frontiers | Frontiers in Ethology

TYPE Original Research
PUBLISHED 24 September 2025
DOI 10.3389/fetho.2025.1675587



OPEN ACCESS

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RECEIVED 29 July 2025
ACCEPTED 04 September 2025
PUBLISHED 24 September 2025

CITATION
Henning JSL, Nielsen T, Hazel S and Atkinson PJ (2025) Do you speak cat? Assessing the impact of a training video on human recognition of cat emotions and behaviours during play interactions.
*Front. Ethol.* 4:1675587.
doi: 10.3389/fetho.2025.1675587



# 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

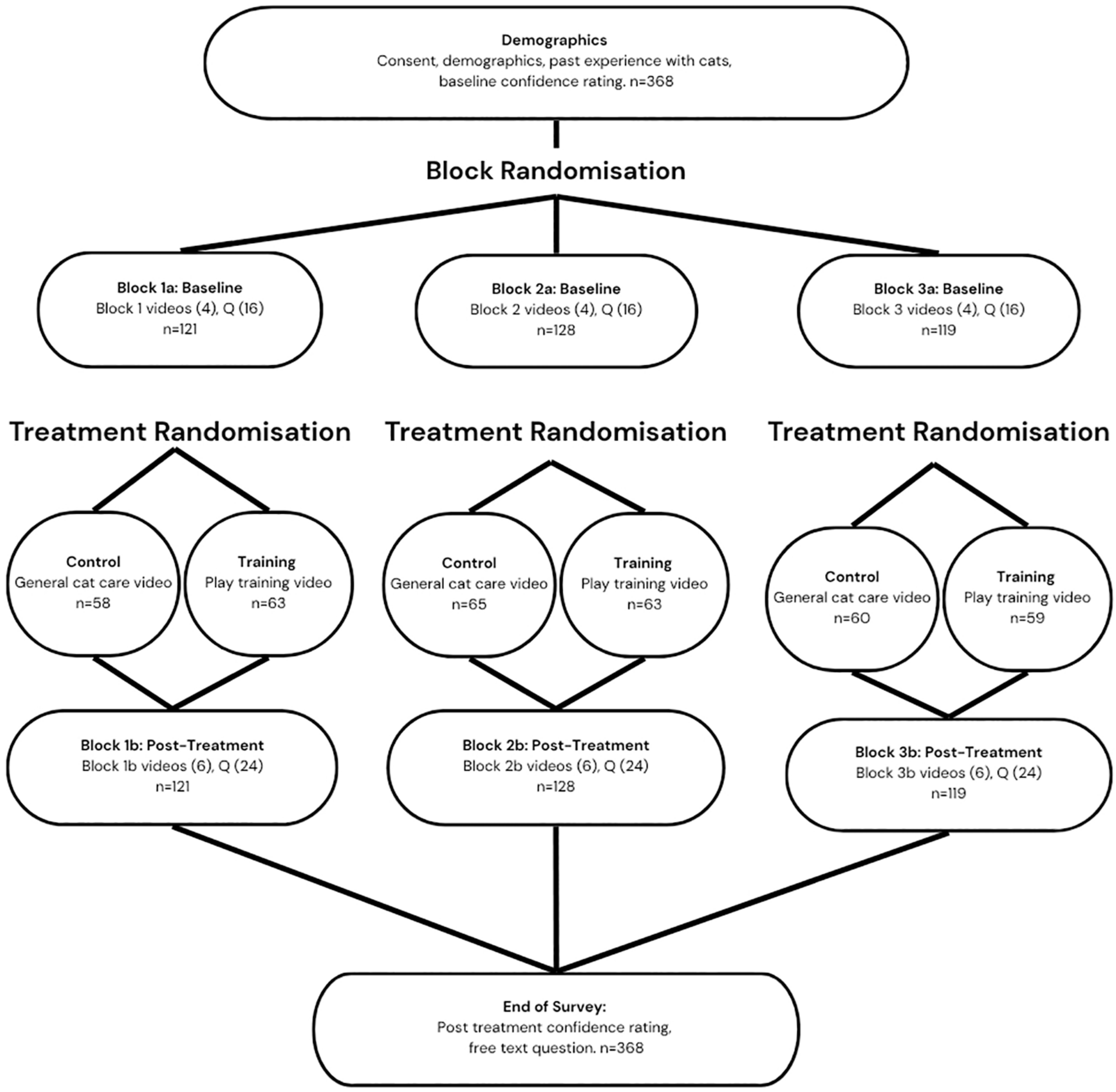


FIGURE 1
Flowchart of an Australia-wide online survey and randomized control trial that examined participant ability to recognize and respond to cat behavioural cues during human-cat 'play' interactions based on short video clips (n=368).

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

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

10.3389/fetho.2025.1675587

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.

