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Conflict and affiliative behavior frequency between cats in multi-cat households: a survey-based study

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Abstract

Objectives The objective of this study was to collect information from cat owners about the frequency of conflict and affiliative signs in their households in order to: (1) assess correlations with the owners' ratings of household cat–cat harmony; and (2) determine if relationships exist between household variables, cat population variables and behavior frequencies.

Methods Responses to an online survey of adult residents of the USA who were the primary caregiver of 2–4 indoor or indoor–outdoor cats were included in the analysis. Spearman's correlations and χ^2 tests were used to compare behavior frequencies with household and cat population variables.

Results Of 2492 owners of multiple cats, 73.3% noted conflict signs from the very beginning when introducing the cats. The more cats in the house, the more frequent the conflict signs. Staring was the most frequently observed conflict sign, occurring at least daily in 44.9% of households, followed, in order of decreasing frequency, by chasing, stalking, fleeing, tail twitching, hissing and wailing/screaming. Hissing occurred at least daily in 18% of households. Affiliative signs were observed more frequently than conflict signs. Physical contact between cats was observed at least daily in around half of the multi-cat households. Higher harmony scores were correlated with less frequent conflict signs and more frequent affiliative signs. No household or cat population variable, including home size or numerically adequate resources provision, was strongly predictive of the frequency of conflict or affiliative signs.

Conclusions and relevance This is the first large-scale online survey to obtain frequencies of conflict and affiliative behaviors and compare them with factors linked to the cats or the home settings. The study confirmed that feline relationships are correlated with the owner's perceived impression of the initial introduction, but other household factors and cat population variables included in the study were not strongly predictive of the frequency of conflict or affiliative signs.

Keywords: Conflict; affiliative behavior; resource; survey; intercat aggression

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Introduction

Domestic cats are a popular pet in the USA and the interest in their welfare is growing. In 2017–2018, the American Pet Products Association estimated that 38% of US households owned at least one cat, with an average of two cats owned per household.[1] Multiple studies have correlated stress, living in multi-cat households, intercat conflict and an increased risk of feline idiopathic cystitis and periuria (house-soiling).[2–8]

Although several studies exist documenting the occurrence of affiliative and conflict behaviors in a small group of cats or groups in shelters or laboratory settings, few studies have documented the frequency of these behaviors in a larger sample size of typical households

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or correlated these frequencies with the owner's general overall impression of relationships within the household.[9–14] A survey by Voith and Borchelt in 1986 included 887 questionnaires of cat owners waiting for care at one of four veterinary clinics on the East Coast, USA. The survey reported the frequency of affiliative and conflict behaviors, but included a relatively small sample size and did not report household factors that may affect these frequencies.[15,16] A retrospective study of cats presented to a behavior service for treatment of intercat aggression found that male cats were more likely to be the initiators of aggression than female cats, but the aggression was equally likely to be directed at a same sex as an opposite-sex housemate.[17] Other factors documented or hypothesized to affect the intercat relationships in a household are relatedness, available resources and the personalities of the cats in the household.[18,19]

Analysis of relationships of cats within a household presents a complex problem, with potential interactions between multiple variables. Bayesian networks have successfully been used in human health and epidemiology research as a graphical model to analyze multiple variables and their interdependence, while decreasing the risk of false positives owing to the large number of variables.[20,21] In the context of this research, a Bayesian network was used to build a predictive model regarding the affiliative and conflict behavior frequencies and to select the key factors with the most important probabilistic relationships with those two responses.

In order to assess the impact of intercat relationships on the stress and welfare of cats, a first step is to identify the frequency of affiliative and conflict behaviors in 'typical' multi-cat households. The goal of the present study was to collect information from owners about how often they observed specific conflict and affiliative behaviors in their households in order to: (1) see if the frequency of specific behaviors correlated with the owners' overall general assessment of household cat–cat harmony; and (2) determine if relationships exist between household factors and frequency of behaviors. We hypothesized that as the number of cats in a household increased, the frequency of conflict behaviors would increase, and an increase in the frequency of conflict behaviors would be correlated with a decrease in the frequency of affiliative behaviors.

Materials and methods

A survey was developed by the authors to collect information from owners regarding the frequency of affiliative and conflict behaviors noted between their cats on a household level. Additional information was gathered to assess the impact of demographics, resources, personality and introductions on these frequencies. Households in the USA with 1–4 indoor or indoor–outdoor cats currently living in the home were targeted through postings on social media and flyers distributed at veterinary clinics and veterinary conferences. Participating cat owners who were the primary caregiver of at least one cat in the house are subsequently referred to as respondents. The survey was anonymous; no personal information was collected from the respondents and completion of the survey implied consent.

The survey was hosted online on the Survey Monkey platform. The survey included multiple choice or Likert-scale questions with options to enter additional information on some questions. Household-level questions on conflict and affiliative behaviors, and overall household harmony were adapted from the Oakland Feline Social Interaction Scale (OFSIS).[22] The OFSIS is a questionnaire developed to measure the incidence, frequency and intensity of 12 cat–cat interactions reflecting conflict between cats. Before opening the survey to respondents, the survey was pre-tested with a small group of cat owners to test the usability of the platform, question flow and content. These pre-test data were not included in the analysis as minor changes were made to the survey following testing. Demographic information, resources and frequency of cat–cat conflict and affiliative behaviors were collected at the household level. All other questions were asked about each cat in the household, so the length of the survey depended on the number of cats in the household (range 28–73 questions). The amount of time to complete the survey ranged from 5 to 30 mins. The survey was available from 30 November 2016 to 14 March 2017. Survey questions can be found in Appendix 1 in the supplementary material.

