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**Pet Memoirs: The Characteristics of Event Memories in Cats and Dogs, as Reported by Their Owners.**

Amy Lewis[1]

Dorthe Berntsen[1]

Aarhus University


[1]Center on Autobiographical Memory Research, Psychological and Behavioural Sciences, Aarhus University, Bartholins Allé 9, 8000 Aarhus C, Denmark.

Correspondence should be addressed to Amy Lewis at: amy_lewis87@hotmail.co.uk

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Abstract

The case for episodic memory in non-human animals has been intensely debated. Although a variety of paradigms have shown elements of episodic memory in non-human animals, research has focused on rodents, birds and primates, using standardized experimental designs, limiting the types of events that can be investigated. Using a novel survey methodology to address memories in everyday life, we conducted two studies asking a total of 375 dog and cat owners if their pet had ever remembered an event, and if so, to report on their pet's memory of the event. In both studies, cats and dogs were reported to remember a variety of events, with only 20% of owners reporting that their pet had never remembered an event. The reported events were often temporally specific and were remembered when commonalities (particularly location) occurred between the current environment and the remembered event, analogous to retrieval of involuntary memories in humans.


*Keywords*: event memory, episodic-like memory, dog cognition, cat cognition, involuntary autobiographical memory

## 1.  Introduction

Episodic memory has been described as uniquely human (Tulving, 2002). Comparative researchers have cast doubt on this claim by revealing many similarities between human and non-human animal memory for past events. Clayton and Dickinson (1998) showed that scrub jays could recall the content of specific episodes (what-where-when information), a finding that has been replicated in numerous species (Babb & Crystal, 2006; Hoffman, Beran, & Washburn, 2009; Martin-Ordas, Haun, Colmenares, & Call, 2010). Other paradigms have investigated characteristics of episodic memory, such as temporal order (Schwartz, Hoffman, & Evans, 2005), free recall (Menzel, 1999), binding (Lewis, Berntsen, & Call, 2018; Martin-Ordas, Berntsen, & Call, 2013), spontaneous retrieval (Lewis, Call, & Berntsen, 2017b), distinctiveness (Lewis, Call, & Berntsen, 2017a), and unexpected recall (Zhou, Hohmann, & Crystal, 2012).

The majority of episodic memory research in animals has been conducted on rodents, birds and primates (for reviews see Crystal, 2009; Lewis, Berntsen, & Call, 2019; Salwiczek, Watanabe, & Clayton, 2010), with fairly consistent findings across species. Surprisingly, there has been relatively few studies on dogs, despite the vast literature on dog cognition (see Arden, Bensky, & Adams, 2016; Miklósi, 2014). The sparse research on dog episodic memory is rather inconsistent, with some evidence for unexpected recall (Fugazza, Pogány, & Miklósi, 2016) but mixed evidence for memory of what is where (Fujita, Morisaki, Takaoka, Maeda, & Hori, 2012; Kaminski, Fischer, & Call, 2008). An interesting study by Pongracz, Benedek, Enz, and Miklosi (2012) used a questionnaire to investigate everyday memory of dogs as reported by their owners, arguing that the close relationship between dogs and owners provides access to a unique source of information. Similar methodology has been used to investigate memory in young children, with parents providing information on their child's memory through questionnaires (see Levick, 2010). Pongracz et al. (2012) findings suggest that dogs have long-term memory for both social information (e.g., family members) and non-social information (e.g., objects). They also found that dogs younger than 24 months had the shortest memory span, suggesting that memory in dogs may undergo developmental changes.

Pongracz et al. (2012) did not specifically address memories for past events. Their study therefore leaves unresolved whether dogs show evidence of remembering episodes in their personal past. Here we used a survey methodology analogous to Pongracz et al. (2012), focussing specifically on memories of past events in pets. Although this method involves a level of subjectivity, it enables us to gain information on the characteristics of dogs' event memories as they occur in everyday life and without imposing restrictions on the type of events dogs may remember. This is in contrast to structured and controlled experiments that test an animal's ability to recall an experimentally designed event at a given time (e.g., Fugazza et al., 2016). To be able to remove these test restrictions is important for two reasons; 1) not all events are remembered equally well, and 2) not all subjects will remember the same types of events. Consequently, exposing an animal to a specific event and testing its memory of that event at a specific time, only tells us something about whether that specific event can be remembered at that specific time by that animal. If the specific event is not a memorable one for that specific animal, it may not be remembered. Indeed, human adults have been found to have difficulties with recalling what-where-when information from a standardized experimental design, particularly the 'what' element (Cheke & Clayton, 2013). The failure of human adults to recall a specific event at a specific time does not entail that humans do not have episodic memory, rather, that they simply cannot remember that particular event. With our method, no restrictions are posed on the type of event that can be remembered, the time at which the event is remembered, nor the environment in which it is remembered, thus allowing for the diversity of event memories in animals to be assessed.

We expanded the study to include cats, as little is known regarding cat cognition despite the similarities between cats and dogs—both are carnivorous mammals that have been selectively bred and domesticated by humans and kept as companions (see Vitale Shreve & Udell, 2015 for a review on cat cognition). Furthermore, a paradigm originally designed to test dogs' memory of an event found that cats can also remember what and where information from a single episode (Takagi et al., 2017), indicating possible similarities between event memories in cats and dogs.