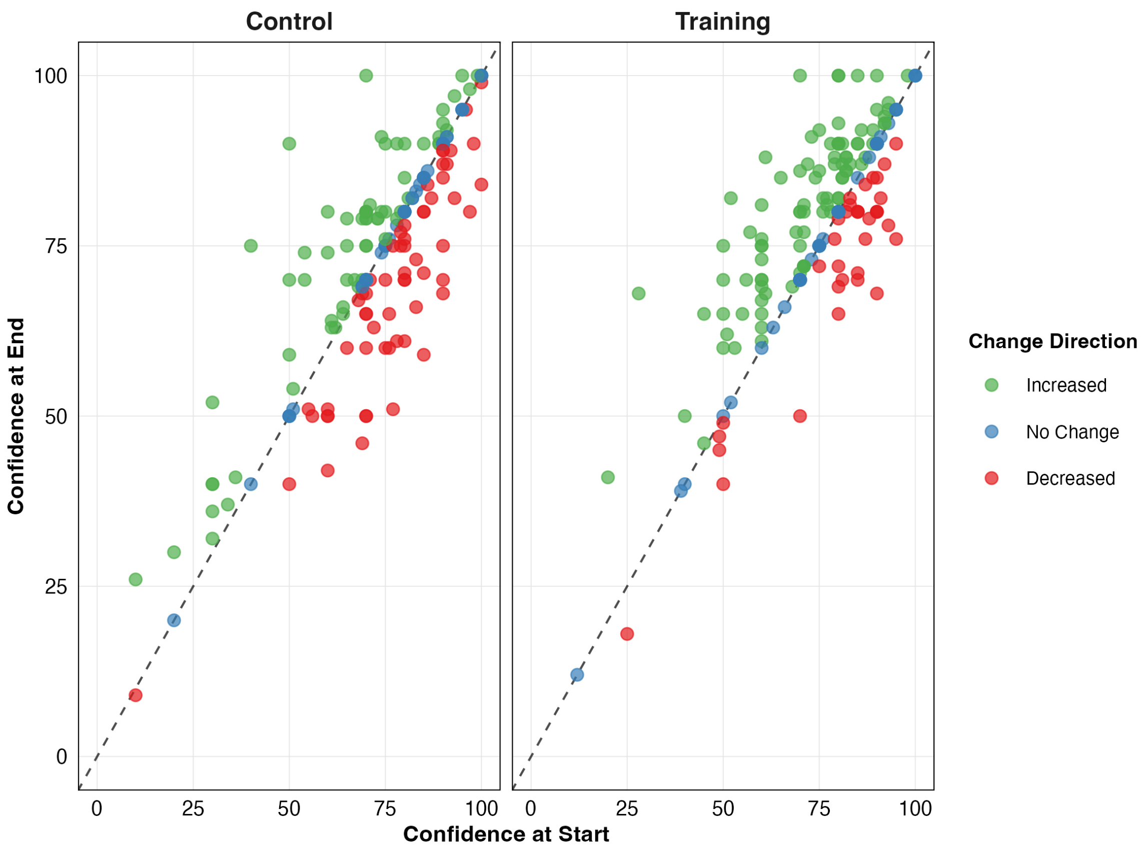


FIGURE 2
Pre- and post-intervention participant confidence ratings for reading cat body language (0-100) by treatment condition (training video or control).

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.

