indoor/Outdoor was defined as mostly indoor with some access to the outdoors and exclusively indoors was defined as a cat with no access to the outdoors except on a harness or within a fully enclosed cat enclosure.

A general linear model analysis of factors associated with cat QOL scores showed higher cat QOL scores where cats were housed exclusively indoors, were more playful, had access to a greater number of games, and where the guardian reported higher CORS scores (Table 4).

An interaction was found between reported health issues and cat age ($P = 0.005$). QOL scores reduced at a greater rate where the cat was older and had health issues.

Factors associated with cat-guardian relationships

One-way ANOVAs showed that CORS scores were higher in human-cat dyads where the cat was housed exclusively indoors, the number of games played within the dyad was greater, the cat had access to a higher number of resources, guardians did not report avoiding play, and where both cat and guardian initiated play (Table 5).

A univariate linear regression showed significant associations between CORS scores and guardian playfulness (APTS) scores ($P < 0.001$), total guardian-cat daily play time ($P < 0.001$), cat QOL scores ($P < 0.001$), and the length of guardianship. The correlation coefficient for CORS and APTS was $R = 0.120$, indicating a weak correlation (standard error = 0.017). The correlation coefficient for CORS and total guardian-cat daily play time was $R = 0.271$, indicating a moderate correlation (standard error = 0.004). The correlation coefficient for CORS and cat QOL scores was $R = 0.375$ indicating a moderate correlation (standard error = 0.037). The correlation coefficient for CORS and length of guardianship was $R = 0.058$, indicating a weak correlation (standard error = 0.06).

A general linear model analysis of factors associated with CORS scores showed higher scores where cats were housed exclusively indoors, the number of games played within the human-cat dyad was greater, the cat had access to a larger number of resources, guardian age was younger, guardians identified as non-binary, guardians did not report avoiding play, both cat and guardian initiated play, the guardian had higher playfulness scores, were single, and where the cat was left home for less than 40 h (Table 6).

Guardian-perceived behaviour changes when play is withheld

Guardians were presented with the following question: "Does your cat's behaviour change if you haven't played with them for a while?" The most common reported behaviour changes when play was withheld (n = 468) were that their cat exhibited more attention-seeking behaviour, followed by increased vocalising, an increase in destructive behaviour, an increase in reclusive behaviour, and increased aggressive behaviour (Table 7). Examples of quotes relating to these reported behaviours are given in Table 8.

Discussion

The objective of the present study was to investigate associations between play and welfare in cats by assessing factors associated with cat QOL score and closeness of cat-guardian relationships. Results

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Table 4. General Linear Model parameter estimates of factors associated with cat quality of life scores (n = 1,583), based on online survey cat guardian responses between June 22nd and July 17th, 2021

Factor	Coefficient	SEM	Significance
Cat playfulness			< 0.001
Not very playful, only plays occasionally	**		
Neither playful nor not playful	1.2	0.41	
Playful, often wants to play	2.6	0.35	
Total 'games' played[a]			0.014
0-1 games	**		
2-4 games	1.2	0.48	
5-6 games	1.5	0.54	
7+ games	1.8	0.62	
Housing[b]			0.018
Outdoor access	**	0.29	
Exclusively indoors	0.68		
Cat age			< 0.001
1-2 years	1.7	0.44	
3-5 years	1.4	0.39	
6-9 years	1.6	0.39	
10+ years	**		
Cat health issues			< 0.001
Yes	**		
No	4.6	0.54	
Stress behaviour score[c]	−0.44	0.07	< 0.001
Cat Owner Relationship Scale (CORS)	0.18	0.02	< 0.001
Interaction: Cat age and health issues			0.005

**Reference category.
[a]Total 'games' played related to games the guardian regularly played with their cat and included: Fetch, playing with catnip toys, playing with noisy toys, playing with boxes, playing with hands, playing with digital devices, playing with wand toys, playing with laser pointers, playing with food, playing with motorised toys, chasing each other and training.
[b]Housing: Outdoor access was defined as any regular unsupervised access to the outdoors without a harness, lead and not within a fully enclosed cat enclosure. Exclusively indoors was defined as a cat with no access to the outdoors except on a harness or within a fully enclosed cat enclosure.
[c]Stress behaviour score relates to a guardian-reported frequency for anxiety, pica and overgrooming respectively, reported on a five-point Likert scale and coded into values (1 being never and 5 being most of the time) with values summed to create a composite score.

Table 5. Results of a one-way analysis of variance (ANOVA) for each factor associated with the cat owner relationship scale (CORS) (n = 1,590) except for: guardian gender (n = 1,582), do you avoid play (n = 1,580), who initiates play (n = 1,451) and relationship status (n = 1,567). Based on online survey cat guardian responses between June 22nd and July 17th, 2021

Factor	CORS score	CORS Range	CI (95%)	*P*-value
Total 'games' played[a]				< 0.001
0-1 games (155)	105.1	58-130	103.1-107.1	
2-4 games (856)	111.7	80-130	111.1-112.3	
5-6 games (390)	114.3	70-130	113.4 -115.2	
7+ games (189)	115.5	77-130	114.2-116.7	
Who initiates play?				< 0.001
Cat (275)	110.6	76-130	109.4-111.8	
Guardian (313)	110.5	77-130	109.4-111.7	
Both (863)	113.9	70-130	113.3-114.5	
Do you avoid play?				< 0.001
Yes (584)	110.8	70-130	110.1-111.6	
No (996)	112.9	58-130	112.3-113.6	
Housing[b]				< 0.001
Outdoor access (524)	109.7	58-130	108.8-110.6	
Exclusively indoors (1,066)	113.3	70-130	112.7-113.8	
Total resources available[c]				< 0.001
0-3 resources (95)	102.7	58-129	100.1-105.4	
4-6 resources (558)	110.7	73-130	109.9-111.6	
7-9 resources (698)	113.4	70-130	112.7-114.1	
10-14 resources (239)	115.3	77-130	114.2-116.4	
Guardian age				< 0.001
18-24 (179)	115.4	86-130	114.2-116.7	
25-34 (616)	112.5	70-130	111.8-113.3	
35-44 (396)	111.4	76-130	110.4-112.5	
45-54 (245)	111.5	58-130	110.2-112.8	
55+ (154)	109.5	73-128	107.8-111.3	
Guardian gender				< 0.001
Non-binary (52)	115.8	96-130	113.6-118.1	
Female (1,429)	112.3	58-130	111.8-112.8	
Male (101)	107.8	79-126	105.7-109.9	
Relationship status				< 0.001
Single with children (65)	108.8	85-130	105.9-111.6	
Partnered with children (297)	108.3	58-130	106.9-109.6	
Partnered	112.9	73-130	112.3-113.7	
Single	113.6	70-130	112.8-114.5	
Number of hours cat left home alone				0.002
0-10 h (527)	112.7	80-130	111.9-113.5	
11-25 h (420)	111.9	73-130	110.9-112.8	
26-39 h (416)	112.8	58-130	111.8-113.8	
40+ h (227)	109.9	76-130	108.5-111.3	

[a]Total 'games' played related to games the guardian regularly played with their cat and included: Fetch, playing with catnip toys, playing with noisy toys, playing with boxes, playing with hands, playing with digital devices, playing with wand toys, playing with laser pointers, playing with food, playing with motorised toys, chasing each other and training.
[b]Housing: Outdoor access was defined as any regular unsupervised access to the outdoors without a harness, lead and not within a fully enclosed cat enclosure. Exclusively indoors was defined as a cat with no access to the outdoors except on a harness or within a fully enclosed cat enclosure.
[c]Total resources available included: scratching post, cat bed, hiding place, water fountain, wand toy, food puzzle, food treats, motorised toy, wall or window perch, harness walks, outdoor cat enclosure, cat grass, self-cleaning litter tray, Feliway™ and automatic feeder.

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Table 6. General Linear Model parameter estimates of factors associated with cat-owner relationship scores (n = 1,372), based on online survey responses of cat guardians between June 22nd and July 17th, 2021

Factor	Coefficient	SEM	Significance
Total 'games' played[a]			0.034
0-1 games	**		
2-4 games	1.2	0.48	
5-6 games	1.5	0.54	
7+ games	1.8	0.62	
Who initiates play?			< 0.001
Cat	**		
Guardian	0.34	0.72	
Both	2.2	0.62	
Do you avoid play?			< 0.001
Yes	**		
No	2.6	0.47	
Housing[b]			< 0.001
Outdoor access	**		
Exclusively indoors	1.8	0.51	
Total resources available[c]			< 0.001
0-3 resources	**		
4-6 resources	3.8	1.1	
7-9 resources	4.6	1.1	
10-14 resources	5.6	1.3	
Relationship status			< 0.001
Single with children	**		
Partnered with children	0.26	1.2	
Partnered	3.1	1.2	
Single	3.9	1.2	
Number of hours left alone			0.002
0-10 h	2.8	0.73	
11-25 h	1.6	0.75	
26-39 h	2.1	0.75	
40+ h	**		
Guardian age			0.032
18-24	2.3	1.1	
25-34	.51	0.85	
35-44	1.5	0.87	
45-54	1.8	0.93	
55+	**		
Guardian gender			0.002
Male	**		
Female	3.3	0.93	
Non-binary	4.1	1.5	
Adult playfulness trait scale (APTS)	0.04	0.02	0.011
Total cat-guardian daily play	0.03	0.01	< 0.001
Length of guardianship	0.26	0.06	< 0.001
Cat quality of life (QOL) score	0.44	0.04	< 0.001

(*Continued*)

**Reference category.

[a]Total 'games' played related to games the guardian regularly played with their cat and included: Fetch, playing with catnip toys, playing with noisy toys, playing with boxes, playing with hands, playing with digital devices, playing with wand toys, playing with laser pointers, playing with food, playing with motorised toys, chasing each other and training.

[b]Housing: Outdoor access was defined as any regular unsupervised access to the outdoors without a harness, lead and not within a fully enclosed cat enclosure. Exclusively indoors was defined as a cat with no access to the outdoors except on a harness or within a fully enclosed cat enclosure.

[c]Total resources available included: scratching post, cat bed, hiding place, water fountain, wand toy, food puzzle, food treats, motorised toy, wall or window perch, harness walks, outdoor cat enclosure, cat grass, self-cleaning litter tray, Feliway™ and automatic feeder.

Table 7. Guardian-reported cat behaviour changes when play was withheld, reported by guardians (n = 468). Guardians could report more than one behaviour change. Based on online survey responses between June 22nd and July 17th, 2021

Behaviour change associated with lack of play	*n*	%
Increased attention seeking behaviour	104	22.2%
Increased vocalising	73	15.6%
Reclusive behaviour	49	10.5%
Increased destructive behaviour	47	10.0%
Increased aggressive behaviour	43	9.0%
Appearing grumpy	34	7.3%
Restlessness	28	6.0%
Increase in time spent sleeping	17	3.6%
More likely to initiate play/bring toys to guardian	16	3.4%
Increased 'zoomies'	16	3.4%
Re-directs playfulness to household cats	15	3.2%
Appears to be 'sad'	14	3.0%
More likely to interrupt guardians sleep time	13	2.8%

indicated that cat playfulness and the number of games played by the cat and guardian were associated with QOL scores while the amount of daily play, the number of games played, who initiated play, whether the guardian avoided play, and guardian playfulness were associated with cat-guardian relationship scores. Cat behaviour, as perceived by their guardian, was reported to change during times when play was withheld. No significant associations were found between play and problem behaviours.

Play factors associated with cat quality of life: Cat playfulness and number of games

Cat playfulness was significantly correlated with higher cat QOL scores. Previous observations suggest that play is more likely to be exhibited during times when animals are physically healthy, have access to ample resources, and are not under stress (Held & Špinka 2011; Ahloy-Dallaire *et al.* 2018). Cat playfulness may therefore be reflective of how a cat is feeling physically or emotionally, with sick, injured or stressed cats being less likely to exhibit playfulness

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Table 8. Examples of guardian-reported cat behaviour changes when play was withheld (n = 468). Based on online survey responses between June 22nd and July 17th, 2021

Example	Quote
Attention-seeking behaviour	*"He behaves to get my attention; does things he knows he's not supposed to, e.g., jumping on top of cabinets." [participant 729]*
Destructive behaviour	*"They are frustrated and destroy property (curtains, couch etc)" [participant 178]*
Increased vocalisation	*"He will start screaming at night while carrying toys up the stairs to my bedroom" [participant 864]*
Reclusive behaviour	*"My cat tends to not engage with us as much. She'll spend time around us, but she's more aloof. As soon as we take her out for a walk or play with her, her behaviour changes the following day and she's very playful and affectionate". [participant 683]* *"She becomes more distant from me…doesn't sleep near me as much…is less accepting of affection." [participant 677]*
Increased aggressive behaviour	*"He gets frustrated and takes it out on myself or the other cat (aggressive, violent play.") [participant 1459]*

(Fagen 1978). In a previous study into the effects of stress on cats, animals assigned to a stress condition of irregular or poor caretaking showed reduced or absent play behaviours (Carlstead *et al.* 1993). Interestingly, contrary to our expectations, daily play times were not significantly associated with cat QOL scores. However, the higher the number of games a cat was reported to regularly engage in was significantly correlated with higher cat QOL scores. This discrepancy may indicate that it is the quality or variety of play available and not simply the quantity of play that may be associated with positive welfare outcomes for cats (Carlstead *et al.* 1991; Ahloy-Dallaire *et al.* 2018; Fernandez 2022).

The following distinction was made in this study between toys and games: toys were defined as stimuli that the cat can interact with while games were defined as actions that a cat (and/or guardian) can take. A game may include a toy. Cats have previously been observed to become habituated to toys quickly, showing decreases in play intensity with increased exposure to a particular toy followed by regaining interest and intensity of play when presented with a new toy (Hall *et al.* 2002). Cats may also become habituated to the types of games available to them. Where cats only had a few games available to them with their guardian, their guardian also reported lower QOL scores. If cats are given access to a greater number or regular variation of games and toys, this may help to minimise habituation and boredom with play, potentially resulting in higher playfulness, QOL scores and overall welfare.

Play factors associated with cat-guardian relationships: Number of games and daily play

As well as being associated with cat QOL scores, a higher number of games regularly engaged with was also associated with higher cat-guardian relationship scores. It is possible that guardians who report having a low CORS score were less likely to interact with their cat, or that regular engagement in a variety of play is beneficial for improving cat-guardian relationships. Similarly for humans, only engaging in a small number of games with their cats may lead guardians to experience boredom and dissatisfaction with play, potentially resulting in guardians playing less with their cats. It has previously been found that routine behaviours, which a person feels obligated to perform, undermine their sense of self and freedom (Iso-Ahola 2022). However, these negative aspects can be mitigated by increasing the variety in, and of, these behaviours, such as undertaking a variety of different activities that achieve the same purpose (Iso-Ahola 2022). Tasks that require too little cognitive engagement (such as repeating the same wand toy game with a cat) also can become boring and aversive, leading people to either disengage with the task or seek to enhance variety and novelty (Shenhav *et al.* 2016). Therefore, engaging with a variety of games is likely to increase both cat and guardian feelings of satisfaction and engagement with their play sessions, enhancing the human-cat bond and making future play sessions more likely. Henning *et al.* (2022b) previously reported that the number of games engaged with by human and cat was also associated with longer play session lengths and total daily play times. Total daily play times were significantly associated with cat-guardian relationship scores. This may be because more play offers more opportunities for human-cat bonding, or it may also be that guardians who are more invested in their cat are more willing to play with them.

Play factors associated with cat-guardian relationships: Who initiates and guardian playfulness

Cat-guardian relationship scores were highest where both cat and guardian were reported to initiate play sessions. Being able to both initiate play and recognise initiation of play requires both cat and guardian to be observant and capable of comprehending each other's communication signals. Communication is key to the health of many relationships; therefore, it is possible that better understanding of human and cat signals, be they vocalisations or body language, is likely to lead to a closer or more enriching cat-guardian relationship. Guardians who are able to understand their cat's signals are also more likely to identify their cat's needs (Heath 2007). Self-determination, including the freedom to choose to initiate and engage in an activity, is also a critical component to enjoyment in activities (Dattilo *et al.* 1998). Therefore, when a cat or guardian is choosing to participate in an activity, instead of being forced to do so, they may be more likely to derive benefit from the activity. Cats have been observed to respond well to being given choice and control within human-cat interactions (Mertens & Turner 1988; Haywood *et al.* 2021). Allowing cats to have choice in their interactions is an important behaviour to encourage within cat guardians. Further, cats have been shown to engage more enthusiastically with humans who are more responsive when the cat is seeking attention (Turner 1991). If a cat is regularly initiating play sessions, it indicates that they are applying, and able to utilise, their own self-determination.

Guardian playfulness was also found to be significantly associated with higher cat-guardian relationship scores. Guardians who are more playful may be more willing to engage in play with their cat and may enjoy playing with their cat more than guardians who are not playful. Henning *et al.* (2022b), which utilised data from the same respondents as the current study, previously found that APTS scores were significantly associated with longer play session times between cats and guardians. A more engaged guardian who

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participates in longer play sessions may be better positioned to build social connections with their cat through increased interaction. In a previous study by Odendaal and Meintjes (2003) into dog-guardian relationships, interactions of between 5 and 24 min were associated (for both dog and human) with: decreases in blood pressure; significant increases in oxytocin, prolactin and phenylethylamine (neurochemicals that are known to be associated with bonding), plasma dopamine concentrations associated with pleasurable experiences and β-endorphin which is involved in learning, memory, analgesia, and euphoric states. Humans in the study also experienced a decrease in plasma cortisol, indicating stress relief (Odendaal & Meintjes 2003). Increased interactions due to guardian playfulness may therefore benefit both cat and guardian.

However, it is important to note that this measure of cat-guardian relationship is solely guardian-reported and is not a direct measure of how the cat experiences the relationship. A recent study by Finka *et al.* (2022) found that cats preferred humans who interacted only when the cat showed interest in interacting and that people who self-reported as having a long history of experience with cats were more likely to force interaction, hold cats against their will and touch places that cats do not typically like to be touched (Finka *et al.* 2022). Direct observational measures of cat experiences of cat-guardian relationships are needed.

Play factors associated with cat quality of life and cat-guardian relationships: Indoor or outdoor housing

Exclusively indoor housing was significantly associated with both higher guardian-reported cat QOL scores and higher cat-guardian relationship scores. To our knowledge, this is the first study to compare QOL scores of indoor- and outdoor-housed cats. Some previous studies have focused on cat adaptation to confinement in cattery, shelter, or laboratory settings. However, these are limited in their ability to assess the needs and welfare of cats within a long-term, indoor-only home (Ottway & Hawkins 2003; Kry & Casey 2007; Stella *et al.* 2014; Rehnberg *et al.* 2015; Foreman-Worsley & Farnworth 2019). It has been suggested that outdoor cats may benefit from higher quality of life generally than indoors cats due to their ability to find their own amusement, express their natural behaviours, and choose whether to be inside or out (Rochlitz 2005). For some, this potential for a higher quality of life outweighs the increased risks of outdoor access, such as infectious disease, road accidents, trauma, and risk to native wildlife (Yeates & Yates 2017). While for others, the inherent dangers of the outdoors and their potential to limit the length of their cat's life outweigh any small difference in potential quality of life (Rochlitz 2005). However, contrary to the suggestion that outdoor cats may have a higher quality of life, the results of the current study showed that cats housed exclusively indoors recorded higher QOL scores than cats with outdoor access. While this is not a definitive result regarding the difference in QOL scores between indoor and outdoor cats, there are several reasons this result may have been observed in our study. Firstly, cat-guardian relationships are central to domestic cat welfare. Cats rely heavily on their guardian to care for their nutrition, shelter and both their physical and mental health. A good relationship with their guardian, therefore, is likely to increase their QOL score. Our results found a significant association with cat-guardian relationship scores and whether the cat was housed exclusively indoors or allowed outdoor access, with indoor cat guardians reporting higher cat-guardian relationship scores. Secondly, guardians who house their cats indoors are better able to observe their cat's day-to-day health. Any changes in behaviour, mobility, or important health markers, such as urination and defaecation regularity and consistency, are more likely to be noticed by a guardian who is observing their cat more often. Conversely, cats with outdoor access may be harder to observe and may eliminate in outdoor areas where their excrement cannot be examined for changes. If indoor-cat guardians are more able to observe changes in their cat's health, they are better placed to make any environmental changes needed, or seek veterinary attention, resulting in increased cat QOL scores. Finally, guardians who keep their cats indoors may have more opportunities to participate in enriching interactions such as play. A previous study by Pyari *et al.* (2021) reported that indoor cats showed stronger interest in play stimuli than outdoor cats. It is possible then, that indoor cat play preferences and needs may differ from outdoor cats. Pyari *et al.* (2021) discussed that this difference may be due to an absence of the ability to express hunting behaviour in indoor cats, leading to what they describe as an increase in predatory play behaviour to compensate. However, predatory play as a term and as a behaviour is not yet fully understood and may in fact be a misnomer. A previous study by Pellis *et al.* (1988) analysed 'predatory play' movements or playful movements during predation and found that these movement patterns were adaptive movements that functioned to protect the cat from injury during predation and in essence were not playful at all (Pellis *et al.* 1988). The trope of cats being 'psychopathic' playful hunters (Evans *et al.* 2021) is a potentially dangerous one for cat welfare, considering the current attitudes to cats and their frequent use as a scapegoat for the more major pressures imposed by people on biodiversity and climate (Palmer 2014; Wald & Peterson 2020). It is important that we acknowledge the play needs of cats and that these needs may differ depending on that cat's background and housing, while not anthropomorphising and casting moral judgments that do not apply to non-human animals and may not be an accurate assessment of their behaviour anyway, as observed here by Pellis *et al.* (1988).

While there are strong arguments for both camps of thought as to whether cats should be housed indoors or out, it is generally agreed that indoor cats require environmental enrichments to support their welfare in an indoor only home (Foreman-Worsley & Farnworth 2019). It is also possible that guardians who are more closely bonded with their cat and therefore may be more worried for their cat's safety may choose to house their cats indoors (Crowley *et al.* 2019, 2020; Foreman-Worsley *et al.* 2021) (as indicated here by the higher cat-guardian relationship scores), and that they may also be more willing to fulfill the play and enrichment needs of their cat. This, in turn, may have resulted in the higher cat QOL scores observed within this study. Further, it may not be that indoor or outdoor housing is strictly better for cats, but instead, how their guardians perceive, monitor, and treat them that has more of an impact.

Behaviour changes during lowered play times

Guardians reported noticing certain behaviour changes when they had not played with their cat for some time. While many guardians reported their cat exhibiting an increase in attention-seeking behaviours, several reported that their cat became more reclusive when play had been withheld. This showcases an interesting dichotomy of reactions to lack of play, with both an increase and decrease in cat engagement with guardian observed depending on the individual cat. This may be due to individual differences between cats and/or their guardians, familial dynamics within the household, the specific environment, or the housing situation of the cat (indoor or

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outdoor). Unfortunately, no clear pattens of differences were able to be deduced between behaviour changes in indoor versus outdoor cats within this study, however it is likely that this may impact behaviours and future studies could investigate this further. For many of the welfare measures we have investigated previously, the emphasis has been on whether play is indicative of welfare (Henning *et al.* 2022a). Observations of behaviour change when play is withheld may also offer us an insight into whether play is a promotor of welfare. Often it is difficult to separate the two concepts from each other, not knowing if more play means more welfare or if greater welfare means more play, or both. Within this study, guardians reported that when play is withheld, observable behaviour changes occur that may indicate a decrease in welfare or well-being. Increased attention-seeking behaviour, especially vocalisations and destructive behaviour, may indicate that the cat is experiencing frustration, a negative affective state that may impact the cat's well-being. Increased reclusive behaviour may also be detrimental to cat welfare. Cats in human homes must share their space with the humans of the household, who utilise most of the space in a house. A cat who becomes reclusive is limited in what areas of the house they feel comfortable accessing and this may limit their physical activity as well as their access to important resources such as food, water, and litter (Carlstead *et al.* 1993). Reclusive behaviour may also indicate that there has been a deterioration in the social relationship between cat and guardian. Within cat social groups, signs of affiliation include spending time around and interacting positively with another cat while avoidance of spaces where another cat is and aversion to interacting may indicate that the cats are not affiliated (Vitale 2022). Put in terms of cat and guardian, if a cat is avoiding spaces where their guardian is and is not interacting as usual, it may indicate that the cat is uncomfortable. Humans within relationships are often acutely attuned to the behaviour of those close to them, and how this behaviour may affect or be indicative of the health of their relationship. It is possible that cats are similarly aware of their guardian's behaviour towards them and what this may indicate about their safety within the relationship. Recent research shows that cats regularly keep a mental tab on where their guardian is within the house (Takagi *et al.* 2021). It is entirely possible that cats are also aware of what constitutes their guardian's regular behaviour and therefore notice any changes to this behaviour. Previous studies have shown that cats are highly sensitive to changes in routine (Stella *et al.* 2011). It is possible that changes the cat perceives in their regular interactions with their guardians may similarly make them uncomfortable. Many of the behaviour changes listed, such as destructive or aggressive behaviour, may also constitute a problem or annoyance for the guardian which may impact their perception of their relationship with their cat. As cat welfare within human homes relies so heavily on human perceptions, this may also constitute an impact to cat welfare.

Limitations and future research

This study has several potential limitations. Since it is not a direct measure, guardian-reported surveys are inherently limited in their ability to accurately capture their animals' behavioural data. Further, due to the self-reporting nature of surveys, an individual's responses may be prone to respondent and recall bias and limited in their ability to predict or assess behaviour (Schwarz & Oyserman 2001; Paulhus & Vazire 2007; Kormos & Gifford 2014). In addition, the survey population sampled may also be biased. Participants were recruited during a global pandemic and overwhelmingly identified themselves as female; the survey also took approximately 20–30 min to complete, and guardians prepared to volunteer for a survey of this length may be more invested in their cat's care than the average cat guardian. Therefore, survey responses may not be an accurate representation of the general population. Due to some overlap between the validated scales and questions such as frequency of stress and other problem behaviours, findings between the two may be limited in their ability for meaningful comparison. Finally, as this was a cross-sectional study it does not prove a causal link between factors that were associated.

Future studies should further investigate the role of play in cat welfare with special attention paid to indoor and outdoor requirements, the mechanisms of how play impacts cat-guardian relationships, communication, socialisation, and play preferences in both cats and guardians.

Animal welfare implications and conclusion

Play has potential to be used as both an indicator and promotor of cat welfare. The present study aimed to assess the play factors associated with welfare in cats. Within this study, multiple welfare-impacting measures were used, including cat QOL score, the quality of the relationship between cat and guardian, the prevalence of problem behaviours and observations of behavioural changes. Results showed significant associations between cat playfulness and the number of games played with cat QOL scores. Cat-guardian relationship scores were significantly associated with the amount of daily play and number of games engaged in, whether the cat and guardian both initiated play sessions and guardian playfulness. Problem behaviours that clustered on a PCA into a stress component were significantly associated with QOL scores, but no other problem behaviours were found to have significant associations with play or welfare measures. Behavioural changes that indicated stress, frustration, or unease were reported when play had been withheld. This study shows support for the association between play and welfare and provides several avenues for further research. Future investigations should focus on the role of play in assessments of cat welfare, the use of play as an intervention to promote welfare, and the mechanisms of how play impacts cat welfare and cat-guardian relationships.

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Consent

CONSENT FORM

1. I agree to take part in the following research project:
Title: The impact of play on behavior and welfare in cats
Ethics Approval Number: H-2021-091

2. I have had the project, so far as it affects me, and the potential risks and burdens fully explained to my satisfaction by the research worker. I have had the opportunity to ask any questions I may have about the project and my participation. My consent is given freely.

3. Although I understand the purpose of the research project, it has also been explained that my involvement may not be of any benefit to me.