To create a questionnaire that would target memories for past events, we generated questions from the autobiographical memory (AM) literature, notably diary studies on involuntary AMs (Berntsen, 1996). We asked dog and cat owners to retrospectively assess an occasion in which their dog or cat remembered an event, incorporating questions from the diary method, such as asking participants whether there were any commonalities between the surroundings at the time their pet remembered the event and the memory itself (see Berntsen, 2009).

## 2. Study 1

### 2.1 Methods

*2.1.1 Participants*

Participants were recruited through Prime Panels provided by TurkPrime, which allowed us to specifically target participants who owned either a dog or a cat (or both). A total of 119 participants took part in the study and were paid $1 upon successful completion of the questionnaire. Sixteen participants were removed from the study due to failing the attention check question(s) and/or not answering the questions asked. The remaining 103 participants were aged between 19-86 years ($M$=37.54, $SD$=12.22), with the majority female (56.31%). All had owned either a dog or cat for a minimum of 8 months (range 0.66-19.00 years; $M$=7.88, $SD$=4.94). All but one were native English speakers, with the vast majority American (95.15%). The number of years in education ranged from 0-20 ($M$=14.16, $SD$=3.49).

*2.1.2 Materials*

The questionnaire was constructed using Qualtrics and was accessible online. All questions (bar two) had forced responses, meaning that to progress through the questionnaire, the participant needed to answer all questions that they were presented with and in the correct format (e.g., a number for a numerical question). Participants that failed to do so were presented with an error message above the erroneous response, stating the reason for the error. All errors had to be corrected before the participant could continue with the questionnaire.

Questions were a mixture of multiple choice (single and multiple responses), numerical and descriptive responses. The questionnaire consisted of four parts (for details see Procedure). Part 1

included information about the study and a consent from. Part 2 included a screening question to confirm the participant had owned a dog or cat for at least 6 months. Part 3 involved questions relating to the participant and their chosen pet's demographics. Part 4 was the event memory questionnaire.

The questions in Part 4 were based on methodologies from the AM literature, specifically retrospective assessments and diary studies. Participants were presented with an example of an event memory and asked if their pet had ever remembered an event. Those that answered yes were asked to think back to an event that occurred in the past, to describe the event and the occasion in which their pet remembered it, and to answer additional questions about the event memory.

We defined an event memory as an experience or event that occurred in the past, which was later recalled (Rubin & Umanath, 2015). As with AM, we did not limit event memories to experiences that occurred only once, but included both specific (one-time events) and general (summaries of similar repeated events) event memories. However, experiences/events that came to be expected by the pet (due to occurring very frequently or occurring at a predictable time/place) were not classed as event memories, as semantic memory may explain these instances (Zentall, Clement, Bhatt, & Allen, 2001). The additional questions about the event memory were based on questions used in diary studies on involuntary AM in humans and enabled us to obtain information about the characteristics of the event memory. Crucially, the difference between our methodology and the AM literature was that we asked participants to describe and answer questions about an event memory their pet had, as opposed to their own memory.

Additionally, two attention check questions were included in Part 4. The purpose of these questions was solely to check that the participants were not answering the multiple-choice questions randomly. Participants that failed either or both of the attention checks were presented with the following automated message, "Unfortunately, you did not pass our attention control and cannot continue any further with this study. We thank you for your time and interest in the study". These participants were subsequently removed from the study.

*2.1.3 Procedure*

Participants accessed the questionnaire online. All participants began with Part 1. Here they were presented with an information sheet explaining the purpose and requirements of the study and a consent form (see Supplemental Material, Study 2 Questionnaire, Part 1). Participants that gave consent were presented with Part 2, those that failed to give consent were presented with the following automated message, "Unfortunately, you did not pass our essential criteria for participation in this study and cannot continue any further. We thank you for your time and interest in the study." These participants were subsequently removed from the study.

In Part 2, participants were asked to "please select which pet(s) you own/have owned for longer than 6 months". Response options were: "Cat(s), dog(s), both cat(s) and dog(s), or none of the above". Participants that chose "None of the above" were presented with the automated message detailed previously and were removed from the study. Participants that answered "both cat(s) and dog(s)" were presented with a follow-up question asking them to "please select whether you would like to answer the remaining questions about: A dog you own/owned for at least 6 months or a cat you own/owned for at least 6 months". Participants that chose "dog(s)" in the initial or follow-up question were then presented with demographic questions relating to themselves and their chosen dog. Before answering the questions about their dog, they were presented with the following instructions:

> "You can choose to answer the following questions about your current dog **or**
> about a dog that you had in the past. The dog you choose must be a dog that you
> have had (or had) for at <u>least 6 months.</u> If you have (or have had) multiple dogs,
> please chose the dog that you have had (or had) the **longest** and <u>answer all the</u>
> <u>questions about that dog only".</u>

Participants could only continue with the study if they confirmed that they had read and understood the instructions. Participants that did not confirm were presented with the automated message detailed previously and were removed from the study. Participants that chose "cat(s)" in the initial or follow-up question were presented with identical instructions and questions to those that chose "dog(s)", with the exception that every instance of the word 'dog' was substituted with 'cat'.

Lastly, participants were presented with Part 4. Here, participants were shown the following example of an event memory (note that for cats, instances of 'dog/puppy' were replaced with 'cat/kitten' and 'barking' was replaced with 'meowing'):

"When my puppy was a few months old, he escaped through the garden fence into my neighbour's garden. My neighbour found him in his house eating his cat's food, having snuck in through the cat-flap. Three months later I was sitting with my dog in the garden. He was barking at me because he was hungry, but I was unable to feed him because he was due at the vets later in the day for an operation. I was trying to get him to stop barking because I could see my neighbour was sitting in his garden next door. Suddenly, my dog ran towards my neighbour and the section of the garden fence where he had previously escaped. He escaped through the fence again and ran to the neighbour's cat-flap (unfortunately for him, the cat-flap was locked)."