Respondents were exited from the survey if they were younger than 18 years of age, did not own at least one indoor cat, did not live in the USA, or lived in households with more than four indoor cats or more than four dogs. All questions in the survey required an answer. Surveys that were started but not completed, or included cats living only outdoors, were excluded from analysis. Owners with only outdoor cats were excluded from the survey owing to concerns that they were less likely to be present during their cat's interactions. Households with up to four cats comprise 95% of feline households in the USA and even more in several European countries (Ceva unpublished market research, 2014). Based on expected survey completion rates, the ability to collect sufficient sample sizes to allow for analysis of households with more than four cats was unlikely and the results of these larger households would not be broadly generalizable to the average feline household in the USA; therefore, the survey was restricted to households of four cats or fewer. Similarly, households with more than four dogs were excluded as they represent <1% of dog owning households in the USA and other countries, and also owing to concerns that the presence of more dogs would affect the interactions of the cats in the house.[23]

The survey included nine sections: owner demographic information; resources; cat demographic and owner bond to cat; harmony questions; reactions and interventions when cat added to the home; personality and biting history; current behavior problems; affiliative and conflict behavior frequencies; and conflict interventions. The data collected in the large survey were too extensive to be discussed fully in one paper, so the decision was made to limit the scope of this paper to behaviors of conflict and aggression and factors that may affect these behaviors. The sections of the survey used in this study are described in more detail below.

Household descriptive data collected included the size and type of house, and the quantity of litter boxes, feeding stations and scratching posts in the house. Respondents were asked to list the names of their cats, starting with the cat that had lived in the house for the longest period followed by the most recent additions. If cats were added at the same time, the respondent chose which cat to list first. This allowed us to look at any effect of the order of addition into the house on the cats' relationships.

Individual cat information collected included sex, age category, breed, neuter status, declaw status, lifestyle, current chronic or debilitating health problems, acquisition information and current behavioral problems. Respondents were asked to rate on a scale of 1–5 how well the two descriptions, 'active and curious', and 'sedentary and shy', described each of their cats.

Respondents were asked to choose the observed frequency of specified affiliative and conflict behaviors in five categories: several times a day; daily; weekly; once a month or less; and never. The frequencies of these behaviors may vary from cat to cat in the house, but the questions were asked about the frequency of the behaviors in the household, so the frequency of each cat's behavior was added together and reported by the respondent as a household summation. Affiliative cat–cat behaviors included nose-touching, sleeping in the same room, sleeping while touching and allogrooming. The cat–cat conflict behaviors assessed were staring, stalking, chasing, fleeing, hissing, wailing or screaming and twitching of the tail. Respondents were asked to rate the cat–cat harmony in their house on a 5-point Likert scale. This rating is subsequently referred to as the harmony score. For the introduction of each cat to the house, the respondent was asked to choose which description was the best fit: 'the introduction went well' or 'the introduction did not go well'.

Prior to data analysis, the individual cat data were used to calculate household-level variables (expressed as percentages) for each household. For example, the percentage of females was calculated by dividing the number of female cats by the total number of cats in the household. An 'active and curious' score and a 'sedentary and shy' score for the household were calculated by averaging the scores for all cats in the household. Surveys where the respondents answered that they preferred not to answer the home size question ($n = 45$) were not included in home-size analyses.

Resource allocation was divided into two categories, households providing a recommended quantity of the resource vs households not providing an adequate quantity of resources. Adequate was defined as a quantity of litter boxes equaling the number of cats plus one and a quantity of food stations or bowls and scratching posts equal to the number of cats in the house.[23,24]

To visualize the inter-relationships in the data, an unsupervised Bayesian network using a maximum weight spanning tree algorithm was performed with all variables. Using this network, a clustering analysis was carried out to identify latent variables (called factors). Finally, an unsupervised Bayesian network using a Taboo algorithm was built on top of those latent variables to have a final probabilistic structural equation model. The algorithm cut the numerical values into classes to find the probabilistic relationships among the variables. If two nodes had no path between them it meant that knowledge of the state of one variable provided no information on the state of the other variable, and so they were considered independent. Variables contributing $<20\%$ of the conditional dependence were also removed from the model in order to keep only the most important effects in the analysis. The Pearson's coefficient was calculated for remaining nodes.

Although the Bayesian network model did not indicate a $>20\%$ contribution of any of the cat or household variables, more traditional statistics were pursued to elucidate if any variables had a small, yet statistically significant, relationship with conflict or affiliative signs and to confirm the findings of the Bayesian network analysis. Variables included in the further analysis were chosen to minimize replication of key concepts but included variables that intuitively may be related to intercat conflict based on our clinical experience and the current literature. For example, in the entire survey, questions were asked about the number of litter boxes in the house, how many different rooms contained a litter box and how many different floors contained a litter box. This question was asked to help identify trends in resource allocation, as many owners report multiple litter boxes but fail to understand that the relative placement of these is an important factor in their use. In the statistical analysis below, the number of litter boxes in the house was included, but the number of rooms and floors with litter boxes was excluded to avoid inclusion of data that replicated key concepts and that are not independent of each other.

Shapiro–Wilk tests were conducted for all scale variables and descriptive statistics calculated for all other

variables. This analysis showed that the distributions of the data were significantly different from a normal distribution, so tests that do not require normality were used for analysis (Spearman's correlation and χ^2 test of independence).

A Spearman's correlation analysis was conducted to assess if a relationship existed between the frequencies of conflict and affiliative signs vs harmony scale, as well as relationships between conflict and affiliative signs. The assumption of monotonicity was assessed graphically with a scatterplot prior to analysis. Significance was set a priori at $P = 0.05$, using a two-tailed test.

Relationships between each household factor and the frequencies of conflict and affiliative signs were assessed with Spearman's correlation for ordinal or scale variables and a χ^2 test of independence for nominal variables. All tests were two-tailed. As multiple analyses were conducted on the same dependent variables, a Bonferroni correction was conducted on the original $P < 0.05$ with 20 analyses per dependent variable to decrease the risk of a type I error. The corrected $P < 0.0025$ with a critical value for Spearman's correlations of 0.061 was set as the level of significance. Cohen's standard was used to evaluate the strength of the relationships, where coefficients between 0.10 and 0.29 represent a small effect size, coefficients between 0.30 and 0.49 represent a moderate effect size and coefficients >0.50 indicate a large effect size.[25]

Bayesian network analysis was performed using Bayesialab 8.0. All other analyses were completed with Intellectus Statisticus.[26]

Results

Of the 5978 surveys started, 1127 respondents were exited from the survey for not meeting the inclusion criteria (four were <18 years old, 51 did not have an indoor cat, 356 lived outside the USA, 623 had ⩾5 cats, 98 had >4 dogs). Of the surveys completed, 928 were excluded because the respondent started but did not finish the survey, and a further three were excluded because they contained outdoor-only cats.