4. I agree to participate in the activities outlined in the participant information sheet.

5. I understand that as my participation is anonymous, I can withdraw any time up until submission of the survey

6. I have been informed that the information gained in the project may be published in a book, journal article,

thesis, news article, conference presentations, website and/or report etc.

7.

I have been informed that in the published materials I will not be identified and my personal results will not be divulged.

8. I agree to my information being used for future research purposes as follows:
Research undertaken by these same researcher(s) or in research undertaken by any researcher(s)

9. I hereby provide 'unspecified' consent for the use of my data or tissue in any future research:

10. I understand my information will only be disclosed according to the consent provided, except where disclosure is required by law.

11. I am aware that I should keep a copy of this Consent Form, when completed, and the attached Information Sheet.

If I want to participate what do I do?

Submission of your survey responses is considered as your consent to participate in the survey and that you have read and understood the above information.

If you wish to speak with an independent person regarding concerns or a complaint, the University's policy on research involving human participants, or your rights as a participant, please contact the Human Research Ethics Committee's Secretariat on:
Phone: +61 8 8313 6028
Email: hrec@adelaide.edu.au
Post: Level 4, Rundle Mall Plaza, 50 Rundle Mall, ADELAIDE SA 5000
Any complaint or concern will be treated in confidence and fully investigated. You will be informed of the outcome.

If you would like to keep a copy of this research project information sheet and consent form, please email the researchers Dr. Susan Hazel (susan.hazel@adelaide.edu.au) or Ms. Julia Henning (julia.henning@adelaide.edu.au).

I have read the above information sheet and agree to take part in the research project: The impact of play on behavior and welfare in cats
(HREC approval # H-2021-091).

○ Yes

Country

In which country do you currently reside?

What is your gender?

- ○ Non-binary
- ○ Female
- ○ Male
- ○ Prefer not to say
- ○ [ ] Prefer to self-describe (below):

What is your age group?

- ○ 18-24
- ○ 25-34
- ○ 35-44
- ○ 45-54
- ○ 55-64
- ○ 65+

How many people live in your home?

- ○ Only me
- ○ 2
- ○ 3
- ○ 4 or more

Of these how many are under 18?

- ○ None
- ○ 1
- ○ 2
- ○ 3
- ○ 4 or more

Please select your relationship status

- ○ Single
- ○ Single with child(ren)
- ○ Partnered
- ○ Partnered with child(ren)
- ○ Prefer not to say

How many cats live in your home?

- ○ 1
- ○ 2
- ○ 3
- ○ 4 or more

Are you the primary caregiver for at least one cat in your home?

- ○ Yes
- ○ No

What is the name of your cat? **Note:** if you have more than one cat, please select the cat that you spend the most amount of time with and answer all questions as if they were about this cat in particular.

What is your cat's breed?

What is your cat's sex?

- ○ Intact Female
- ○ Intact Male
- ○ Spayed Female
- ○ Neutered Male

How old is your cat?

Cat age in years:

How long have you lived with this cat?

Years:

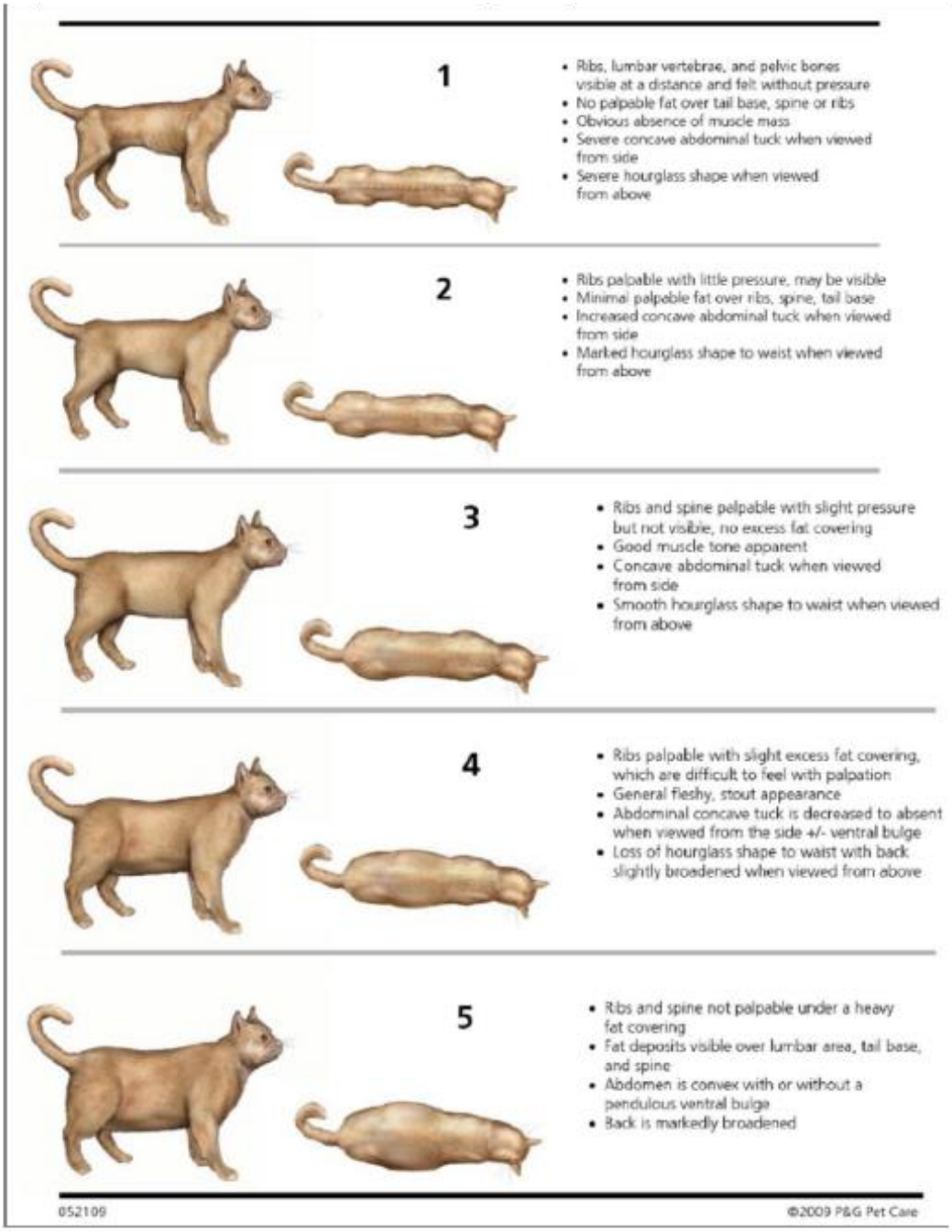
Does your cat have any ongoing health issues?

- ○ Yes
- ○ No

If yes, Do you believe these health issues affect your cat's activity levels?

- ○ N/A
- ○ Definitely yes
- ○ Probably yes
- ○ Might or might not
- ○ Probably not
- ○ Definitely not

Body condition scoring chart


1
• Ribs, lumbar vertebrae, and pelvic bones visible at a distance and felt without pressure
• No palpable fat over tail base, spine or ribs
• Obvious absence of muscle mass
• Severe concave abdominal tuck when viewed from side
• Severe hourglass shape when viewed from above
2
• Ribs palpable with little pressure, may be visible
• Minimal palpable fat over ribs, spine, tail base
• Increased concave abdominal tuck when viewed from side
• Marked hourglass shape to waist when viewed from above
3
• Ribs and spine palpable with slight pressure but not visible, no excess fat covering
• Good muscle tone apparent
• Concave abdominal tuck when viewed from side
• Smooth hourglass shape to waist when viewed from above
4
• Ribs palpable with slight excess fat covering, which are difficult to feel with palpation
• General fleshy, stout appearance
• Abdominal concave tuck is decreased to absent when viewed from the side +/- ventral bulge
• Loss of hourglass shape to waist with back slightly broadened when viewed from above
5
• Ribs and spine not palpable under a heavy fat covering
• Fat deposits visible over lumbar area, tail base, and spine
• Abdomen is convex with or without a pendulous ventral bulge
• Back is markedly broadened
052109
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Looking at the body condition score chart above, please select which number best represents your cat:

- ○ 1
- ○ 2
- ○ 3
- ○ 4
- ○ 5

How many days a week is your cat left alone (without a human) for longer than two hours?

- ○ 0
- ○ 1
- ○ 2
- ○ 3
- ○ 4
- ○ 5
- ○ 6
- ○ 7

How many hours is your cat alone (without a human) each week **total**?

- ○ Less than 10
- ○ 11-15

- ○ 16-20
- ○ 21-25
- ○ 26-30
- ○ 31-35
- ○ 36-40
- ○ More than 40 hours

Which of these options best describes your cat?

- ○ Not at all playful, does not play
- ○ Not very playful, only plays occasionally
- ○ Neither playful nor not playful
- ○ Playful, often wants to play
- ○ Very playful, always wants to play

Is your cat:

- ○ Always Indoors (this includes if they have access to a fully enclosed cat run)
- ○ Mostly Indoors
- ○ Indoors/Outdoors
- ○ Mostly Outdoors
- ○ Always Outdoors

Block 2

When do you like to play with your cat? Please select **all** that apply.

- [ ] Weekends
- [ ] Mornings
- [ ] Afternoons
- [ ] Before or after work
- [ ] Before bed
- [ ] On my lunch break
- [ ] Whenever, I'm always available to play
- [ ] Other, please specify: _____

Please indicate the length of a typical play session with your cat.

Hours _____

Minutes _____

What is the maximum amount of time you spend playing with your cat per day?

Hours

Minutes

Do other people play with your cat?

- Yes
- No

On average how much time per day to they play with your cat?

Hours

Minutes

When I am playing with my cat I feel:
(0 being not at all and 100 being completely)



What sort of games do you and your cat like to play together? Please select all that apply.

- [ ] Playing with wand toys
- [ ] Playing with motorised toys

- [ ] Playing with just our hands and cat paws
- [ ] Playing with boxes together
- [ ] Playing with noisy toys
- [ ] Playing with laser pointers
- [ ] Playing with games on digital devices e.g. ipad
- [ ] Playing chasing games
- [ ] Playing games that involve food
- [ ] Playing training games such as agility or learning tricks
- [ ] Other, please specify:

Generally, who initiates the play session?

- ○ Me- I usually initiate play
- ○ My cat - my cat usually initiates play
- ○ Both – We both take turns initiating play
- ○ Another person from the household usually initiates play
- ○ Another cat from the household usually initiates play
- ○ Another animal from the household usually initiates play, please specify this animal's species:

Generally, who ends the play session?

- ○ Me - I usually end the play session
- ○ My cat - My cat usually ends the play session
- ○ Both - we both take turns ending the play session

- ○ Another person from the household usually ends the play session
- ○ Another cat from the household usually ends the play session
- ○ Another animal from the household usually ends the play session, please specify this animal's species:

  [ ]

Which do you prefer your cat to play with?

- ○ You
- ○ Another person in the household
- ○ A toy
- ○ Another animal in the household
- ○ No preference

Do you ever avoid playing with your cat? If yes, what has led you to avoid playing with your cat?

- ○ [ ] Yes, please explain
- ○ No

Do you ever experience injury from playing with your cat?

- ○ No
- ○ Yes, minor injuries such as light scratches

- ○ Yes, I have experienced injury such as significant scratches or bites
- ○ Yes, I have experienced major injury. Please describe: [ ]

On days when you are home, how much time do you observe your cat to spend playing with a toy or object on their own during the day?

Hours [ ]

Minutes [ ]

If you have more than one cat, do they play together?

- ○ No- They do not play together
- ○ Yes, they play together with me
- ○ Yes, they play together without me
- ○ Yes – They play together with and without me
- ○ I do not have more than one cat

1. Does your cats behaviour change if you haven't played with them for a while?

- ○ No

○ Yes, please describe:

Does your cat exhibit any of the following?

	Never	Seldom	Sometimes	Often	Most of the time	N/A
Aggression towards household members	○	○	○	○	○	○
Aggression towards unfamiliar people	○	○	○	○	○	○
Aggression towards other cats that live in the home	○	○	○	○	○	○
Aggression towards other animals that live in the home	○	○	○	○	○	○
Aggression towards unknown cats	○	○	○	○	○	○
Aggression towards unknown animals	○	○	○	○	○	○
Play Aggression	○	○	○	○	○	○
Urinating outside the litter box	○	○	○	○	○	○
Defecating outside the litter box	○	○	○	○	○	○
Urinating or defecating on furniture	○	○	○	○	○	○
Spraying behaviour	○	○	○	○	○	○
Sucking on material e.g. wool	○	○	○	○	○	○

	Never	Seldom	Sometimes	Often	Most of the time	N/A
Over-grooming	○	○	○	○	○	○
Pica (eating non-edible materials e.g., plastic, clay)	○	○	○	○	○	○
Anxiety	○	○	○	○	○	○
Scratching furniture and/or wall/ curtains	○	○	○	○	○	○
Overly active at night when people are trying to sleep	○	○	○	○	○	○
Yowling (or excessive vocalisations/noise making)	○	○	○	○	○	○

What of the following is available to your cat? Please select all that apply:

- ☐ Scratching post(s)
- ☐ Cat bed(s)
- ☐ Hiding place(s)
- ☐ Water fountain(s)
- ☐ Wand toys
- ☐ Food puzzles
- ☐ Food Treats
- ☐ Motorised toys
- ☐ Self-cleaning litter tray
- ☐ Feliway spray or diffuser

- [ ] Wall or window perch
- [ ] Automatic feeder
- [ ] Outdoor enclosed cat-run or catio
- [ ] Walks outside on a harness
- [ ] Cat grass or other cat specific plant
- [ ] Other, please specify: _____

For the next set of questions, please read the following definitions of terms:

Social Play: A cat playing together with a person, another cat or another animal. For example – you and your cat playing together with a toy or your cats play fighting

Object/Solo Play: A cat playing by itself with a toy or object. For example – your cat playing **alone** with a ball of scrunched up paper or a toy

Locomotor Play: A cat playing by simply moving its body. For example – your cat running around the house or jumping around.

With these definitions in mind, please answer the following questions:

Which of these definitions fits the type of play your cat **most often** engages in?

- ○ Social Play
- ○ Object/Solo play
- ○ Locomotor play
- ○ My cat does not play

Over an average day what is the percentage of play time your cat spends in each of these play types? Please make sure answers total 100%

Social Play	0
Object/Solo play	0
Locomotor play	0
Total	0

How often does your cat engage in social play?

- ○ Multiple times a day
- ○ Once a day
- ○ Once every few days
- ○ Once a week

- ○ Once a month
- ○ Less than once a month

How often does your cat engage in object/solo play?

- ○ Multiple times a day
- ○ Once a day
- ○ Once every few days
- ○ Once a week
- ○ Once a month
- ○ Less than once a month

How often does your cat engage in locomotor play?

- ○ Multiple times a day
- ○ Once a day
- ○ Once every few days
- ○ Once a week
- ○ Once a month
- ○ Less than once a month

Is there anything else you would like to tell us about your cat, how you play together or how they play?

Cat Owner Relationship Scale:

Howell, TJ, Bowen, J, Fatjó, J, Calvo, P, Holloway, A and Bennett, PC 2017 Development of the cat-owner relationship scale (CORS). Behavioural Processes, 141, 305–315. https://doi.org/10.1016/j.beproc.2017.02.024

Cat Quality of Life Measure:

Tatlock, S, Gober, M, Williamson, N and Arbuckle, R 2017 Development and preliminary psychometric evaluation of an owner-completed measure of feline quality of life. The Veterinary Journal, 228, 22–32. https://doi.org/10.1016/j.tvjl.2017.10.005

Adult Playfulness Trait Scale:

Shen, XS, Chick, G and Zinn, H 2014 Validating the Adult Playfulness Trait Scale (APTS): An examination of personality, behavior, attitude, and perception in the nomological network of playfulness. American Journal of Play, 6(3), 345–369.

Chapter 6: Do You Speak Cat? Assessing the Impact of a Training Video on Human Recognition of Cat Emotions and Behaviours During Play Interactions.

Context Statement

Chapter 6 further investigates Aims 1 and 2 and follows on from previous Chapter findings which consistently documented two themes:

The potential importance of communication for optimal play and better human-cat relationships: In Chapter 3, guardians reported using various behavioural and vocal cues to assess their cats' desire to play. In Chapter 4 mutual initiation of play (potentially indicating successful communication between the dyad) was associated with longer play times, and, in Chapter 5, mutual play initiation was significantly associated with higher cat-guardian relationship scores.

Concern about injury/cat aggression during play: Chapter 3 reported that guardians experienced negative emotions including fear and concerns about being injured or provoking cat aggression during play, while Chapter 4 demonstrated that over one-third of guardians avoided play due to fear of injury and, in Chapter 5, 40.2% of participants reported play aggression as a problem behaviour.

However, previous Chapters relied on participant report and, therefore, the accuracy of participant claims was not assessed. Further, participant concerns over cat-related play injuries, as well as the potential impact of these concerns on play availability and the human-cat bond, warranted further investigation into potential strategies for minimising injury risk. Chapter 6 addresses these gaps by empirically testing human accuracy in recognising cat behavioural cues during play interactions and evaluating the effectiveness of a brief educational training video through a randomised controlled trial design. Additionally, Chapter 6 assesses if, and how, participant interaction choices differed based on their recognition of cat valence (positive or negative).

Results demonstrated that almost 25% of cats displaying overt negative states were misclassified and, concerningly, participants performed at levels approximating chance when identifying subtle negative behaviours that serve as early warning signals for potential aggression. These findings support earlier findings in this thesis of guardian fears around

injury and cat aggression. Further, the results of this Chapter indicate that play aggression reported in Chapter 5 may be partially explained by limited guardian ability to recognise when cats do not wish to engage in play. Of further concern, this Chapter highlights a disconnect between recognition of a cat's negative state and making appropriate response choices, with 19.4% of participants indicating they would engage in high-risk interactions, even after correctly identifying a cat in an overtly negative state (this number rises to 44% for cats in a subtle negative state). The findings suggest that injury prevention requires education on appropriate interaction choices, not just recognition of behavioural cues or cat emotional valence. The educational intervention utilised in this study demonstrated mixed results, producing small improvements in accuracy overall, while paradoxically reducing participant ability to detect subtle negative behaviours.

This Chapter provides important contributions to our comprehension of the welfare risks within human-cat play for both human and cat. Additionally, this Chapter highlights the importance of effective human-cat communication for mitigating these risks, specifically the critical need for humans to be able to recognise and, more importantly, respond appropriately to cat communications during play interactions. In particular, the inappropriate response choices identified within this Chapter, despite correct recognition of cat state, reveal a critical need to further investigate the potential factors influencing or maintaining these choices, and to find effective strategies beyond cat behaviour education for reducing cat stress and minimising human injury risk during human-cat play interactions.

Statement of Authorship

Statement of Authorship

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Contribution to the Paper	Conceptualisation, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Writing –original draft, Writing – review and editing
Overall percentage (%)	70%
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.
Signature	Date 25/09/25

Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate in include the publication in the thesis; and

iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

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Do you speak cat? Assessing the impact of a training video on human recognition of cat emotions and behaviours during play interactions

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Human-cat interactions require accurate interpretation of cat behavioural cues to ensure welfare and safety for both species. Misinterpretation of cat communications during play can lead to unwanted interactions that prolong stress for cats and increase the risk of human injury. A survey investigated factors associated with human ability to recognize cat emotional valence during human-cat 'play' interactions and a randomized controlled trial assessed the effectiveness of an educational training video. Participants were randomized to receive either a training video on cat play cues or a control video. A total of 368 adult participants within Australia categorized cat behaviours in videos of human-cat interactions as positive or negative. Novel use of a hierarchical summary receiver operating characteristic (HSROC) framework was used to assess participant accuracy. Results showed that participants were generally accurate when recognizing overt cat behaviours but performed at levels approximating chance when recognizing subtle negative cues. Previous vocational cat experience was associated with higher accuracy in negative interactions. Training had a small but significant positive impact on overall performance but paradoxically significantly decreased subtle negative behaviour recognition. On average, one in four cats in an overtly negative state were misclassified by participants. Even when valence was correctly recognized, a concerning proportion of participants still selected that they would engage in high-risk interactions with a cat in a negative state. Brief educational interventions may be insufficient or counterproductive for teaching subtle cue recognition in cats, highlighting a need for more comprehensive training approaches that prioritize early stress signals and appropriate response strategies. When promoting human-cat play interactions, care should be taken to ensure guardians are able to recognize when their cat does not wish to play and understand how to correctly respond to cats in a negative state.

KEYWORDS

human-animal interaction, cat behaviour, emotion recognition, educational intervention, animal welfare, HSROC analysis, bite prevention

Introduction

Humans and cats have a long, shared history that has become increasingly close and complex over the past several decades due to a progressive shift in sentiment towards cats as close companions and family members (Fox and Gee, 2016; McConnell et al., 2017). This shift has coincided with an increase in cats being kept indoors due to environmental and safety concerns (Foreman-Worsley et al., 2021) and a growing commercialised companion animal industry that both drives and reflects consumer conceptualisations of the human-cat bond (Hill et al., 2008; Vänskä, 2016; Apaolaza et al., 2022). Often this conceptualisation of cats is heavily anthropomorphised, re-framing cats as pseudo-babies, best friends or family members (Bouma et al., 2024). While these conceptual shifts may offer improvements to welfare by fostering empathy for cats in a way that promotes greater awareness of needs, proactive health care and even stronger legal protections (Henning et al., 2023), they may also be a double-edged sword, engendering unrealistic ideas of cats as companions that will fit easily into our homes and behave according to our expectations (Bradshaw and Casey, 2007; Bouma et al., 2024). This becomes problematic when faced with the reality that, while there is some evidence proximity to humans has influenced cat evolution (Hattori et al., 2022); the process of domestication for cats is not truly complete (Driscoll et al., 2009; Turner and Bateson, 2014), with cats retaining many of their wild instincts, behavioural repertoires and needs. Cats may have adapted to be tolerant of, and even enjoy the company, of people, but their needs and preferences for housing, interaction, touch and communication are inherently different to those of their human companions.

Misconceptions of cat needs and behaviours have previously been associated with negative welfare outcomes such as insufficient provisioning of necessities (litter trays, food and water), lack of environmental and interactive enrichment, the use of punishment (e.g., hitting, spraying with water) and forced interactions (Grigg and Kogan, 2019; Croney et al., 2023; Udell et al., 2023). The disparity between our expectations of cats as companions and their fundamental requirements may therefore become an issue for cat welfare and a pressure point in the human-cat relationship, particularly in interactive contexts such as play (Ellis et al., 2013; Henning et al., 2022). While misconceptions can affect all aspects of cat care, play interactions present unique challenges. Social play is a highly cooperative interaction, requiring mutual awareness of each other's communications—signals that, in different contexts, could be interpreted as aggressive or threatening. In ideal situations, repetition of such a collaborative interaction may help refine and improve communication within a human-cat dyad (Mitchell, 2015). However, the high communicative demands of social play also mean that misinterpretation can lead to prolonged, unwanted interactions that negatively impact cat welfare and result in human injury. For instance, humans often show a tendency to view the world, and the animals close to us, through a human-centric lens which tends towards anthropomorphism (Mota-Rojas et al., 2021). This can lead to a belief that cat behaviours stem from classically human defined emotions and motivations (Foster et al., 2011), many of which are unlikely to be present in cats, such as spite, guilt or hate (Bradshaw, 2012, 2018). During play interactions, this anthropomorphic lens may cause guardians to misinterpret a cat's behavioural cues: for example, viewing a cat that inflicts injuries during play as being inherently vicious or seeking retribution for a previous offence (e.g., the guardian leaving them to go away for a holiday), rather than recognizing these behaviours as communications of discomfort or a desire to end the interaction.

Miscommunication in human-cat interactions has the potential to result in injury for the human and distress for the cat. Cat bites are responsible for three-quarters of all mammalian bites that result in infection (Dimcic et al., 2020) and can lead to serious health outcomes, including long-term disability and, rarely, death (Oehler et al., 2009; Kheiran et al., 2019). Potential complications commonly include necrosis, deep abscesses, osteomyelitis, septicemia, sepsis, septic arthritis, endocarditis and meningitis (Love et al., 2000; Oehler et al., 2009; Savu et al., 2021). Cat scratches can also cause severe injury such as corneal lacerations (Chang et al., 2012) and transmit serious zoonotic diseases such as rabies (Fehlner-Gardiner et al., 2024; Meriño-Olivella et al., 2024), and cat scratch disease (bartonellosis), which can cause chronic lymphadenopathy, and has recently been linked to the development of mental illnesses such as depression and schizophrenia (Lamps and Scott, 2004; Flegr and Hodný, 2016; Akhtar et al., 2024). Moreover, cat-related injuries result in substantial financial burden to both individuals and government healthcare systems (Griego et al., 1995; Forrester et al., 2018; Campagna et al., 2023).

For cats, unwanted interactions can cause prolonged stress which may result in health issues such as feline idiopathic cystitis (Sparkes, 2018) and 'problem' behaviours such as increased aggression (Salman et al., 1998; Heath, 2007; Amat et al., 2009). These changes can impact the human-cat bond and may increase the risk of negative welfare outcomes such as surrender and euthanasia (Houpt et al., 1996; Salman et al., 1998; Heath, 2007; Rochlitz, 2007). Considering the serious potential outcomes to both human and cat, efforts to minimize risks during human-cat interactions are needed. One area for potential risk mitigation is during play interactions. Previous studies have found that guardians report avoiding play due to concerns about being injured (Henning et al., 2022) and the majority of cat-inflicted injuries are from the victim's own cat (Palacio et al., 2007; Chen et al., 2016). Research also indicates that the foremost causes of cat aggression towards people are play-related, and petting-related, aggression (Amat et al., 2009). These two types of aggression may overlap, with a previous study demonstrating that guardians often consider petting to be a type of play (Henning et al., 2025). Most reported cat bites are the result of cat defensive responses to human provocation or mishandling (Dire, 1991; Patrick and O'Rourke, 1998; Palacio et al., 2007) with one study finding that aggression towards humans functioned to enable escape from petting (Fritz et al., 2022). These findings indicate that guardian education around handling and interacting with their own cats may be critical for minimization of human injuries and cat distress.

Previous studies have looked at human recognition of cat communication based on photos (Bouma et al., 2024), videos of cat facial expressions (Dawson et al., 2019), videos of the entire cat

(Graham et al., 2024; Khoddami et al., 2024) vocalisations (Schötz and van de Weijer, 2014; Ellis et al., 2015; Prato-Previde et al., 2020), and both unimodal and multimodal media (de Mouzon et al., 2024). Two studies have tested an educational intervention on human ability to understand cat cues (Haywood et al., 2021; Graham et al., 2024). Graham et al. (2024) tested the impact of an online training video on human recognition of different levels of fear in kittens, finding that a five-minute video, focused on full body behaviours (avoidance, freezing, and piloerection) as well as localized behaviours (ear, tail, and abdomen positions), significantly improved participant odds of correctly rating different levels of kitten fear compared to a control. Haywood et al. (2021) assessed the efficacy of providing participants with best practice cat interaction guidelines on their subsequent choices when interacting with cats in a shelter setting. These guidelines utilized the acronym "CAT" and focused on "C": providing the cat with choice and control "A": paying attention to cat cues and "T": limiting touch. Results showed that people in the treatment group made choices more aligned to the guidelines (CAT), and that cats in the study responded more favourably to these participants compared to those in a control group (Haywood et al., 2021). To our knowledge, no previous studies have looked at human recognition of cat play cues or perception of cat emotions within human-cat 'play' interactions or assessed how humans choose to interact with cats exhibiting a negative state.

The aims of the present study were to use videos of human-cat 'play' interactions to 1) investigate factors associated with participant ability to categorise the overall valence of a cat, i.e. overall positive or overall negative, 2) assess the impact of a training video focusing on cat play cues on participant categorisation performance 3) describe participant choices for interaction with a cat based on cat valence and 4) investigate participant perceptions of cat emotions.