Participants were then asked an attention check question to establish whether they had fully read the example. The question asked participants how the dog in the above example had escaped (through the gate/through the garden fence/through the window). Participants that answered this correctly (through the garden fence) were then asked whether their pet had remembered an event. Participants that answered no, finished the questionnaire here, participants that answered yes were presented with the questions shown in Table 1. Note that Table 1 shows the questions for the dog responders, the questions for the cat responders were identical and in the same order, except for the word 'dog' was replaced by 'cat'.

*2.1.4 Data coding*

Participants' responses to the event description variable (see Table 1) were coded as follows (variable names in brackets):

1. [Memory type]: although we asked participants to describe an event memory, not all descriptions were clear instances of an event memory. For example, some of the descriptions did not contain enough information to determine whether they described events or not, whereas others were

descriptions of memories that were not about events, but rather about a memory of a person or object. We therefore coded the descriptions as either 1) event memory (EM) or 2) other memory (OM). To be classed as an EM, the description needed to include both a specific time/place/occasion in which an experience occurred that lasted less than a day (an event), and an occasion/instance in which the pet remembered/seemed to remember the experience (memory of the event). The event could occur multiple times (it was not limited to a specific episode) but could not be predictable or expected due to occurring very frequently or occurring at a predictable time/place. Memories that did not meet these criteria were coded as OM. Descriptions that were ambiguous or unclear were coded as 3) unknown.

2.  [Theme]: all memories were subsequently classed into 1 of 10 themes: escaping or getting lost, interaction with an animal or person, interaction with an object, accident or injury and/or veterinary treatment, weather, receiving or obtaining food, being bathed or washed, locating lost or hidden objects, a walk or trip out, other. If the memories fell into more than one category, they were classified according to the key theme of the memory.

3.  [Objective event occurrence]: for all EMs, we coded the number of times the event occurred before it was remembered. EMs that had events that occurred only once were coded as 1) once, whereas EMs in which events occurred at least twice before they were remembered were coded as 2) more than once. This enabled us to distinguish between specific and general events. Although we provided participants with a direct question about event occurrence (see Table 1), by coding this information ourselves we could check whether the question was understood as intended by the participants, and whether the participants' ratings and objective codings showed consistency.

4.  [Cueing]: all EMs were coded as either 1) contextually cued or 2) not contextually cued. To be contextually cued, the description of the occasion in which the event was remembered needed to include something in the environment that seemed to trigger the memory (e.g., a person, a location, an object etc.). If there was no clear or obvious contextual cue, the event was coded as 2) not contextually cued. If it was unclear as to whether something in the environment cued the memory, it was coded as 3) unknown.

5.  [Content]: all OMs were coded in terms of their content. We used seven content types: individual, location, object, food, sound, activity, and time. Each memory was not limited to one content type (i.e., a memory could be coded as having multiple content types). Note that it was not possible to code the content of EMs. This was because EMs, by referring to events, had multiple content components associated with them, such as spatial, temporal, sensory and social components. For example, an EM about a dog getting lost and then remembering the occasion when it previously got lost may involve content regarding location, people, sounds, smells etc. Some of this content is difficult to code in an objective manner, because many of the details need not explicitly be stated in the EM descriptions, but would have to be inferred (for example, it is not clear whether the dog remembered just the location in which it got lost, or it also remembered how the location smelt and people it met when it was lost). In contrast, OMs typically included fewer units of information, which could be coded in an objective way. For example, an OM that described a dog that came running whenever it heard the sound of a can of dog food being opened, explicitly mentioned a sound and a food item that was remembered by the dog, regardless of spatial, social or other types of content.

6.  [Objective valence]: the valence of EMs and OMs from the perspective of the pet were coded on a scale of 1-3, with "1" being negative, "2" neutral and "3" positive. If it was unclear as to the valence of the memory it was coded as "0" (unknown) and removed from the analysis of valence. Although we provided participants with a direct question about valence (see Table 1), by coding this information ourselves we could check whether the question was understood.

*2.1.5 Inter-rater reliability*

All coding was conducted by the first author, with 20% of the memories coded by an additional external coder. Agreement between the coders was measured using Cohen's Kappa when sample sizes >10. For sample sizes <10, agreement was calculated as the percentage of agreed responses. In both cases, all instances of "unknown" were excluded from the analyses. Additionally, agreement between the objective ratings and the participants ratings of event occurrence and valence

were measured in the same way. A high agreement between the objective and participants' ratings would suggest participants understood these questions, and thus support the validity of their response.

Inter-rater reliability for memory type was high ($\kappa = 0.65$ $p =0.004$) and was excellent for theme ($\kappa = 0.98$ $p <0.001$). For cueing, agreement was excellent (percent agreement = 87.50%). For objective valence, agreement between coders was fair ($\kappa = 0.30$ $p =0.056$) and was excellent when only EMs were considered (percent agreement = 87.50%). Agreement between objective valence and the participants ratings of valence was good ($\kappa = 0.54$ $p <0.001$). For event occurrence, agreement between coders was good (percent agreement = 75%) and was fair between the objective and the participant ratings ($\kappa = 0.19$ $p =0.050$).