For the 3920 responses that met the inclusion criteria, 1428 (36.4%) respondents owned one cat, 1424 (36.3%) owned two cats, 689 (17.6%) owned three cats and 379 (9.7%) owned four cats. Female respondents comprised 94.2% (n = 3693) of the completed surveys, 4.3% (n = 169) of the respondents were male and 1.5% (n = 58) preferred not to answer. The data reported below are restricted to the 2492 multi-cat households (6431 cats).

Affiliative and conflict behaviors

The signs of conflict behavior between housemate cats, from the most to the least frequently displayed, are presented in Table 1 and were stare, chase, stalk, flee, twitch tail, hiss and wail/scream. The most abundant frequency category for each behavior was: daily for stare, chase and stalk; weekly for flee and twitch tail; and never for hiss and wail/scream.

Of 2492 households with multiple cats, 12.3% (n = 307) reported that these signs of conflict never occured between their cats. Of the 2185 households that reported some of the signs, 73.3% (n = 1602) of owners noted them from the very beginning when introducing the cats, 23.6% (n = 515) noted that their cats' relationships changed gradually and 3.1% (n = 68) noted that their cats' behavior changed abruptly (Figure 1).

For households reporting conflict, the evolution of the conflict signs over time was described as maintaining the same frequency for 50.6% of the cases (n = 1115), becoming less frequent in 46.2% (n = 1019) and only 3.2% being more frequent over time (70 households). These tendencies were similar, regardless of the number of cats in the home: conflict maintained the same frequency (53%, 51%, 44% for the two-cat, three-cat and four-cat households, respectively), became less frequent (44%, 46% and 52%, respectively) and was more frequent over time (3%, 3% and 4%, respectively).

The signs of affiliative behavior between housemate cats are presented in Table 2, from the most to the least frequently displayed. Physical contact between cats was observed at least daily in around half of the

Table 1 Frequency of cat–cat conflict behaviors noted in any of the cats in the multi-cat household in response to housemate cats (n = 2492)

Conflict behaviors	Several times a day	Daily	Weekly	Monthly or less	Never
Stare	329 (13.2)	789 (31.7)	546 (21.9)	354 (14.2)	474 (19.0)
Chase	307 (12.3)	789 (31.7)	700 (28.1)	341 (13.7)	355 (14.2)
Stalk	234 (9.4)	638 (25.6)	627 (25.2)	390 (15.7)	603 (24.2)
Flee	190 (7.6)	560 (22.5)	615 (24.7)	455 (18.3)	672 (27.0)
Twitch tail	152 (6.1)	476 (19.1)	686 (27.5)	563 (22.6)	615 (24.7)
Hiss	109 (4.4)	340 (13.6)	565 (22.7)	733 (29.4)	745 (29.9)
Wail/scream	41 (1.6)	91 (3.6)	206 (8.3)	425 (17.1)	1729 (69.4)

Data are n (%)

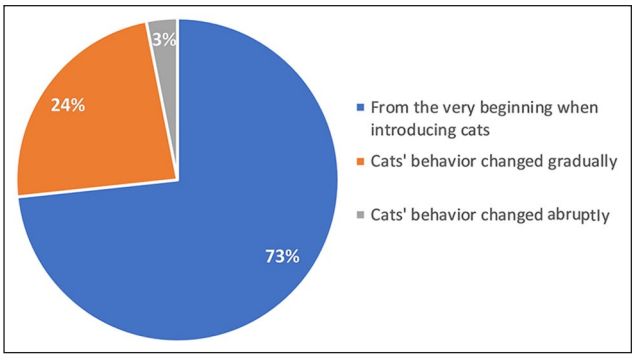

Figure 1 Initiation of conflict between cats

multi-cat homes. The affiliative behaviors from the most to the least frequently displayed were sleeping in the same room as another cat, grooming another cat by licking around the head or ears, sleep-touching with a housemate cat and nose-touching with a housemate cat. The most abundant frequency category was several times a day for all affiliative behaviors except nose-touching, which was daily.

Spearman's correlation analysis was conducted to determine if relationships existed between the frequency of conflict and affiliative signs. Table 3 is a Spearman's correlation matrix reporting the Spearman's correlation (r_s) for these relationships. A Spearman's correlation value can range from –1 (indicating a perfect negative correlation) to +1 (indicating a perfect positive correlation). A correlation of zero indicates no relationship between the variables. The statistically significant correlation values are shown in bold in Table 3. Significant positive correlations were observed between each conflict sign, indicating that as the frequency of one conflict sign increases, so does the frequency of the other conflict sign. A similar positive correlation was observed for affiliative signs. Weak correlations were observed between some pairs of affiliative and conflict signs, most notably a negative correlation between the conflict signs flee and hiss, and all affiliative signs, and a positive correlation between chase and all affiliative signs except sleep-touching.

Reported conflict and affiliative signs and reported intercat aggression

In 421 households (16.9% of surveyed households), owners reported intercat aggression as a problem they were experiencing with their cats. The mean ± SD number of cats was slightly higher for households with reported intercat aggression (2.90 ± 0.80; SEM = 0.04) vs households without reported intercat aggression (2.51 ± 0.71; SEM = 0.02).

To validate that the frequency of conflict signs would be higher in households reporting intercat aggression, the percentage of cats in the house reported to have intercat aggression was compared with each of the conflict signs. Positive correlations were observed between the percentage of cats with intercat aggression in a household and conflict signs: stare ($r_s = 0.28$), chase ($r_s = 0.24$), stalk ($r_s = 0.30$), flee ($r_s = 0.35$), twitch tail ($r_s = 0.28$), hiss ($r_s = 0.40$) and wail/scream ($r_s = 0.35$). Negative correlations were observed between the percentage of cats with intercat aggression and affiliative signs, but although the correlations were statistically significant, they were small in absolute value indicating a weak relationship: nose-touching ($r_s = –0.11$), allogrooming ($r_s = –0.11$), sleeping in the same room ($r_s = –0.10$) and sleep-touching ($r_s = –0.11$). P values for all correlations with intercat aggression were $P < 0.001$. These correlations indicate that as the percentage of cats in a household with intercat aggression increases, the frequency of conflict signs increases and the frequency of affiliative signs decreases slightly.