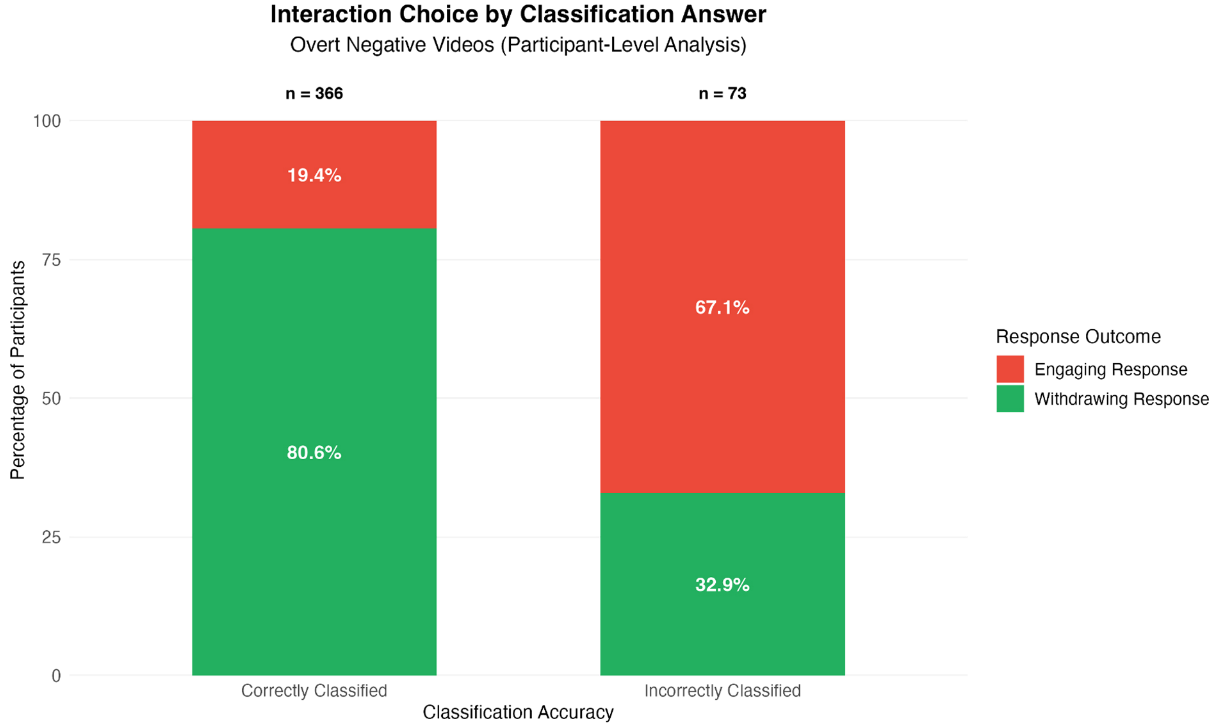


FIGURE 3
Proportion of participant interaction choices (engaging or withdrawing) following correct vs. incorrect classification of overt negative videos based on responses to an online survey between 23rd May and 10th June 2025. Percentages and counts represent participants who selected each option at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

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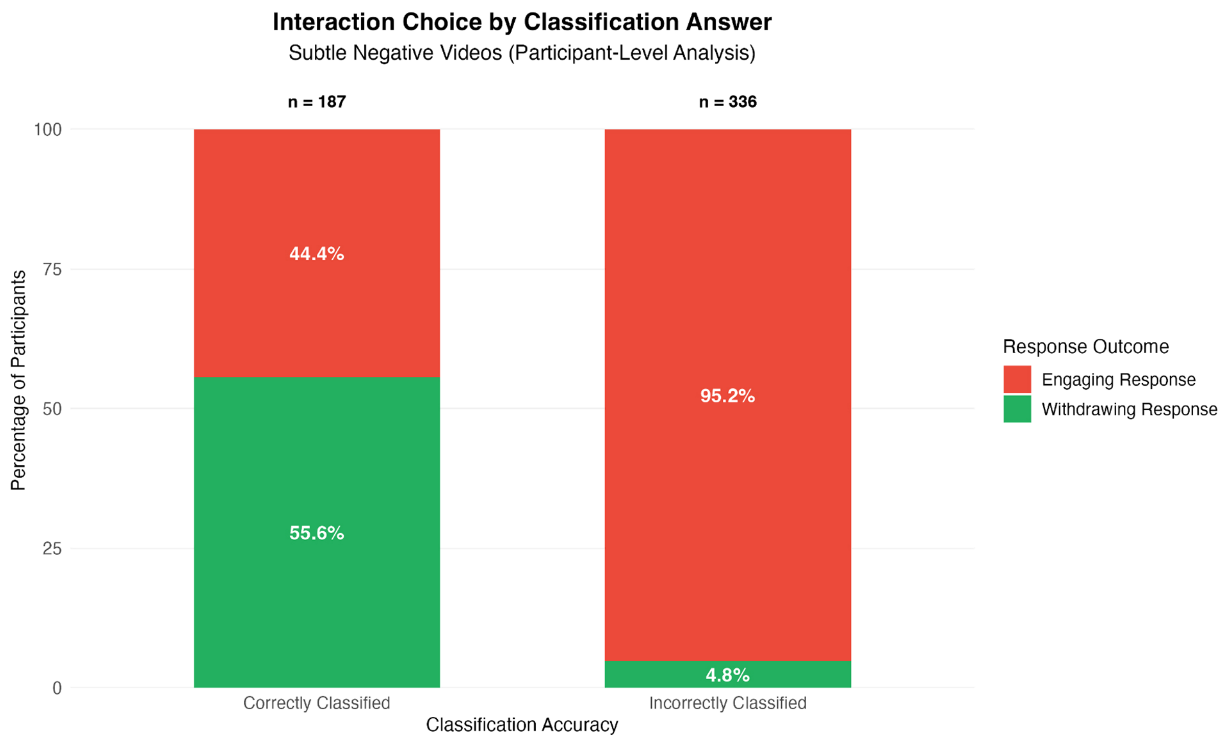


FIGURE 4
Proportion of participant interaction choices (engaging or withdrawing) following correct vs. incorrect classification of subtle negative videos based on responses to an online survey between 23rd May and 10th June 2025. Percentages and counts represent participants who selected each option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

## Funding

The authors declare that no financial support was received for the research, and/or publication of this article.

## Acknowledgments

With thanks to the expert panel for their participation and comments, to the Animal Behavior, Welfare and Anthrozoology Lab (ABWAL), for their feedback during study design, to those that test-ran our study, for their effort identifying bugs and reporting completion times, and to those that participated in the general public survey, for their time in completing our study.

## Conflict of interest

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## Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fetho.2025.1675587/full#supplementary-material

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