*2.1.6 Statistical analyses*

All analyses were performed using IBM SPSS (version 25). Analyses were performed on the data from 103 participants, with cases in which participants did not answer a question appropriately excluded (e.g., answering a numerical question with non-numerical information). Alpha was set to 0.05 and corrected using Bonferroni in cases of multiple testing of responses to the same question.

To establish whether dogs and cats remember past events (as reported by their owners), descriptive statistics regarding the number of pets that remembered a past event were reported. No inferential statistics were performed on this data, as we were interested in any number of reports of past events, as opposed to a number significantly greater than an expected frequency (i.e., we were not looking to reach an arbitrary threshold for the number of pets that were reported to remember an event, rather we were looking to see whether *any* pets reportedly remembered an event). Species differences were investigated by comparing the proportion of reported memories by species using a two-tailed Fisher's exact test. Additionally, as participants did not necessarily describe an EM (i.e., some described OMs), we compared the number of EMs observed to the number of OMs using an exact Chi-square goodness of fit test. Species differences were assessed by comparing the frequency of EMs and OMs using a two-tailed Fisher's exact test.

To investigate the characteristics of EMs, we conducted Chi-square goodness of fit tests on the EMs on the following variables (rated by participants): event occurrence, retention time, retrieval

type, and other occasions. The same analyses were also run on the OMs. Comparison of EMs and OMs was conducted using Chi-square independence tests, with memory type (EM, OM) by each of the variables described above. The same analyses were used to investigate any species differences, with species (cat, dog) by each of the variables described above (collapsed across memory type). Alpha was adjusted to 0.013 to correct for multiple testing.

To investigate the age of the pet at the time of remembering the event we conducted a 2 (species) by 2 (memory type) Analysis of Variance (ANOVA), with age at memory as the dependent variable (DV). Likewise, the valence of the event was investigated using a 2 (species) by 2 (memory type) ANOVA, with valence as the DV. For valence, we also ran additional analyses using the objective coding of valence (based on a 1-3 scale). As the scale did not follow a normal distribution curve, two exact Kruskal-Wallis H tests (one split by species and one split by memory type) were conducted instead of a 2 x 2 ANOVA.

The number of commonalities reported was investigated using a 2 (species) by 2 (memory type) ANOVA, with number of commonalities as the DV. The frequency of each type of commonality for EMs, OMs, cats, and dogs was investigated using 4 respective Cochran's Q tests. Chi-square tests of independence were conducted as post-hoc tests where necessary, with alpha correction applied.

To investigate the frequency of the different themes, we ran two Chi-Square goodness of fit tests, one on EM themes and one on OM themes, collapsed across species (due to expected frequencies under 5 when split by species). We investigated whether EMs were contextually cued by comparing the frequency of cued and non-cued EMs with a Chi-square goodness of fit test. For OMs, we looked at the type and frequency of content remembered using an Exact Cochran's Q. We split this by species, running one test on dogs and one on cats.

**2.2 Results**

*2.2.1 Participant and pet demographics*

The majority of participants (52.43%) said that they owned or had owned both a cat and a dog, the remaining participants had either only owned a cat (28.16%) or only owned a dog (19.42%).

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Of the 54 participants that owned both a cat and a dog, the majority of participants chose to answer the questionnaire about a dog (64.82%), resulting in a total of 55 (53.40%) participants answering the questions about a dog and 48 (46.62%) about a cat. The majority of dogs were male (67.27%) and pure-breed (83.64%), which was also the case for cats (66.67% males and 58.33% pure-breeds).

*2.2.2 Past event descriptives*

The majority of participants reported that their pet had remembered a past event (82/103). No significant difference was found between the proportion of cats (0.77) and dogs (0.81) that reportedly remembered a past event (Fisher exact test; $N$=103, $p$=0.628). Of the 82 memories provided by the participants, 50 were subsequently coded as EMs and 29 as OMs (3 were unknown), which was significantly different ($\chi^2(1, N$=79$) = 5.58$, $p$=0.024), meaning that the majority of participants that reported an event successfully described an EM. In addition, the frequency of EMs and OMs did not differ between species (Fisher exact test; $N$=79, $p$=0.483). The average age at memory was 3.79 years (*SD*=3.00) and ranged from 3 months – 15 years and was not influenced by memory type or species (*F*s <0.91, *p*s >0.344).

*2.2.3 Characteristics of EMs and OMs*

More than half of EMs had an event occurrence of once (*n*=27), suggesting they were memories of temporally specific (and not general) events. A significant difference in retention time was found, with minutes being the least frequent (*n*=0) and months the most frequent (*n*=16). EMs were remembered "a few times" on other occasions (*n*=22) significantly more than "never" (*n*=7). There was no significant difference between the frequency of retrieval types (voluntary versus involuntary); however, numerically more were involuntary (*n*=30; see Table 2). Additionally, the majority of EMs were cued (*N*=42) as opposed to non-cued (*N*=7) ($\chi^2(1, N$=49$) = 25.00$, $p$<0.001).

Comparing EMs to OMs, the number of EMs was found to decrease as event occurrence increased, whereas the opposite effect (for the most part) was found for OMs (Table 2). No significant differences were found between EMs and OMs in retention time, retrieval type, or other occasions (Table 2). Regarding commonalities, a significant difference was found between the frequency of the different types of commonalities for both EMs ($\chi^2$(9, N=50) = 87.39, $p$<0.001, and OMs, ($\chi^2$(9, N=29)

= 57.85, $p<0.001$), with "location" being the most frequent in both cases. Regarding theme, EM themes were found to differ significantly in frequency ($\chi^2$(9, N=50) = 43.20, $p<0.001$), with "interaction with an animal/person" occurring the most often. In contrast, the frequency of OM themes did not differ significantly ($\chi^2$(4, N=29) = 5.31, $p=0.257$) (see Table 3). For OM content, the frequency of type of content differed significantly for dogs ($\chi^2$(7) = 31.40, p<.001) and for cats ($\chi^2$(7) = 15.02, $p=.036$), with location being the most common content for dogs, and objects for cats (Table 3).