Reported harmony score and conflict and affiliative signs

The harmony score for each household was compared with each of the conflict signs. Negative correlations were observed between the harmony score and frequency of conflict signs: stare ($r_s = –0.28$), chase ($r_s = –0.19$), stalk

Table 2 Frequency of cat–cat affiliative behaviors noted in any of the cats in the multi-cat household in response to housemate cats (n = 2492)

Affiliative behaviors	Several times a day	Daily	Weekly	Monthly or less	Never
Sleep in the same room as another cat	1440 (57.7)	749 (30.1)	182 (7.3)	64 (2.6)	57 (2.3)
Groom another cat by licking around the head or ears	700 (28.1)	575 (23.1)	447 (17.9)	263 (10.6)	507 (20.4)
Sleep-touching with housemate cat	657 (26.4)	455 (18.3))	418 (16.8)	380 (15.2)	582 (23.4)
Nose-touching with housemate cat	574 (23.0)	792 (31.8)	556 (22.3)	274 (11.0)	296 (11.9)

Data are n (%)

Table 3 Spearman's correlation matrix among conflict and affiliative sign frequencies

Variable	Conflict signs							Affiliative signs			
	Stare	Chase	Stalk	Flee	Twitch tail	Hiss	Wail/ scream	Sleep same room	Nose-touching	Allogroom	Sleep-touching
Conflict signs											
Stare	–										
Chase	**0.55**	–									
Stalk	**0.65**	**0.74**	–								
Flee	**0.51**	**0.66**	**0.65**	–							
Twitch tail	**0.49**	**0.48**	**0.51**	**0.55**	–						
Hiss	**0.45**	**0.42**	**0.45**	**0.55**	**0.55**	–					
Wail/scream	**0.29**	**0.31**	**0.35**	**0.42**	**0.39**	**0.44**	–				
Affiliative signs											
Sleep same room	0.00	**0.08**	0.00	**–0.08**	**–0.07**	**–0.12**	–0.05	–			
Nose-touching	0.02	**0.07**	0.02	**–0.06**	–0.03	**–0.11**	–0.03	**0.39**	–		
Allogroom	**–0.07**	**0.06**	–0.04	**–0.12**	**–0.11**	**–0.19**	–0.05	**0.51**	**0.58**	–	
Sleep-touching	**–0.07**	0.01	–0.05	**–0.16**	**–0.13**	**–0.20**	**–0.06**	**0.54**	**0.52**	**0.77**	–

The critical value is 0.061 for a significance level of $P < 0.0025$ used on a Bonferroni correction with 20 analyses per dependent variable. The values in bold meet this significance level

($r_s = -0.27$), flee ($r_s = -0.40$), twitch tail ($r_s = -0.35$), hiss ($r_s = -0.48$) and wail/scream ($r_s = -0.31$). The conflict signs with a moderate effect size were flee, twitch tail, hiss and wail/scream. Positive correlations were observed between the harmony score and frequency of affiliative signs: nose-touching ($r_s = 0.33$), allogrooming ($r_s = 0.38$), sleeping in the same room ($r_s = 0.31$) and sleep-touching ($r_s = 0.39$). P values for all correlations with intercat aggression were $P < 0.001$. These correlations indicate that higher harmony scores (as perceived by the respondents) are correlated with a decreased frequency of conflict signs and an increased frequency of affiliative signs.

Household and cat population variables

Descriptive statistics for the household and cat population variables that were analyzed are listed in Tables 4 and 5. Resources are listed as households providing a recommended quantity of the resource (yes) vs households not providing an adequate quantity of resources (no) based on the number of cats in the household. An adequate quantity was defined as a quantity of litter boxes equaling the number of cats plus one and a quantity of food stations or bowls and scratching posts equal to the number of cats in the house.[23,24] Individual cat demographic data (vs pooled by household) and resources provided listed by number of cats in the house can be found in Appendices 2 and 3 in the supplementary material.

Household variables (as defined in Table 4) and the frequency of each conflict sign were compared with a χ^2 test of independence. The results of the χ^2 tests between conflict signs and home size were not significant, nor were the results comparing conflict signs and an adequate quantity of resources. The observed frequencies were not significantly different than the expected frequencies, indicating that conflict signs are independent of providing adequate quantities of resources. Adding a new cat to the house within the past 6 months was related to the frequency of all conflict signs except staring. The observed frequencies of the conflict signs were higher than expected frequencies for 'daily' and 'several times a day' in households that added a cat within the past 6 months. Table 6 presents the results of the χ^2 tests. Tables for observed vs expected frequencies of χ^2 tests can be found in Appendix 4 in the supplementary material.

Cat population variables and the frequency of conflict signs were compared using a Spearman's correlation. The strongest relationships found between cat population variables and conflict signs were with the number of cats, age of the cats (young or senior), personality ('active and curious' and 'shy and sedentary' scores) (Table 7). Although the values in bold in Table 7 are statistically significant, these correlations were relatively low in absolute value.

Household variables and the frequency of each affiliative sign were compared with a χ^2 test of independence. The results of the χ^2 test between affiliative signs and home size were not significant. Providing an adequate quantity of litter boxes and food stations was related to a decrease in the frequency of allogrooming, sleeping in the same room and sleep-touching, but not nose-touching. A relationship was also observed between allogrooming and sleep-touching and adding a cat to the house in the past 6 months. The observed frequencies of allogrooming and sleep-touching were higher than expected frequencies for 'daily' and 'several times a

Table 4 Household variables (n = 2492 multi-cat households)

Household variables	n (%)
Size of house (square feet)	
<1499	1031 (41.4)
>1500–3499	1307 (52.4)
3500	109 (4.4)
Prefer not to answer	45 (1.8)
Newly added cat	
A new cat added to the house in the past 6 months	Yes: 294 (11.8) No: 2198 (88.2)
Resources	
Litter boxes ⩾number of cats plus one	Yes: 1839 (73.8) No: 653 (26.2)
Food stations or bowls ⩾number of cats	Yes: 1560 (62.6) No: 932 (37.4)
Scratching posts ⩾number of cats	Yes: 1541 (61.8) No: 951 (38.2)