Methods

Ethics statement

The protocol for this study was conducted with approval from the Human Research Ethics Committee at the University of Adelaide, approval code: H-2025-072.

Participants were recruited through passive snowballing from posts on the Facebook and Instagram pages of the research team's laboratory (Animal Behavior, Welfare and Anthrozoology Laboratory). Inclusion criteria required participants to be 18 years of age or older at the time of the survey, to currently reside in Australia and to have internet access. Participation was voluntary and participants could leave the study at any time. Informed consent included notifying participants of survey length, investigator name, study purpose, and details of data storage including what data would be kept and for how long. Anonymous survey links were used, and no identifying information was collected or stored.

Expert panel reference classification of human-cat interaction videos

Videos of human-cat interactions were sourced online through YouTube using purposive sampling by JH. For selection, videos required a creative commons licence and were shortened (where necessary) to be less than 15 seconds long.

A panel of five experts in feline behaviour, including behaviour-member veterinarians and researchers, were used as a reference standard for this evaluation. They categorised 25 selected videos into distinct behavioural states of positive or negative valence based on cat behaviour. Videos with at least 80% consensus on category (positive or negative) were ultimately classified accordingly and considered for use within the general public component of this work. Of the videos used in the resulting general public survey, 15 received 100% agreement while one received 80% agreement. The panel also responded to free text questions asking them to identify the cat emotions within each video. From the panel's free text responses, the most common answers were taken and compiled into a list that was then used as the emotion options given to participants in the public study. In addition, the panel listed the body language or behavioural indicators used to make their categorizations and reported how they would interact with a cat in two selective videos of each of the behavioural valences. Finally, they suggested changes to the survey and educational video to be presented to participants.

To better understand the drivers of participant variability, the 16 videos selected for use were then further categorised as overt videos or subtle videos by the research team, before participant recruitment. Overt videos were defined as: videos with immediately visible and unmistakable behaviours (e.g., spitting, piloerection, trembling, pre-pounce wiggle, playing with a toy) pronounced movements (e.g., pouncing, running), and/or clear, recognisable vocalisations audible in the video (e.g., growling, hissing, play trill or meow). Subtle videos were defined as: videos with small-scale movements that may require closer observation to detect (e.g., whisker movements, changes in facial expression), gradual or slight shifts in body posture or tension (e.g., stiffening), and quiet, ambiguous or absent vocalisations.

Participant categorisation of human-cat interaction videos

Survey structure

The present study was executed through a survey format, hosted online through the platform, Qualtrics®. To expose participants to a broad spectrum of human-cat interactions, participants were randomized upon commencement of the survey into one of three blocks of 10 videos from the 16 videos originally classified by the expert panel. Each variation of the survey contained two videos of each subtle valence (positive and negative) and three videos of each overt valence, manually set per block to be shown either during the baseline assessment or after the treatment of a training video or control (Figure 1). The four videos shown in the baseline always

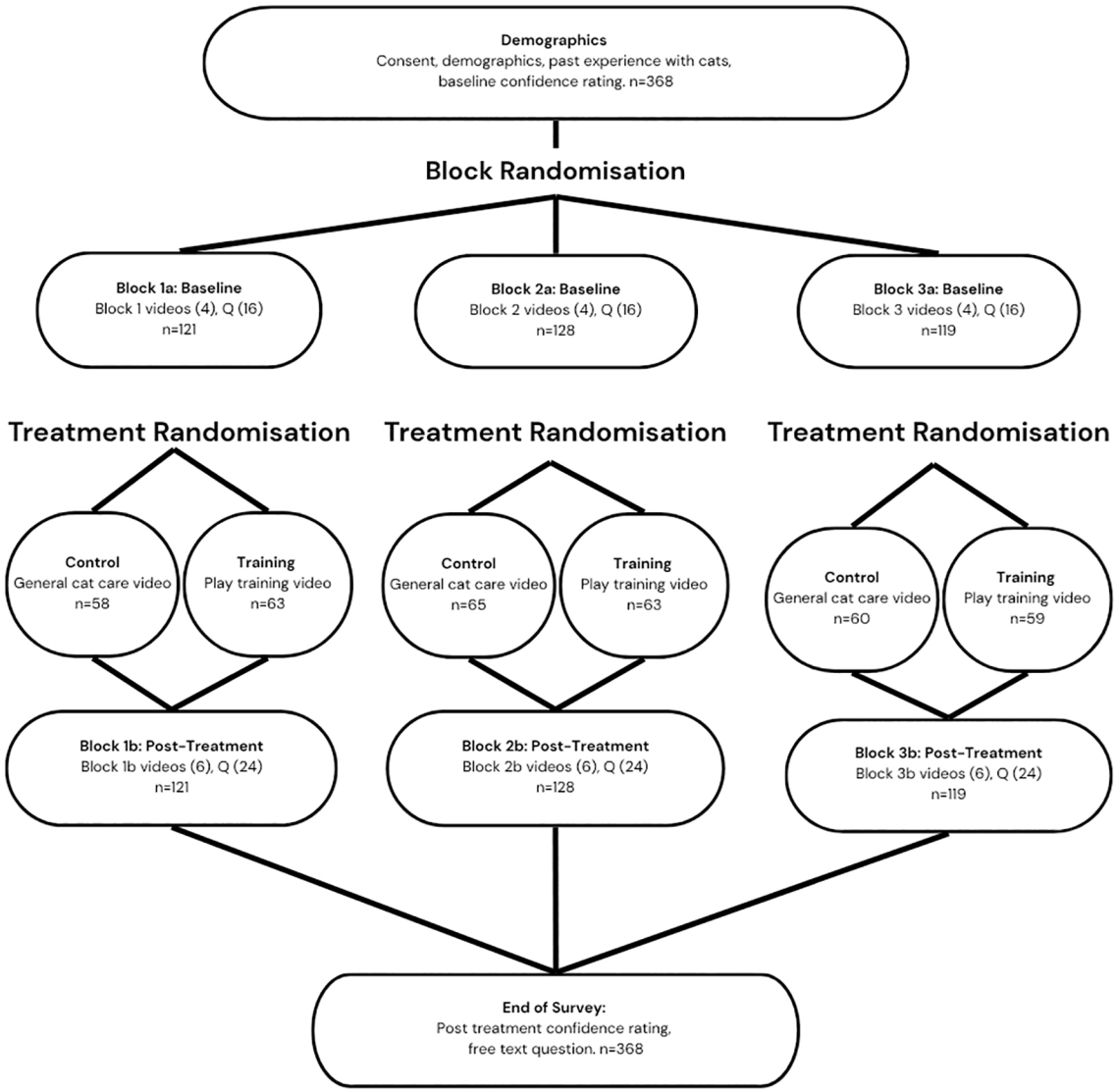


FIGURE 1
Flowchart of an Australia-wide online survey and randomized control trial that examined participant ability to recognize and respond to cat behavioural cues during human-cat 'play' interactions based on short video clips (n=368).

included one video of each valence and subtlety type, while the six post treatment videos always contained one of each subtle video type and two of each overt video type. Due to limitations in the number of videos sourced that fit each criterion, and with the intention of showing a sufficient spectrum of valences and subtlety in each block, all blocks contained the same subtly valenced videos, while some overt videos appeared in multiple blocks, and others appeared only once, with the order manually set by the research team. For a description of the 16 videos used within the study, please see the Supplementary Materials.

Baseline data collection for participant human-cat interaction classification

To answer objectives 1 and 2, after initial consent and demography questions and a baseline self-rating of confidence in understanding cat body language, each participant watched four human-cat interaction videos and was asked to categorise the interaction in the video as 'overall positive', 'overall negative' or 'I'm unsure', based on the cat's behaviour.

To answer objective 3, examining participant choices for interacting with the cat in the video, we asked participants to select the interactions they would be likely to engage in with the cat, within the context of the video they were shown, from nine options including stroking the cat, picking the cat up, rubbing the cats belly, playing with the cat using their hands, playing with the cat using a toy, disciplining/correcting the cat with an open text to specify how, staying near but not interacting with the cat, walking away from the cat or 'other' with a free text box. To assess objective 4, participant perceptions of cat emotions during human-cat interactions, we asked participants to select what emotion they perceived the cat in each video to be experiencing from a list of 10 options including happy, curious, frustrated/annoyed, angry,

relaxed, bored/uninterested, stressed, playful, scared/threatened or 'other' with a free text option. Participants were also asked to list any body language cues used when determining their answers.

Randomized controlled trial of educational video

From each block (1a–1c), participants were then randomized to either the training video or control group (see Figure 1), using the randomize functionality of Qualtrics. Participants were shown either a 2.5-minute training video: an informative video on recognising cat behavioural cues during play interactions, or a control video: a 2.5-minute video on general cat care such as litter maintenance (see Supplementary Materials). Following this, participants watched an additional six videos of human-cat interactions, were asked the same classification question for each and repeated the self-rating of confidence in understanding cat body language. Data collection was open for participation between 23rd May and 10th June 2025.

Data management

Duplicate entries from the same user were avoided using Qualtrics 'prevent multiple submissions' option which utilizes cookies to identify individual devices and re-direct users who have already completed the survey. Potential bot responses were flagged using reCAPTCHA scores and further assessed manually for unrealistic survey timings (less than five minutes) and incoherent or inconsistent text answers. Where bots were suspected, after manual checking, those responses were removed from the data. Only participants who were shown, and responded to, at least 8/10 of the categorization questions (categorizing a video as positive or negative) were included in analysis. Where response demographics were sparse, some answers were grouped for analysis. These included: 'years with cats', originally continuous, grouped to reflect participants having lived with cats or having never lived with cats and, 'past relevant vocational experience', originally answered as none, veterinarian, vet tech, vet nurse, shelter worker, shelter volunteer, cat fostering, behaviourist, animal trainer, breeder or showing cats, animal management work or other (please specify), grouped for analysis as past relevant experience or no past relevant experience. Options given for how participants would interact with a cat in a given video were grouped and categorized by their broad functions for an analysis of interaction choices based on the participants prior classification of the video as positive or negative. Interaction choices that removed the person from the interaction were categorized as withdrawing; this included the options: walking away from the interaction or staying near the cat but not interacting. All other interaction options were categorized as engaging.

Data analysis

To assess randomization, treatment allocation and demographic distribution balance was examined across blocks and treatment groups using initial descriptive assessment and statistical t-tests, chi-square or Fisher's exact tests as appropriate.

Descriptive statistics were used to describe the study population. Changes in confidence ratings between groups was analysed using a Welch t-test.

To investigate participant choices for interacting with cats based on a cat's valence as assessed by the expert panel (objective 3), to assess interaction choices given participant perception of the cat's valence as positive or negative (as assessed by the participant's answer to the preceeding classification question), and to explore how participants perceived cat emotions (objective 4), descriptive analysis was used.

To answer objective 1, instead of investigating and reporting an overall accuracy score, we elected to analyse our accuracy results using a diagnostic test evaluation framework. This involved separately considering the accuracy of participants' classifications of the positively valenced videos, synonymous with their diagnostic sensitivity (DSe), and their classification of the negatively valenced videos, synonymous with their diagnostic specificity (DSp). DSe was defined as the proportion of positively valenced videos correctly classified, and DSp as the proportion of negatively valenced videos correctly classified (Equation 1)

$$DSe_{participant} = \frac{count\ \ classified\ \ as\ \ positive\ \ by\ \ participant}{count\ \ classified\ \ as\ \ positive\ \ by\ \ panel} \quad (1)$$

and

$$DSp_{participant} = \frac{count\ \ classified\ \ as\ \ negative\ \ by\ \ participant}{count\ \ classified\ \ as\ \ negative\ \ by\ \ panel}$$

Answers of 'I'm unsure' in response to questions categorizing valence were included as an incorrect response.

We then anticipated a probable random effect of participant on their accuracy. That is, some participants may be inherently more likely to respond with a positive valence, and others more likely to respond with a negative valence, as the threshold between these two valences may be variable between participants. Therefore, to analyze the classification data, we followed an approach commonly used for meta-analyses of diagnostic test evaluation, where DSe and DSp are the measure of interest, and a random study-level effect is included. In our scenario, each participant acted as a distinct study to input data into the analysis. As suggested by Harbord et al. (2008), the bivariate/hierarchical summary receiver operating characteristic (HSROC) modelling approach was used, as it is the most rigorous available method, accounting for the correlation between the binomially structured DSe and DSp due to the participant-level threshold between valences.

We first characterized the baseline performance of the participants by calculating the pooled estimate of their DSe and DSp on all positive and negative valenced videos, respectively, confining our analysis to participant responses without or before exposure to the training video (i.e., pre-training for participants allocated to the training video, and both pre- and post-training for participants allocated to the control video, corresponding to 75% of participant responses). A correlation coefficient (rho) of < -0.5 indicated substantial threshold effect (negative correlation between DSe and DSp).

In the absence of substantial threshold effect, we then conducted multivariable meta-regression on the baseline performance to investigate the factors influencing DSe and DSp. We first investigated whether survey structure (i.e., block allocation) influenced results and included it in subsequent models only if the 95% confidence intervals of its regression coefficients (at any level) for either DSe or DSp did not overlap with zero. We then

included participant age category, past vocational experience with cats, past cat guardianship or self-rated confidence to understand the influence of participant factors on their accuracy. A covariate was classified as significant if the 95% confidence interval of the meta-regressed coefficient did not overlap with zero. Only responses for which this data was available were included in analysis i.e., if the data was missing for a participant in one covariate, they were removed from the corresponding analysis. We calculated the change to either DSe or DSp by taking the sum of the baseline/intercept coefficient and i) the coefficient of the level deemed significant (categorical variables) or ii) the coefficient of the variable (continuous variables).

We repeated this across the whole set of baseline participant responses, and then on the distinct subgroups of responses to only overt or only subtle videos, to investigate variability of accuracy between the presumed easily classified videos (overt) and more challenging to classify videos (subtle).

Finally, we compared the baseline performance of all participant responses without or before exposure to the training video (75% of responses) to the post-training performance of the participants allocated to training, by calculating the pooled estimate of DSe and DSp of participant responses after the training video (corresponding to 25% of participant responses). We directly compared the mean and 95% confidence intervals of the baseline and post-training DSe and DSp estimates and considered them significantly different if the confidence intervals did not overlap. We included a random effect of block allocation if this had a significant effect, as previously described.

Statistical analyses were completed using RStudio 4.5.1 (R Core Team, 2025) using functionality from the contributed tidyverse and mada packages (Wickham et al., 2019; Doebler and Sousa-Pinto, 2025). The complete R code used within this study for HSROC statistical analyses can be found at https://doi.org/10.25909/29614706.

Results

Demographics

A total of 545 responses were recorded, of which 177 were excluded from analysis due to bot identification or because the response did not meet criteria for completeness. In the final analysis, 368 participants were included.

Most participants identified as female, were aged between 18-34, currently lived with 1 cat, had no previous vocational cat experience, had previously sustained a cat injury and resided in South Australia. Participants had lived with cats for a median of 20 years (see Table 1). When asked about situations in which they may worry about sustaining an injury, 37.8% of participants reported being concerned when playing with a cat, while 17.9% reported never being concerned about cat-inflicted injuries (see Supplementary Materials).

Results of randomisation testing found no significant differences in treatment or block allocation and demographic distribution balance in any of the thirty tests performed (all $p > 0.05$), indicating that randomization was successful.

Factors associated with accuracy at recognising cat valence (positive or negative)

Participant overall accuracy in classifying the videos ranged from 40% to 100%. There was no threshold effect observed between any subgroup. Overall and in subtle videos, participant DSe and DSp were slightly positively correlated: rho 0.15 (95% CI; 0.05, 0.25) and 0.17 (95% CI; 0.06, 0.26), respectively, and slightly negatively correlated for overtly classified videos: rho -0.14 (95% CI; -0.24, -0.04).

There was a significant impact of block allocation on baseline participant specificity both overall and in subtle videos, with block two being the most challenging for participants ($p = 0.009$ and 0.002 respectively). Because of this, all subsequent results, both overall and in the subtle subgroup, were reported by including block in the meta-regression, and Block 1 as the baseline category.

Overall, past vocational experience, cat guardianship and participant perceived confidence in their rating had a positive effect on specificity. However, participants demonstrated a 28% reduction in their ability to recognize subtle negative versus overt negative interactions (Table 2), and the only participant factor that improved this was their past vocational experience with cats.

The training video had a marginal positive effect on participant abilities to identify both overt positive and negative interactions, although it demonstrated a substantial negative impact on their ability to identify subtle negative interactions (Table 3).

Confidence in ability to understand cat body language

Average post-treatment confidence ratings out of 100 (where 0 is not at all confident and 100 is completely confident) were 73.1 ± 17.1 (mean ± SD) and 77.9 ± 14.6 for the control and training video groups respectively. The results of a Welch t-test showed participants in the training group ($M = 3.26$, $SD = 9.20$) had a significantly greater ($p = .001$) increase in confidence compared to the control group ($M = -0.01$, $SD = 9.79$) (Figure 2).

Participant interaction choices

Participants were asked to report how they would interact with the cat shown in the video and within that video's context. For instance, 90.8% of participants chose to walk away from a cat at least once across the three overt negative videos, while 13.9% of participants chose to stroke a cat at least once across the three overt negative videos. Participants most commonly chose withdrawing actions when viewing overt negative videos (90.8% walk away, 78.3% stay near but not interact). While for subtle negative videos most participants chose engaging interactions, with the most common choice being to stroke the cat, chosen by 73.6% of participants at least once across the two subtle negative videos. For overt positive and subtle positive videos, people were most likely to choose engaging interactions, with playing with a toy

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TABLE 1 Demographic information from online survey of Australian residents between 23rd May and 10th June 2025.

Demographic	Control group N=183	Training video group N=185	Overall N=368
Gender			
Female	156 (85.7%)	166 (89.3%)	322 (87.5%)
Male	7 (3.8%)	8 (4.3%)	15 (4.1%)
Non-binary	15 (8.2%)	9 (4.8%)	24 (6.5%)
Prefer not to say	4 (2.2%)	3 (1.6%)	7 (1.9%)
Age			
18-24	28 (15.3%)	15 (8.2%)	43 (11.7%)
25-34	65 (35.5%)	80 (43.5%)	145 (39.5%)
35-44	41 (22.4%)	38 (20.7%)	79 (21.5%)
45-54	28 (15.3%)	23 (12.5%)	51 (13.9%)
55-64	15 (8.2%)	22 (12%)	37 (10.1%)
65+	6 (3.3%)	6 (3.3%)	12 (3.5%)
Current # of cats			
No cats	38 (20.8%)	29 (15.7%)	67 (18.3%)
1 cat	64 (35%)	69 (37.3%)	133 (36.4%)
2 cats	49 (26.8%)	59 (31.9%)	108 (29.5%)
3+ cats	32 (17.5%)	26 (14.1%)	58 (15.8%)
Vocational Cat Experience			
None	114 (62.3%)	117 (63.2%)	226 (61.4%)
Past vocational experience*	69 (37.7%)	68 (36.8%)	142 (38.6%)
Previous injury**			
Scratched	157 (85.8%)	151 (81.6%)	308 (83.7%)
Bitten	94 (51.4%)	103(55.7%)	197 (53.5%)
Never Injured	19 (10.4%)	22 (11.9%)	41 (11.1%)
Years lived with cats:			
Mean (SD)	21.2 (15.3)	21.1 (16.4)	21.2 (15.9)
Median	20	20	20
Range	0-67	0-78	0-78

*Relevant vocational cat experience included: veterinarian, veterinary tech, veterinary nurse, breeding or showing of cats, behaviourist, animal trainer, animal management, shelter worker or volunteer, cat foster carer, veterinary student, cattery worker, and previous work with large felines. **Participants were able to select multiple answers when selecting previous injuries experienced: total observations n=546.
N = 368 for all variables except number of cats (n=366) and age (n=367).

chosen by 95.9% of participants at least once across the three overt positive videos, and stroke the cat chosen by 90.8% of participants at least once across the two subtle positive videos (see Table 4).

Participant negative valence accuracy and subsequent interaction choices

Figures 3 and 4 display the percentage of participants who selected an engaging or withdrawing interaction following correct or incorrect classification of the video. Numbers represent participants who correctly or incorrectly classified at least one overt or subtle video and percentages show what interaction choice they made based on their classification accuracy. For instance, for overt negative videos, 366 participants correctly classified an overt negative video at least once across three videos. Of these, 19.4% selected at least one engaging interaction on a video, having correctly classified that video as negative, and 80.6% of these participants only chose withdrawing interactions on videos they had correctly classified (Figure 3). Of those who incorrectly classified an overt negative video at least once, 67.1% chose engaging interactions and 32.9% only chose withdrawing responses (Figure 3). For subtle negative videos, 44.4% of participants who correctly classified a subtle

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TABLE 2 Mean and 95% confidence interval of the pooled sensitivity (DSe) and specificity (DSp) of participants to classify human-cat interactions as positive or negative, respectively.

Video Type	Mean % (95% CI)	Variable impact			
		Age n=362	Past vocational experience n=363	Guardianship history n=362	Confidence* n=362
Overall					
DSe	77.6 (73.5, 81.3)	NSI	NSI	NSI	NSI
DSp	67.4 (63.0, 71.5)	NSI	5.1 (0.2, 8.7)	11.0 (0.5, 22.5)	1.7 (0.2, 2.9)
Overt					
DSe	78.1 (75.4, 80.6)	NSI	NSI	NSI	NSI
DSp	76.7 (73.9, 79.3)	NSI	NSI	NSI	NSI
Subtle					
DSe	67.2 (61.2, 72.8)	NSI	NSI	NSI	NSI
DSp	48.7 (42.3, 55.1)	NSI	8.1 (0.3, 15.1)	NSI	NSI

Baseline categories: Past vocational experience: None, Guardianship history: None, *Confidence in reading cat body language, based on 10-point increments in confidence.
The impact of participant factors are shown relative to the baseline category. Subgroups of all interactions, only overt and only subtle interactions are expressed. NSI, no significant impact.

negative video, at least once across two videos, selected to engage with a cat while 55.6% chose to withdraw. For those that were incorrect in their classification, 95.2% chose to engage and 4.8% chose to withdraw (Figure 4).

Human perception of cat emotions in videos of human-cat interactions

Participants were asked to identify the emotion experienced by the cat in each video (Table 5). In the overt negative and positive videos, participants mainly selected the appropriately valenced emotion (negative and positive). Cats in overtly negative videos were mostly perceived as feeling frustrated/annoyed (40.2%), and for the overt positive videos as playful (79.8%). For the subtle negative videos, participants mostly selected positive emotions (54.7%) rather than negative (38.5%), though the most common responses were selected at similar levels and represented mixed responses (playful 20.9%, frustrated/annoyed 19.8%). In subtle positive videos, a positive emotion (relaxed 36.4%) and a negative emotion (bored 31.1%) were also selected at similar levels.

Discussion

The current study aimed to investigate the factors associated with human ability to recognize cat valence in a series of videos of human-cat 'play' interactions and to assess the impact of a training video on this ability. There was substantial between-participant variability in accuracy, though on average participants were more accurate at identifying positive than negative and overt than subtle behavioural cues. Whilst there was a small improvement in accuracy in the training video group, we observed a paradoxical decrease in participant ability to recognize subtle negative behaviours after training. In addition, participant choices when asked how they would interact with cats in different states and their perceptions of cat emotions within the videos provided insights into some of the misconceptions of appropriate interactions and misinterpretations of cat behaviour.

While previous research has utilized various methodological approaches when assessing human accuracy to recognize and interpret animal behavioural cues, most studies have typically relied on group-level averages for analysis, which does not account for individual participant effects (e.g., threshold effects). Here, we proposed the novel use of a hierarchical summary receiver operating characteristic (HSROC) framework, used for diagnostic test evaluation meta-analyses (Rutter and Gatsonis, 2001). By accounting for participant-level random effects and modelling correlations between recognition of behavioural states within individual participants to detect threshold effects where present, HSROC may have provided a more robust and functionally meaningful evaluation of human ability to categorize animal behavioural states, improving our study's validity and overall representativeness of true recognition ability of members of the public, relative to the panel of experts.

TABLE 3 Mean and 95% confidence interval of the sensitivity (DSe) and specificity (DSp) of participants in the training group to classify human-cat interactions as positive or negative after seeing an educational video.

Video Type	Mean % (95% CI)	Change % (95% CI)
Overall		
DSe	80.6 (74.9, 85.3)	3.0 (1.4, 4.0)
DSp	71.4 (64.6, 77.3)	4.0 (1.6, 5.8)
Overt		
DSe	80.0 (76.4, 83.3)	1.9 (1.0, 2.7)
DSp	78.1 (74.2, 81.5)	1.4 (0.3, 2.2)
Subtle		
DSe	63.2 (53.4, 72.0)	-4.0 (-7.8, -0.8)
DSp	29.9 (22.1, 38.9)	-18.8 (-20.2, -16.2)

Values are compared to participant pre-training accuracies, and the change (including direction) is expressed, n= 184.

Participant accuracy in recognising valence in human-cat interactions

Participants performed best at classifying positively valanced overt videos (78.1%) and maintained an above chance accuracy when classifying subtle positive videos (67.2%) (Table 2). These results are consistent with previous studies that found participants were most accurate at categorising cat behavioural expressions in positive compared to negative states (Dawson et al., 2019; de Mouzon et al., 2024).

For overt negative videos, despite achieving above-chance accuracy (76.7%), participants still misclassified nearly one in four cats displaying overtly negative behaviours in human-cat play interactions (Table 2). Considering overtly negative behaviours represent the highest and most immediate risk for cat distress and human injury, this proportion of misclassification is worrying. Of further concern is the significant drop in accuracy, to levels approximating chance (48.7%) when participants were attempting to classify subtle negative behaviours (Table 2). These findings demonstrate not all participants recognised obvious cat distress behaviours, and most failed to recognize negative behaviours that are subtle or potentially ambiguous. This is consistent with previous reports that participants struggle to recognize subtle stress responses in cats and dogs (e.g., freezing behaviour) and that only very prominent behaviours (e.g., excessive vocalisation, posture with ears back) were recognized as signs of stress by more than two-thirds of guardians (Mariti et al., 2012, 2017). To our knowledge, only one previous study has specifically assessed differences in human recognition of overt and subtle behaviours in cats. Results showed no difference in participant performance based on behaviour subtlety (Khoddami et al., 2024), except for in the case of two positively valenced behaviours (allo-grooming and head rubbing). This is contrary to our own findings.