Regarding species, no differences were found for event occurrence, retention time, retrieval type and other occasions (collapsed across memory type) ($\chi^2$s <2.69, $p$s>0.484), however, a species difference was found for valence ($F$(1,75) =4.35, $p=0.040$, $\eta_p^2$ =0.055), with dogs' events rated as more positive ($M$=3.48, $SD$=1.39) than cats' events ($M$=2.66, $SD$=1.53). There was no interaction with memory type, nor a main effect of memory type ($F$s <1.53, $p$s<0.219).[1]

The total number of commonalities (i.e., overlapping features between the retrieval situation and the remembered event) differed by species ($F$(1,75) =9.09, $p=0.004$, $\eta_p^2$ =0.108), with more commonalties for cats ($M$=2.51, $SD$=1.17) compared to dogs ($M$=1.89, $SD$=0.95). There was no interaction with memory type nor a main effect of memory type ($F$s <2.32, $p$s>0.132). The frequency of the types of commonalities also differed for both dogs ($\chi^2$(9, $N$=45) = 96.22, $p<0.001$) and cats ($\chi^2$(9, $N$=37) = 70.18, $p<0.001$), with "location" being the most common for both species (Fig.1), suggesting location as a frequent memory cue. Additionally, due to the large numerical difference between the frequency of "weather" and "sound" commonalities between species (Fig.1), we conducted two additional post-hoc tests. We ran two Fisher exact tests comparing species to weather and species to sound. Alpha was corrected to 0.025. A significant difference was found for sound ($p=0.002$), with a greater frequency for cats ($N$=11) than dogs ($N$=2). No difference was found for weather ($p=0.086$).

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[1] This replicated with exact Kruskal-Wallis H tests using objective valence: significant species differences ($\chi^2$(1) = 4.20, $p=.042$) but not memory type ($\chi^2$(1) = 2.58, $p=.107$).

**2.3 Discussion**

The findings suggest that both cats and dogs have EMs. More than half of EMs described events that occurred once, suggesting the recall of temporally specific events. These events were often remembered when cued by something in the current environment that shared commonalities with the remembered event, consistent with involuntary AMs (see Berntsen, 2009), and also with findings in great apes (Lewis et al., 2019; Lewis et al., 2017b; Martin-Ordas et al., 2013). Location was the most frequent commonality. This may reflect the importance of spatial information for dogs and cats, for instance in relation to hunting/foraging (see General Discussion). Interestingly, cats had a greater number of 'sound' commonalities than dogs. This may be due to the superior hearing range of cats (as compared to most mammals, see Heffner & Heffner, 1985), making sounds more distinct as cues, compared to dogs.

Additionally, EMs were often recalled months after they had occurred and on multiple occasions, suggesting that EMs persisted over time. The majority of EMs involved an interaction with a person or animal, suggesting that EMs of dogs and cats are often socially orientated. This may reflect an innate social preference in dogs and cats. For instance, dogs often perform better than primates in social cognition tasks involving humans (e.g., Brauer, Kaminski, Riedel, Call, & Tomasello, 2006). Alternatively, owners may have found it easier to report upon events that involved themselves interacting with their pet, which may have inflated the number of events reported in this theme. It was also found that dogs' memories were more positive than cats. This may reflect species differences, or a bias in the types of events reported by owners across species. For instance, events involving bathing and weather that were generally negative for cats were not reported at all for dogs (cf. Table 3), even though it is likely that dogs also remember these events.

### 3. Study 2

Study 2 was conducted for three key reasons: 1) to replicate the results from Study 1 using a larger sample, 2) to improve the clarity of questions, and 3) to gain further information on the characteristic of EMs (for detailed changes, see Materials).

**3.1 Methods**

*3.1.1 Participants*

A total of 256 participants were recruited through Prime Panels provided by TurkPrime, which allowed us to specifically target participants who owned either a dog or a cat (or both). We calculated a minimum sample size for each species of 101 in order to have 95% power to detect significant species differences. This calculation was based on the species effect observed on valence in Study 1, suggesting a critical *t* of 2.344 (using GPower 3.1.9.2 – Faul, Erdfelder, Lang, & Buchner, 2007). Eight participants were removed from the study due to failing the attention check question(s) and/or not answering the questions asked. The remaining 248 participants were aged between 20-77 years (*M*=39.38, *SD*=11.74), with 61% female. All had owned either a dog or cat for a minimum of 7 months (range 0.58-23.00 years; *M*=7.67, *SD*=4.74) and the vast majority of participants were American (88.31%). All but two participants were native English speakers. The number of years in education ranged from 1-25 (*M*=14.70, *SD*=3.77). Participants were paid $1 upon successful completion of the questionnaire.

