



Too much too soon? Risk factors for fear behaviour in foster kittens prior to adoption

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ABSTRACT

Many companion kittens spend their sensitive period for socialization (~2–9 weeks of age) in foster care, and the quality of these early life experiences can impact behavioural development. This study aimed to improve early kitten care by using an online survey to investigate risk factors for fear behaviour in foster kittens prior to adoption (7–9 weeks of age) based on early management practices, foster parent personality traits, and evaluations of kitten behaviour. The main behavioural outcomes of this study were whether kittens showed caregiver-reported fear behaviour during interactions with unfamiliar people and unfamiliar objects just prior to adoption. Fear behaviour included displays of avoidance, freezing, crouching, ears back, piloerection, and aggression. We analyzed the impacts of kitten ($n=235$) and foster parent ($n=72$) characteristics, exposure to social stimuli (i.e., general handling, mimicking handling during a vet visit, exposure to people), and exposure to non-social stimuli (e.g., interactive toys, scratching material, different surfaces, etc.) provided. Using mixed logistic regression models, with foster parent as a random intercept to account for clustering at the foster home level, we found that kittens who were reported fearful at intake into foster care had significantly greater odds of displaying fear behaviours towards unfamiliar people and unfamiliar objects than kittens who were not reported fearful at intake. Additionally, kittens who received exposure to cognitive enrichment-based non-social stimuli had greater odds of displaying fear towards people compared to kittens who did not receive cognitive exposure. Kittens whose foster parent had a high score for emotional stability had greater odds of displaying fear towards people compared to those who had a low score for emotional stability. Further, kittens who received high exposure to social stimuli had reduced odds of displaying fear towards people than kittens who received low social exposure, as predicted. Some of these findings challenge recommendations for high amounts of exposure to social and non-social stimuli during early socialization. High social exposure was ineffective at reducing fear levels towards unfamiliar objects, and high cognitive enrichment-based non-social exposure appears to have exceeded kitten limits for optimal behavioural development. While appropriate socialization is beneficial for development, the current study highlights the need for further research to understand the impact of different socialization practices on kitten behavioural development, and the importance of accurately identifying when kittens are fearful and adapting socialization practices appropriately.

1. Introduction

The quality of experiences early in life can influence emotional and behavioural development, and impact long-term animal welfare (Mason, 2000). In cats, persistent negative emotional states, such as fear, can directly impair animal welfare and put animals at an increased risk for medical conditions, such as respiratory or gastrointestinal illness (Amat et al., 2016), and serious behavioural issues such as aggression

(DiGiacomo et al., 1998; Levine, 2008; Salman et al., 2000, 1998). Therefore, it is important to understand and mitigate the development of negative emotional states early in life.

Companion kittens entering shelter systems typically spend the early weeks of their lives in foster care with volunteer community members, primarily due to their vulnerable health status (Attard et al., 2013; Dinnage et al., 2009). Coincidentally, this time overlaps with the sensitive period for socialization, which in kittens is from approximately 2 to 9

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weeks of age (American Veterinary Medical Association, 2015; Bateson, 2014; Karsh, 1984; Karsh and Turner, 1988; Lowe and Bradshaw, 2001). Experiences during this time are crucial for learning about social partners and environmental features to prevent related fear later in life for many species (Bateson and Gluckman, 2011), including cats (e.g., Collard, 1967), dogs (e.g., Scott, 1957), and rats (e.g., Baldini et al., 2013). For example, adult cats who received supplemental handling as kittens show increased time spent in proximity to people and decreased latency to approach people when compared to cats with limited handling as kittens (Karsh, 1984; McCune, 1995).

Beyond social factors, non-social experiences during the socialization period can also impact fear later in life. For example, puppies are known to form site attachment to their early physical environments and can develop neophobia in novel situations later in life if reared in environmentally impoverished conditions during their socialization period (Serpell and Jagoe, 1995). No similar studies have been conducted with kittens; although one study found that kittens handled daily over the first 45 days of life had increased interactions with unfamiliar toys and took longer to learn an active avoidance response than kittens who were not handled, indicating a reduced fear response (Wilson et al., 1965). These examples suggest the potential for a cross-modal effect on fearfulness where lack of social experience leads to fear of novel environments and experiences, and vice versa.

Beyond early handling, most previous research on factors influencing behavioural development in kittens focuses on experiences post-adoption and on aggression as the outcome, rather than fear. One study found that caretaker-reported aggression and stereotypic behaviour post-adoption were increased in kittens who were separated from their mother before 8 weeks of age (Ahola et al., 2017). Another study found that a range of early kitten management factors (e.g., mother presence, bottle-feeding, singleton versus group, adoption age) were not associated with the display of aggression in adult cats in the home (O'Hanley et al., 2021). However, these studies did not assess kitten fear or explicitly investigate the quality of early environmental and social experiences.