Table 5 Cat population variables reported as a percentage of cats in the household meeting the description

Variable	Mean (%)	SD
Indoor–outdoor (vs indoor-only)	27.14	0.74
Declawed	17.58	33.24
Female	48.75	33.31
Young (<1 year)	6.09	17.94
Adult (1–7 years)	45.47	37.76
Mature (7–12 years)	32.23	34.34
Senior (>12 years)	16.21	26.79
Chronic or debilitating health issue	15.45	25.75
Living in house <6 months	5.74	17.41
Living in house 6 months to 2 years	16.75	28.64
Living in house >2 years	77.51	32.3

day' in households that added a cat within the past 6 months. Table 8 presents the results of the χ^2 tests. Tables for observed vs expected frequencies of χ^2 tests can be found in Appendix 5 in the supplementary material.

Cat population variables and the frequency of conflict signs were compared using a Spearman's correlation. The strongest relationships found between cat population variables and affiliative signs were with number of cats, lifestyle (indoor–outdoor), sex and age of the cats, length of time in house and personality ('active and curious' and 'shy and sedentary' scores) (Table 9). Although the values in bold in Table 9 are statistically significant, these correlations are relatively low in absolute value.

The introduction of the second cat into a two-cat household was examined to see if there was a difference in the frequency of conflict and affiliative behaviors in households where 'the introduction went well' vs 'the introduction did not go well'. There was a statistically significant relationship between the introduction description and all current conflict and affiliative signs except chase. Table 10 presents the results of the χ^2 tests. Conflict signs occurred more frequently and affiliative signs less frequently in households where the introduction did not go well than in households where the introduction was described as going well. Tables for observed vs expected frequencies of the χ^2 tests can be found in Appendix 6 in the supplementary material. As an example of this relationship, Figure 2 compares the frequency of nose-touching in households where (a) 'the introduction went well' vs households where (b) 'the introduction did not go well'.

Bayesian network analysis

A Bayesian network model (Figure 3) was used to identify clusters of variables, take into account the interdependence between the parameters, identify key parameters and characterize the relationship between all variables collected during the study. Four clusters were identified by the Taboo algorithm: one affiliative factor; two conflict factors; and one personality factor.

The key variables that characterized the affiliative factor were sleeping in the same room (22.1% contribution), allogrooming (48.7% contribution) and sleep-touching (29.2% contribution), with allogrooming being the most important. The conflict variables can be divided into two main clusters of signs: one characterized by fleeing (34.7% contribution) and tail twitch (65.4% contribution); and the second characterized by stalking (40.2% contribution) and chasing (59.7% contribution).

As indicated by the descriptive analysis, there is a relationship between conflict and affiliative behaviors, but the relationship is weak. The flee/tail twitch conflict factor and the affiliative factor are directly connected to each other indicating that frequency of fleeing and tail twitching are predictive of the value of the affiliative factor, but the connection is not strong (overall contribution in the network of 0.2%). No household or cat population variable was strongly predictive of the frequency of conflict or affiliative signs. A higher active score was predictive of a higher affiliative factor, confirming the relationship noted by Spearman's correlation.

Discussion

These findings confirm that an increase in conflict behaviors does correlate with a decrease in affiliative behaviors for most of the included behaviors except chase. More frequent chase might not be correlated with a decrease in affiliative behaviors because it may be difficult to distinguish pursuit from play-related chase. In the sections of the survey where owners could

Table 6 χ^2 test of independence among conflict sign frequency and household variables

Variable	Flee	Chase	Stalk	Stare	Hiss	Twitch tail	Wail/ scream
Home size (df = 8)	6.3	3.31	4.44	5.64	4.41	8.06	8.03
	$P=0.614$	$P=0.914$	$P=0.816$	$P=0.688$	$P=0.818$	$P=0.428$	$P=0.431$
Litter boxes ⩾number of cats plus one (df = 4)	7.59	15.42	2.71	10.6	16.12	0.82	5.79
	$P=0.108$	$P=0.004$	$P=0.608$	$P=0.031$	$P=0.003$	$P=0.936$	$P=0.216$
Food stations or bowls ⩾number of cats (df = 4)	2.66	3.85	3.74	6.58	0.98	9.15	5.08
	$P=0.617$	$P=0.427$	$P=0.443$	$P=0.160$	$P=0.913$	$P=0.057$	$P=0.279$
Scratching posts ⩾number of cats (df = 4)	10.33	4.73	2.57	2.82	1.06	2.99	2.82
	$P=0.035$	$P=0.316$	$P=0.632$	$P=0.589$	$P=0.901$	$P=0.560$	$P=0.588$
A new cat added to the house in the past 6 months (df = 4)	**20.43** **$P<0.001$**	**60.77** **$P<0.001$**	**35.03** **$P<0.001$**	7.33 $P=0.119$	**17.44** **$P=0.002$**	**27.81** **$P<0.001$**	**18.81** **$P<0.001$**

Significance level of $P<0.0025$ based on a Bonferroni correction with 20 analyses per dependent variable. The values in bold meet this significance level
df = degrees of freedom

Table 7 Spearman's correlation among conflict sign frequency and cat population variables

Variable	Flee	Chase	Stalk	Stare	Hiss	Twitch tail	Wail/ scream
Number of cats	**0.17**	**0.13**	**0.12**	**0.11**	**0.22**	**0.13**	**0.15**
Indoor–outdoor	–0.01	–0.03	0.00	0.03	0.03	0.03	0.01
Declawed	–0.04	–0.05	–0.04	–0.02	0.01	–0.02	0.03
Female	0.05	0.00	–0.01	0.06	**0.14**	0.02	–0.06
Young (<1 year)	0.02	**0.14**	**0.07**	0.03	0.00	0.00	–0.01
Adult (1–7 years)	0.05	**0.16**	**0.10**	0.05	–0.04	–0.01	0.00
Mature (7–12 years)	0.01	**–0.09**	–0.04	–0.03	**0.09**	0.06	0.03
Senior (>12 years)	–0.03	**–0.16**	**–0.09**	–0.02	0.01	0.00	0.01
Chronic or debilitating health issue	0.03	–0.04	0.01	0.01	0.06	0.05	0.03
Living in house <6 months	**–0.07**	**–0.07**	**–0.10**	–0.05	–0.01	–0.02	0.02
Living in house 6 months to 2 years	0.06	**0.12**	**0.08**	0.04	–0.01	0.01	–0.01
Living in house >2 years	0.05	**0.13**	**0.07**	0.03	0.06	0.04	0.01
'Active and curious' score	**–0.08**	0.05	0.01	0.00	**–0.11**	**–0.08**	–0.06
'Sedentary and shy' score	**0.09**	0.00	0.02	0.06	**0.10**	**0.10**	0.06