*3.1.2 Materials*

We used the same questionnaire as in Study 1, with a few modifications. First, because the objective ratings and participants' ratings of both valence and event occurrence were not in high agreement in Study 1, we clarified these questions in the survey. Second, we added four questions (Table 4). The status question was used to establish whether participants' personal views about their pet would influence whether they reported their pet as having remembered an event or not (Pongracz et al., 2012). The training question was included as we assumed pets with prior experience in cognitive tasks would be more likely to remember a past event. Age at event and longest retention time enabled us to see the age range in which pets encoded events that were later remembered, and to see for how long an event had been remembered. Longest retention time differed from the retention time variable because it measured the *longest amount of time* that had passed between the event occurring and the event being remembered, as opposed to the amount of time between the event occurring and the *first* time it was remembered.

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Third, we removed the question on retrieval type (voluntary and involuntary) because the participants responses suggested the question was not fully understood, and because we were able to gain some insight on the retrieval process by looking at whether commonalities occurred and if the memory appeared to be cued. Finally, the wording of some of the questions was changed for improved clarity and some of the responses were changed from categorical to continuous responses to allow more sophisticated statistical analyses. Participant consent and the study requirements remained the same as Study 1 (for the full questionnaire see Supplemental Material, Study 2 questionnaire).

*3.1.3 Procedure*

The procedure was identical to Study 1.

*3.1.4 Data Coding*

The coding was identical to Study 1, except for the addition of 'non-memory' in memory type. This referred to instances in which a participant's description of an event memory did not include a description of a memory of *any* kind (e.g., the participant described an event involving their pet, but not an event that their pet remembered). We also added 'action' as an additional content category for OMs due to a number of OMs involving some kind of action.

*3.1.5 Inter-rater reliability*

The same external coder as Study 1 coded 20% of the memories and inter-rater reliability was calculated in the same way as Study 1. Inter-rater reliability for memory type was good ($\kappa = 0.52$ $p$ $<0.001$) and for theme was high ($\kappa = 0.69$ $p$ $<0.001$). For cueing agreement was excellent (percent agreement = 86.67%[2]). For valence, agreement between coders was high ($\kappa = 0.78$ $p$ $<0.001$), and between the objective and the participants' codings was also high ($\kappa = 0.74$ $p$ $<0.001$). For event occurrence, agreement between coders was perfect ($\kappa = 1.00$, $p$ $<0.001$) and agreement between the objective and the participants' codings was fair ($\kappa = 0.37$ $p$ $<0.001$).

*3.1.6 Statistical analyses*

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[2] Cohen's Kappa could not be calculated because one coder had 0 cases of 'non-cued'.

We used the same analyses as Study 1, with the exception of the retention time of EMs and OMs which we investigated using a 2 (species) x 2 (memory type) ANOVA, with retention time as the DV. We included additional analyses on the longest retention time, using a 2 (species) x 2 (memory type) ANOVA. All non-memories were excluded from the analysis of the memory type variable. We also investigated whether status and training influenced participants reporting of whether their pet remembered an event using two Chi-Square tests of Independence, with alpha corrected to .025.

### 3.2 Results

*3.2.1 Participant and pet demographics*

The majority of participants said that they owned both a cat and a dog (52.02%), the remaining participants had either only owned a dog (24.60%) or only a cat (23.39%). Of the participants that owned both a cat and a dog, the majority chose to answer the questionnaire about a dog (62.02%), resulting in a total of 56.86% participants answering the questions about a dog and 43.15% about a cat. The majority of dogs were male (57.45%) and pure-breed (70.92%). Additionally, the majority had not participated in any previous training (69.50%) and were regarded as a family member by their owners (63.83%). For cats, the majority were female (52.34%) and pure-breed (60.75%). As with dogs, the majority had not participated in any previous training (85.98%) and were regarded as a family member by most participants (47.66%), followed by a domestic animal (45.80%).

*3.2.2 Past event descriptives*

The majority of participants reported that their pet had remembered a past event (198/248). No significant difference was found between the proportion of cats (0.78) and dogs (0.82) that reportedly remembered a past event (Fisher exact test; *N*=248, *p*=0.523). Of the 198 memories provided by the participants, 105 were subsequently coded as EMs, 79 as OMs and 12 as non-memory (2 were unknown), which was significantly different ($\chi^2$(2, *N*=196) = 70.48, *p*<0.001). However, the difference between the number of EMs and OMs did not quite reach significance ($\chi^2$(1, *N*=184) = 3.67, *p*=0.065).

Age at event ranged from 1 month to 15 years, with an average of 3.41 years ($SD$=3.12; Mode:1.00 year) and did not differ significantly by species or memory type ($F$s <2.29, $p$s >0.132). Age at memory ranged from 3 months to 15 years, with an average of 4.13 years ($SD$=3.36, Mode:1.00 year), and again did not differ significantly by species or memory type ($F$s <2.68, $p$s >0.104). With regards to pet status and training, we found that status had no effect on whether a pet remembered an event or not ($\chi^2$(3, $N$=248) = 4.65, $p$=0.199), however training did, with 93.35% of pets that had received training remembering an event compared to 76.84% of pets that had not received training ($\chi^2$(1, $N$=236) = 6.43, $p$=0.011).

*3.2.3 Characteristics of EMs and OMs.*

The majority of EMs had an event occurrence of once ($n$=84) as opposed to more than once ($n$=21), in contrast to OMs, which occurred more frequently. The frequency with which the event was remembered on other occasions did not differ for EMs or OMs (Table 5). The number of cued EMs (86.28%) was significantly greater than the number of non-cued (13.73%) ($\chi^2$(1, $N$=102) = 53.69, $p$<0.001).