Foster parents provide many kittens with their earliest experiences with humans and the style of these interactions and other personal characteristics may influence kitten behavioural development. For example, the quality of behavioural outcomes for assistance dogs appears to be influenced by intrapersonal factors, such as volunteer puppy-raiser expectations, competency, and passion (Mai et al., 2020). Greater caretaker knowledge about cat behaviour has also been found to be correlated with fewer reported behaviour problems, less use of positive punishment toward perceived misbehaviour, and increased tolerance of potential problems if present (Grigg and Kogan, 2019). Shelters often provide guidelines for foster parents on how to set up the kitten environment and a brief introduction to the types of social and non-social experiences to provide to kittens during their socialization window (e.g., BC SPCA, n.d.; University of California Davis and University of Wisconsin, 2017). However, it is not known whether foster parents actually follow these guidelines.

The objectives of this study were to better understand how foster parents manage young kittens, and to determine risk factors for foster-parent reported fear behaviour in kittens just prior to adoption. Types of exposures offered for social and non-social experiences were of particular interest given previous literature highlighting the importance of these experiences for limiting fear later in life. We hypothesized that increased exposure to different types of social and non-social experiences during the socialization period would generalize and reduce overall fearfulness to novel stimuli in kittens. This hypothesis predicts that the impacts of exposure will be cross-modal (i.e., social experiences can impact non-social outcomes and vice versa), and that high variety and amount of exposure to both social and non-social stimuli will result in a reduction in reported fear behaviours towards either social or non-social stimuli at the end of the socialization period (i.e., adoption age). We also explored the impact of other factors predicted to influence

kitten fearfulness based on previous research, including kitten characteristics such as coat colour (e.g., González-Ramírez and Landero-Hernández, 2022), sex (e.g., Ha and Ha, 2017), and maternal presence (e.g., Lowell et al., 2020), as well as the effect of foster parent characteristics.

2. Materials and methods

2.1. Survey

The online survey (Table S1 in Supplemental Material) used in this study was hosted through Qualtrics® survey software and was available online from 14 October to 8 November 2021. Survey participation was open to foster parents worldwide who were at least 18 years of age and currently fostering kittens who were between 7 and 9 weeks of age and had been in foster care with that individual for at least one week. Participants were recruited through convenience sampling with a snowball sampling approach on social media platforms (Facebook, Twitter, TikTok) on both personal pages and lab pages (OVC Companion Animal Behaviour and Welfare Lab), as well as through an advertisement on our lab website. Additionally, humane societies and charities, professional cat bloggers, and other related shelter and animal behaviour contacts were emailed with an advertisement and survey description asking them to share on their own social media pages or email their foster communities directly. The survey protocol was reviewed and approved by the University of Guelph Research Ethics Board for compliance with federal guidelines for research involving human participants (REB #21-05-023).

Foster parent participants were asked to answer questions about: (1) their household demographics, previous fostering and professional animal experience, and personality traits using the validated Ten-Item Personality Inventory (TIPI; Gosling et al., 2003); (2) current kitten information at the litter level (such as presence of a mother cat in foster care, and social and non-social stimuli exposures provided during weeks 7–9 of age); (3) individual kitten characteristics including details on kitten sex and coat colour (i.e., tabby [brown, grey, orange], solid black, solid grey, solid white, bi-colour [e.g., black with white, white with black, grey with white, white with grey], tri-colour [calico, tortoiseshell], and other); and (4) individual kitten assessments including behaviours displayed when interacting with unfamiliar people and unfamiliar objects during weeks 7–9 of age (i.e., behavioural outcomes for the final weeks of the socialization period just prior to adoption). To aid with the behaviour assessments, participants were provided with an infographic of typical fear responses shown by kittens based on previous research from our group (Graham et al., *in prep.* *Fear validation study*. See Supplemental Material).

Questions about social and non-social stimulus exposures were asked in two ways. Enrichment-based non-social exposures were asked with options for “Yes”, “No”, or “N/A”, and included exposure to small toys, interactive toys, exploratory items, puzzle feeding devices, elevated items, scratching materials, hiding areas, scent stimuli, visual stimuli, training, and outdoor access. Experience-based exposure to social and non-social stimuli (i.e., general handling, movement opportunities such as climbing stairs, different surfaces) were asked using a Likert-type scale (0–4) ranging from “Not at all” to “A great deal”, and participants were asked to incorporate both time and amount in their response (e.g., “Not at all” = no exposure versus “A great deal” = daily exposure and lots of variety). These exposures were included as they promote exploration and play to engage the kitten with the world around them and support the performance of natural cat behaviour (Bateson and Martin, 2013; Landsberg et al., 2013). See Table S1 in Supplemental Material for full details.