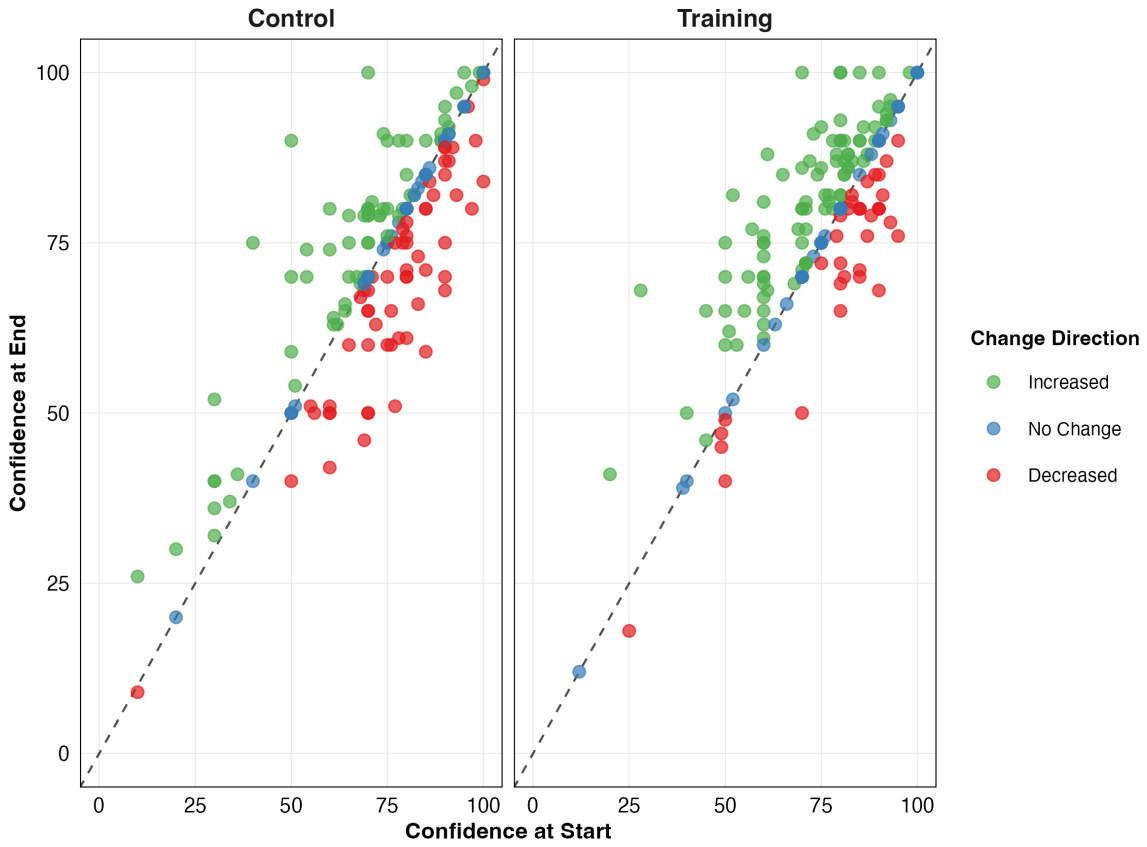


FIGURE 2
Pre- and post-intervention participant confidence ratings for reading cat body language (0-100) by treatment condition (training video or control).

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TABLE 4 Proportion of participants who selected each interaction choice across videos showing overt and subtle positive and negative cat behaviours, based on responses to an online survey between 23rd May and 10th June 2025.

Interaction Type	Interaction choice	Overt negative	Subtle negative	Overt positive	Subtle positive
Withdrawing	Walk away from the cat	334 (90.8%)	59 (16%)	25 (6.8%)	65 (17.7%)
	Stay near but not interact	288 (78.3%)	188 (51.1%)	43 (11.7%)	148 (40.2%)
Engaging	Stroke the cat	51 (13.9%)	271 (73.6%)	78 (21.2%)	334 (90.8%)
	Play with cat with a toy	42 (11.4%)	114 (31%)	353 (95.9%)	223 (60.6%)
	Play with your hands	19 (5.2%)	112 (30.4%)	220 (59.8%)	24 (6.5%)
	Discipline/correct cat*	9 (2.4%)	3 (0.8%)	11 (3%)	0 (0%)
	Pick the cat up	3 (0.8%)	22 (6%)	24 (6.5%)	40 (10.9%)
	Rub the cat's belly	1 (0.3%)	155 (42.1%)	44 (12%)	10 (2.7%)
	Other**	23 (6.2%)	31 (8.4%)	18 (4.9%)	27 (7.3%)

Percentages and counts represent participants who selected each option at least once across the 3 overt positive, 3 overt negative behaviour, 2 subtle positive and 2 subtle negative behaviourvideos. Participants could choose multiple options per video.
*Discipline/correct the cat included: ignoring the cat, withholding food, picking up and moving the cat elsewhere, admonishing the cat for their behaviour, redirecting to a toy.
**'Other' included: apologising to the cat, transferring control to the cat, leaving cat alone, talking to cat, giving treats, changing touch location, offering hand for cat to sniff, judgements about the person in the interaction, kissing the cat and cuddling the cat.

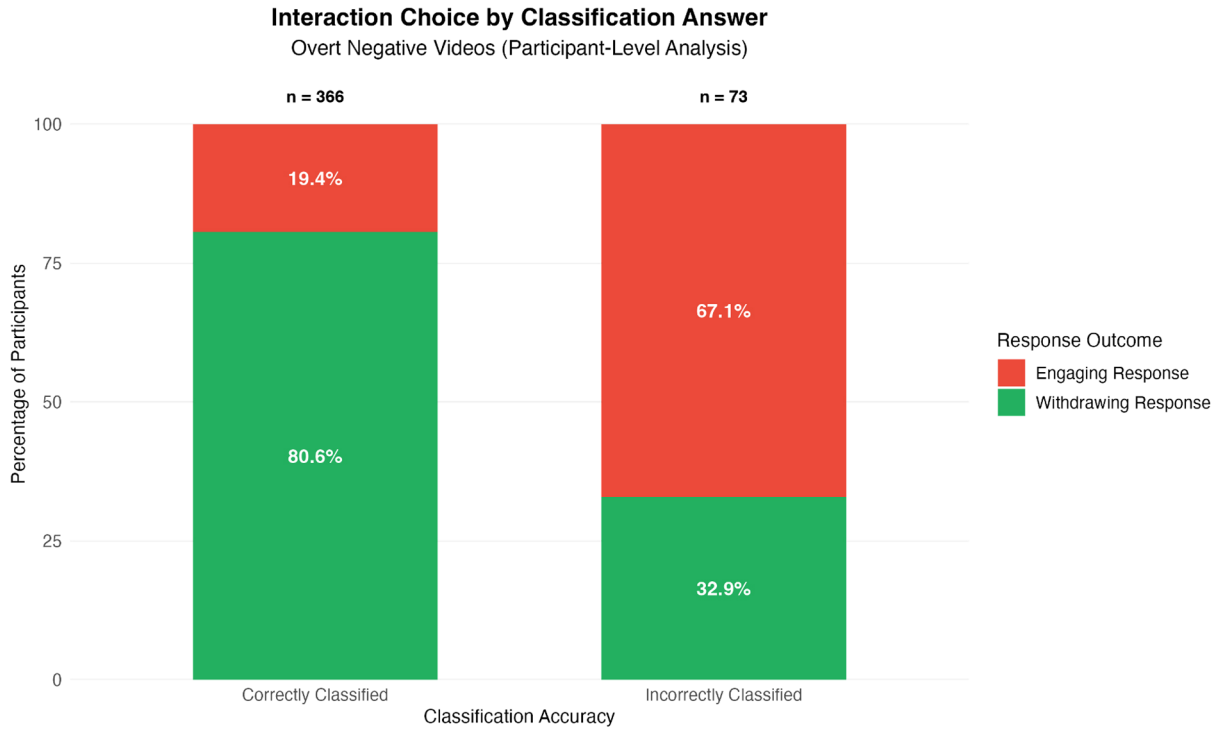


FIGURE 3
Proportion of participant interaction choices (engaging or withdrawing) following correct vs. incorrect classification of overt negative videos based on responses to an online survey between 23rd May and 10th June 2025. Percentages and counts represent participants who selected each option at least once across the 3 overt negative behaviour videos.

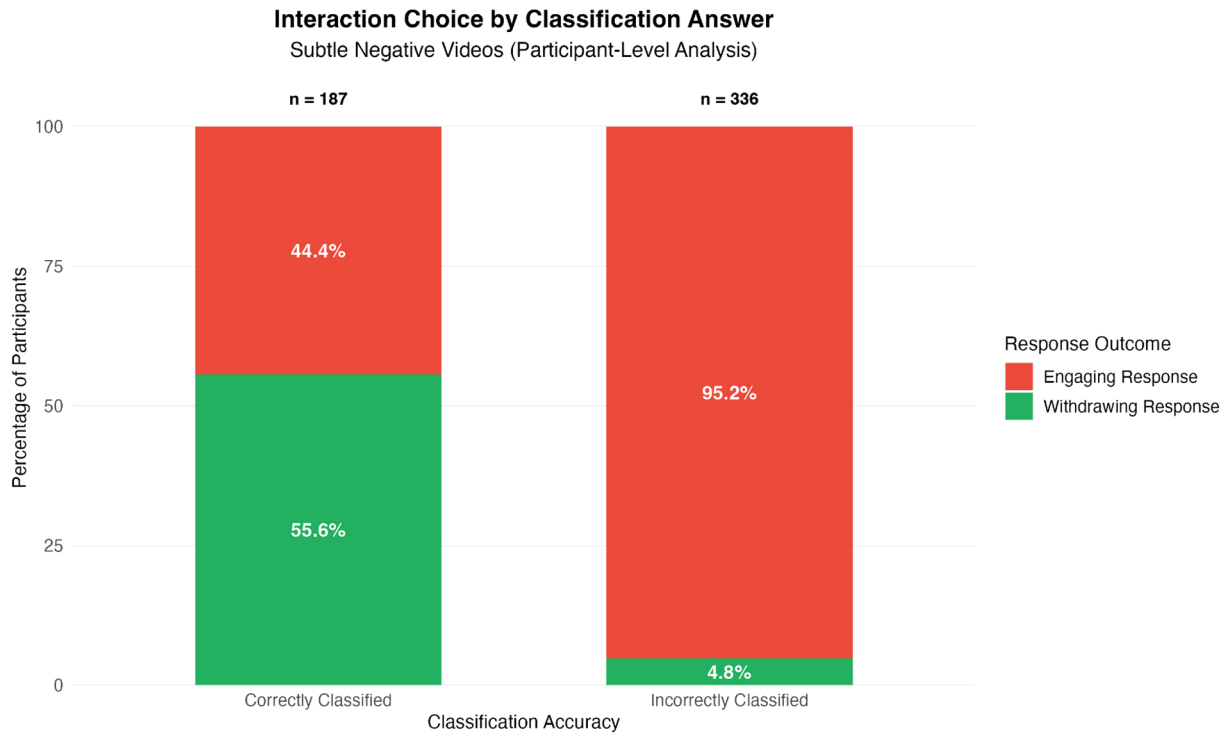


FIGURE 4
Proportion of participant interaction choices (engaging or withdrawing) following correct vs. incorrect classification of subtle negative videos based on responses to an online survey between 23rd May and 10th June 2025. Percentages and counts represent participants who selected each option at least once across the 3 subtle negative behaviour videos.

TABLE 5 Participant selection of perceived cat emotions in videos showing overt and subtle positive and negative cat behaviours based on responses to an online survey between 23rd May and 10th June 2025.

Valence	Emotion choice	Overt negative	Overt positive	Subtle negative	Subtle positive
Positively valenced	Playful	24 (2.2%)	877 (79.8%)	153 (20.9%)	77 (10.5%)
	Happy	0 (0%)	58 (5.3%)	106 (14.5%)	48 (6.6%)
	Curious	13 (1.2%)	101 (9.2%)	26 (3.6%)	54 (7.4%)
	Relaxed	1 (0.1%)	21 (1.9%)	115 (15.7%)	266 (36.4%)
	Total	28 (3.5%)	1057 (96.2%)	400 (54.7%)	445 (60.9%)
Negatively valenced	Frustrated/Annoyed	443 (40.2%)	11 (1.0%)	145 (19.8%)	18 (2.5%)
	Scared/Threatened	289 (26.2%)	3 (0.3%)	18 (2.5%)	0 (0%)
	Angry	167 (15.1%)	2 (0.2%)	3 (0.4%)	1 (0.1%)
	Stressed	150 (13.6%)	8 (0.7%)	25 (3.4%)	3 (0.4%)
	Bored/Uninterested	1 (0.1%)	3 (0.3%)	91 (12.4%)	227 (31.1%)
	Total	1050 (95.2%)	27 (2.5%)	282 (38.5%)	249 (34.1%)
	Other*	15 (1.4%)	15 (1.4%)	49 (6.7%)	36 (4.9%)

* 'Other' for each video type included: Overt negative; spoilt, confused, a little annoyed, conflicted, touched out (does not want to be touched), avoidant, mixed emotions, seeking connection, displeased. Overt positive: mixed emotions, hunting, focused, learning, feeling like a big cat. Subtle negative: defeated, overstimulated, hesitant, contact seeking, mixed emotions, tolerating/patient, vaguely positive, obedient, trying to do the right thing, sad, confused, confident, trusting, under duress, wants to be touched, tired, overwhelmed. Subtle positive: patient, neutral, distracted, engaged, slightly overwhelmed, conflicted, content, uncomfortable.
Percentages and counts represent the number of times an emotion was selected. Participants could choose multiple options per video.

Differences in results between this study and ours is likely due to study design and focus disparities, with Khoddami et al. (2024) investigating human recognition of cat-cat interactions rather than human-cat interactions, and using videos that only portrayed one focal interaction (e.g., a nose touch between cats) compared to the longer, multi-focal interaction videos used within the present study.

Several factors may have contributed to the chance level recognition of subtle negative behaviours observed within our study. In a previous study, participant accuracy was best if participants were given multimodal cues (i.e., visual and audio) when categorising cats in different states, than when given unimodal cues (only visual or only audio) (de Mouzon et al., 2024). It is possible the difference in participant performance between overt and subtle negative videos observed within our study is partially explained by the observation that, while vocalisation sounds and frequencies vary greatly between individual cats (Urrutia et al., 2019), human-directed vocalisations tend to be more common and most variable in positive states (e.g., seeking connection or food) (Schötz et al., 2024). Vocalisations in negative states are less varied (Schötz et al., 2019), with cats initially becoming silent and only vocalising (e.g., yowling, hissing) when experiencing high levels of distress (Rand et al., 2002; Horwitz and Rodan, 2018). Therefore, early warning signs that a cat is in a negative state do not generally include vocalisations. This is true for the subtle negative videos used within our study, in which the cats shown did not vocalise. If bimodal cues are easier for people to recognize, a cat's tendency to become quiet in stressful situations may mean that people are unlikely to detect the behaviour before it reaches an extreme point.

Previous research has indicated that perceptual decisions may involve the retrieval of information from memory (Shadlen and Shohamy, 2016), including in tasks related to emotion recognition in humans (Bègue et al., 2019). Delayed feedback significantly impairs category learning, particularly in complex, multi-cue recognition tasks (Maddox et al., 2003). Negative behaviours that are obvious or overt, such as hissing or scratching, create strong immediate associative learning through stimulus-outcome contingencies. Conversely, subtle negative behaviours are less obvious and easier to miss or misinterpret and, when this happens, humans may receive no corrective feedback if the cat does not escalate. Even when an escalation does occur, the delay between the subtle sign and the later overt consequence may prevent formation of associative links. Because of this, people are likely to continue to miss subtle signals and therefore continue engaging in interactions that may lead to cat stress and possible human injury.

Factors associated with participant accuracy

We found substantial individual variability in ability to recognise cat behaviours, with participant accuracy ranging from 40-100%. Factors associated with this variability were: past cat-related vocational experience, whether the participant had ever lived with a cat, and the level of confidence in understanding cat body language (Table 2). Participants with cat-related vocational experience were significantly better at recognizing subtle negative behaviours. This is supported by previous studies (Schötz and van de Weijer, 2014; Dawson et al., 2019; de Mouzon et al., 2024). Within the present study, participant experience living with cats was also associated with higher accuracy for overtly negative videos. Previous research reports conflicting results. In one study, people having cared for cats was associated with higher scores when recognising kittens in neutral or positive valences, but lower scores when recognising moderate fear in kittens (Graham et al., 2024). In another, cat guardians performed better than those who had never had cats at recognising cat vocalisations made during brushing or when in isolation, though not in other contexts (Prato-Previde et al., 2020). Other studies have found no significant differences in accuracy associated with years spent living with cats (Dawson et al., 2019; de Mouzon et al., 2024). However, one study observed that cat guardian performance was enhanced when participants interpreted their own cats' vocalisations, compared to those of unknown cats (Ellis et al., 2015) which may partially account for the lack of association between accuracy scores and years spent with cats observed across previous studies and our own. Methodology in previous studies has varied greatly, making direct comparisons of findings difficult.

Another factor associated with participant accuracy was the participant's self-rated confidence in understanding cat body language. Here, higher participant confidence was significantly associated with a small increase in capacity to recognize overall negative behaviours (Table 2). This result, while of small magnitude, is contrary to previous findings of human emotion recognition, where self-reported confidence is not generally correlated with better emotion recognition (Kelly and Metcalfe, 2011; Bègue et al., 2019). Instead, studies find that people tend to over-estimate their ability to correctly infer the thoughts and feelings of others (Ickes et al., 1990; Marangoni et al., 1995; Ickes, 2003; Realo et al., 2003). These differences may be due to variations in methodology, or in people's confidence in recognising behaviours in people versus in cats.

Impact of a training video on participant accuracy

A training video focused on teaching participants about cat behavioural and play cues was partially successful at improving participant accuracy to recognise overt cat valence in human-cat interactions. This is consistent with previous studies where improvements in recognition of animal behavioural cues have improved after an educational intervention (Wilson et al., 2003; Lakestani and Donaldson, 2015; Haywood et al., 2021; Graham et al., 2024). However, our training video also significantly decreased participant accuracy in recognising subtle negative behaviours. It is unknown if this finding is unique to our study, or if similar declines may have been observed in other studies if the overtness or subtlety of behaviours had been considered, as overall accuracy scores may obscure differences in recognition of subtle and overt behaviours from findings. The results of our study suggest that the subtlety or overtness of behaviours should be accounted for in future investigations.

The decrease in participant ability to recognize subtle negative behaviour raises important questions about the delivery of educational interventions regarding cat behaviour. Ideally any intervention should improve participant ability to recognize early warning signs of stress so that participants can stop an interaction before it escalates to a level that may risk human health and cat welfare. While understanding overt behaviours is also necessary, at this point, there is already heightened risk of a cat-inflicted injury, and the cat themselves is already experiencing negative welfare impacts associated with stress (Palacio et al., 2007). It is therefore important to prioritize recognition of early potential stress signals to help prevent interactions from escalating to levels where negative behaviours become overt. Several factors may have contributed to the unexpected decrease in subtle negative behaviour recognition observed after the training video. These include the length and scope of the video; the training video was very short (2.5 minutes) and attempted to cover a lot of information. Whilst a discussion of subtle cues was covered in the video, it was included towards the end when participant attention may have waned. Further, salience bias, where people pay more attention to, and better remember, stimuli that is more prominent, visible or emotionally striking (Bradley et al., 1992), may have been a factor, with images of cats in overtly negative states distracting attention from the less extreme visuals of subtle behaviours. Further, the training video did not contrast subtle negative behaviours indicative of stress or discomfort directly against the visually similar, but emotionally distinct, behaviours seen in cat play such as a playful paw swipe versus a defensive warning gesture, which may be a prudent addition for future studies to include. Further research is needed to define and describe subtle behavioural signs in cats and to identify the most effective ways of educating the public on recognising these signs.

Interacting with cats in a negative state

Participants reported being likely to engage cats in a variety of interactions, regardless of the cats' identified negative state. Participant interaction choices when viewing subtle negative videos showed considerable variability and a substantial proportion of participants selected choices that may be high risk for escalation, with participants indicating they were likely to stroke the cat, rub the cat's belly and play with the cat using their hands (Table 4). When interaction choices were assessed based on participant valence accuracy, 19.4% of participants viewing overt negative videos still chose to engage with a cat despite correctly recognising the cats state as negative (Figure 3). This recognition-response gap was even more evident in participants viewing subtle videos, where 44.4% of participants chose to engage with a cat despite correct recognition of the cat's negative valence (Figure 4). This is supported by a previous study on child recognition of dog behaviour cues which also found that, despite recognizing the emotional states of dogs, most participants still reported intending to approach dogs in frightened states (Aldridge and Rose, 2019). These findings indicate that recognition of behavioural or emotional states alone is not enough to prevent unwanted interactions and that the processes behind how people choose to interact with animals in a negative state may involve more complicated psychological processes. This is supported by a previous study where, rather than reducing unwanted interaction choices, greater experience with cat guardianship and higher self-rated cat knowledge were instead generally predictive of people engaging in interaction choices known to be less preferred by cats such as belly touching (Finka et al., 2022). Future studies are needed to investigate the perceptions and cognitive processes that may lead people to physically engage with cats despite recognising their negative behavioural cues or understanding their preferences.

Interestingly, 37.8% of participants in this study reported worrying about sustaining an injury while playing with their cat (see Supplementary Material). Despite this concern, many participants chose interactions that carry a high risk of injury, such as belly rubbing selected by 42.1% of participants viewing subtle negative videos (Table 4). In most cats, showing the belly or rolling over does not necessarily mean a cat wants to be touched on the tummy (Martin, 2023). While there are rare cats who enjoy this interaction, for most cats this area can get overstimulated easily, which can result in a scratch or bite to the hand (Martin, 2023). While belly exposure can be an invitation for connection (though generally not through belly rubbing) if the body is relaxed, it can also be used as a method of defense, with all four paws, claws and mouth available to defend and attack (Beaver, 2003). Similarly, playing with a cat with bare hands, selected by 30.4% of participants when the cat was displaying subtle negative behaviours (Table 4), is likely to increase the risk of human injury. Previous studies have identified hands and arms as common locations for cat-inflicted injuries, with one study finding that 48% of injuries from cats occurred on the hands (Palacio et al., 2007). Cat injuries are a serious public health risk, with bites being particularly susceptible to infection (occurring after 30% of bites) and complications (Garcia, 1997; Westling et al., 2006). Results of our study indicate a critical need for greater education on the risk of serious injury from belly rubbing or playing with cats bare handed.

Above, we have mostly focused on the risk for human injury during an interaction, but it is important to recognize that these interaction choices are also likely to heighten cat stress levels (Ellis, 2018; Fritz et al., 2022), may induce discomfort or fear for the cat (Stella et al., 2013) and, if repeated, can lead to prolonged stress, behavioural problems and health issues (Buffington, 2002; Amat et al., 2009; Stella et al., 2011, 2013). Further, some interactions that were not flagged as high risk based on human injury, or that fell within the category of withdrawing, may still carry risk for the cat. As so, their omission from the high-risk designation or inclusion in the withdrawal category should not be seen as an endorsement. For instance, 78.3% reported that they would stay near but not interact with a cat in an overt negative state (Table 4). This interaction was included under the 'withdrawing' actions, but for cats in an overtly negative state, staying close by may prolong stress. When feeling threatened or stressed, many cats have a natural instinct to retreat from the stressor (Kry and Casey, 2007), though this varies between individuals (Stella and Croney, 2019). If a cat is experiencing stress and exhibiting distancing behaviours (common in the overt videos), staying near the cat may exacerbate cat stress by prolonging exposure

to the stressor (the person) and potentially interfering with their ability to cope through escape. Stress in cats has been associated with a broad range of health issues (Buffington, 2002; Gaskell et al., 2007; Amat et al., 2016; Aziz et al., 2018; Sparkes, 2018) and behavioural changes (Amat et al., 2009, 2016), many of which are likely to negatively impact the human-cat bond (Houpt et al., 1996) and are associated with increased risk of abandonment, surrender or euthanasia (Salman et al., 1998; Heath, 2007). Educating guardians on the health and behavioural ramifications of cat stress and emphasising the benefits of, and necessity for, respecting a cat's desire to be left alone in minimizing this stress is needed.

Participant perception of cat emotions

Experiences and emotions are argued to be at the core of animal welfare (Kremer et al., 2020). Accurate recognition of emotions may therefore enable guardians to mitigate welfare risks through alteration of interactions in response to cat emotional state. Within our study, human recognition of cat emotions showed considerable variability. For videos of cats displaying subtle negative behaviours, participant perceptions of emotions were mixed and often inaccurate. The most commonly selected emotion was 'playful' (20.9%), followed by 'frustrated/annoyed' (19.8%), 'relaxed' (15.7%) and 'happy' (14.5%) (Table 5). These findings indicate that participants commonly misinterpreted subtle negative states as positive and may confuse behaviours used to communicate a desire to end an interaction (e.g., pushing away a hand, giving a warning bite) as playful. Similarly, a study on adult recognition of dog behaviours reported that participants struggled when distinguishing between dogs displaying 'aggression' and 'play fighting', often misinterpreting aggressive signals as playful behaviour and vice versa (Tami and Gallagher, 2009).

For positive videos, participants showed higher accuracy in emotion recognition. Cats in overtly positive videos were mostly perceived as feeling 'playful' (79.8%), while cats in subtly positive videos were most commonly perceived as feeling 'relaxed' (36.4%), suggesting participants could more readily identify positive emotional states across both overt and subtle presentations (Table 5). Of note, participants were more likely to select 'other' and choose to self-describe the emotion when responding to subtle videos (6.7% for subtle negative, 4.9% for subtle positive) compared to overt videos (1.4% for both overt negative and positive) (Table 5). This suggests that participants found it more difficult to categorize emotions in subtle videos. However, these self-descriptions included answers that were not emotions, but instead constituted traits (e.g., tolerant), judgements (e.g., spoilt) or activities (e.g., hunting), indicating potential confusion about the distinction between emotional states and behavioural descriptions. The common misconceptions of emotions in cats displaying subtle negative behaviours further supports the necessity of educating the public on how cats display stress signals, what these signs may mean for cat emotional states and how they should inform our interaction choices.

Implications for human-cat play interactions

The findings of the present study demonstrate a concerning lack of human ability in recognizing negative behaviours in cats and, where people do correctly recognize cat distress, a dangerous disconnect between people's recognition and their ability to appropriately respond to that distress. These findings may have serious real-world implications and suggest there is an urgent need to educate cat guardians about both i) recognizing cat behaviours and ii) selecting appropriate interactions when the behaviour has been recognized. Further, the decrease in subtle negative video accuracy observed post-treatment in the training video group highlights the need for careful consideration when creating informative resources on cat behaviour. For instance, it may be prudent to focus any educational messaging on the need to assess a cat's desire to play before engaging in an interaction, considering the cats current emotional state when initiating or continuing play, the importance of recognizing subtle cues that the cat wishes the play to end and the potential consequences of failing to do so. Information that encourages people to prioritize negative or ambiguous signals when assessing if an interaction should continue may also assist in minimizing welfare and health risks. That is, if a cat is exhibiting any ambiguous or negative behaviours, even if they are also exhibiting behaviours that appear playful or positive, the person should halt the interaction and allow for a 'check-in' or 'consent check', whereby the person should observe the cats behaviour and only continue the interaction if the cat themselves re-initiates engagement (e.g., rubbing against the person's body) (Haywood et al., 2021). Though care should be taken to ensure appropriate nuance is understood, specifically that a cat re-initiating contact may still have experienced distress and may desire a change in the style of interaction. Findings also indicate that people engaging in unwanted interactions may do so for multiple reasons. Those uncovered in our current study include 1) not being able to recognize the negative state and 2) recognising the state but still choosing to engage. These are two distinct issues that may require different educational approaches. In the case of those that cannot recognise distancing cues, education would first need to improve understanding of cat behaviours while in the case of those who can recognise cues, education may need to be more individualised, first establishing any narratives that may be maintaining poor interaction choices (e.g. the person thinks that a cat in a negative state needs comforting through touch) and correcting these narratives to reduce unwanted interactions. Further research into the perceptions and beliefs that may contribute to normalization or justification of unwanted interactions is critically needed. Overall, our results indicate that training interventions need to address both recognition of cat behaviours and emotional states as well as how to act interact appropriately in response to these cat behaviours or states. Generally, results suggest public education on allowing cats space when they are exhibiting negative signals is needed.

Limitations and future research

The current study has a number of potential limitations. Firstly, the sample of randomized control trial participants may include selection bias, as participants overwhelmingly identified as female. In addition, over 80% currently lived with a cat while 38.6% has previous relevant vocational experience (Table 1). This is unlikely to be a representative sample of the general population at risk of cat-related injuries and is especially under representative of those with no or little cat experience, or children, due to the 18+ inclusion criteria of the study. Considering that children are at greater risk for facial and neck injuries from cats (Palacio et al., 2007), future studies that include children, specifically investigate the ability of children to recognize, interpret and respond to cat behavioural cues, and identify effective training interventions with a child's capabilities in mind are needed. Further, participants were self-selected and, because of this, may be more likely to be interested in cats, behaviour or animal welfare. This may also have biased our sample, and results may not be reflective of the general population – although our study probably represents an over-estimate of the general public's ability to determine cat behavioural valence and therefore highlights the even greater need for education in this space.