Regarding retention time, memories were recalled (for the *first* time) from 5 minutes to 12 years after the event occurred ($M$=294.80 days, $SD$=639.01 days), with no main effect of memory type, species nor an interaction ($F$s <0.44, $p$s>0.507). Fig.2 shows the distribution of memories over retention time. Note that the frequency of memories with long retention times are underestimated here. This is because the maximum retention time was naturally restricted to the amount of time a pet had been owned. For example, if a pet had been owned for 1 year, the owner could not report on any potential memories their pet may have had that were longer than 1 year.

There was also no main effect of memory type, species nor an interaction on longest retention time (the *longest period* in which an event had been remembered) ($F$s <0.73, $p$s >0.394), with an average retention time for dogs of 2.72 years (range = 1 hour -10 years, $SD$=2.85 years) and for cats 3.18 years (range = 8 hours -14 years, $SD$=4.05 years). Fig.3 shows the distribution of the memories over the longest retention time. Note that the frequency of memories with long retention times are underestimated here (as with Fig.2).

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For theme, we found that the frequency of theme types differed significantly for EMs ($\chi^2$(9, $N$=104) = 85.62, $p$<0.001), with 'interaction with an animal/person' occurring the most frequently. There was also a significant difference in the frequency of themes for OMs ($\chi^2$(8, $N$=79) = 58.97, $p$<0.001), with "other" being the most common (n=24) (Table 6). For the content of OMs, the frequency of type of content differed significantly for dogs ($\chi^2$(8) = 39.36, p<0.001) and for cats ($\chi^2$(8) = 24.14, $p$=0.002), with 'location' being the most common content for both species (Table 6). Likewise, a significant difference in frequency between type of commonality was found for EMs, OMs, dogs and cats ($\chi^2$s> 141.21, $p$s<0.001), with 'location' being the most common in all cases (Fig.4).

Regarding valence, we found a main effect of memory type ($F$(1,180) =12.36, $p$=0.001, $\eta_p^2$ =0.064), indicating that OMs were more positive ($M$=3.72, $SD$=1.30) than EMs ($M$=3.04, $SD$=1.72). We also found a species difference for valence ($F$(1,180) =5.68, $p$=0.018, $\eta_p^2$ =0.031), reflecting that the memories reported for dogs were rated as more positive ($M$=3.53, $SD$=1.53) than the ones reported for cats ($M$=3.05, $SD$=1.62) [3]. No other species differences were found.

### 3.3 Discussion

The results from Study 2 largely replicated Study 1, that is, both cats and dogs were reported to have EMs, with the majority being temporally specific, cued by location and about a social situation. Additionally, Study 2 found that the longest retention time averaged years. The status of the pet in the family did not influence whether a pet was reported to remember a past event, suggesting that the owner's personal views of their pet did not influence their reports of their pet's memory. Prior training and/or memory testing experience had a positive effect on pets' ability to remember a past event. Importantly, this suggests that the experiences an animal has impacts cognitive ability. For

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[3] The main effect of memory type replicated using an exact Kruskal-Wallis H test with the objective coding of valence ($\chi^2$(1) = 6.80, $p$=0.009), but failed to show a main effect of species ($\chi^2$(1) = 1.74, $p$=0.195).

instance, trained dogs differ from non-trained dogs in communicative behaviour in cognitive tasks (Marshall-Pescini, Passalacqua, Barnard, Valsecchi, & Prato-Previde, 2009) and are better at problem solving (Marshall-Pescini, Valsecchi, Petak, Accorsi, & Previde, 2008). Importantly, the increased number of reported events for trained dogs in the present study was not a result of a large number of memories related to training/memory testing, with only a total of 7/198 memories about training/memory testing.

## 4. General discussion

The purpose of this study was to investigate the characteristics of domestic cats and dogs' memories of past events as they occur in everyday life and as reported by their owners. Five key findings were revealed. First, both cats and dogs have long-term memories of past events. Second, these memories share many characteristics with human involuntary AM. Third, social information and location were frequently remembered. Fourth, location was the most common retrieval cue. Fifth, dogs' memories of past events were more positive than cats.

Both cats and dogs reportedly remembered events that occurred many months ago. Dogs can recall memories from weeks ago (Demant, Ladewig, Balsby, & Dabelsteen, 2011), but as far as we are aware, the longest delay observed in cats has been minutes (Okujava et al., 2005; Takagi et al., 2017), although see Saito and Shinozuka (2013) for an example of long-term recognition in cats. Furthermore, the retention periods we were able to observe necessarily were limited to the duration in which participants had owned their pet. That is, participants that owned a pet for six months could only report memories that had retention periods of six months or less. As such, the frequency of the longer retention periods (and the length of the longest retention period), may have been greater had all participants owned their pets for many years.

Regarding the characteristics of involuntary AM, specific events are often spontaneously remembered when features in the present environment provide a unique overlap with features of the remembered event (Berntsen, 2009). Our results are consistent with this, in that the majority of EMs had events that occurred only once (temporally specific events) and were often cued by features in the present environment that shared commonalities with the remembered event. Thus, the EMs reported

here may have been retrieved spontaneously as a result of a unique overlap of features serving as memory cues (see Lewis et al., 2019).

Regarding types of cues, location was the commonality reported most frequently for both species. That is, at the time of remembering an event, the current location matched the location of the event. This suggests that memory of locations is particular prominent in cats and dogs, consistent with findings that dogs and cats can remember where a hidden item was located by using spatial information (Fiset, 2007; Fiset & Doré, 1996; Fiset, 2009). These findings may reflect a natural tendency for cats and dogs to process spatial information, which is a useful ability for foraging.