At the end of the survey, participants could enter a prize draw for the chance to win one of three \$100CAD prize packs of \$25CAD of kitten supplies for the foster parent and a \$75CAD donation to their associated shelter in their name (or anonymously if preferred).

2.2. Statistical analysis

Data were analyzed using mixed logistic regression models with Stata statistical software (v15.1 for Mac, StataCorp. 2015, College Station, Texas, USA) to assess risk factors for fear behaviours in kittens. The main outcomes of interest were whether or not kittens displayed fear behaviours when interacting with unfamiliar people and when interacting with unfamiliar objects. The binary outcome variables were created using foster-parent reports of fear behaviours displayed by kittens during interactions with unfamiliar people and objects in the weeks just prior to adoption—if any fear behaviour was reported (i.e., avoidance, freezing, crouching, ears back, piloerection, and aggression), the kitten was categorized as “displays fear to people/objects”. Because there were multiple kittens from each foster home, a random intercept of participant ID was included to account for any clustering at the foster home or litter level. We included whether or not a kitten was reported fearful at intake into foster care as a binary independent variable, as well as other kitten characteristics (e.g., sex, coat colour, presence of the mother, litter size, time in foster care), and foster parent characteristics (e.g., demographics, previous experience with kittens/cats).

Many kittens received exposure to the same social and non-social stimuli which resulted in minimal variation in exposure for some of these variables (see Table 2 and Fig. 1). Therefore, new independent variables related to early socialization were defined by creating average scores from the different exposures of interest to capture overall experience. Scores reflecting average levels of exposure were created for social stimuli (i.e., exposure to general handling, mimicking handling during a vet visit, and unfamiliar people) and experience-based non-social stimuli (i.e., exposure to transportation, household objects, movement opportunities, different surfaces, and auditory stimuli). For enrichment-based non-social stimuli (i.e., small toys, interactive toys, exploratory items, puzzle feeding devices, elevated items, scratching materials, hiding areas, scent stimuli, visual stimuli, and training), we manually grouped similar exposure categories based on function to create four categories: tactile opportunities (i.e., scratching materials and interactive toys), retreat opportunities (i.e., hiding areas, elevated items, and visual stimuli), play opportunities (i.e., small toys, exploratory items, and interactive toys), and cognitive opportunities (i.e., puzzle feeders, training, and scent stimuli). There was insufficient variation in tactile, retreat, and play opportunities (i.e., most or all kittens received these exposures), therefore, the variable for cognitive opportunities was the only independent variable considered for inclusion in the final models. These new scores were included as independent variables in the final models to investigate the influence of the impact of social and non-social experiences during the socialization period on fear behaviour just prior to adoption. Personality traits of the foster parent were also included as independent variables in the final models. The

original variables for foster parent personality traits were not found to be linear with the log odds of the outcome variable as continuous or when transformed and were therefore categorized at the median score into high and low scores. Additionally, exposure to unfamiliar animals was not included in the logistic regression models due to a low proportion of kittens receiving this exposure and no foster parent-reported behaviour during these interactions.

Prior to full modeling, correlations between the independent variables were assessed using Spearman rank or Phi correlation coefficients to identify potential issues with collinearity. If two variables were highly correlated (i.e., $>|0.70|$), the most biologically meaningful variable was selected for further analysis. The assumption of linearity between the continuous independent variables and the outcome variable on a log odds scale was graphically assessed using locally weighted regression curves (LOWESS) and by testing the inclusion of a quadratic term in the model. If the relationship was nonlinear and could not be appropriately modeled as a quadratic relationship, the continuous variable was dichotomized using its median value; the variables for social exposure and experience-based non-social exposure were impacted by this process and were therefore included as binary covariates. Initially, univariable mixed logistic regression models were fitted to examine the association between the independent variables and displays of fear behaviours. Variables were considered for inclusion in the multivariable models using a liberal significance level ($\alpha=0.20$; Dohoo et al., 2014). All variables significant in the univariable analyses were included in main effects multivariable mixed logistic regression models and were removed in a manual backward stepwise fashion. Variables were retained in the multivariable models if they were statistically significant ($\alpha=0.05$) or were considered an explanatory antecedent or distorter variable (i.e., confounding variable). Confounding variables were non-intervening variables that caused a change of greater than 20% in the coefficient of other statistically significant variables in the models when removed (Dohoo et al., 2014). For variables that had a minimum of 10 kittens per category, two-way interactions were evaluated among all main effects and were retained in the models if they were statistically significant ($\alpha=0.05$).