The study may also be limited by the design of the training and control videos. A short video run length of 2.5 minutes was selected with an online survey style participant in mind, due to longer surveys often having higher rates of drop-out and respondent fatigue. However, this may have impacted the benefit of the intervention and a longer video, or in-person intervention may have allowed for more nuance. Training interventions used in future studies may benefit from placing greater emphasis on how behavioural signals function in combination and strongly encouraging participants to interpret videos with the whole cat and context clues in mind. It is also possible that the control video inadvertently included information or primed participants in a way that may have improved control participant performance. The videos used for categorisation may have also introduced some limitations. Perception of emotions in humans (Aviezer et al., 2008; Calbi et al., 2017) and dogs (Molinaro and Wynne, 2025) have been shown to be susceptible to the context with which an image or video is presented. Despite instructions to base answers only on the cat's behaviour, it is likely that participants were influenced by the context visible within the videos and this may have altered their answers. Options for emotions given to participants were based on and limited to those assessed by the expert panel and were not linked to a clear, established emotion framework. Future studies would benefit from utilizing an established framework for emotions within their study design. Finally, the broad terms of 'positive' and 'negative', used for classifying interactions by both expert panel and general public participants, are a simplification of what is a complicated and multi-faceted spectrum of valence (Kremer et al., 2020). This simplification was made for ease of use and clarity for participants, who we expected to be generally familiar with a 'positive' or 'negative' behaviour and to generate initial, foundational findings from which future studies can build on. As such, it is suggested that future studies may find it valuable to explore human recognition of valence with more detail or granularity, for example by including ambiguous behaviours or transitional states or by framing behaviours and emotions by their functions. However, it is notable that the HSROC analytical framework used in this study required binary classifications, so would need to be adapted if the classification had more than two levels.

Conclusion

This study aimed to assess human ability in recognising cat behavioural cues during human-cat play interactions, presenting a novel application of HSROC techniques. While participants demonstrated above chance recognition of overt cat behaviours, almost 25% of cats in an overtly negative state were still misclassified (Table 2). Further, participants performed approximately at the level of chance when classifying videos of cats in a subtle negative state. These findings raise significant concerns for cat welfare and human safety in human-cat interactions. Results demonstrated that 19.4% of participants would choose to engage with a cat displaying overt negative behaviours, even when they had correctly recognised the cat's negative valence (Figure 3), this number rose to 44.4% when participants recognized cats displaying subtle negative behaviours (Figure 4). These findings reveal a concerning disconnect between recognition and appropriate response. Our brief educational intervention showed mixed results: demonstrating a small improvement in overall accuracy while paradoxically impairing detection of early warning signs that are most critical for preventing escalation to serious distress or injury. Future interventions should emphasize appropriate response strategies that prioritize cat choice, consent and allowing space. Given the serious health and safety risks associated with cat bites and scratches, and the welfare implications of prolonged stress in cats, developing effective educational strategies for improving human recognition and response to cat communication is crucial. Further, in the interests of public health and animal welfare, care should be taken to provide nuance when promoting human-cat play, such as the need to continually assess cat desire to play, the risk of touching sensitive areas (e.g., belly) or playing with bare hands, and the importance of giving space when a cat is displaying negative behaviours.

Data availability statement

The datasets presented in this article are not readily available due to ethics restrictions. Requests to access the datasets should be directed to julia.henning@adelaide.edu.au.

Ethics statement

The studies involving humans were approved by Human Research Ethics Committee at the University of Adelaide, approval code: H-2025-072. The studies were conducted in accordance with the local legislation

and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

JH: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Project administration, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. TN: Conceptualization, Methodology, Supervision, Validation, Writing – original draft, Writing – review & editing. SH: Conceptualization, Methodology, Project administration, Resources, Supervision, Validation, Writing – original draft, Writing – review & editing. PA: Data curation, Formal Analysis, Investigation, Methodology, Software, Supervision, Validation, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

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Supplementary Results – as published at doi:10.3389/fetho.2025.1675587

Perceptions of Injury Risk

Table 6. Situations in which participants reported being concerned they may sustain an injury from a cat (n=368). Based on online survey responses between 23rd May – 10th June 2025.

Situation	Count	Percentage
When giving medications	183	49.7%
When at veterinarian	167	45.4%
During bathing	155	42.1%
When touching street cat	147	39.9%
During play	139	37.8%
When picking up a cat	133	36.1%
If children are unsupervised	91	24.7%
During grooming	73	19.8%
When touching friend's cat	67	18.2%
Other situations*	35	15.2%
When cat is on lap	17	4.6%
Do not worry about cat injury	66	17.9%

*Other situations included: when cat is sleeping, when feeding a cat, when intercepting a cat fight, when intercepting a cat and dog fight, when putting a cat into a carrier, when cat is over excited, surprise or random attacks, as part of veterinary or shelter work, when cat is injured or in pain, when cat is scared, re-directed aggression when neighbourhood cats visit, when a sudden noise occurs, when inexperienced people handle a cat, when interacting with an unfamiliar cat.

Randomization:

Table 7. Randomization Check Results: Statistical Tests of Demographic Variables Across Treatment Groups and Experimental Blocks

Variable	Test Type	Comparison	P-Value
Age	T-test	Treatment	0.4153
Age	ANOVA	Block	0.5785
Years with Cats (cat owners only)	T-test	Treatment	0.8749

Years with Cats (cat owners only)	ANOVA	Block	0.7997
Number of Cats (cat owners only)	T-test	Treatment	0.8849
Number of Cats (cat owners only)	ANOVA	Block	0.9161
Gender	Chi-sq/Fisher	Treatment	0.2254
Cat Ownership	Chi-sq/Fisher	Treatment	0.8084
Past Experience: vet	Chi-sq/Fisher	Treatment	1
Past Experience: vet	Chi-square	Block	0.9867
Past Experience: vet nurse	Chi-sq/Fisher	Treatment	0.7811
Past Experience: shelter worker	Chi-sq/Fisher	Treatment	0.8376
Past Experience: shelter worker	Chi-square	Block	0.7366
Past Experience: shelter volunteer	Chi-sq/Fisher	Treatment	0.4071
Past Experience: shelter volunteer	Chi-square	Block	0.0768
Past Experience: foster carer	Chi-sq/Fisher	Treatment	1
Past Experience: foster carer	Chi-square	Block	0.7403
Past Experience: trainer	Chi-sq/Fisher	Treatment	0.1383
Past Experience: animal management	Chi-sq/Fisher	Treatment	1
Past Experience: other	Chi-sq/Fisher	Treatment	0.8676
Past Experience: other	Chi-square	Block	0.5
Past Experience: none	Chi-sq/Fisher	Treatment	1
Past Experience: none	Chi-square	Block	0.4682
Injury History: never	Chi-sq/Fisher	Treatment	0.7684
Injury History: never	Chi-square	Block	0.3129
Injury History: scratch	Chi-sq/Fisher	Treatment	0.3463
Injury History: scratch	Chi-square	Block	0.3146
Injury History: bite	Chi-sq/Fisher	Treatment	0.4689
Injury History: bite	Chi-square	Block	0.6966
Injury History: other	Chi-sq/Fisher	Treatment	1

Supplementary Materials

Video Descriptions

Table 8. Descriptions of videos used for questions within an Australian survey of general public abilities to recognise and respond to cat behavioural cues.

Video ID	Valence	Type	Description of Video
TIN	Negative	Subtle	Cat and human in a training/play session. Human uses hand gestures to cue behaviours in cat. Cat performs trained behaviour but avoids touch and eye contact, holds ears back, keeps face down towards the floor. Human grabs cat's chin and forces their face up. Cat pushes hand away.
E8L	Negative	Subtle	Cat rolls over, showing belly and rubs body against mattress. Human rubs cats belly roughly. Cat raises back paws and holds them stiffly near the hand. Rough rubbing continues. Cat's body stiffens. Cat holds hand

			with all four paws, claws out. Cat bites hand quickly. Ears are back and to the side. Human removes hand.
BTG	Positive	Subtle	Cat sitting on human's lap. Human rubs cat's nose ridge with one finger. Cat body is relaxed, ears are up and forward, eyes close slightly and slowly. Cat remains inactive but moves head and eye focus around in a relaxed manner.
UM7	Positive	Subtle	Human and cat are playing together with a wand toy. Cat repeatedly batts at toy. Human moves toy away before re-presenting it. Cat looks to the side, as if distracted by a noise or visual in the distance.
9L1	Negative	Overt	Cat is pressed into a corner and hisses, human pokes cat's tail with foot. Cat lip licks and swallows in absence of food. Ears are to the side and back, tail is swishing. Cat growls. Person continues to poke tail with foot while cat pushes themself further into the corner.
B08	Negative	Overt	Human raises hand to touch cat on top of head. Cat's ears go to the side and back. Cat flinches, dodges the touch, turns away and makes a low-pitched vocalisation. Human takes hand away. Cat returns to original position. Human repeats the attempt to touch. Cat repeats behaviours to avoid. Human points finger close to cat's nose. Cat sniffs finger with ears still to the side. Person pokes cats chest and attempts to poke cat's side. Cat leaps from bed and escapes.
MTM	Negative	Overt	Human reaches out hand to touch cat, cat hisses and rears back, human pushes cat slightly backwards and maintains hand at cat's throat level. Cat holds mouth open, vocalising and places teeth near finger, but does not bite down. Cats ears are back, pupils are dilated, cat repeatedly lip licks and swallows in absence of food, cat makes stressed low yowling vocalisations.
RXN	Negative	Overt	Human reaches towards cat. Cat makes low vocalisation and moves to avoid touch. Human pokes cat. Cat stands up and moves towards human, making low vocalisation. Human pushes cat back and presses fingers into cat's throat. Cat vocalises multiple times and turns away. Human continues to poke cat. Cat turns towards human and continues to vocalise. Ears are back and mouth is pressed tightly together with whiskers straight and forward.
2VJ	Negative	Overt	Cat is on top of a fridge. Human is ducking down behind the fridge and then quickly standing up and poking cat before ducking behind fridge again. Cat's tail is swishing quickly, ears are back. Cat hisses multiple times and lip licks.
WQM	Negative	Overt	Human points finger in cats face. Cat slaps hand away, tail swishing. Human points finger at cat's face again. Cat's ears are sideways and back, body stiff, cat lip licks and makes low growl.
WUX	Positive	Overt	Human throws mouse toy off of bed. Cat retrieves it and brings it back to human. Cat makes a play trill vocalisation.
LMT	Positive	Overt	Cat and human pass a felt ball back and forth to each other. At one point the cat grabs the ball and sniffs/nibbles it.
FPA	Positive	Overt	Kitten rears up and pounces repeatedly on human's hand, which the human is wiggling. Kitten pounces to the side before pouncing back on the hand.

OZ3	Positive	Overt	Cat is playing with blanket dangling from human's chair. Human pulls at blanket. Cat and human play tug of war.
NR8	Positive	Overt	Human open and closes hand near cat's face and paws. Cat grabs hand with front paws (claws sheathed) then lets it go and softly batts at hand. This repeats. Cat gently chews hand occasionally. Ears are forward and up, body is relaxed.
LFJ	Positive	Overt	Cat in a crouch position, eyes focused on toy, performs pre-pounce butt-wiggle and pounces on toy.

Training and Control Video Scripts:

For access to training or control video links, please contact the research team directly.

Training Video Script:

While some cat behaviours can be subtle, if you look at the whole picture, your cat's communication can be very clear. Here are some behaviours that mean your cat is saying No or Stop. If your cat is hissing, they are uncomfortable and giving a clear warning for you to stop. If your cat bites you with speed and force, immediately stop. This is different to play biting which is slower and gentle. A swipe or scratch that is fast and forceful is also a clear No. If your cat is flinching or avoiding your touches, leaning their body away or moving to another area, they do not want to interact. Ears held flat down or tight against the head may mean your cat is uncomfortable. On the other hand, these are some behaviours that mean your cat is saying yes! Or that they're feeling playful. If your cat is bringing you their toys or headbutting or pawing at you to get your attention, they might be trying to initiate play. If your cat is actively engaging in the play session, by moving toward you, batting a toy back at you, keeping their focus on you or the toy or otherwise keeping the play going, it's a good sign they are enjoying themselves. A relaxed cat will have ears that are forward facing and up. It can be hard to tell what a cat's tail movements mean. A flicking cat tail can mean the cat is curious about the interaction or it can mean that they are progressively getting overstimulated. It's best to keep an eye on the tail and if its swishing becomes faster or more aggressive, take it as a sign to back off. Remember, it's important to look at the whole picture. One behaviour or body part alone isn't enough to tell us how a cat is feeling. We need to look at the whole cat, all their body parts, their sounds as well as context clues like whether they are hiding away or looking loose and relaxed. Watch the whole cat, and you can have a pretty good idea of whether your furry friend is in the mood for a play.

General Cat Care Script:

People often think of cat's as low maintenance pets. But, just like dogs, cats need regular care and interaction to be happy in our homes. Here is a crash course on the basics of setting up your home to be an enriching environment for your cat. Provide your cat with access to fresh water at all times. Feed them a balanced and complete diet (you can speak to your vet about what's best for your cat). Try to provide at least 1 litter tray per cat, plus one for the household. Litter trays should be set up somewhere quiet, easily accessible and away from

food and water. Be sure to scoop waste from the box daily, replace the litter at least weekly and, wash the tray itself in a mild detergent as needed, but at least once a month. Cats need to be able to express their normal behaviours while in a human home. If they can't express these behaviours, cats can become stressed, and this can lead to behaviour problems or illness. Some natural behaviours for cats are scratching and playing. If cats aren't given appropriate opportunities to express these behaviours, it can mean that they express them in less desirable places (like scratching your furniture). To avoid this, be sure to provide your cat with a suitable scratch post. Ideally one that is big and sturdy enough for them to rest their whole bodyweight against. Keep a few toys around the house that your cat can play with. But only keep a few toys out at a time, rotating different toys weekly. Rotating toys keeps your cat entertained and helps to avoid boredom. Keeping items like boxes around the house can also provide your cats with a place to play or sleep. Cats also benefit from your company. So, try to spend some time daily with your cat in ways that you both enjoy. Whether that's playing, petting, or just spending time next to each other. Even short moments of connection help keep your cat feeling comfortable in your shared space. And finally, remember to take your cat to the vet for regular check-ups and advice. Follow these basic tips and you will have all the starting ingredients for a very happy environment for your cat.

Consent

Please note: this survey is best viewed on a desktop or laptop but a mobile phone may also be used.

This survey has sound elements that will require the volume to be up on your device.

The survey will take approximately 20 minutes to complete.

Participant information:
Project title: Do you speak cat? Assessing Human Recognition and Response to Feline Play Cues
Human Research Ethics Committee (HREC) approval number: H-2025-072
Principal investigator: Susan Hazel Student researcher: Julia Henning
Student's degree: PhD Veterinary Science

Dear Participant, You are invited to participate in the research project described below.

What is the project about? This research project aims to assess human perception and identification of cat behaviours cues.

Who is undertaking the project? This project is being

conducted by Susan Hazel, Julia Henning, Torben Nielsen and Peter Atkinson. This research will form the basis for the degree of PhD in Veterinary Science at the University of Adelaide under the supervision of Susan Hazel.

Why am I being invited to participate? You are being invited as you are over 18, currently reside within Australia, are fluent in English, have internet access and have indicated your interest in completing the survey by clicking this link.

What am I being invited to do? You are being invited to complete a short survey where we will ask you some questions about yourself, present you with a short informative video on cats and ask you to categorise cat behaviours from a series of short sample videos.

How much time will my involvement in the project take? The survey should take approximately 20 minutes.

Are there any risks associated with participating in this project? Some videos included in the survey may show cats experiencing minor distress, this may be distressing to look at, though care has been taken to ensure that videos are short and do not contain any graphic material. If you feel uncomfortable at any time, you can withdraw from the study by clicking out of the survey.

What are the potential benefits of the research project? This research may result in greater understanding of human capabilities when interpreting cat behaviour. This information could be used to inform educational materials as well as vets and behaviourists to empower cat guardians to better understand and respond to their cat's behaviour signals, leading to greater cat welfare and a stronger human-animal bond.

Can I withdraw from the project? Participation in this project is completely voluntary. If you agree to participate, you can withdraw from the study at any time by simply clicking out of the survey.

What will happen to my information? All information collected and stored in the survey will be anonymous and non-identifiable. An anonymous survey link is being used that ensures your IP address remains anonymous, so you can be assured your responses are non-identifiable. Non-identifiable, anonymous data will be retained for 5 years from the date of the last publication by Susan Hazel in a secure box account. accessible by Susan Hazel, Julia Henning, Torben Nielsen and Peter Atkinson. Box accounts are encrypted and require multi-factor authentication to ensure your data is protected. This box account will only be accessible by Susan Hazel, Julia Henning, Torben Nielsen and Peter Atkinson. Findings from this study may be published in a book, journal article, thesis, news article,

conference presentations, website and/or report. Only unidentifiable summary data will be included in publications. Data may be used in future studies. If there is a valid request, data will be shared within the research group or with internal or external researchers Data will be retained/shared for up to five years after the date of last publication The data custodian, Susan Hazel, will be responsible for approving any sharing of data collected during this study. Sharing or re-use of non-identifiable data from this study will not be subject to further review by a Human Research Ethics Committee. Participants can request a summary of the findings by providing their email address at the end of the survey or by emailing the researchers (julia.henning@adelaide.edu.au or susan.hazel@adelaide.edu.au). Your information will only be used as described in this participant information sheet and it will only be disclosed according to the consent provided, except as required by law.

Who do I contact if I have questions about the project? Julia Henning can be contacted at julia.henning@adelaide.edu.au Susan Hazel can be contacted at susan.hazel@adelaide.edu.au Has this study been approved by a Human Research Ethics Committee? The study has been approved by the Human Research Ethics Committee at the University of Adelaide (approval number H-2025-072). This research project will be conducted according to the NHMRC National Statement on Ethical Conduct in Human Research 2023.

What if I have a complaint or any concerns? If you have complaints or concerns regarding the survey, you can contact the research team: Name: Julia Henning Email: julia.henning@adelaide.edu.au

Insurance and Compensation: The study has been indemnified by The University of Adelaide which is enforceable by a participant to seek compensation in addition to your right to seek compensation under the common law through the legal system in legal proceedings. Complaints If you wish to speak with an independent person regarding concerns or a complaint about this study, the University's policy on research involving human participants, or your rights as a participant, please contact the Human Research Ethics Committee's Secretariat on: Phone: +61 8 8313 6028 Email: hrec@adelaide.edu.au Post: Research Services, Level 3, Rundle Mall Plaza, 50 Rundle Mall, ADELAIDE SA 5000 Any complaint or concern will be treated in confidence and fully investigated. You will be informed of the outcome.

If I want to participate, what do I do? Continue & complete the survey below

Yours sincerely, Assoc. Prof Susan Hazel, Julia Henning, Dr. Torben Nielsen and Dr. Peter Atkinson.

CONSENT FORM

1. I am over 18 years of age and agree to take part in the following research project: Title: Do you Speak Cat? Ethics Approval Number: H-2025-072.
2. I have had the project, so far as it affects me, and the potential risks and burdens fully explained to my satisfaction by the research worker. I have had the opportunity to ask any questions I may have about the project and my participation. My consent is given freely.
3. Although I understand the purpose of the research project, it has also been explained that my involvement may not be of any benefit to me.
4. I agree to participate in the activities outlined in the participant information sheet.
5. I understand that I can withdraw from the study at any time up until submission of the survey
6. I have been informed that the information gained in the project may be published in a book, journal article, thesis, news article, conference presentations, website and/or report etc.
7. I have been informed that in the published materials I will not be identified and my personal results will not be divulged.
8. I agree to my information being used for future research purposes as follows: Research undertaken by these same researcher(s) or in research undertaken by

any researcher(s)
9. I hereby provide 'unspecified' consent for the use of my data or tissue in any future research.
10. I understand my information will only be disclosed according to the consent provided, except where disclosure is required by law.
11. I am aware that I should keep a copy of this Consent Form, when completed, and the attached Information Sheet.

If I want to participate what do I do? Submission of your survey responses is considered as your consent to participate in the survey and that you have read and understood the above information. If you wish to speak with an independent person regarding concerns or a complaint, the University's policy on research involving human participants, or your rights as a participant, please contact the Human Research Ethics Committee's Secretariat on: Phone: +61 8 8313 6028 Email: hrec@adelaide.edu.au Post: Level 4, Rundle Mall Plaza, 50 Rundle Mall, ADELAIDE SA 5000 Any complaint or concern will be treated in confidence and fully investigated. You will be informed of the outcome. If you would like to keep a copy of this research project information sheet and consent form, please email the researchers Dr. Susan Hazel (susan.hazel@adelaide.edu.au) or Mrs. Julia Henning (julia.henning@adelaide.edu.au). I have read the above information sheet and agree to take part in the research project: Do you speak cat? Assessing Human

Recognition and Response to Feline Play Cues (HREC approval #H-2025-072).

Do you agree to participate?

- ○ I agree to participate
- ○ I do not agree to participate

Please confirm:



Demographics

In which state or territory of Australia do you currently reside?

- ○ South Australia
- ○ Western Australia
- ○ Victoria
- ○ New South Wales
- ○ Queensland

- ○ Tasmania
- ○ Northern Territory
- ○ Australian Capital Territory

What is your gender?

- ○ Non-binary
- ○ Female
- ○ Male
- ○ Prefer not to say
- ○ [ ] Prefer to self-describe (below):

What is your age group?

- ○ 18-24
- ○ 25-34
- ○ 35-44
- ○ 45-54
- ○ 55-64
- ○ 65+

How many years have you lived with cats? (If you have never lived with cats please select 'none')

○ _____ Please specify number of years

○ None

How many cats do you currently live with?

○ 0

○ 1

○ 2

○ 3 or more

Do you have any relevant previous experience in cat behaviour? Please select all that apply

☐ Veterinarian

☐ Vet tech

☐ Vet nurse

☐ Shelter worker

☐ Shelter volunteer

☐ Fostering cats

☐ Behaviourist

☐ Animal Trainer

☐ Breeding or showing cats

☐ Animal management work

☐ _____ Other (please specify)

☐ None of the above

In what situations might you be concerned about a cat injuring you or someone else? Select all that apply

- [ ] I do not worry
- [ ] During play sessions
- [ ] Picking them up/holding them
- [ ] At the vet
- [ ] Giving them medication
- [ ] Bathing them
- [ ] When sleeping
- [ ] When they're on my lap
- [ ] Feeding them
- [ ] Touching a cat on the street
- [ ] Touching a friend's cat
- [ ] If they're unsupervised with my child
- [ ] Grooming a cat
- [ ] Other (please specify) _____

Instructions

Next you will be shown some videos of cats interacting with humans.

These videos are short (5-15 seconds) and will require

concentration.

After watching, you will be asked to categorise the videos as positive or negative based **only** on the cat's behaviour.
Please ignore the human's behaviour when selecting your answers.

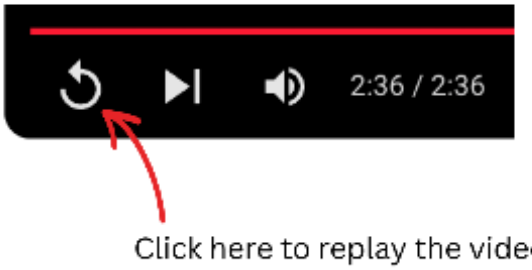
Categories:
Overall positive interaction: The cat exhibits a positive response to the human or interaction. The cat may seem attentive, engaged or appear to enjoy the interaction with the human.

Overall negative interaction: The cat exhibits a negative response to the human or interaction. The cat may seem uninterested, avoidant, fearful, or like they wish to stop the interaction.

If you are unsure you can select **"I'm unsure".**
There are no right or wrong answers to the following questions. Results are not identifiable.

Please ensure your volume is up.
Note: some videos have sound while others do not.

You may watch the videos as many times as you like before answering any questions.
Simply press the replay button after the video finishes:



Pre-Training



Please watch the video in full and then answer the

following questions

Imagine yourself in the video you just watched. Based on the cat's behaviour, how would you interact with the cat? (please select all that apply)

- [ ] Stroke the cat
- [ ] Rub the cats belly
- [ ] Pick the cat up
- [ ] Play with the cat with a toy
- [ ] Discipline/correct the cat (please specify how)
- [ ] Play with your hands (e.g. rough and tumble play)
- [ ] Walk away from the cat
- [ ] Stay near the cat but not interact
- [ ] The video did not load
- [ ] Other (please specify)

Based **only** on the cat's behaviour in the video, please categorise the interaction as one of the following:

- ○ Overall positive interaction
- ○ Overall negative interaction
- ○ I'm unsure
- ○ The video did not load

What cat body language or cat behaviour helped you decide if the interaction was positive or negative? (you can give up to three behaviours e.g., hissing, pouncing on toy, ears forward).

Please pick the emotion that **best** describes how the cat was feeling in the video you just watched.

- ○ Happy
- ○ Curious
- ○ Frustrated/Annoyed
- ○ Angry
- ○ Relaxed
- ○ Bored/Uninterested
- ○ Stressed
- ○ Playful
- ○ Scared/Threatened
- ○ Other (please specify)



Please watch the full video and then answer the question below:
Note: the 'next' button is on a timer and will not appear until the end of the video at normal speed.

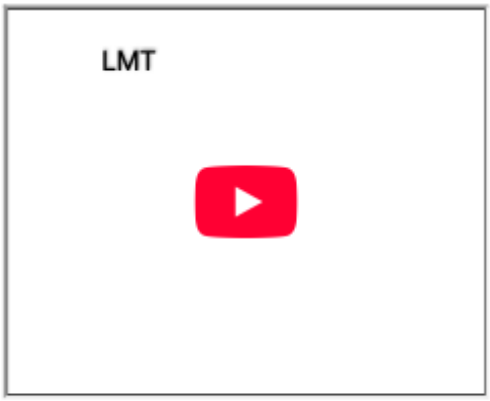
- ○ I watched the full video
- ○ I watched some of the video
- ○ I did not watch the video

Post-Training

You will now be shown a second set of videos.

Please note that some videos have sound while others do not have any audio.

You may watch the videos as many times as you need before answering.



Please watch the video in full and then answer the following:

Imagine yourself in the video you just watched. Based on the cat's behaviour, how would you interact with the cat? (please select all that apply)

- [ ] Stroke the cat
- [ ] Rub the cats belly
- [ ] Pick the cat up
- [ ] Play with the cat with a toy
- [ ] Discipline/correct the cat (please specify how)
- [ ] Play with your hands (e.g. rough and tumble play)
- [ ] Walk away from the cat
- [ ] Stay near the cat but not interact
- [ ] The video did not load

☐ Other (please specify)

Based **only** on the cat's behaviour in the video, please categorise the interaction as one of the following:

- ○ Overall positive interaction
- ○ Overall negative interaction
- ○ I'm unsure
- ○ The video did not load

What cat body language or cat behaviour helped you decide if the interaction was positive or negative? (you can give up to three behaviours)

Please pick the emotion that **best** describes how the cat was feeling in the video you just watched.

- ○ Happy
- ○ Curious
- ○ Frustrated/Annoyed
- ○ Angry

- ○ Relaxed
- ○ Bored/Uninterested
- ○ Stressed
- ○ Playful
- ○ Scared/Threatened
- ○ [ ] Other (please specify)

Follow up questions

Please rate from 0-100 your current confidence in your ability to read and understand cat body language

0 10 20 30 40 50 60 70 80 90 100

Confidence level [ ]

Thank you for your time, is there anything else you would like to tell us?