The critical value is 0.061 for significance level of $P<0.0025$ used on a Bonferroni correction with 20 analyses per dependent variable. The values in bold meet this significance level

add comments, some owners mentioned that they considered their cats chasing each other to be a play behavior rather than a conflict-related one. Owners may struggle to distinguish low-level conflict from light play.

Compared with the extensive numbers of behaviors encompassed by comprehensive ethograms, such as Stanton et al[27] and Cameron-Beaumont,[28] this survey focused on a narrow subset of conflict and affiliative behaviors. Despite the limited number of behaviors included, there was a correlation between owner-reported intercat aggression and the conflict and affiliative behaviors selected, indicating that a subset of some key behaviors may be able to be examined to assess the presence of intercat conflict.

Higher harmony scores were associated with a lower frequency of conflict signs and a higher frequency of affiliative signs. This confirms that owners were able to rate the overall harmony of the cat–cat relationships in their house but may be more aware of overt conflict signs vs subtle signs, as the highest negative correlation

Table 8 χ^2 test of independence among affiliative sign frequency and household variables

Variable	Nose-touching	Allogrooming	Sleep in same room	Sleep-touching
Home size (df = 12)	4.35	12.77	13.55	11.1
	$P = 0.824$	$P = 0.120$	$P = 0.094$	$P = 0.196$
Litter boxes ⩾number of cats plus one (df = 4)	11.23	**23.07**	**27.76**	**21.04**
	$P = 0.024$	$\mathbf{P < 0.001}$	$\mathbf{P < 0.001}$	$\mathbf{P < 0.001}$
Food stations or bowls ⩾number of cats (df = 4)	12.63	**23.62**	**22.03**	**34.72**
	$P = 0.013$	$\mathbf{P < 0.001}$	$\mathbf{P < 0.001}$	$\mathbf{P < 0.001}$
Scratching posts ⩾number of cats (df = 4)	2.4	2.55	7.02	7.2
	$P = 0.663$	$P = 0.635$	$P = 0.135$	$P = 0.126$
A new cat added to the house in the past 6 months (df = 4)	6.39	**25.11**	9.43	**23.97**
	$P = 0.172$	$\mathbf{P < 0.001}$	$P = 0.051$	$\mathbf{P < 0.001}$

Significance level of $P < 0.0025$ based on a Bonferroni correction with 20 analyses per dependent variable. The values in bold meet this significance level
df = degrees of freedom

Table 9 Spearman correlation among affiliative sign frequency and cat population variables

Variable	Nose-touching	Allogrooming	Sleep in same room	Sleep-touching
Number of cats	**0.22**	**0.24**	**0.19**	**0.26**
Indoor–outdoor	–0.06	**–0.12**	**–0.10**	**–0.11**
Declawed	–0.01	0.01	–0.01	0.03
Female	**–0.13**	**–0.20**	**–0.11**	**–0.19**
Young (<1 year)	**0.08**	**0.12**	**0.09**	**0.12**
Adult (1–7 years)	**0.11**	**0.09**	0.05	**0.08**
Mature (7–12 years)	**–0.07**	**–0.10**	**–0.07**	**–0.09**
Senior (>12 years)	**–0.09**	**–0.09**	–0.05	**–0.09**
Chronic or debilitating health issue	0.00	0.00	0.01	–0.01
Living in house <6 months	0.05	0.06	0.04	**0.08**
Living in house 6 months to 2 years	0.05	0.03	0.01	0.04
Living in house >2 years	–0.06	0.06	0.04	**–0.09**
'Active and curious' score	**0.21**	**0.16**	**0.15**	**0.16**
'Sedentary and shy' score	**–0.15**	**–0.15**	**–0.15**	**–0.15**

The critical value is 0.061 for a significance level of $P < 0.0025$ based on a Bonferroni correction with 20 analyses per dependent variable. The values in bold meet this significance level

between harmony score and a conflict sign was found for hissing instead of the more frequent signs of stare, chase, stalk, flee and twitch tail.

Cat population variables and conflict or affiliative behaviors that were significantly correlated exhibited only a weak relationship. Subtle differences emerged, indicating that in young or adult households, conflict may be more active and include chasing and stalking, whereas these behaviors are less common in mature or senior cat households.

Personality measures have been suggested as a method to improve cat welfare by grouping compatible cats in multi-cat households.[29] In this study, 'sedentary and shy' cats were more likely to flee, stare and hiss than 'active and curious' cats. Evaluation of feline personality utilizing recently published models of feline personality, either the 'Feline Five' described by Litchfield et al,[29] or the six dimensions described by Bennett et al,[30] and the effects of personality of conflict signs would be an interesting area for further investigation.