Model fit was assessed by graphically evaluating the homoscedasticity and normality of the best linear unbiased predictors (BLUPs). Pearson and deviance residuals were also assessed to determine if there were any outlying observations, which were then inspected for recording errors and impact on the models. Using the variance components from the multivariable logistic models, we estimated the variance partition coefficients using the latent variable technique (Dohoo et al., 2014).

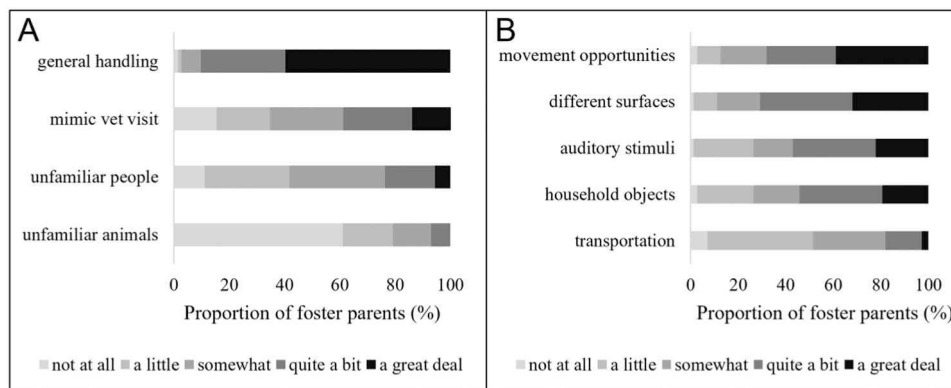


Fig. 1. Experienced-based social (a) and non-social (b) exposures provided to foster kittens ($n=235$) between 7 and 9 weeks of age as reported by foster parent participants ($n=72$). Participants reported using a 5-point Likert-type scale, with lightest bars representing less exposure (“not at all”) and darkest bars representing more exposure (“a great deal”).

3. Results

3.1. Responses

In total, 89 foster parent responses were received. Seventeen responses were removed due to noncompletion or not meeting the inclusion criteria, leaving 72 individual foster parent responses for the final analyses, with a total of 235 kittens in foster care at the time of survey participation. Kitten litter size ranged from 1 to 8 kittens (average: 4.2 kittens).

3.2. Descriptives

The majority of participants identified as women (67/72 [93.0%]), resided in a mid-sized community (41/71 [57.8%]) in Canada (55/72 [76.4%]), and considered themselves experienced fosters (38/72 [52.8%]; Table 1). Participants had been fostering for an average of 4.4 years (range: less than 1 year to 18 years), with an average of 3.7 litters annually (range: 1–10+), and had an average age of 42.7 years (range: 22–72). The average participant personality score for extraversion was lower than general population averages, whereas participant averages for agreeableness, conscientiousness, emotional stability, and openness to experience were higher than general population averages (Gosling et al., 2003; Table 1).

Of the 235 kittens, 119 (50.6%) were female and 116 (49.4%) were male, 109 (46.4%) received high exposure to social stimuli, 127 (54.0%) received high exposure to experienced-based non-social stimuli, and 67 (33.3%) were reported fearful at intake into foster care (Table 2). For the enrichment-based non-social exposures, most kittens received tactile (n=223; 94.9%) and retreat (n=229; 97.5%) opportunities, and all kittens received play opportunities (n=235; 100%); 124 kittens (52.8%) received cognitive opportunities (Table 2). Additionally, nearly all kittens (n=221; 94.0%) were reported to receive positive reinforcement (e.g., treats, food, play, verbal praise, attention) during exposure to new

Table 1

Demographic characteristics of kitten foster parent participants of an online survey which examined risk factors for fear behaviour in kittens within foster care (n=72; unless otherwise noted).

Characteristic	N (%)
Gender	
Woman	67 (93.0)
Man	3 (4.2)
Non-binary	1 (1.4)
Prefer not to answer	1 (1.4)
Country of residence	
Canada	55 (76.4)
United States	14 (19.4)
Other ^a	3 (4.2)
Community type (n=71)	
Small (fewer than 29,999 people)	2 (28.2)
Mid-sized (30,000 to 999,999 people)	41 (57.8)
Large (more than 1 million people)	10 (14.1)
Foster experience	
Beginner	11 (15.3)
Experienced	38 (52.8)
Expert	23 (31.9)
	Average (range; SD)
Years fostering	4.4 years (<1, 18; 4.2)
Annual number of litters fostered	3.7 litters (1, 10+; 2.4)
Personality traits^b	
Extraversion	4.00 (1.5, 7; 1.54)
Agreeableness	5.45 (2.5, 7; 1.22)
Conscientiousness	6.18 (4, 7; 0.78)
Emotional stability	5.14 (1.5, 7; 1.43)
Openness to experience	5.51 (2.5, 7; 1.05)

a Other countries of residence were Belgium, Indonesia, and United Kingdom.

b Population averages (Gosling et al., 2003): Extraversion: 4.44 (SD=1.45), Agreeableness: 5.23 (SD=1.11), Conscientiousness: 5.40 (SD=1.32), Emotional stability: 4.83 (SD=1.42), Openness to experience: 5.38 (SD=1.07).

