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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

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-

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

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

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.

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