[ ]

Chapter 7: Exploring Viewer Perceptions of Videos Depicting Cat-Dissented 'Play' and Their Potential to Contribute to Harmful Interactions

Context Statement

Chapter 7 continues to explore Aim 2 (guardian perspectives of play). However, the lens of this exploration directs focus on how guardian perceptions may contribute to poor cat welfare. The present Chapter follows from the findings of Chapter 6, which identified both a worrying lack of recognition of negative behaviours and a disconcerting gap between recognition of a cat's negative state and responding appropriately to that state. Chapter 7 investigates this gap through the human perspectives and beliefs that may contribute to it. To explore these perspectives in an unfiltered form, a study of comments on social media videos was devised using reflexive thematic analysis. Eleven videos of human-cat interactions that had been self-identified by the uploader as 'play', and that included a cat displaying observable dissent behaviours were identified on social media. The first 100 comments on these videos were then collected and assessed for their overall sentiment (supportive, critical, neutral or unclear). Comments in support of, or neutral to, the interaction contained in the video were then included in the analysis. Nine themes emerged demonstrating patterns of misinterpretation and rationalisation in viewer perceptions that may contribute to normalising or justifying negative human-cat 'play' interactions. Building on from Chapter 6, Chapter 7 demonstrates that, beyond simple inability to recognise negative behaviours, the choice to interact with cats in a negative state may be influenced by an individual's beliefs or perceptions. This Chapter highlights how individual and societal perceptions of human-cat play can have serious consequences for cat welfare, considers the potential mechanisms behind these perspectives, and how they may create barriers to human behaviour change. The implications of these findings, for future educational interventions aimed at improving human-cat play interactions, are discussed.

This Chapter has been submitted for publication to Anthrozoos and is in the format for this journal.

Statement of Authorship

Statement of Authorship

Title of Paper	Exploring Viewer Perceptions of Videos Depicting Cat-Dissented 'Play' and Their Potential to Contribute to Harmful Interactions
Publication Status	☐ Published ☐ Accepted for Publication ☒ Submitted for Publication ☐ Unpublished and Unsubmitted work written in manuscript style
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Principal Author

Name of Principal Author (Candidate)	Julia Henning
Contribution to the Paper	Conceptualisation, Data curation, Formal analysis,Investigation, Methodology, Project administration, Resources, Software, Validation, Visualisation, Writing –original draft, Writing – review and editing.
Overall percentage (%)	70%
Certification:	This paper reports on original research I conducted during the period of my Higher Degree by Research candidature and is not subject to any obligations or contractual agreements with a third party that would constrain its inclusion in this thesis. I am the primary author of this paper.
Signature	Date 02/10/2025

Co-Author Contributions

By signing the Statement of Authorship, each author certifies that:

i. the candidate's stated contribution to the publication is accurate (as detailed above);

ii. permission is granted for the candidate in include the publication in the thesis; and

iii. the sum of all co-author contributions is equal to 100% less the candidate's stated contribution.

Name of Co-Author	Susan Hazel
Contribution to the Paper	18% Conceptualisation, Data curation, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Writing - review and editing.
Signature	Date 14/10/25

Name of Co-Author	Torben Nielsen
Contribution to the Paper	12% Conceptualisation, Data curation, Investigation, Methodology, Resources, Supervision, Validation, Writing - review and editing.
Signature	Date 14/10/25

Please cut and paste additional co-author panels here as required.

Exploring Viewer Perceptions of Videos Depicting Cat-Dissented 'Play' and Their Potential to Contribute to Harmful Interactions

Julia Henning, Torben Nielsen and Susan Hazel

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No potential competing interest is reported by the authors

Abstract

Human-cat play interactions may provide valuable opportunities for increasing cat welfare and strengthening the human-cat bond. However, these benefits only apply if both parties are assenting to the interaction, otherwise, the play risks causing stress and potential injury to either party. Online videos of human-cat dyads tagged as 'play' often include visible cat discomfort, raising questions about how uploaders and viewers perceive cat dissent within play interactions. The present study aimed to explore themes in how viewers interpret and justify human-cat play interactions despite visible signs of cat distress. Eleven publicly hosted online videos of human-cat interactions, self-identified by the uploader as 'play', in which the cat is displaying dissent behaviors, were included in the study. Video comments were analyzed inductively using reflexive thematic analysis and video contents were observed and described. Nine major themes emerged: 1) If they didn't like it, you would know – believing 'real' distress would be obvious, 2) Lost in translation – misconceptions about cat body language and preferences, 3) They just get it – assuming trust and understanding 4) You'll win them over – pushing through dissent to establish bonding, 5) "That's cat love" – reframing dissent behaviors, and human tolerance of them as expressions of love, 6) Satisfying the killer inside – fulfilling cat predatory needs with rough play, 7) …But it's cute – Overlooking dissent because of aesthetic 'cuteness', 8) Just having a laugh – finding humor in cat displeasure, and, 9) "Karens take a seat" – defensive reactions to external criticism. As play is increasingly promoted by advocates and practitioners as a tool for human-cat bonding and feline enrichment, our findings highlight a critical need for educating the public about recognising, and more crucially, respecting cat dissent, as well as cat preferences for touch and interaction and the serious human health risks of cat bites and scratches.

Keywords

Cat welfare, human-animal interactions, human-cat play, bite prevention, human-animal bond

Introduction

Domestic cat welfare is highly susceptible to human influence. This is especially true for human-cat interactions, where regular positive interactions may be protective of welfare while repeated negative interactions may have detrimental effects (Mellor et al., 2020; Rault et al., 2020). Play is a human-animal interaction with particular potential for maintaining and improving cat welfare and supporting the human-cat bond (Henning et al., 2022). The mechanisms behind this are multifaceted. Current literature suggests that play supports neurological development of critical social skills (Guyot et al., 1980; Yogman et al., 2018), is intrinsically rewarding (Vanderschuren, 2010), generates opportunities for shared experiences that may strengthen social bonds (Busia & Griggio, 2020) and, requires metacommunication about behaviours that, in different contexts, could be interpreted as aggressive (Bekoff & Allen, 2012)

Because of this, in recent years, play interactions have been recommended as an important element for responsible cat care (Delgado, 2024). However, it is important to emphasise that play is only beneficial for welfare if it is perceived as play by both parties (Burghardt, 2005). That is, in some situations, a person may believe an interaction is play, while their cat may instead find the interaction distressing. In such situations, play, intended as enrichment, may instead negatively affect cat welfare and increase the risk of human injury. It is therefore important that people are aware of cat preferences and the necessity for recognising and

respecting cat choice within an interaction. The ability to agree, or refuse, to participate in an interaction is a concept that may fall under the terms 'consent', 'assent' or 'dissent'. Several researchers have presented arguments as to why 'consent' should not be used within animal research (Braun, 2025; Healey & Pepper, 2021), citing an inability of animals to exercise or waive rights, to conceptualise or anticipate the consequences of doing so and, due to concern that applying 'consent' to animals may discharge humans of their responsibilities, leading to negative welfare outcomes (Braun, 2025; Healey & Pepper, 2021). Within this study, which focuses specifically on human-cat play interactions that can be one-off or repeated, we choose to use the terms assent and dissent (Healey & Pepper, 2021) and define each below.

Assent: the cat displays observable behavioral signs of active and voluntary willingness to engage and continue in the play interaction *and* is in a state to freely exercise their agency. i.e. free of coercion or pressure and capable of dissenting to the interaction or leaving the interaction without challenge.

Dissent: At any time before or during the play interaction, the cat displays observable behavioral signs of refusing, attempting to end, or being uncomfortable within the interaction.

During an interaction, determining assent or dissent in a non-verbal species is generally based on observations of body language and vocalisations (Ellis, 2018; Healey & Pepper, 2021; Horowitz, 2021; Walsh et al., 2024). However, this relies on people being capable of objectively recognising cat behavioral cues. Previous research has shown that people struggle to correctly interpret cat communication, with ability highly variable between individuals

(Dawson et al., 2019; Graham et al., 2024, Henning et al., 2025), though most people generally perform above chance (de Mouzon et al., 2024; Graham et al., 2024; Henning et al., 2025). A potential reason for human difficulty in recognising cat signals is the subtlety of some cat behaviors (Ellis, 2018; Martin, 2023). However, while some of their behaviors may be subtle, cats, like humans, have a broad repertoire of behavioral cues and are highly capable communicators, especially in contexts like physical interactions, where communication may be vital for survival (Bradshaw, 2016; Brown & Bradshaw, 2014; Penar & Klocek, 2018). Further, there is considerable evidence to suggest that cats specifically alter their cues to be understood by a human audience (McComb et al., 2009; Yeon et al., 2011; Turner, 2017, Scholtz et al., 2019; Tavernier et al., 2020; Quaranta et al., 2020). Considering this capability, along with the fact that many cat dissent behaviors are overt, such as hissing, and biting with force, cat dissent should be recognisable to most people. However, recognition alone may not prevent unwanted interactions. In a recent study, 40% of participants reported they would interact with a cat in a negative state, even when they recognized that the cat was feeling negatively about the interaction (Henning et al., 2025). Of further concern, a considerable number of these participants specifically chose to engage in high-risk interactions such as stroking, playing with bare hands or rubbing the cat's belly despite the cat displaying overtly negative signals such as hissing (Henning et al., 2025). These findings raise important questions about why a human would persist in an interaction despite recognising cat dissent cues and what human cognitions may contribute to these unwanted play interactions.

Unwanted interactions are commonly observed in videos of cats posted online (Stumpf et al., 2024). Online cat videos may therefore present an opportunity for a natural study of people's

perceptions of human-cat interactions. In 2015, over 2 million cat videos were posted on YouTube (Marshall, 2015), a number now sitting at 35 million for the hashtag #cat alone (YouTube.com, 2025). Previous research indicates that cat videos provide viewers with a mechanism for emotional regulation, act as a means of procrastination (Myrick, 2015) and evoke pleasure from observing cats in an uninhibited state (O'Meara, 2014). However, not all cat videos depict positive interactions. A concerning proportion of online animal videos, intended for amusement, contain animal suffering (Stumpf et al., 2024), with one recent study observing stress reactions in 82% of companion animal videos intended to be funny (Kühnöhl et al., 2025). In some cases, viewers may not recognise this distress. For instance, in Stumpf et al (2024), only 46% of participants noticed animal suffering in videos. Distress may also become part of the appeal, with a disturbing minority of viewers seeming to enjoy and, in extreme cases, commission videos of animal cruelty, especially against cats (SMACC, 2021). While graphic examples of animal cruelty may generate viewer concern, less obvious mistreatment may be more insidious, contributing to harmful interactions through a social media landscape that encourages sharing and imitation of popular content and generates online echo chambers of similarly minded people, where rough handing of, or harmful interactions with, companion animals may become normalized (Volker & Fels, 2021). Because of this, cat videos may serve as both a reflection of, and contributor to, problematic human-cat interactions. However, little is known about the specific perceptions and beliefs that may contribute to unwanted human-cat interactions both online and in-person. Viewer perceptions of such videos may offer valuable insights into this issue.

The aim of this study was to qualitatively analyze the comments on online videos that support interactions despite the cat observably dissenting to a human-play interaction.

Through these comments, the present study explores how viewer perceptions, beliefs and cognitions relate to real world human-cat interactions, and how these views may contribute to, or normalize, potentially harmful play interactions.

Methods

Ethics Statement

Ethics approval was granted through the University of Adelaide's Human Research Ethics Committee (approval number: HREC/HRE/2025/0322(v3).

Data collection

The present study analyzed viewer comments on publicly hosted online videos of human-cat dyad 'play' interactions. To avoid inclusion of AI generated videos, only videos uploaded between 2018 and 2023 were considered for inclusion in the study. Data collection involved identifying videos on YouTube, TikTok, Instagram and Facebook that met the following inclusion criteria: 1. The video depicts a human-cat interaction. 2. In order to determine that the interaction had been perceived as 'play' by the human involved, the video needed to have been categorised by them as 'play' through either the video's title, description or hashtags. 3. In order to determine that the interaction was unwanted, the cat in the interaction needed to be observed to display one or multiple dissenting behaviors as detailed below and in Table 1. 4. In order to determine human persistence in an unwanted interaction, the human needed to be observed to continue the interaction after the cat was observed to be dissenting and 5. In order to ensure the viewers had ample opportunity to recognise cat dissent behaviours, the cat needed to be visible for at least 95% of the video. Search terms included: "playing with my cat", "cat playing with me", "cat playing with owner", "cat playing with human" "play

fighting with my cat" and "cat wants to play with me". Search results were filtered to show videos with the highest view count first. Results for each search term were checked until no further videos were available for a specific term, or until duplicate videos began to appear, suggesting a saturation point. Where a video met inclusion criteria, manual collection of video metrics and viewer comments was undertaken using Excel version 16.100.1 Video metrics included the number of views, number of likes, number of comments and year of upload. For data manageability, and to avoid videos with high numbers of comments disproportionately influencing analysis, only the first 100 video comments for each video were collected. Where videos had less than 100 comments, all comments were recorded. Finally, video contents were descriptively summarised (See Table 2) and assessed for cat and human maturity (adult or child), human gender and for environmental information (See Table 3). Demographic information for humans within the videos was assessed through uploader profiles or through visual assessment using physical anatomy, body proportions, facial proportions, secondary sexual characteristics and gender expression (e.g. clothing, hair, make-up). Cat maturity (adult or kitten) was assessed based on body size, build and coat characteristics.

Assessing dissent

For a video to meet the criteria of dissent, the cat in the video displayed one or multiple of the dissenting behaviors in Table 1. For behaviors that may be ambiguous (e.g., whiskers splayed forward and stiff, which could also indicate alertness or curiosity), and to avoid incorrectly classifying a cat as dissenting where their behavior could have an alternative explanation (e.g., licking nose due to dryness, or momentary alteration of hearing direction appearing as 'sideways' ears), multiple repetitions, or multiple different potentially ambiguous behaviors were needed to meet the criteria of dissent. Conversely, for unambiguous

behaviors such as hissing or struggling against restraint, any display was considered sufficient for constituting dissent.

Table 1: Observable behaviors that may indicate dissent in cats, as identified in the literature and within this study.

	Vocalisation	Face/Head	Body	Locomotion	Interactive
Unambiguous	Pain shriek (Tavernier et al., 2020) Hiss (Bennett et al., 2017) Yowl (Tavernier et al., 2020) Spit (Tavernier et al., 2020) Growl (Tavernier et al., 2020) Caterwauling (K. Vitale, 2022) Moan (Tavernier et al., 2020)	Whiskers held tight to cheeks (Martin, 2023) Ears pinned back (Martin, 2023) Swallowing in absence of food (Vitale, 2022) Baring teeth (Stanton et al., 2015)	Body stiffening (de Souza Dantas, 2025; Horwitz & Rodan, 2018) Tail tucked (Martin, 2023) Trembling (de Souza Dantas, 2025) Tail thrashing (Martin, 2023) Tail Slap (Stanton et al., 2015) Piloerection (Martin, 2023)	Attempting to escape [not restrained] (Gourkow & Phillips, 2015) Fleeing (de Souza Dantas, 2025) Hiding (Ellis, 2018) Walking away from interaction (de Souza Dantas, 2025)	Struggling against restraint (Rand et al., 2002) Uninhibited bite (de Souza Dantas, 2025) Uninhibited scratch (de Souza Dantas, 2025) Blocking touch [physically blocking touch with one or both front paws] (novel to this study)
Potentially Ambiguous		Whiskers splayed forward & stiff (Rodan et al., 2022) Ears flat & sideways (Ellis, 2018) Tucking head and neck (Ellis, 2018) Averting gaze (Rodan et al., 2022) Scan (Gourkow & Phillips, 2015) Fully dilated pupils (Vitale, 2022) Lip/nose lick (Moody et al., 2018) Rapid blinking or half blinking (Bennett et al., 2017)	Lower back rippling/twitching (de Souza Dantas, 2025) Flinch/Startle (Hague et al., 2013) Shaking off (Martin, 2023) Arching back (Martin, 2023)	Leaning away from modifier/dodging touch (Martin, 2023) Backing away (de Souza Dantas, 2025)	Immobilising hand [holding human hand still with two or more paws, claws protruded and/or with mouth and teeth] (novel to this study)

Descriptive Analysis

Video metrics, human and cat demographic information, environmental information and observations of human and cat behavior data was assessed through descriptive analysis in Excel version 16.100.1.

Coding of viewer comments

Prior to further analysis, all viewer comments were coded broadly as being support, criticism, neutral or unclear using the below criteria. This broad coding was undertaken in order to focus further analysis on supportive or neutral comments and to exclude comments that were critical or unclear. This choice was made in order to investigate the perceptions and beliefs thought most likely to contribute to harmful play interactions. Thus, after initial coding was completed, all viewer comments coded as criticism or unclear were excluded from analysis.

Support: the comment demonstrates support for the interaction through endorsement, affirmation or praise of the person or their choices within the video; admiration or enthusiasm for the interaction itself or for the bond between the human and cat; expresses amusement or pleasure at, or makes jokes about, the video content.

Criticism: the comment demonstrates criticism for the interaction through reproach, disapproval or condemnation of the interaction or the person's choices, expressing distress, anger or concern about the cat or human's mental or physical state or otherwise verbalises dislike for the interaction contained within the video.

Unclear: The intent of the comment was unclear, or the comment itself was incomprehensible.

Neutral: The comment included statements, questions or information with no clear sentiment.

Reflexive Thematic Analysis:

Reflexive thematic analysis (Clarke & and Braun, 2017) was applied to viewer comments coded as supportive or neutral to generate insights into viewer perceptions and attitudes and to report common themes, using the six-step process developed by Braun and Clarke (2006). The six phases were worked through and alternated between in a non-linear fashion as needed. *First phase:* researchers familiarised themselves with comment data over several days by actively reading viewer comments multiple times, speaking the comments aloud and then printing, compiling and displaying viewer comments visually for further comparison. During this phase, researchers noted observations of initial trends and flagged comments of interest. *Second phase*: Researchers generated initial shorthand codes from the content of the entire data set. Each shorthand code was highlighted in an assigned individual colour, for efficient coding and identification. To limit the imposition of pre-existing frameworks onto comment data, an inductive method of comment analysis was used (Clarke & and Braun, 2017). Analysis was conducted at both semantic and latent levels, using a fine-grained coding approach informed by a constructionist view. As codes evolved throughout this phase, tracked changes and previous iterations of code were regularly examined. *Third phase*: upon completion of coding, common themes were generated and then revised as needed by

collapsing similar themes together or splitting themes into distinct components. *Fourth phase:* From this, initial themes were then summarised, reviewed and further cross checked by the research team for suitability. Reviewing was undertaken by the research team, along with eleven members of the Animal Behavior, Welfare and Anthrozoology Lab (ABWAL) at the University of Adelaide. Where disagreement or emergence of new or altered themes occurred, backtracking through the six phases was undertaken prior to further review and cross-checking by the research team until full agreement was met. *Phase 5:* themes were named and defined to communicate the core of the theme with readability and clarity in mind. *Phase 6:* themes were tabulated and an explanation of each, with evidence provided through example quotes, was generated. Finally, the analysis process was evaluated against the 15-point checklist for good reflexive thematic analysis (Braun & Clarke, 2006) to ensure a thorough, systematic, and rigorous approach. Quotes were only shortened where necessary for protecting commenter anonymity or improving readability, while maintaining and respecting the original meaning. Where quotes have been shortened, a '[…]' is used.

Results

Eleven videos met inclusion criteria and were included in analysis (Table 2).

The percentage of supportive comments, within the first 100 comments on each video ranged from 75% (video H) to 93% (video G). In six of the eleven videos, less than 10% of comments expressed criticism (videos B, E, G, I and K). The highest percentage of critical comments was 19% (video H). Neutral comments were uncommon, ranging from 0% (videos D and G) to 4% (Videos B, C and K).

Table 2: Summary of online videos used for analysis and sentiment within the first 100 viewer comments or all comments where there were fewer than 100 comments as accessed between 13th-19th August 2025.

ID	Description of video	Likes	Total Comments	Viewer comment sentiment*			
				Support	Criticism	Neutral	Unclear
A	Man holding a cat and singing while cat attempts to escape from the hold.	80,000	7,545	79%	12%	2%	7%
B	Man holding hand out with fingers tensed and bent, mimicking a cat paw with claws out. Cat slaps, scratches and bites at hand.	76,000	7,513	90%	2%	4%	2%
C	Cat and woman are sitting on a bed. Cat is scratching and biting woman's arm. Woman pushes cat backwards by the throat, makes faces and yells at cat. Cat bites woman's arm again and jumps at woman's face. Woman continues 'teasing' faces and yelling.	18,000	294	82%	14%	4%	0%
D	Man makes erratic gestures with his hand in front of cat's face. Cat whines and attempts to leave. Man pushes cat around with hand, puts hand on cat's throat and pushes.	3,400	45	86%	12%	0%	2%
E	Woman pointing her finger in kitten's face and making repeated attempts to touch kitten. Kitten shows signs of distress. Woman continues to try and touch kitten.	1.9 million	10,700	92%	6%	1%	1%
F	Baby watching cat. Cat jumps at baby before trying to move away. Baby follows cat. Cat shows signs of distress and attempts to move away again. Parent in background vocally encourages baby to follow cat.	2.4 million	18,200	84%	11%	2%	3%

G	Man holds kitten in a mock human-standing position and uses hands to manipulate kitten's body to emulate 'dancing'. Kitten shows signs of distress but does not attempt to escape.	18.8 million	141,500	93%	1%	0%	6%
H	Baby touching and pulling on cat's tail. Cat moves out of baby's reach. Baby follows and attempts to grab cat's tail again. Cat bites baby. Baby flinches and looks toward parent who vocally encourages baby to keep engaging with cat.	17,800	1,150	75%	19%	2%	4%
I	Woman pushes down cat until they are in a flat, laying position. Woman repeatedly pokes, pushes, grabs and squishes the cat while the cat alternates between freezing and attempting to escape.	77,300	155	89%	1%	3%	7%
J	Woman and cat on a bed. Cat shows signs of distress. Woman raises hand over cat's head. Cat bites woman. Woman laughs before screaming and grabbing the cat by their chest fur and pushing them backwards with force.	3.1 million	13,000	77%	9%	3%	11%
K	Man approaches street cat and attempts to touch cat. Cat shows signs of distress and bites man. Man continues to try and touch cat.	164,000	14,060	84%	7%	4%	5%

*Sentiment only assessed for the first 100 comments on each video

Videos featured mostly adult humans (9/11, 81.8%), who were male (5/11, 45.5%) and were interacting with their own cat (10/11, 90.9%). Cats within videos were mainly mature (9/11, 81.8%). Most videos included human injury (7/11, 63.6%) and took place on a bed (5/11, 45.5%) or in a lounge room (5/11, 45.5%) (Table 2).

Table 3: Descriptive characteristics of demographics and context in eleven videos of human-cat 'play' interactions where the cat is not assenting.

Human gender	Male	5 (45.5%)
	Female	4 (36.4%)
	Unknown	2 (18.2%)
Human age	Adult	9 (81.8%)
	Child (Under 2)	2 (18.2%)
Cat age	Mature	9 (81.8%)
	Kitten	2 (18.2%)
Relationship*	Own cat	10 (90.9%)
	Unfamiliar cat	1 (9.1%)
Human injury**	Present	7 (63.6%)
	Not present	4 (36.4%)
Toy	Present	0 (0%)
	Not present	11 (100%)
Environment	On bed	5 (45.5%)
	In lounge-room	5 (45.5%)
	Outside	1 (9.1%)

*Relationship was assessed through the uploader's video description.

**Human injury included: Scratch to the hands or arms, scratch to the face, bite to the hand or arms, bite to the face and ranged from minor, superficial wounds to moderate, deep wounds with visible tearing or puncturing of skin and observable blood.

Themes:

Based on reflexive thematic analysis of viewer comments, nine themes were developed (Table 4). These themes varied in complexity, reflecting differences in how participants described and made sense of the videos and their own related experiences. Most themes were

conceptually cohesive and are therefore presented without subthemes, whereas one theme encompassed multiple, distinct but related patterns of meaning and is therefore organised into subthemes to add clarity.

Table 4. Themes and their definitions for public perceptions surrounding cat dissent in human-cat 'play' interactions

Theme	Description
If they didn't like it, you would know	The belief that cats experiencing genuine distress would display more obvious or dramatic behaviors, leading to dismissal of existing distress cues as not meeting the threshold for "real" objection.
Lost in translation	Sub theme: Missing the point Human misconceptions about cat body language and behavioral cues that may reinforce inappropriate play interactions. Sub-theme: They love it! Viewer misperceptions that have become entrenched beliefs about cat play preferences.
They just get it	Viewer perceptions of cat capacity to understand human intentions, play "rules", and/or limitations, and belief that cat understanding negates the possibility of the interaction being harmful.

You'll win them over	The perception that continuing a negative interaction is necessary or justified in order to create a bond with the cat.
"That's cat love"	The belief that aggressive behaviors from cats are expressions of love, that enduring harm from these behaviors demonstrates the human's genuine affection for the cat, and the perception that accepting or romanticising these dysfunctional dynamics is an inherent part of what it means to love a cat, often given in combination with misogynistic language.
Satisfying the killer inside	The belief that cats have innate predatory/aggressive drives that require or justify rough play.
…But it's cute	Overlooking signs of cat stress, mistreatment, or potential risk to the human because of the perception that the interaction or the cat itself is 'cute'.
Just having a laugh	Perception of the interaction, and/or the cat's visible displeasure within the interaction, as amusing, funny or enjoyable.
"Karens take a seat"	Viewer belief that any criticism of the interaction was misplaced, illogical or overblown, generally comments were defensive in nature and used

	language designed to outcast and mock the other viewer.

If they didn't like it, you would know

This theme captures a belief that genuine cat distress would be unambiguous, leading viewers to dismiss dissent cues as insufficient evidence of harm. *"Any cat owner will know the difference between aggression and play".*

For some commenters, dismissing signs of dissent was justified by the belief that if a cat did not want to be in an interaction, they would leave:

"I've 4 cats & if one of them didn't want to play they wouldn't stay!".

This belief persisted even when signs of cat distress or potential risk to the human were recognised:

"This cat is playing and not aggressive. She has her claws in. Yes, that's a common occurrence. It was the same with us. If she didn't want to, she'd run away. But everyone here knows so well."

Other viewers justified their interpretation based on a perceived lack of serious human injury, reasoning that the cat was 'holding back' or not using their full strength in the attacks:

"The way you know the cat is just playing is that when his leg claws are pitter pattering on you-they are NOT literally ripping your arm to shreds, because... yeah, that is the grapple move they know instinctively... and he is holding that back. For you. Kinda sweet".

Viewers often perceived that a cat was 'holding back', even when videos included a visible human injury:

"If they were really mad your arm would be dripping blood".

Blood was often used by viewers as a determinant of whether an interaction was play or not:

“That was a nibble, no blood no bite. If that cat was angry, you'd be running”.

In videos depicting a human injury with visible blood, the discourse shifted to the amount of blood or the degree of damage:

“*She's excited, but still definitely in control. Ever see a carnivore kill its prey and bite through the bones? If she really wanted to bite you, your hand would be a shredded bloody pulp”* .

Though some commenters seemingly recognised, at least partially, that the cat was dissenting, many still dismissed the seriousness of these dissent cues because they didn’t meet their pre-conceived threshold of what ‘true’ dissent would look like:

“This is the "warning" attack, kind of half hearted just to let you know he's dangerous. The full on attack is very different and can leave you very bloody in seconds” .

Lost in Translation

This theme was organised into two subthemes that reflect distinct but related forms of misinterpretation of cat behavior: failures to recognize cat dissent cues as such, and entrenched misinterpretations about cat behaviors or preferences.