Table 2

Demographic characteristics of kittens (n=235, unless otherwise stated—based on survey response) as reported by foster parent participants (n=72).

Characteristic	N (%)
Sex	
Female	119 (50.6)
Male	116 (49.4)
Coat colour (n=214)	
Tabby (brown, grey, orange)	68 (31.7)
Solid black	30 (14.0)
Solid grey	20 (9.3)
Bi-colour (e.g., black and white)	52 (24.3)
Tri-colour (e.g., calico, tortoiseshell)	28 (13.1)
Other (including white)	16 (7.5)
Presence of the mother in foster care (n=72 litters)	
With nursing mother throughout care	22 (30.6)
No mother, bottle-fed exclusively throughout care	9 (12.5)
Inconsistent (partial time with mother, not exclusive)	6 (8.3)
Kittens arrived already weaned, with mother previously	9 (12.5)
Kittens arrived already weaned, no mother, only bottle-fed previously	1 (1.4)
Kittens arrived already weaned, unknown history of mother	22 (30.6)
Unknown	3 (4.2)
Estimated age at intake into foster care (average: 4.00 [SD=2.6] weeks)	
Less than 1 week	37 (15.7)
1 week	10 (4.3)
2 weeks	8 (3.4)
3 weeks	36 (15.3)
4 weeks	34 (14.5)
5 weeks	31 (13.2)
6 weeks	17 (7.2)
7 weeks	22 (9.4)
8 weeks	25 (10.6)
Estimated age at time of survey	
7 weeks	64 (27.2)
8 weeks	54 (23.0)
9 weeks	117 (49.8)
Reported fearful at intake into foster care (n=203)	
No	136 (67.0)
Yes	67 (33.3)
Received positive reinforcement during socialization experiences	
No	14 (6.0)
Yes	221 (94.0)
Average social stimulus exposure^a	
Low	126 (53.6)
High	109 (46.4)
Average experience-based non-social stimulus exposure^b	
Low	108 (46.0)
High	127 (54.0)
Enrichment-based non-social stimulus exposure	
Tactile opportunities	223 (94.9)
Designated scratching materials (e.g., scratching post, horizontal scratching mat, designated floor/carpet areas)	
Interactive toys (e.g., feather wands, string toys)	
Retreat opportunities	229 (97.5)
Hiding areas (e.g., covered beds, boxes, underneath furniture)	
Elevated surfaces (e.g., perches, cat tree, furniture)	
Visual stimulation (e.g., view of a window, aquarium, TV/tablet screen)	
Play opportunities	235 (100.0)
Small toys (e.g., balls with bells, furry mice, crinkle balls, stuffed toys)	
Explorative items (e.g., boxes, tunnels, paper bags)	
Cognitive opportunities	124 (52.8)
Scent stimulation (e.g., catnip, silver vine)	
Puzzle feeding devices (e.g., puzzle feeders, food hiding toys)	
Training (e.g., to do tricks or respond to commands)	
Outdoor access (not included in analyses)	
Supervised outdoor access (e.g., fenced backyard, patio, catio, on leash)	25 (10.6)
Unsupervised outdoor access (i.e., free roaming)	10(4.3)

a Exposures included: general handling, mimicking handling during a vet visit, and unfamiliar people.

b Exposures included: transportation opportunities, household objects, movement opportunities, different surfaces, and auditory stimuli.

stimuli (Table 2). The average estimated age of kittens at intake into foster care was 4.0 weeks. The majority of kittens were estimated to be 9 weeks of age at the time of the survey (49.8% [117/235]). As reported by the foster parent, the plurality of kittens had a tabby coat colour (either brown, grey, or orange tabby; 31.7% [68/214]) and either had a nursing mother throughout care (22/72 litters [30.6%]) or arrived at foster care already weaned with an unknown history of the mother (22/72 litters [30.6%]). Additional kitten demographic information is available in Table 2.

3.3. Socialization opportunities provided

On average, foster parents reported interacting with their kittens for 186 minutes (3.1 hours) daily (range: 0–600 minutes). The majority of foster parents provided their kittens access to each of the different enrichment-based non-social stimulus exposures, including access to small or interactive toys, designated scratching materials, hiding areas, elevated platforms, and exploratory items (Table 2). Of the experience-based social exposures, general handling was provided by the highest proportion of foster parents, whereas exposure to unfamiliar animals was provided the least (Fig. 1a). Of the experienced-based non-social exposures, movement opportunities were provided the most, whereas transportation opportunities were provided the least (Fig. 1b).