It was surprising this survey found that providing an adequate quantity of food, litter box and scratching resources was not related to the frequency of conflict signs, as providing an adequate quantity of resources is a common recommendation for households with intercat conflict. Other studies have found that cats have preferences for litter box size and type, if the box was previously used and litter type, so these factors may be more important than the quantity of boxes provided.[31–35] Other resources not examined by this survey, such as the provision of resting locations and hiding locations, may also be important and affect the frequency of conflict

Table 10 χ^2 test of independence among conflict and affiliative sign frequency and introduction of the second cat into a two-cat household (n = 1424)

Conflict behaviors	Flee	Chase	Stalk	Stare	Hiss	Twitch tail	Wail/ scream
Introduction characterized as 'went well' or 'did not go well' (df = 4)	**43.52** ***P*** **<0.001**	12.17 *P* = 0.016	**21.28** ***P*** **<0.001**	**24.65** ***P*** **<0.001**	**71.81** ***P*** **<0.001**	**24.43** ***P*** **<0.001**	**15.9** ***P*** **<0.001**
Affiliative behaviors	Nose-touching	Allogrooming	Sleep same room	Sleep-touching			
Introduction characterized as 'went well' or 'did not go well' (df = 4)	**47.93** ***P*** **<0.001**	**83.36** ***P*** **<0.001**	**71.97** ***P*** **<0.001**	**71.19** ***P*** **<0.001**			

Significance level of $P < 0.0025$ based on a Bonferroni correction with 20 analyses per dependent variable. The values in bold meet this significance level
df = degrees of freedom

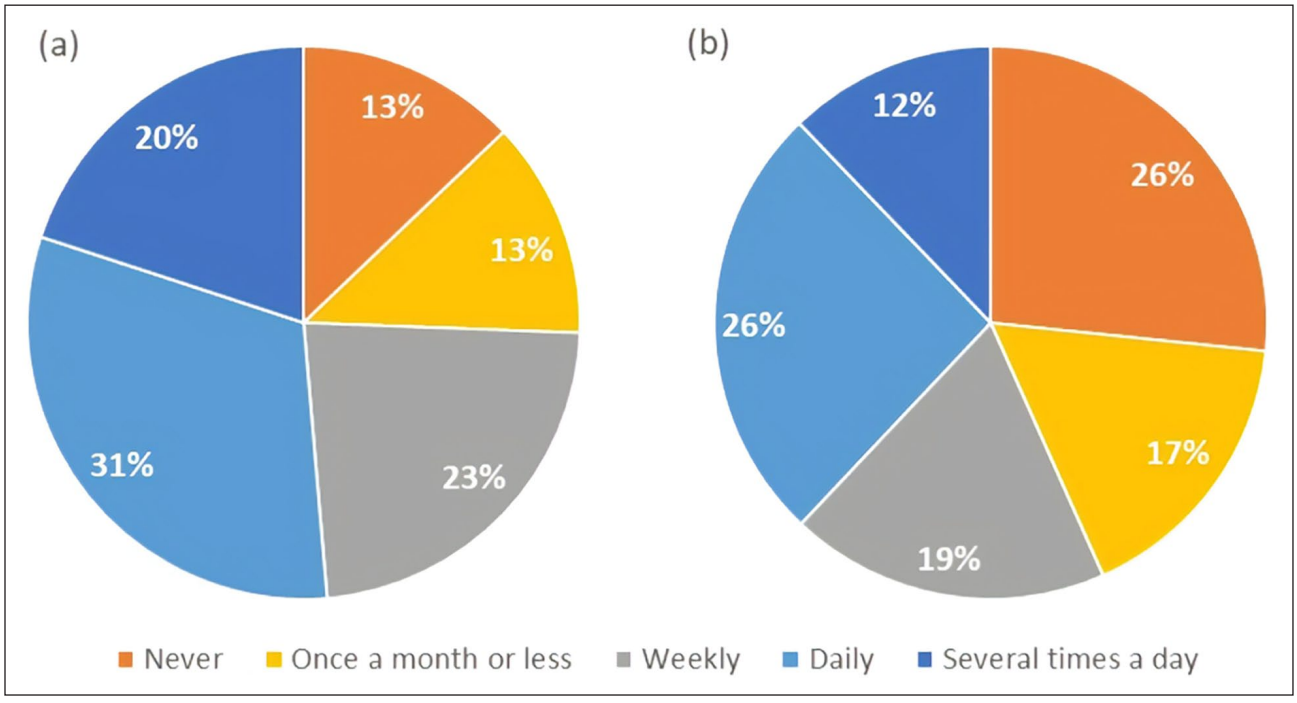

Figure 2 Frequency of nose-touching behavior in households where (a) 'the introduction went well' vs households where (b) 'the introduction did not go well'

behaviors, and their omission is a limitation of this study. In contrast to the conflict behaviors, allogrooming, sleeping in the same room and sleep-touching were decreased in frequency in households providing an adequate quantity of litter boxes and food stations. Although house size was not related to the frequency of these affiliative signs, providing a greater quantity of resources may indicate more space for the cats to utilize and therefore fewer interactions. A future study could analyze resource allocation, space usage, and the correlations with frequency and character of interactions.

Signs of conflict were most likely to occur from the very beginning when introducing a new cat. The characterization of the introduction as 'went well' or 'did not go well' correlated with the current frequency of conflict and affiliative signs. If the introduction 'went well', more frequent affiliative signs and less frequent conflict signs were noted than in households where the introduction 'did not go well'. Adding a new cat to the house in the past 6 months was related to the frequency of all conflict signs except stare. This is consistent with the findings of Levine et al[36] that the owner's perception of how the