Sub theme: Missing the point

In contrast to the previous theme, where viewers dismissed or rationalized away *recognized* distress signals, within the present theme viewers struggled to perceive signals as distress in the first place, and often fundamentally misinterpreted cat behaviors entirely. Some viewers used specific behaviors as examples of a happy or playful cat that, in reality, are examples of a distressed or dissenting cat. For example, tail wagging and pinned back ears in cats are two behaviors commonly used as distinct indicators of stress in cats (Martin, 2023): *"His tail is*

wagging, meaning he's happy" and *"I love it when the ears go back like wasp wings -- they mean business!"*.

In other comments, viewers reflected on their own cats, correctly identifying some behaviors indicative of dissent, while failing to recognise others:

"He would be very excited, flick his tail around, ears back, but no raised fur or vocal threats - It was JUST for fun".

Sub-theme: They love it!

Some viewers demonstrated misinterpretations that had become underlying beliefs about how cats like to play, such as believing that some cats fundamentally enjoy rough play interactions:

"Some cats like this kind of play. People who don't understand cat behaviour would say it's violent and threatened for its life".

Viewers often used their own cats as evidence in support of this belief:

"*I used to play with my cats just like this! They loved it!"*.

Other viewers demonstrated an ability to recognize a risk to the human, while still overlooking the possibility of risk to the cat based on their belief that the cat "enjoys it":

"I use a special pair of gloves when fighting with one of my cats. he gets really brutal, but he enjoys it, and in the end, he gets some treats and we're friends again".

They just get it

This theme encompasses viewer perceptions around cat capacity to understand a human's intentions, 'rules' and limitations, and that cat understanding of these factors negated the possibility of harm, because the cat would 'know' that the interaction was play. For instance,

viewers assumed that cats who had bonded, or established trust with a specific human would understand when that human was playing and that, because of this, the cat would not find the interaction distressing or harmful. Based on this assumption, behaviors from cats that would be interpreted as dissent in another scenario (e.g. biting a stranger) were instead dismissed or reinterpreted as the cat being playful, playing pretend or 'having fun'.

"This cat was just being a brat and having fun with the guy because he trusts him and is happy to see him".

Viewers also perceived that cats were able to infer the (viewer-perceived) good intentions of the human in the video. This assumed capability was subsequently used by viewers to justify the interaction as non-harmful, overlooking the possibility that cats may still experience distress during an interaction regardless of a human's perceived or actual intent i.e., a cat may recognise that a familiar human is engaging in play while nonetheless finding the interaction aversive.

"They're not really mad though because they know it's you and not a real threat"

"Animals that were socialized understand the difference between play fight and violence" .

For some, this perception of cat capacity extended to include cats understanding and following specific 'rules' around play.

"*100% like my cat did [laughing face emoji] [heart emoji]... we had an arrangement, in these situations he was allowed to "play".. But when I grabbed his leg and hold it, he stopped and licked my hand, like he wants to say 'Ok sorry this was a little bit too much, let's stop..'".*

Others marvelled at the perceived ability for cats to recognise human physical differences and understand the need to curtail or alter their play to avoid harming their human playmate.

"It's cool that he knows to use just enough force to not make me bleed"

"It's so astonishing how animals know to be gentle with babies" .

You'll win them over

This theme captures the viewer perception that continuing with a negative interaction is beneficial, necessary or justified in order to establish a level of trust or bonding with the cat.

"You'll need to be patient & you will win him over"

Some viewers believed perseverance with negative interactions would assist in convincing a cat to 'love' you.

"My cousin taught me how to make even the most vicious cat love you: react to their bites or scratches like nothing happens, continue to pet them and show no pain. I saw crazy cats tore his arms apart, blood everywhere, getting so confused, and became his best friends in matter of hours. You will need iodine though".

Cat dissent behaviors were often assumed to be due to previous mistreatment or abuse. This assumption was subsequently used to explain a cat's behavior or to support or justify the human's choice to persevere in the unwanted interaction.

"…I don't think she's mad, I think she was abused ..poor thing"

"He's just testing you out in a way that cats do when they got trust issues".

Viewers often referred to their own cat's history as proof that others should engage in similar interactions if they wanted to gain a cat's trust.

"We adopted an aggressive cat more than a decade ago. I don't know his story before the adoption, but probably he came from a family where he was abused by children and his aggression was most likely a reason he ended up at the [shelter name]. He would scratch and bite us when something wasn't to his liking. The only way to stop this behavior was not to withdraw your hand and let him bite. Eventually, since this wasn't a chase anymore, he lost interest in biting. He turned into the best cat we ever had"

“That’s cat love”

This theme illustrates a pattern in viewer comments where cat dissent behaviors (e.g., biting and scratching), human tolerance of these behaviors, and the dynamic interplay of these two factors, was recontextualised and romanticised as examples love or a loving relationship:

Here, viewers believed that aggressive behaviors from cats were expressions of love:

“All cats do this, that's cat love”.

In particular, visuals of cats biting were often rationalized as a cat trying to show affection:

“This is called ‘Love bites’ and is pretty much another way for cats to show affection”.

Viewers also interpreted a human enduring pain from these behaviors as a demonstration of genuine affection, or evidence of a human’s love for the cat:

“We can see a true cat lover when he/she got scratched to the blood every-where on the hand and arm and still pet the cat tenderly afterward.”

Interactions where cats inflicted pain and humans tolerated it were also romanticised by viewers as an inherent part of the human-cat bond:

“That's true love. A bit of pain a bit of glory. Most all a bond that will never stop”.

Even when viewers labelled this relationship as being ‘toxic’, their comments still expressed a perception that to accept this dysfunctional dynamic is part of what it means to love a cat:

“The only toxic relationship worth being in.”

“Cat lovers are fkn masochists ...me included”.

Some viewers perceived that evidence, such as scars, of tolerating injury during a play interaction were a badge of honour:

“The Cat Tattoos on your hand! A privilege for cat lovers”.

These perceptions of human-cat relationships were sometimes accompanied by misogynistic undertones:

"it's literally the metaphore [sic] of Amber and Depp relationship, he, talented and working hard, she - abusive and pretty [winking face with tongue emoji]"

Or were overtly misogynistic:

"Remember, cats are like women. They are strays that walk the streets feral and lure a sucker to take them in because they're cute and provide for they're [sic] life. They come to you when they want something like food or affection. They get mad easy and are insatiable. They won't let you give affection unless they want it and for a limited time only. Then they slink away arrogantly and watch you in the shadows even at night".

Satisfying the killer inside

This theme describes viewer justification for engaging in rough play as a way to satisfy a cat's predatory 'needs' or maintain their predatory skills.

"Ahhh reminds me of my old cat. We sparred so much that believe it's the reason he became the world's best hunter. He killed everything from ants to birds".

On the basis of meeting a cat's predatory instincts, viewers justified ignoring advice designed to reduce injury risks, such as not playing with hands:

"I know they tell you not to do hand play like that with cats, but how can you deny them the fun of such worthy adversary".

In some cases, this importance of meeting predatory needs was linked to a perception that domestic cat behaviors were the same, or similar to those of large-cat species:

"It's good to let their inner tiger out once in a while."

"that cat is going for the 'neck' of hand..... just like a lion or tiger goes for it"

This association was used within viewer rationalizations for why injuries during play should be expected:

“sometimes there's a little accident, but that's the price for having miniature tigers in my home”.

Further, viewers often used anthropomorphic labels when characterizing their cat’s predatory needs and justified engaging in rough play as a means to meet them:

“The "I need murder" and "I need affection" part of a cat's mind are directly adjacent”

“*Wonderful outlet for the killer inside every cat”.*

…But it’s cute

This theme reflects the propensity of viewers to overlook or trivialize harmful interactions, signs of cat stress or mistreatment, and/or potential human risk, when they perceived that an interaction, a cat or human was ‘cute’.

This operated in several ways; firstly, viewers expressed acceptance of problematic interactions or cat distress because the aesthetic cuteness of the interaction was enjoyable for them to watch:

“… but the video is cute so eh”.

In other examples, viewers explicitly belittled a cat’s visible dissent behaviors because of their perceived ‘cuteness’:

“*He wants to look aggressive [pleading face/puppy dog eyes emoji] what he doesn't know is that he looks cuter [tears of joy emoji]”*

“what he feels: [dragon emoji] what we see: [caterpillar emoji]”

Cuteness was also invoked when invalidating human distress, if the human in the video was perceived as 'cute'; this element was especially present in videos where the human was an infant:

"*[baby name] did change his face when he got bit, so darn adorable"*.

Viewers also rationalized their desire to touch a cat who was displaying dissent cues as being a consequence of the animal's cuteness.

"why do I want to pick the little kitty up. too cute [smiling face with hearts emoji]".

This rationalization was often coupled with viewers objectifying the cat. For example, on a video of a kitten:

"that cat looks too cute I almost thought it was a toy [face with heart eyes emoji] I want to put it in my pocket and take it home [rolling on the floor laughing emoji]"

And, on a video of a plump cat being pushed around: *"it's dough, gotta roll".*

Further, viewers often combined cute and violent imagery when responding to perceived cuteness:

"I would snuggle that little munchkin into oblivion!! [smiling face with hearts emoji]".

Finally, and most concerningly, even when cat distress was recognized to the point that viewers expressed concern for the cat's negative experience, 'cuteness' still prevailed in nullifying potential mistreatment:

"I wonder if his heart is pounding at times like this. He's trying his best. I feel bad for the kitten, but it's cute".

Just having a laugh

This theme encompasses viewer perceptions of interactions, and/or the cat's visible distress within them, as amusing, humorous, or enjoyable.

Within this theme, viewers explicitly expressed being entertained by visible cat displeasure or discomfort.

"The way the cat does not like it's butt getting pet is so funny [laughing with tears of joy emoji]"

Viewer's often reminisced about their own similar experiences with cats when expressing their enjoyment at a video:

"When we're fighting like this, it's really exciting".

In some cases, viewers acknowledged knowing that such interactions were experienced negatively by their cats, however these same viewers found this element amusing:

"That is hysterical. I used to make [cat name] dance. She hated it"

Similarly, other viewers demonstrated a level of self-reflection over the problematic nature of their enjoyment, while still maintaining that such interactions are entertaining:

"What is it about provoking fights with cats, and enduring the scratches that we love? I never learn my lesson"

Others exhibited confusion at their own amusement:

"*I feel like I should not find a man teasing his cat this funny, yet I can't stop watching these lol".*

Concerningly, some viewers openly voiced their enjoyment at watching mistreatment or finding humour in witnessing human injury:

"The way she grabbed the cat neck had me crying [loudly crying emoji, laughing with tears of joy emoji x2]"

"Hahahahahahaa That cat is so antagonized, but he can take that biting I can't believe it. That shit hurts really bad. it's very funny for some reason."

“Karens take a seat”

This theme encompasses a pattern in which viewers defended their own positive interpretations of an interaction by expressing their belief that viewers who were critical of the interaction must be overly sensitive or inexperienced individuals who do not ‘understand’.

“Can tell who the people that don’t know about cats are ha”.

Others attested that criticisms of the interaction were illogical, an overreaction or people deliberately blowing things out of proportion:

“Anyone with a crumb of common sense can tell that this video isn't animal abuse.”

Within this pattern, viewers mocked those with differing opinions, often using pejoratives, such as ‘Karen’, a term used to describe someone (usually a woman) who is acting in a rude, entitled or obnoxious manner, generally towards a service worker or stranger (Blitvich, 2022):

"How precious…Karens take a seat in the back that kitty is being gentle”.

Discussion

Human perceptions regarding cat behaviors, cognitive abilities, preferences and needs have major consequences for cat welfare, especially in contexts such as play where misconceptions can inflict physical and mental harm. Our findings demonstrate patterns of misinterpretation, justification and rationalization in viewer comments that illuminate broader issues within human conceptualization of human-cat relationships. The themes identified reveal a spectrum of perceptions and beliefs that may function to allow viewers to maintain positive interpretations of potentially problematic interactions. While some themes captured simple misinterpretations of cat behaviors, others demonstrated problematic perceptions and complex cognitions, such as cognitive dissonance, that may hinder the chances of reducing

unwanted interactions for cats. The themes presented within this study provide important foundational knowledge to inform future studies and interventions.

Trivializing cat dissent:

When a cat's early dissent signals go unrecognised or ignored (as they were in each of the videos included in this study) a cat experiences acute stress than may become chronic if unwanted interactions occur repeatedly (Henning et al., 2025). This can have serious consequences for cat health and wellbeing (Amat et al., 2009; Sparkes, 2018). Despite this, cat dissent behaviors were frequently trivialized by viewers. In some cases, extreme injury was used as a yardstick against which lesser wounds were invalidated (If they didn't like it, you would know). In others, dissent was reinterpreted as normal play (Lost in translation), a show of affection (That's cat love), evidence of trust (They just get it) or interpreted as a temporary barrier to be overcome through persistence (You'll win them over). Even when stress behaviors *were* recognized by viewers, they were often disregarded (…But it's cute) or reframed as a harmless (They just get it). This is supported by previous research where approximately one in ten participants believed stress (both physical and mental) held no consequences for cats (Mariti et al., 2017).

Trivializing the damage of unwanted play interactions may, in part, function as a method of cognitive dissonance reduction or resolution (Cancino-Montecinos et al., 2020; Michel, 2018). Cognitive dissonance describes the mental discomfort that occurs when a person simultaneously holds two or more opposing cognitions, acts in a way that contradict their values, or is presented with new information challenges a deeply held belief. The internal inconsistency of these conflicting cognitions, such as recognizing animal distress while

simultaneously deriving pleasure from the interaction can lead to psychological tension that is uncomfortable to sit with, motivating a person to resolve the discrepancy and restore cognitive consistency (Cancino-Montecinos et al., 2020; Michel, 2018). Often, reducing or resolving cognitive dissonance, will involve rejection of the newer belief in favour of what is known and comfortable (Festinger, 1957). Cognitive dissonance resolution strategies therefore include denying evidence that goes against your own beliefs, downplaying the importance of such evidence, or outweighing dissonant information with counterarguments (Festinger, 1957). Within the present study, viewer comments contained multiple examples reminiscent of these resolution strategies. For example, when faced with evidence of cat distress, viewers who enjoyed similar interactions with their cats, raised the bar for what constitutes 'real' cat distress (If they didn't like it you would know), reassured themselves of their bond with their cat (That's cat love), reasoned that their cat understands it is harmless play (They just get it), and blamed others for misunderstanding (Karens take a seat). Such strategies allow viewers who identify as 'cat lovers' to avoid challenging their own behaviors or perceptions while continuing to enjoy their preferred interactions.

Viewer enjoyment of cat distress

Worryingly, many viewers expressed that they enjoyed watching cats in distressed states. Some seemed to find distress amusing (Just having a laugh) while others took pleasure in viewing a cat attempt to assert their autonomy (…But it's cute, Just having a laugh). In both cases, an underlying element of enjoyment appeared to be a cat being powerless. Cuteness has previously been observed to generate feelings of power and aggression in humans (Evans & Riley, 2023), often manifesting in affectionate but violent language (Ngai, 2005) e.g., *"I would snuggle that little munchkin into oblivion!! [face with heart eyes emoji]"*. Indeed, 'cute

aggression' is a term that describes how cuteness can spark urges to squeeze or pinch cute things, in the absence of a desire to harm them (Stavropoulos & Alba, 2018). Feelings of power or aggression associated with viewing 'cute' animals may be further bolstered by the condescending nature of 'cuteness' which infantilizes distress or aggressive behaviors and highlights powerlessness e.g., *"what he feels: [dragon emoji] what we see: [caterpillar emoji]".* Perceived cuteness may therefore contribute to people overlooking cat distress out of a desire to feel superior, or to physically engage with the cat. As for viewers who found cat distress humorous, previous research suggests humans often find amusement in 'benign violations' (McGraw & Warren, 2010). Violations may include situations where a person or animal's body, dignity, societal or moral norms are violated. For this to elicit amusement the viewer must recognize the violation and simultaneously assess it as benign i.e. non-serious. Many of the comments within 'Just having a laugh' appear to fit within this framework. Another contributing factor may be desensitization, where repeated exposure to videos may have led to diminished responses (Engelhardt et al., 2011). This may be exacerbated by social media algorithms that distribute highly engaging videos to greater numbers of viewers (Brady et al., 2023). Videos of animal suffering are disproportionately successful on social media sites (Kühnöhl et al., 2025) and are therefore more likely shown regularly to users. Further, viewers may be primed to respond in certain ways through the use of titles that provide the intended response to the video (e.g., 'funny cats') or through addition of comical or cutesy soundtracks that may influence viewer perceptions (Steffens, 2020; Stumpf et al., 2024).

Downplaying human injury:

Seven of the eleven videos within this study included an observable human injury. Despite often looking harmless (e.g., small wound size, limited bleeding) cat bites carry a high risk of

infection (Birdsey et al., 2016; Garber & Glauser, 2023) and serious complications, including long term disability and, in rare cases, death (Kheiran et al., 2019). However, viewer comments often downplayed observed human injuries and the risk of cat-related injuries in general. In some cases, viewers reframed the injury as a sign of 'love' from the cat, or a badge of honour (That's cat love), others questioned or belittled the force of the attack, especially if blood was not visible (If they didn't like it, you would know), 'accidents' were normalized by some viewers as a part of living with cats (Satisfying the killer inside) while conversely, others rationalized that injury risk was low because cats know how to be gentle (They just get it). Similar perceptions have been observed around dog bites. In one study, viewers downplayed the seriousness of dog bites, viewing them as a normal part of human-dog interactions (Owczarczak-Garstecka et al., 2018). In another, participant definitions of what constituted a bite varied greatly according to the context in which the bite happened, the severity of the injury or the dog's intent behind the action (Westgarth & Watkins, 2015). Considering cat bites pose a serious human health risk, perceptions that downplay or normalize injury could have serious ramifications, such as people underestimating injuries and failing to seek timely medical intervention. Normalization of bites may also hinder the success of prevention strategies if people feel that injuries are normal or unavoidable (Owczarczak-Garstecka et al., 2018).

Of cats and women

Women and cats have long been linked in the cultural zeitgeist (White, 2023). Cats are often stereotyped as feminine-coded, with negative connotations such as being manipulative, unpredictable and difficult (Maddicott, 2020). Within our study, viewers made similar associations, both implicitly and explicitly e.g., *"Remember, cats are like women..."* (That's cat

love). These associations have resulted in real and serious consequences for women and cats throughout history, exemplified by the mutilation of cats believed to be witches in disguise (Evans & Riley, 2023; Lawrence, 2003), and the well-established link between domestic violence and animal abuse (Jegatheesan et al., 2020). Researchers and practitioners should therefore be cognizant of how cultural stereotypes can shape the ways people interpret and respond to cat behavior. For instance, sentiments such as "*If she didn't want to, she'd run away"* and *"If they were really mad your arm would be dripping blood"* bare striking resemblance to questions such as "If it was so bad, why didn't she leave?" and "why didn't she fight back" directed at female victims of intimate violence (Heritage, 2023; Lawless, 2008). Just as these questions fail to understand the nuance of such situations and are problematic within human discourse, so too is the idea that staying or not fighting back 'enough' equals assenting in cats. Leaving and 'fighting back' both come with risk. For instance, attempted escape may result in increased unwanted handling (e.g. being picked up) while 'fighting back' may be met with retaliation in the form of physical pain or withholding of resources such as food (Henning et al., 2025). Further, cats may remain in, or curtail attacks during, an interaction due to individual temperament, their intrinsic instinct to avoid threats (Blanchard et al., 1991), as part of a 'freeze' response (Hagenaars et al., 2014) or to reduce the risk of escalation (Bradshaw, 2016). When stressful interactions persist, a cat may exhibit 'learned helplessness', where they appear to submit to an interaction because they have learned that they have no control over the outcome (Hargrave, 2015).

The parallels between viewer comments and misogynistic beliefs likely reflect broader societal feelings of entitlement towards certain bodies, particularly those of women, children, and non-human animals (Arcari, 2019; Manne, 2020). Such individuals are often construed, consciously or subconsciously, as being subordinate (Whitehead, 1979; Wainryb and Turiel,

1994; Guenther, 2024) and because of this, those in positions of power may feel entitled to override, coerce or violate their autonomy. In such situations, if dissent is displayed, it is often reframed as something to overcome with persistence (Cox, 2020) *("You'll need to be patient & you will win him over").* Of note, such assumptions are beginning to be challenged within the human literature. Contemporary parenting discourse, for example, has begun to emphasise children's bodily integrity and autonomy, advocating that children should be empowered to refuse any unwanted physical interaction or affection (Adegbesan 2021; Hammond, 2022) regardless of the authority or familiarity of the person requesting it (Townsend & Earp, 2024; Nafisah et al., 2024).

Viewer comments from the present study highlight problematic beliefs about cat behaviors that may stem from, or be associated with, general beliefs about human relationships and longstanding societal failures to recognise constrained agency in asymmetrical relationships. The confidence of commenters that these perceptions are well-known truths (*"Any cat owner will know the difference"*) suggest a critical need to re-educate cat 'lovers' and guardians on behavioral indicators of dissent in cats. As with women and children, the ability to leave, resist, or retaliate is shaped by power, risk, and dependency, rendering simplistic interpretations of behavior inadequate.

Implications for potential interventions

Educational interventions aimed at reducing unwanted interactions may fail to achieve desired results if they do not account for guardian perceptions. Beliefs that downplay injury risks, normalize 'accidents' as part of human-cat relationships, or demonstrate defensive responses to alternative perspectives are in keeping with common barriers to injury

prevention (Hemenway, 2013). These include low levels of perceived danger ('it would never happen to me'), low perceived self-efficacy to make behavior changes to avoid injury ('accidents happen') and defensive responses that deny the risk (Peters et al., 2013) or victim blame others (Hemenway, 2013). Similar perceptions are observed for dog bites (Westgarth & Watkins, 2015), persisting even when participants had experienced bites (Saleem et al., 2020). Because of this, interventions that focus on the consequences of cat-related injuries and do not also tackle perceptual barriers may fail to stimulate human behavior change.

More complex cognitive barriers may require specific intervention strategies. For instance, cognitive dissonance about what is or is not an appropriate interaction may be tricky to counteract within a brief or information-only intervention and is likely to require open conversations. Further, having previously met with dissonance, people are likely to avoid information and situations that may be likely to trigger or increase dissonance (Cancino-Montecinos et al., 2020). Therefore, care should be taken when broaching these topics with guardians as they may choose to withdraw to protect their own beliefs. Of particular note, within the theme 'Karen's take a seat', viewers delegitimized external critique, displacing their cognitive discomfort onto the people presenting an opposing view. This is particularly important for potential intervention strategies, as it suggests educational messages that challenge a guardian's self-view (e.g., of being a 'good cat guardian'), may provoke dissonance and result in resistance to, or rejection of, the messaging. In many of the themes within this study (though not all), trivialization of cat dissent by viewers does not appear to be due to lack of empathy or a simple lack of awareness but is perhaps a response to conflicting feelings that threaten a viewer's sense of enjoyment, identity or competency. Future interventions may benefit from using messaging that preserves and builds upon a guardian's self-view, uses

inclusive language, avoids moral or binary statements, invites collaboration and fosters curiosity, positioning the intervention as a joint effort in increasing understanding.

Finally, social media may magnify these perceptions through algorithms that reward engagement regardless of problematic content. Considering the influence of social media and perceived social norms in maintaining cognitive processes (Peters, 2022; Whitt et al., 2023), guardian social media usage and media literacy are likely important elements to consider when creating preventative interventions.

Limitations

This study has some limitations. Analysis only utilized English comments that may be limited in their representation of diverse populations. Viewer comments in general may also not be representative of the broader population. A potential strength of the study is the unobtrusive nature of analysing public comments, which may allow researchers to observe uninhibited perspectives without introducing potential response biases or influencing behavior (Costello et al., 2017). However, viewer bias may still exist within the data. Viewers may have self-moderated their comments for a public audience or self-censored due to awareness of prevailing opinions (Hayes et al., 2005). Conversely, the anonymity and distanced nature of online commenting may have emboldened viewers to share more extreme views than they actually hold (Lapidot-Lefler & Barak, 2012). Analysis of viewer comments is also limited as follow up questions or in-depth discussions are not possible. Further, while a considerable number of comments were examined, only 11 videos were included in analysis and, due to the objectives of the study, analysis on these videos only included comments showing a supportive or neutral sentiment. Videos may therefore not cover the full spectrum of unwanted play interactions. Future studies that also include and contrast comments on

videos of positive interactions, where cats are observably displaying assent, and that include videos from different cultures and languages may illuminate further information beneficial to reducing unwanted interactions.

Conclusion

The findings of the present study demonstrate patterns of misinterpretation, rationalization and justification in viewer perceptions that may contribute to negative cat welfare through harmful human-cat 'play' interactions. Beyond simple misinterpretation of cat body language, viewer comments reflected entrenched beliefs about cat preferences and human-cat dynamics, were indicative of cognitive dissonance and, in some cases, echoed harmful narratives akin to human discourse around women and victims of intimate harm. These findings suggest that traditional educational approaches focusing solely on correcting interpretation of cat body language are likely insufficient for long-term alteration of human behavior. Future interventions aimed at reducing unwanted human-cat play interactions should incorporate strategies to address human pre-conceptions, cognitive biases, and the social media environments that contribute to normalizing animal distress, alongside education on cat behaviors, preferences and how to appropriately respond to a cat displaying dissent.

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Chapter 8: General Discussion

8. General Discussion

Human-cat play interactions comprise several elements that suggest potential as a tool for assessing and improving cat welfare (Held and Špinka, 2011). However, such play interactions may also carry risk of cat stress and human injury if the interaction is not mutual and appropriate (Haywood et al., 2021). No previous studies have explicitly examined the link between human-cat play and cat welfare. To ensure that play interactions are optimized to improve cat welfare and are not inadvertently placing cats at added risk, it was determined that research into the associations between human-cat play and cat welfare was needed. To begin to fill this gap, the present thesis had the overarching Aim of investigating whether, and in what ways, human-cat play interactions were associated with cat welfare.

Two primary Aims further guided this exploration. The first was to investigate associations between human-cat play interactions and welfare in cats and the second was to assess human perceptions and experiences of human-cat play and explore how these may impact human-cat play interactions. Throughout the Chapters of this thesis, these Aims were explored through multiple angles with findings identifying associations between human-cat play interactions and *both* positive and negative welfare outcomes. Furthermore, there were meaningful impacts of human perceptions on the amount and quality of human-cat play interactions (e.g., human fears of injury associated with reduced play interactions, human inability to identify cat stress linked with greater likelihood of inappropriate interaction choices). Importantly, findings related to both Aims often intersected, demonstrating complex interconnections between human-cat play and welfare outcomes. The play interaction itself was also associated with multiple variables including individual factors from both species that,

combined, could influence whether the interaction was likely to lead to enhanced or diminished welfare. Important factors relating to both the human and the cat are shown in Figure 8.1 and these are discussed in more depth in the following sections.