3.4. Mixed logistic regression results

Two logistic regression models (Table 3) were used to examine the main behavioural outcomes: kittens' display of fear behaviour during interactions (1) with unfamiliar people, and (2) with unfamiliar objects. Displays of fear behaviour towards unfamiliar people were significantly associated with being reported fearful at intake into foster care, receiving exposure to enrichment-based cognitive non-social stimuli, the emotional stability of the foster parent, and exposure to social stimuli. Kittens who were reported fearful at intake into foster care had greater odds of displaying fear behaviour towards unfamiliar people at adoption age than kittens who were not reported fearful at intake (Table 3). Kittens who received exposure to cognitive non-social opportunities had greater odds of displaying fear behaviours towards people at adoption age compared to kittens who did not receive exposure to cognitive opportunities (Table 3). Related to foster parent personality, kittens whose foster parent had a high score for emotional stability (i.e., low neuroticism) had greater odds of displaying fear towards people at adoption age compared to those who had a foster parent with a low score for emotional stability (Table 3). In contrast, kittens who received high exposure to social stimuli had reduced odds of displaying fear towards unfamiliar people. No other variables were significant in the model, including the amount of exposure to experienced-based non-social stimuli and time spent in foster care. Based on the model's variance components, we estimated that 24.3% of fear behaviours displayed during interactions with unfamiliar people are explained at the foster home/litter level.

Displays of fear behaviour towards unfamiliar objects were also significantly associated with being reported fearful at intake into foster care. Kittens who were reported fearful at intake into foster care had greater odds of displaying fear behaviour towards unfamiliar objects at adoption age than kittens who were not reported fearful at intake (Table 3). No other independent variables were significant in the displays of fear behaviour towards unfamiliar objects, including the amount of exposure to social stimuli or non-social stimuli. Based on the model's variance components, we estimated that 91.8% of fear behaviours displayed during interactions with unfamiliar objects are explained at the foster home/litter level.

4. Discussion

In the current study, we found that foster parents provide their

Table 3

Results from mixed logistic regression models for fear behaviours^a displayed by kittens between 7 and 9 weeks of age (n=235) as reported by foster parents (n=72) during interactions with unfamiliar people and objects just prior to adoption, including random intercepts for litter^b.

Context of kitten displaying fear behaviours	Variable (s)	OR	95% CI	P-value
Interactions with unfamiliar people	Kitten not reported fearful at intake into foster care	REFERENT		
	Kitten reported fearful at intake into foster care	43.75	10.65, 179.71	<0.0001
	No exposure to cognitive non-social stimuli ^c	REFERENT		
	Exposure to cognitive non-social stimuli ^c	20.62	4.43, 95.82	<0.0001
	Low average social exposure ^d	REFERENT		
	High average social exposure ^d	0.26	0.07, 0.97	0.044
Interactions with unfamiliar objects	Low foster parent emotional stability score	REFERENT		
	High foster parent emotional stability score	4.20	1.13, 15.63	0.032
	Kitten not reported fearful at intake into foster care	REFERENT		
	Kitten reported fearful at intake into foster care	8.84	1.21, 64.41	0.032

^a Fear behaviours included: avoidance, freezing, crouching, ears back, piloerection, and aggression. Foster parents were provided with an infographic of pictures and descriptions of each behaviour (See Supplemental Material).

^b Random intercept variances for each context: *Unfamiliar people*: 1.06 (95% Confidence Interval: 0.14, 7.91); *Unfamiliar objects*: 36.82 (5.42, 250.22).

^c Cognitive opportunities included exposure to puzzle feeding devices, scent stimuli, and training.

^d Social exposures included exposure to general handling, mimicking handling during a vet visit, and unfamiliar people.

kittens with a variety of exposures during the socialization period, which is generally considered beneficial for behavioural development and long-term kitten welfare. Expert recommendations and shelter-provided guidelines for early kitten rearing typically suggest providing exposure to physical and cognitive stimulation, including positive social interactions, play engagement, exposure to common household items, and access to safe hiding areas, vertical space, and scratching surfaces (e.g., American Association of Feline Practitioners, 2004; BC SPCA, n.d.; San Francisco SPCA, n.d.; Seksel, 2008).