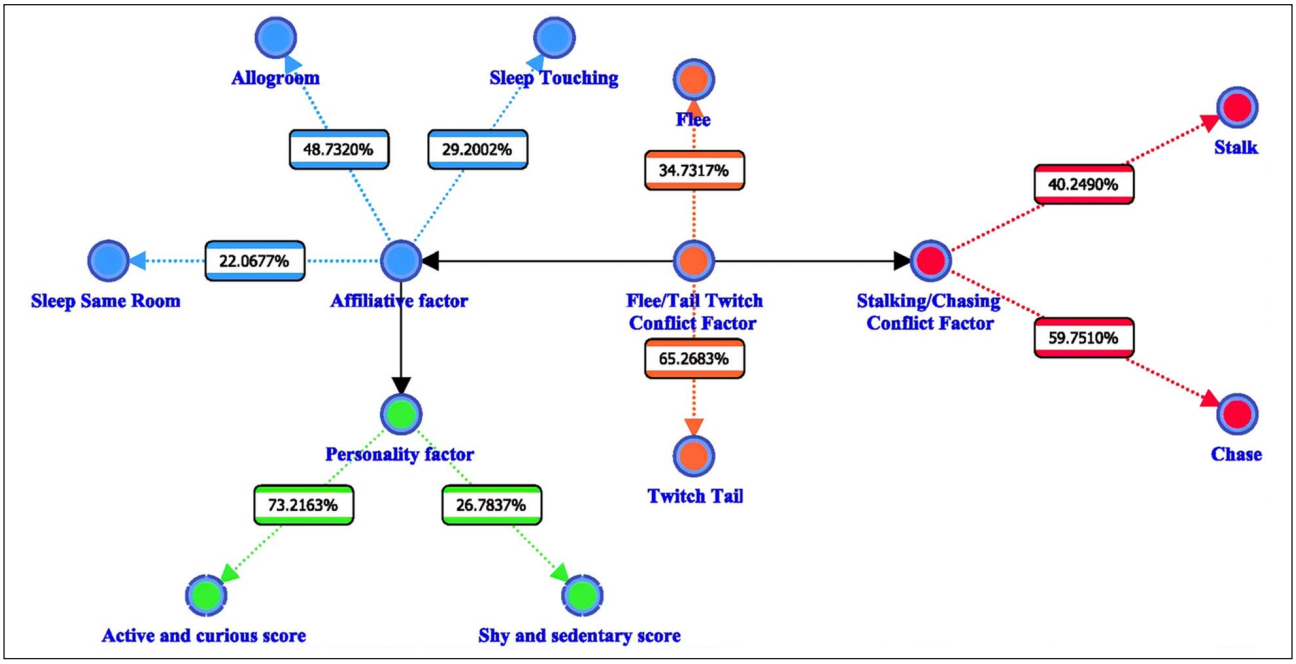

Figure 3 Bayesian network model for the relationship between household and cat population variables. Variables with less than a 20% contribution were removed

initial introduction went may be predictive of the quality of the cat–cat relationships in the house in the first year. A future direction in the study of intercat conflict could be to look at the evolution of conflict signs over time to see if early conflict includes more chasing, fleeing and hissing, and then if the conflict evolves into staring.

It is important to acknowledge the limitations of this study. First, the survey was composed of a convenience sample, not a random sample of cat owners. The link to the survey was predominantly promoted by animal experts, which likely skewed it toward owners more knowledgeable about cat behavior and potentially more knowledgeable about the prevention of intercat conflict. Future studies could implement a more random sampling method, or collect data to describe the demographics of the general US cat-owning households and then restrict the data collection to certain quotas of different categories or weight the results to accurately reflect the demographics of the general population. An additional option would be to ask questions in the survey to try and assess the owner's knowledge about cats to determine if knowledge correlated with conflict or measures used to prevent and address conflict.

Second, the survey relied on the subjective reporting of behaviors by owners and did not include observations of the behaviors by an expert. However, online surveys have been shown to be a reliable method for behavioral data collection in both dogs and cats.[37,38] This provides access to a larger sample population than an observation-based study and allows for screening of factors for further smaller, observation-based studies.

The third limitation was the limited range of behaviors and resources included in the survey. This was done intentionally to simplify the survey and reach a wider sample of cat owners than would be possible with an in-depth ethological study. Both the second and third limitations could be addressed in future studies by directly observing a subsample of the surveyed cats to assess the reliability of owner observations and reporting, as well as compare results of a more complete ethological observation with the limited range of behaviors.

The fourth limitation was that questions about cats' relatedness or identification of dyads within the household were omitted owing to concerns about survey length and complexity. As many owners acquire their cats from rescue shelters, or as strays, the true relatedness of these cats may not be known, even for cats acquired at the same time. Identification of dyads within the household requires that the owner be knowledgeable about feline behavior, as well as accurately characterize the relationships within the household, so these factors seemed difficult to determine by online survey with certainty. However, relatedness and dyad groupings have been well documented to affect the frequency of affiliative signs and relationships between cats.[14,39]

The final limitation of the study was the decision to collect and analyze data on a household level instead of an individual cat basis. The number of cats in the house was found to correlate with the frequency of conflict and affiliative signs, but it is difficult to determine if this reflects a true increase in conflict as the number of cats in the house increases or if it is an artifact of the owner

summing together the behaviors of all of the cats in the house. The average number of cats in households with reported intercat aggression was slightly higher at 2.90 vs 2.51 for households with no reported intercat aggression, so although it is difficult to determine the extent, a relationship likely exists between the number of cats in the house and the frequency of conflict behaviors.

Conclusions

This study is the first large-scale online survey used to obtain frequencies of conflict and affiliative behaviors in US households, and compare them with factors linked to the cats or the home settings. Affiliative signs were observed more frequently than conflict signs. Higher harmony scores (as perceived by the respondents) were correlated with less frequent conflict signs and more frequent affiliative signs. Hissing occured on a daily or more frequent basis in 18% of households. Physical contact between cats was observed at least daily in around half of the multi-cat households. The study confirmed that feline relationships are influenced by the behaviors displayed at the initial introduction, but other household factors and cat population variables were not strongly predictive of the frequency of affiliative and/or conflict signs. In multi-cat households, 73.3% of owners noted conflict signs from the very beginning when introducing the cats. The recent addition of a new cat to the home was correlated with the frequency of conflict signs.

Several trends emerged for interesting areas of future research, including the evolution of conflict and affiliative behaviors over time, the effects of personality and age on these behaviors, and the impact of conflict or affiliative relationships on the health and welfare of cats.

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Author note Some of the results were presented as an abstract (<250 words) and a poster presentation at the European Veterinary Congress of Behavioural Medicine and Animal Welfare in Berlin, Germany, 2018.

Supplementary material The following files are available online:

Appendix 1: Feline survey questions, Elzerman et al
Appendix 2: Cat demographic information per cat in multi-cat households
Appendix 3: Resources provided listed by number of cats
Appendix 4: χ^2 results (Table 6 Conflict signs)
Appendix 5: χ^2 results (Table 8 Affiliative signs)
Appendix 6: χ^2 results (Table 10 Introduction of cats)

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Ethical approval This work did not involve research on animals and the survey did not collect any personally identifiable data or information on sensitive subjects so is exempt from the requirement of institutional review board or ethical committee review.

Informed consent The survey was anonymous; no personal information was collected from the respondents and completion of the survey implied consent. No animals or humans are identifiable within this publication, and therefore additional informed consent for publication was not required.

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