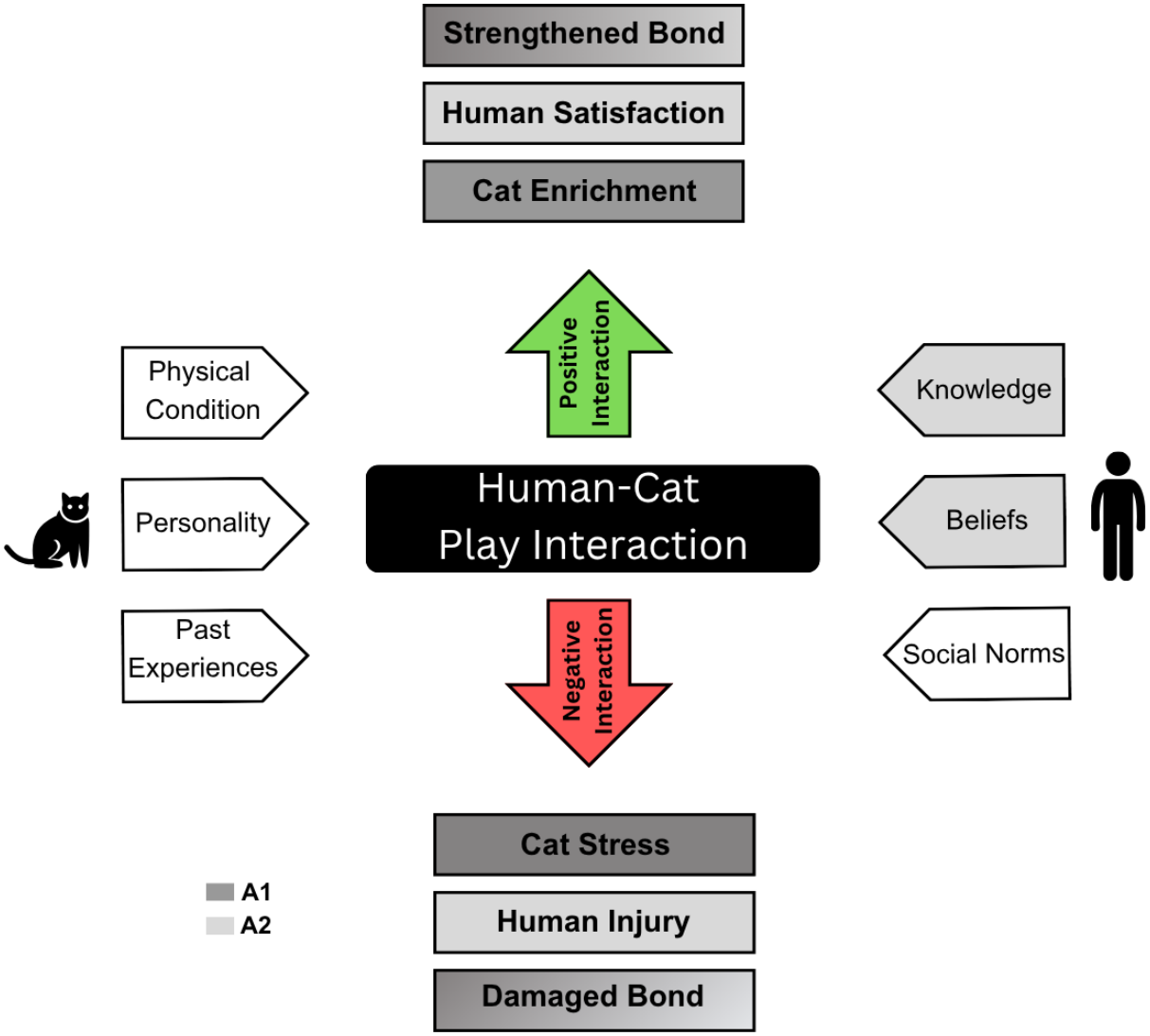


Figure 8.1 Conceptual framework of human and cat factors influencing human-cat play interactions and outcomes. This framework illustrates cat and human-related factors that may contribute to the quality of human-cat play interactions, which in turn can lead to positive or negative welfare and wellbeing outcomes for both species. Factors and outcomes relating to thesis Aims are highlighted in dark grey (A1: associations between play and cat welfare) and light grey (A2: exploring human perceptions and experiences). Where an outcome relates to both Aims, a gradient of both colours is used.

8.1 Cat-Related Factors

The characteristics and factors unique to an individual cat, such as their physical health, past experiences and personality (Figure 8.1), impact the form and experience of human-cat play interactions and, through this, their potential welfare outcomes. Findings from this thesis showed correlations between factors such as cat age, playfulness, health status and the amount and style of play cats engaged in with their guardians (Chapters 2, 3, 4 & 5). This is supported by previous research demonstrating that, just like humans, cats are individuals with unique personalities (Bennett et al., 2017; Litchfield et al., 2017), life histories (Jacobson et al., 2022) and variations in physical ability and health status (Bellows et al., 2016; Henning et al., 2021). Each of these factors may alter how a cat experiences play interactions with a human.

A cat's personality may affect their willingness to engage in play with a human, with more confident or playful cats typically being more partial to interactive activities (Turner, 2021). Life history factors such as socialisation (Guyot et al., 1980), the environment a cat was raised in (Campbell et al., 2024), and the husbandry style they are used to (e.g., indoor or outdoor) (Scandurra et al., 2023; Shajid Pyari et al., 2021) can also alter cat play drive and preference. Previous research has demonstrated clear individual variability in cat preference for toys, interactions with humans (Vitale & Udell, 2019; Vitale Shreve et al., 2017) and choice of social companions (Crowell-Davis et al., 2004). These individual preferences shape what type of play interaction will be most beneficial for the cat (Delgado, 2022). A recent study assessing oxytocin expression in cats, based on attachment type and guardian interactions, found that securely attached cats were more likely to initiate interactions and experienced increases in salivary oxytocin after an interaction, while anxiously attached cats were more likely to

experience forced interactions from their guardian and demonstrated a tendency to decreased oxytocin after an interaction (Chang et al., 2025).

Physical variations such as breed, size, age, and health factors, including pain, mobility or sensory impairments, may necessitate particular consideration when approaching play interactions (Carr, 2022). Kittens and young-adult cats generally have higher play needs and motivations compared to senior cats, whose reduced mobility and energy levels may require guardians to adapt their play strategies accordingly (Chapter 3; Hoummady et al., 2025). Similarly, cats with impairments or disabilities will require modifications to toys or interaction styles to make play accessible e.g., using noisy toys with a blind cat (Carr, 2022). All of these individual factors (physical, mental and experiential) combine and influence the type and quality of a play interaction and its subsequent welfare outcome and deserve consideration to ensure play is engaging and beneficial (Figure 8.1).

8.2 Human-Related Factors

From the beginning of this thesis, the relationship between human behaviours and cat outcomes was identified as a key factor for consideration within associations between cat welfare and play (Chapter 2). As research progressed, findings from each Chapter consistently highlighted the inextricability of domestic cat welfare from the humans who determine their daily experiences. For instance, guardian knowledge, beliefs and social norms (Figure 8.1) shape subsequent interaction choices about how (Chapter 3 & 6), when (Chapter 4), and whether to initiate play (Chapter 4 & 6) and these choices directly influence cat welfare by providing (or withholding) opportunities for enrichment and bonding (Chapter 5), or conversely, creating harmful interactions through inappropriate play choices, prolonging unwanted interactions or not allowing a cat autonomy within the interaction (Chapter 7).

8.2.1 Knowledge

Knowledge of cat behaviours and preferences (Figure 8.1) influence how capable a person is to adequately meet cat needs (Croney et al., 2023). Cats communicate primarily through body language, behaviours and vocalisations (Ellis, 2018; Horowitz, 2021). If a person does not have adequate knowledge of these behaviours and what they indicate, they may misinterpret communications, fail to notice important cues and can inadvertently cause cat stress (Rault et al., 2020). Knowledge of normal cat behaviours and cat preferences for how to be touched and interacted with is particularly important within play interactions, where behaviours may overlap, at least superficially, with aggressive or predatory actions (Delgado & Hecht, 2019). Without a sufficient understanding of cat communication, guardians may play in ways that cause a cat discomfort, potentially leading to prolonged cat stress, a cat showing defensive responses that could be misinterpreted as problematic behaviour (e.g., 'aggression'), and potential human injury (Ramos and Mills, 2009; Fritz et al., 2022). Within this thesis (Chapters 6 and 7), deficits were observed in human knowledge of cat behaviours. Additionally, findings revealed a concerning gap between recognition of behaviours and appropriate response choices, suggesting that even when people could identify positive or negative behaviours, they often lacked the practical knowledge to respond appropriately. While lack of knowledge may increase negative welfare risks, adequate knowledge may improve cat welfare (Haywood et al., 2021). In Chapters 4 and 5, mutual initiation of play sessions, suggestive of guardian ability to understand cat play initiation cues, was associated with both higher daily play times and stronger human-cat bond scores. These findings demonstrate how the knowledge a human brings into a play can contribute to the net positive or negative outcome of that interaction. While inadequate knowledge poses

welfare risks during play, arming guardians with adequate knowledge may help to create positive, mutually beneficial play experiences that strengthen the human-cat bond (Haywood et al., 2021; Graham et al., 2024).

8.2.2 Beliefs

In addition to knowledge, human decisions are also guided by perceptions and beliefs (van Eeden et al., 2021). These perspectives can manifest as facilitators or barriers to safe play interactions (Hemenway, 2013). For instance, if a person perceives play to be beneficial, they may be more likely to engage in play interactions than someone who does not (Waters et al., 2022). Interestingly, perceptions of what constitutes play were broad and highly variable within guardians (Chapter 3). These broad perceptions may create several problems that can impact subsequent human-cat play interactions, produce misunderstandings between professionals and guardians (Chen et al., 2023), lead to missed opportunities for quality play in favour of less appropriate interactions (McInnes et al., 2011), and, in some cases, may result in cats experiencing negative interactions (Chapter 7).

In addition to this foundational perception of what play entails, other perceptions and beliefs may affect the type and quality of human-cat play interactions, and their likelihood of increasing or diminishing cat welfare (Croney et al., 2023). Key problematic perceptions identified within this thesis included beliefs about cat play preferences, what normal human-cat relationships look like and the importance of respecting cat agency, particularly when a cat is dissenting. For instance, in Chapter 7, some viewers who misperceived a negative interaction as positive also believed that cats enjoy 'rough play' or that biting was a cat's way of showing love (Chapter 7). These problematic beliefs are particularly concerning because they can persist despite clear signs of cat distress, if people's beliefs lead them to misinterpret

defensive behaviours as 'playful' or 'loving' responses (Chapter 7). Because perceptions influence human behaviour (Powers, 1973), entrenched perceptions or beliefs such as these may expose cats to ongoing, repeated negative interactions that may be extremely harmful to cat welfare (Croney et al., 2023). Addressing these perceptions may therefore greatly improve the quality of play interactions.

A person's past experiences may also contribute to beliefs and perceptions that affect the likelihood of a behaviour, such as play, occurring (Cardinal et al., 2013) and the type of any play interaction that does occur (Chapter 4). If humans feel positively about their past play experiences, they may be more likely to repeat them. However, if play becomes associated with negative feelings, such as boredom or fear of injury, this can lead to avoidance of play and, therefore, reduced play interaction opportunities, as observed in Chapter 4. Reduced play interactions may also compromise opportunities for developing human-cat communication and building social bonds (Chapters 2 and 4) with guardian avoidance of play also associated with lower human-cat bond scores (Chapter 5). Thus, perceptions and beliefs may not only shape individual play interactions but also create patterns that impact long-term cat welfare and human-cat bonding.

8.2.3 Social Norms

Along with knowledge and beliefs, human behaviour choices are also significantly influenced by the broader social and cultural norms an individual is exposed to (Ferguson and Bargh, 2004). Humans often internalise perceptions of what is "normal" or acceptable based on what they observe among peers, family, or in media (Tankard and Paluck, 2016). The internalised perceptions then influence behaviour, which in turn can be socially reinforced by peers through approval, laughter or social media 'likes' (Cialdini and Goldstein, 2004;

Sherman et al., 2016). Perceptions of what behaviours other people in your social circle approve of, and social reinforcement when these behaviours are performed may therefore become a barrier or facilitator to individual behaviour change. In a previous study, guardians were more likely to adopt recommended practices if they believed that other cat guardians also valued and engaged in them (van Leeuwen & ter Mors, 2024).

Similarly to individual beliefs, broadly held misperceptions can also contribute to human behaviour in human-cat play interactions. Examples of this include widely held, but inaccurate, beliefs about cats being solitary or low-maintenance animals (Machado et al., 2025), and anthropomorphised accounts of cat nature such as them being 'evil' or capable of acts such as revenge (Croney et al., 2023). Findings in Chapter 7 demonstrate perceptions that are likely to be formed and maintained, at least partially, by social norms. In some instances, these perceived norms were even used explicitly to dismiss criticisms of the behaviour in the videos (Chapter 7). While further research into this gap, especially considering the recent intensification of social bubbles of social media (Hartmann et al., 2025), is needed, these initial findings suggest factors that impact human-cat play interactions are not limited to deficits in individual knowledge or skill, but are also embedded in broader social contexts that further shape beliefs of what "appropriate" play looks like. As such, effective strategies to enhance cat welfare during play may require not only improving individual knowledge, but also shifting collective norms to reframe respectful, cat-led play as the socially desirable standard.

8.3 Application of Findings

8.3.1 Educating Recognition of Cat Assent and Dissent Behaviours

The findings of this thesis highlight the importance of guardian ability to recognise and respect cat dissent during play for cat welfare. Without this, guardians may engage in play when it is unwanted by the cat (Chapter 6) or may continue play beyond when a cat wishes it to stop (Chapter 7), causing undue cat stress and placing themselves at risk of injury. The findings of this thesis, and the results of previous studies, demonstrate substantial individual variation in human ability to correctly recognise cat behavioural cues (Dawson et al., 2019; Graham et al., 2024), and to respond appropriately to these cues (Chapters 6 and 7). These findings indicate a need for adequately educating the general public on cat behaviours, interaction preferences and how to appropriately respond to a cat in a negative state (Chapters 6 and 7).

Along with individual variability, previous research suggests that the the average person may find it especially difficult to accurately recognise assent in cats as this requires complex interpretations of a meaningful preference (Fenton, 2021). For this reason, 'sustained dissent', in which an animal exhibiting prolonged or repeated dissent is released from a procedure, has previously been proposed and utilised within a laboratory setting (Fenton, 2021). While the emphasis on dissent instead of assent holds practical potential, the sustained dissent model is not ideal in a human-home setting where interactions occur regularly, cats may display altered or learned responses such as perfunctory cooperation or suppression of escape behaviours (Bobier et al., 2024), and where guardians are not trained in behavioural recognition. To account for these factors, and in line with the findings of this thesis, emphasis on immediate respect of dissent is suggested. Coined 'occurrent dissent', the occurrence of any *potential* dissent behaviour, regardless of how brief, should be prioritised, interactions stopped immediately and the cat given physical space to leave, disengage, or choose to re-engage as they wish. Further, any re-engagement or continuation would need to be initiated

by the cat and stopped again at the first sign of dissent (Haywood et al., 2021). This accounts for the practical realities of varying guardian skill levels by reducing the need for nuanced behavioural interpretation. That is, guardians need only recognise the presence of potential indicators of dissent, rather than assessing the degree of distress or requiring the dissent to be indisputable. Further, occurrent dissent reduces ambiguity by establishing clear, actionable steps, and creates a more protective threshold that would likely result in earlier intervention and fewer prolonged negative experiences for cats. By emphasising cessation at any *potential* indicator of dissent, and allowing for cat re-engagement, occurrent dissent shifts the risk of misinterpretation in favour of cat welfare. For instance, if a guardian stops an interaction because a cat shows signs of being uncomfortable when, in fact, the cat actually wanted to continue, this error has minimal impact because the cat can choose to re-engage.

It is important to note that successful application of occurrent dissent still relies on human recognition of cat communication cues, all be it at a reduced level of competency. Educational efforts are still crucial to improve general recognition of cat behavioural cues, especially those that are early and subtle. Later, more obvious behaviours may indicate that the cat is already experiencing significant distress (Mariti et al., 2017). Educational interventions should therefore prioritise teaching recognition of early indicators and emphasise the need to stop at any indication of cat distress (i.e. occurrent dissent).

8.3.2 Recognition is Not Enough: Encouraging Better Response Choices

Regardless of ability to recognise cat dissent, a concerning number of people still choose to engage in inappropriate play interactions with cats (Chapters 6 and 7). Simply improving recognition of cat behaviours is therefore unlikely to fully address poor interaction choices. Consideration of what additional factors might impact human interaction choices is necessary.

The COM-B model (Capability, Opportunity, Motivation-Behaviour) (Michie et al., 2011) has been increasingly adopted in behavioural research as a framework for understanding the facilitators and barriers to altering human behaviour toward animals (Furtado et al., 2022; Ma & McLeod, 2023; White et al., 2023; Powdrill-Wells et al., 2025). This model proposes that behaviour change occurs when individuals have the necessary capability, opportunity, and motivation to make change possible (Michie et al., 2011). Within COM-B, barriers and facilitators to behavioural change encompass an individual's physical and psychological capabilities to perform the behaviour, the physical and social opportunities available in their environment, and their motivations, both reflective (beliefs, attitudes) and automatic (emotions, habits) (Michie et al., 2011).

Below, the synthesised findings of this thesis have been mapped to the COM-B model, allowing for further identification of the factors influencing whether guardians choose to engage in appropriate human-cat play interactions (Figure 8.2) The COM-B model has previously been utilised by Delgado et al., 2024 when investigating barriers to wand-toy style play in human-cat dyads. Findings suggested that the most common barriers to play were lack of time and not having access to a wand toy. Further, greater knowledge about cat play needs was identified as a facilitator of play, with higher knowledge scores associated with more frequent wand-toy play. Interestingly, within this study, regular play was associated with higher cat quality of life scores, and cats who received regular wand toy play were reported as less likely to bite and scratch during play. Though, even with wand-toy only play, 5% of participants still reported biting occurring (Delgado et al., 2024). In contrast to Chapter 4 of this thesis, the findings of Delgado et al., 2024 did not find fear of injury to be a significant barrier to play, with fewer than one percent of participants reporting they worried about

injury. Differences in these results may be due to the narrowed focus of Delgado et al., 2024 on wand-toy play only, with injury potentially less likely in this type of play due to the distancing nature of the toy involved.

Importantly, within the COM-B model, factors interact dynamically and can be altered by the addition of interventions. Using the findings of this thesis, Figure 8.2 is therefore also designed to provide an initial framework for informing future interventions and creating targeted messaging. For example, increased knowledge of cat play needs (capability) through a public education campaign may enhance confidence in ability to avoid injury (motivation), while increased positive play experiences from implementation of this knowledge may reinforce both capability and automatic motivation through habit formation.

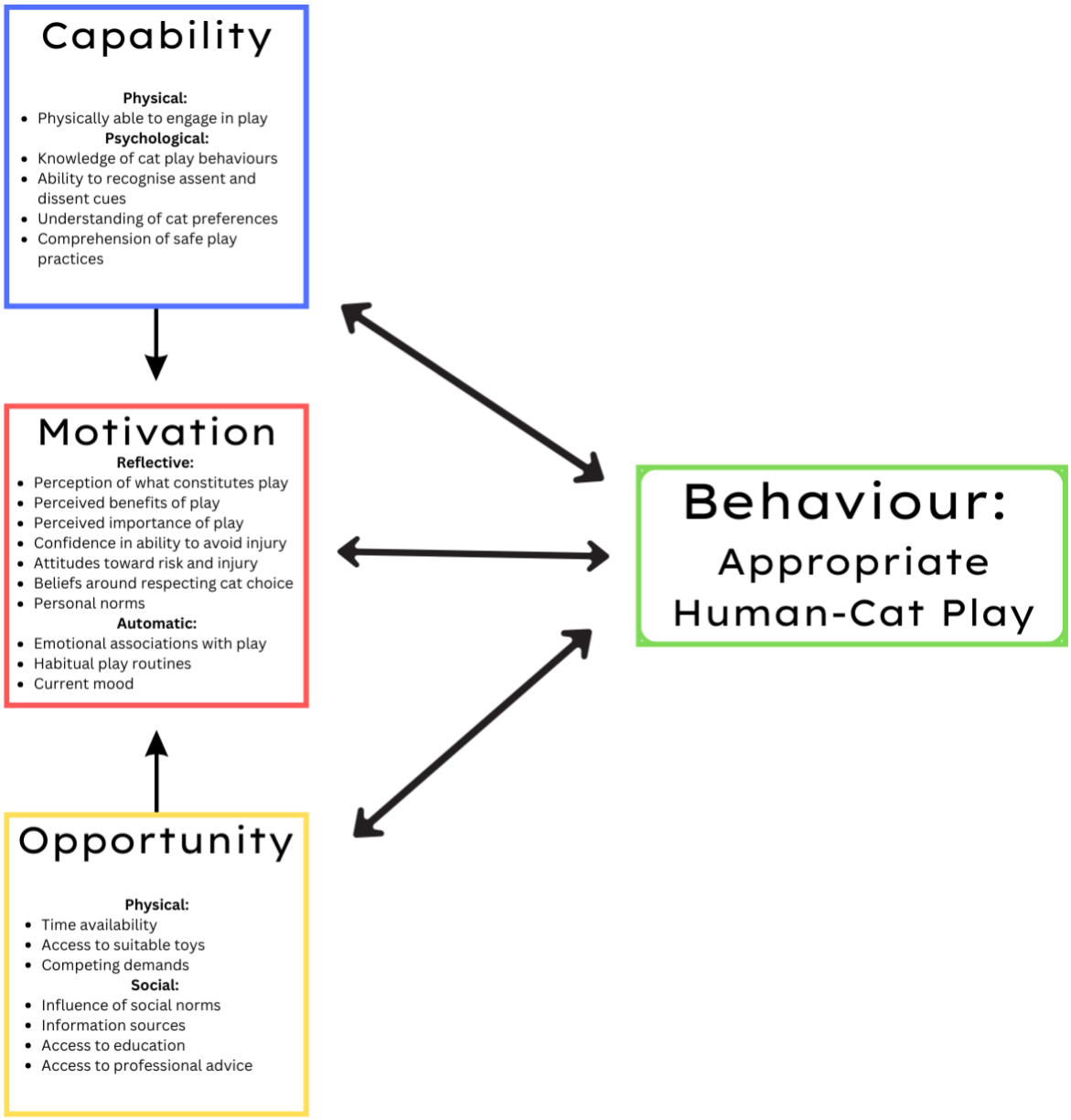


Figure 8.2. Mapped findings from Henning et al 2022a, 2022b, 2023, 2025a, 2025b and 2025c to a COM-B framework, identifying barriers and facilitators influencing guardian likelihood to engage in appropriate human-cat play behaviours.

8.3.3 Protecting the Human Cat Bond

Beyond cat enrichment, play may provide important opportunities for strengthening the human-cat bond through active communication, shared positive experiences and quality time together (Chapters 2,3,4 and 5). Importantly, strong human-cat bonds may themselves be protective of negative welfare outcomes (Hosey and Melfi, 2014). However, negative play

interactions have the potential to weaken this bond, causing friction due to cat dissatisfaction, human frustration, cat stress or human injury (Rault et al., 2020). Play interventions may therefore need to first protect the human-cat bond from potential negative effects before positive impacts are possible. Factors identified within this thesis that may jeopardise positive play interactions include guardian avoidance of play due to fear of injury or boredom (Chapters 3, 4 and 5) and misconceptions of cat communications (Chapters 6 and 7). To rectify these patterns, interventions should: 1) affirm the importance of both human and cat enjoyment within appropriate play interactions, 2) educate and encourage play interactions that prioritise the safety of both species and 3) provide training to enhance human ability to comprehend cat communication. A diversity of play has been associated with increased daily play times (Chapter 4), higher cat quality of life and closer human-cat bonds (Chapter 5). Encouraging rotation and diversification of play interactions may help in alleviating guardian experiences of boredom during play and will help to avoid cat habituation (Hall et al., 2002). Education on recognising early warning signs of cat dissent and implementing safe play practices (e.g., using a long-handled wand toy) and preventing post play frustration in cats (e.g., through enabling completion of the hunting sequence with a toy and slowly winding-down play sessions) may assist in reducing human fear of injury and injury risk (Delgado, 2022).

Human-cat communication can be a pivotal part of what makes human-cat bonds unique. Indeed, the variability in vocal cues between individual human-cat dyads has previously been likened to the development of in-group jargon or dialects (Schötz, 2020). Due to the meta-communicative nature of play, play interactions can be a rich environment for growing social communication (Bekoff and Allen, 1998). However, this growth requires guardians to have a

basic understanding of cat behaviours and an ability to detect and respond to dissent, else the interaction may do more harm than good. Educational interventions and establishing an occurrent dissent model with guardians prior to encouraging play interactions may help to ensure that play interactions strengthen, and do not diminish, human-cat communication and bonding.

Guardians may also benefit from the knowledge that play interactions can make their bond closer and lead to positive emotions in their cats (Kotrschal et al., 2014; Heath 2018). In a previous study, guardians reported experiencing positive outcomes (e.g., feelings of happiness) from dog walking, but these feelings were reliant on the perception that their dogs were also enjoying the experience (Westgarth et al., 2017). Guardian desire to make their cats happy may therefore be a promising avenue for promoting regular, healthy human-cat play interactions which in turn may further strengthen human-cat bonds. Of note, quantity of play (daily play times and session lengths) was not associated with cat quality of life scores within this thesis (Chapter 5) but quality of play (diversity/number of games played by a dyad) was. While further research is needed to support these findings, this finding suggests that human-cat dyads may benefit from focusing on engaging in high quality, enjoyable play sessions rather than meeting arbitrary play times. If the human-cat bond is protected through prevention of negative play outcomes, play sessions may then become a source of enrichment, communication and bonding that serves cat and human.

8.4 Gaps and Limitations

The present thesis is limited by the human-report nature of much of its data collection. Many of the measures used throughout the thesis Chapters have relied on human observation and

interpretation as a proxy for direct cat measures. To account for this, validated measures were used wherever possible, and an expert panel was utilised to validate video observations of cat behavioural states. However, further research is needed that includes direct measures of cat welfare outcomes such as direct observations, behavioural data (e.g., activity tracking, cognitive bias testing) and physiological measures (e.g., heart rate variability, cortisol, oxytocin). This thesis is potentially limited in its applicability across cultures and regions due to its exclusive use of English language and the Western background of the researchers and much of the literature cited. Additionally, much of the study's findings are correlational, not causational and therefore causality cannot be inferred. Terminology such as 'fun' could be considered anthropomorphic, future studies may reduce anthropomorphism by using more neutral language (e.g., 'positive'). Formal power calculations were conducted where appropriate; however, because studies were exploratory and suitable effect size estimates were unavailable, these calculations were necessarily approximate. Sample sizes were therefore guided by feasibility and precedent in the literature, which may limit statistical power. However, quantitative studies within this thesis achieved large sample sizes, suggesting statistical power is likely adequate.

Future research directions that would be beneficial include investigations into the play differences between cats in single vs multi-cat houses and the potential effect of household dynamics, including the presence or absence of other animals and children. In addition, how these household dynamics impact human time availability, perspectives and beliefs would be beneficial. Longitudinal studies on the impact of human-cat play on cat welfare, human-cat bonds and interspecies communication would help to clarify the degree to which play may impact welfare outcomes such as chronic health conditions, problem behaviours and risk of

surrender. The utility of play for establishing social bonds, both intra- and inter-specifically, and for reducing cat stress, especially in new or stressful situations such as in shelter environments or when moving to indoor-only housing remains un-explored. This particular avenue of human-cat play, as itself an intervention for mitigating poor welfare, may be especially promising; with the caveat of learning from the findings of the current thesis and ensuring that any play interventions are first and foremost rooted in cat choice and preference.

8.5 Concluding Remarks

This thesis aimed to investigate whether, and how, human-cat play interactions were associated with cat welfare, and what factors may influence these interactions. Findings suggest that human-cat play interactions are influenced by both human and cat factors and, depending on these factors, play interactions may be associated with both positive and negative cat welfare outcomes. The results of this thesis provide important information for future research, interventions and educational materials. Results indicate that cat welfare cannot be understood in isolation from human factors which influence both the quality of human-cat play interactions and how the cat is managed and cared for. Perhaps most critically, this research highlights the importance of ensuring cat agency and choice within interactions. For the millions of cats living in human homes worldwide, this research demonstrates that improving cat welfare is not simply about encouraging more play interactions but instead about fostering understanding of cat behaviours, preferences and needs, respect for cat autonomy and healthy human-cat bonds. If humans recognise, respect, and respond appropriately to cat signals and preferences, play may be a powerful tool for

enhancing welfare, strengthening bonds and enriching the lives of both cats and their human companions.

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