High amounts of social and non-social exposure are generally recommended for young kittens to reduce later fear and we found that a high amount of exposure to social stimuli was effective at reducing fear towards unfamiliar people; however, our results suggest that this approach might not be effective for all kittens and that there might be limits to the type and how much exposure should be recommended. While lower fearfulness was predicted with high amounts of social and non-social exposure based on previous research (e.g., Casey and Bradshaw, 2008; Karsh, 1984), we found that exposure to cognitive non-social stimuli appears to have exceeded kitten limits for optimal behavioural development, with exposure being associated with increased fear responses to unfamiliar people. Further, neither social nor non-social exposures were effective at reducing fear levels at the

pre-adoption assessment for displays of fear during interactions with unfamiliar objects. This unanticipated effect might be due to the manner in which these exposures were provided, which could have led to flooding if the experience was too intense. When exposure to a new and potentially fear-provoking stimulus is conducted at high intensity, it can cause overstimulation, pushing individuals beyond their ability to cope, and ultimately leading to increased and prolonged fear responses (Landsberg et al., 2013; Riemer et al., 2021; Yin, 2009). Shelter guidelines typically discuss the importance of using a graded approach to providing new experiences to kittens (e.g., BC SPCA, n.d.; San Francisco SPCA, n.d.) and it is unknown whether foster parents were following these guidelines. Increased fear at the time of adoption is concerning as it has direct consequences for adoption outcomes and kitten welfare and might also impact how the kitten adapts to their new home and social environment. While early experiences with people have also been shown to reduce fear to people in puppies (e.g., Puurunen et al., 2019; Tiira and Lohi, 2015), it is suggested that the efficacy of socialization likely depends on the diversity, amount, and proper timing of socialization experiences (Puurunen et al., 2019). The survey-based approach of the current study was not able to fully probe the quality of the experiences provided to kittens, which is critical to understanding whether the amount or variety in exposure versus the way in which exposures are being conducted is the more important factor. Future research incorporating qualitative approaches or controlled behaviour assessments will be key to this investigation.

The current study highlights the importance of accurately identifying when kittens are fearful and adapting socialization practices accordingly. Being reported as fearful at intake into foster care was an important predictor for displays of fear behaviour by kittens during interactions with unfamiliar people and objects at adoption age. Given that many kittens entering shelters come from feral colonies or environments where they are under-socialized to humans (e.g., barns, industrial areas), understanding the needs of kittens who are fearful at intake is particularly important. These fearful kittens may have been under-socialized at younger ages or may have had negative experiences prior to entering foster care that enhanced their fear responsiveness; this increased fear may also be inherited by genetics and being more prone to fearfulness (e.g., McCune, 1995). A primary goal of providing socialization to kittens during their sensitive period is to promote positive and lasting associations with people and the environment (see reviews by Finka, 2022; Turner, 2021). Our finding that a high amount of exposure to social stimuli (i.e., general handling, mimicking handling during a veterinary visit, and exposure to unfamiliar people) was protective against increased kitten fear levels during interactions with unfamiliar people supports previous research that has investigated the impacts of early exposure to people during the socialization period later in life (e.g., McCune, 1995). Kittens in the current study spent between 1 and 9 weeks in foster care; however, we did not find that fear responses were influenced by age at intake (i.e., time spent in foster care). The current study investigated responses when kittens were still within their socialization period (between 7 and 9 weeks of age) and therefore further research is needed to explore whether these responses occur prior to this period in the socialization window (e.g., prior to 7 weeks, as in Karsh and Turner, 1988) and/or persist into adulthood. Individual behavioural styles among cats have been found to be consistent over time from kittenhood up to 2 years of age (Lowe and Bradshaw, 2001; Urrutia et al., 2023, 2022) so consistency is likely; however, it would be beneficial to examine responses at different timepoints throughout a kitten's life to observe lasting effects of early socialization.

As highlighted above, it was not possible to ascertain the quality of the exposures conducted by foster parents in the current study, and research exploring *how* foster parents interact with their kittens is needed to fully understand the importance of amount versus quality. One key aspect of quality is appropriately adjusting to the needs of the individual kitten and removing stimuli when the intensity of exposure is too high and evoking a prolonged fear response. Research from our

group has shown that clear and concise training in identifying kitten behaviour improves human accuracy in rating validated fear behaviours in kittens (Graham et al., *in prep. Fear validation study*; Graham et al., *in prep. Fear identification study*). This type of training can help ensure fear is recognized early and kittens are not flooded during socialization exposures. Training and previous experience has been found to improve ratings of cat and dog behaviour among people with differing levels of experience with the animal of interest (Bahlig-Pieren and Turner, 1999; Diesel et al., 2008; Feaver et al., 1986; Tami and Gallagher, 2009). Therefore, it may be beneficial to provide foster parents with training or detailed guidelines on identifying specific features of kitten behaviour to help assess fear levels upon intake into foster care and reduce the potential for misclassification bias.

The variances in the displays of fear behaviour estimated at the foster home level suggest moderate to high clustering within the foster home and could be due to litter characteristics (e.g., genetic effects) or to factors occurring within the home that impact the litter as a whole (e.g., foster parent personality or approaches to socialization). We investigated the impact of litter size as well as presence of the mother cat, among other kitten and foster parent characteristics, on fear outcomes but did not find any significant associations. While many foster parents in the current study provided a moderate to high proportion of the exposures that we asked about to their kittens, our measures were based on mean scores that assessed variety and overall amount of exposure rather than level of exposure to a particular experience. There is the potential that one or more of the exposures included in the composite variables acted as a suppressor variable which may have influenced the original relationship between the exposures and the outcomes (Dohoo et al., 2014). We were also not able to adequately investigate the impact of all enrichment-based non-social opportunities due to lack of variation (i.e., too few observations for a particular category or level of exposure) in the variable. Future research could investigate more comprehensive measures of exposure to both social and non-social stimuli, as well as how these exposures are provided, to further explore factors that impact differences at the foster home or litter level.

Human personality traits are known to impact the relationships we have with our cats as well as cat behaviour in the home (Finka, 2022; Finka et al., 2019; Wedl et al., 2011). Our finding that kittens whose foster parent had a high score for emotional stability (i.e., low neuroticism) had greater odds of displaying fear towards people compared to those who had a low score is contradictory to other recent research. Cat caretakers with high scores for neuroticism (i.e., low emotional stability) have been found to be associated with cats who are more aggressive and fearful and these caretakers were more likely to report that their cats had "behavioural problems" (Finka et al., 2019). In another study, cat caretakers with high scores for neuroticism had more anxious attachments to their cats, which may present as a more vigilant or careful caretaking style (Reevy and Delgado, 2014). However, in these previous studies, cats were mature (minimum 9 months old) and had been in the home for at least three months, whereas kittens in the current study were 7–9 weeks old and in the home for a maximum of 9 weeks (minimum 1 week). The average score for emotional stability in the participating study population was higher than the general population average (Gosling et al., 2003). Therefore, it is possible that people with a higher emotional stability may be more willing to foster fearful kittens or even foster kittens in general, reflecting a potential bias in the current study population. Data obtained from online surveys may also be prone to selection bias (Gosling et al., 2004) and this may have been the case with our study population. Future exploration into the impact of human personality on the relationship we have with kittens both in foster care and in adoptive homes, as well as the use of more in-depth personality assessments (e.g., the 44-item Big Five Inventory, John and Srivastava, 1999), is important for understanding the impact of human personality on kitten and cat behaviour.

Future research would also benefit from comparing foster parent reporting of behaviour with real-time objective behaviour assessments

either in-home or through video recordings to reduce the potential for misclassification bias, determine the severity of the fear response, and validate risk factors for the development of fear behaviour. Additionally, future research should explore the impacts of kittens' social relationships, such as with the mother cat, littermates, and/or foster parent, on fear behaviour since these relationships have the potential to influence attachment style (reviewed by Turner and Bateson, 2000); kitten behaviour (e.g., Martínez-Byer et al., 2023), and social buffering, which could reduce emotional responses to fear-provoking situations (e.g., Kikusui et al., 2006). The nature of these close social relationships with kittens may provide useful insight into their ability to mitigate fear responses in different scenarios within kittenhood and throughout their lifetimes.

Overall, the findings from this study suggest that high amounts of exposure to social and non-social stimuli may not be necessarily beneficial during early socialization and may depend on initial fear levels of kittens. High social exposure was effective at reducing kitten fear levels towards unfamiliar people but not towards unfamiliar objects; however, enrichment-based cognitive non-social opportunities appear to have exceeded kitten limits for optimal behavioural development and were associated with increased fear responses to unfamiliar people. Over a third of kittens in the current study were reported fearful at intake into foster care and these kittens had higher odds of also being fearful at their pre-adoption assessments, emphasizing that improved strategies for appropriately socializing fearful kittens are needed. This study highlights the need for further understanding the impact of the quality of socialization practices and the importance of being able to accurately identify when kittens are in a fearful emotional state to adapt socialization experiences as needed.

Author statement

Courtney Graham: contributed to the conception and design of the study, acquisition of data, analysis and interpretation of data, and drafted and revised all drafts critically for important intellectual content. David Pearl: contributed to the conception and design of the study, acquisition of data, analysis and interpretation of data, and drafted and revised all drafts critically for important intellectual content. Lee Niel: contributed to the conception and design of the study, acquisition of data, analysis and interpretation of data, and drafted and revised all drafts critically for important intellectual content.

CRedit authorship contribution statement

Niel Lee: Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – review & editing. **Pearl David L:** Methodology, Supervision, Writing – review & editing. **Graham Courtney:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Visualization, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at [doi:10.1016/j.applanim.2023.106141](https://doi.org/10.1016/j.applanim.2023.106141).

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