Interaction with another animal or person was consistently reported as the most frequent EM theme, suggesting that dogs and cats EMs are often socially orientated. However, this may be a result of the living environment of these pets as opposed to a natural trait. Dogs and cats are kept as companion pets and spend a lot of time interacting with humans. Furthermore, they rely on humans as a source of food and shelter. Consequently, this interaction and dependence upon humans may explain why events with humans are often remembered (as opposed to other events). Interestingly, interaction with an animal/person was not the most frequent type for OMs, with "other" being the most frequent theme, closely followed by interaction with an object. On inspection of the "other" themed OMs, we found that many described a pet's memory of a place/location/person.

Another consistent finding was that dogs' memories were rated as more positive than cats. This may be due to differing opinions between dog and cat owners. Alternatively, it could reflect difficulties with reporting positive memories in cats due to the limited behavioral responses they can exhibit (e.g., dogs can wag their tails and bark to show happiness, whereas cats have less salient ways of showing happiness). The lack of any other significant difference between dogs and cats suggests that dogs and cats share a similar memory system for events, which is consistent with findings that dogs' cognitive abilities are not superior to other mammals (Lea & Osthaus, 2018).

An important limitation of the present study is that the data are based upon owners' reports. Thus, some subjectivity and retrospective biases are inherently involved. While we fully acknowledge this limitation, it seems unavoidable when studying memories of cats and dogs as they occur in

everyday life, outside of laboratory settings. Nonetheless, the generally high agreement between the objective codings and participants' ratings lend some support to the validity of the participants' responses, thus strengthening the validity of the results. Although it was not possible to verify the content of the event descriptions themselves, the level of detail and variety of event descriptions provided suggest participants were not falsely describing generic events that people expect pets to remember, but rather were describing personal events that they believed their pet remembered (see Supplemental Material, Examples of participants' event descriptions). Additionally, approximately 20% of owners reported their pet as never remembering an event, suggesting that there is not a general bias in which all pet owners believe their pets to have memories of this kind.

Assessing the characteristics of event memories in the daily lives of cats and dogs is not something that can be easily implemented using experimental methods. Introducing a survey methodology that is based on standard AM methods and variables, our findings suggest that both dogs and cats have event memories that share at least some characteristics with human event memories, in particular involuntary AMs. The vast variety of individual events reported reveals the diversity of events dogs and cats can remember. Future studies may wish to corroborate our findings using more objectifiable measures, or to use a similar methodology to investigate the memory of past events in other species.

## 5. Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the American Psychological Association and were approved by the ethics review board at Center on Autobiographical Memory Research.

## 6. Acknowledgements

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## 8. Tables

**Table 1.** Questions included in Part 4 of the questionnaire [variable names in brackets].

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1  **[Event description]** Describe the occasion when your dog seemed to remember an event. Was the event your dog remembered a special event for your dog or was it more of an everyday/common event*?*

2  **[Age at memory]** How old was your dog when it remembered the event?

3  **[Retention time]** When your dog remembered the event, how much time had passed since the event first occurred?  My dog remembered something that happened... (minutes/hours/weeks/months/years)

4  **[Valence]** How emotional was the event for your dog? (1 = "Very negative"; 5 = "Very positive").

5  **[Event occurrence]** Did the event occur just once, or did it occur multiple times? (Once/2-4 times/5-10 times/20+ times)

6  **[Commonalities]** Think about the occasion in which your dog remembered the event. Were they any similarities between the event and the occasion in which your dog remembered the event?
(Person(s)/Object(s)/Location(s)/Activity(s)/Weather/Smell(s)/Sound(s)/Time of day/None/Other)

7  **[Retrieval type]** Did your dog deliberately remember the event to achieve a want or desire, or did it remember because something reminded him/her of the event? (My dog deliberately remembered the event/Something reminded my dog of the event).

8  **[Other occasions]** Has your dog remembered the event on other occasions that you are aware of? (Never/A few times/ Often/ Very often).

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*Note:* All multiple-choice questions allowed for only a single response, except for question 6 in which multiple responses were allowed. All instances of "dog" were replaced by "cat" for participants that chose to answer about a cat.

**Table 2**. Percentage of participants' responses to the given variables, split by memory type and collapsed across species.

| Variable | Response | Percentage of response by memory type | | | | EM by OM |
|---|---|---|---|---|---|---|
| | | EM (*N*=50) | | OM (*N*=29) | | |
| Event occurrence | *Once* | 54.00% | *p*<0.001[a] | 20.69% | *p*=0.064 | *p*<0.001 |
| | *2-4 times* | 26.00% | | 10.35% | | |
| | *5-10 times* | 12.00% | | 24.14% | | |
| | *10+ times* | 8.00% | | 44.83% | | |
| Retention time | *Minutes* | 0.00% | *p*=0.002 | 6.90% | *p*=0.102 | *p*=0.376 |
| | *Hours* | 14.00% | | 10.35% | | |
| | *Weeks* | 26.00% | | 20.69% | | |
| | *Months* | 32.00% | | 27.59% | | |
| | *Years* | 28.00% | | 34.48% | | |
| Retrieval type | *Voluntary* | 40.00% | *p*=0.157 | 55.17% | *p*=0.577 | *p*=0.192 |
| | *Involuntary* | 60.00% | | 44.83% | | |
| Other occasions | *Never* | 14.00% | *p=0.016* | 20.69% | *p*=0.818 | *p*=0.676 |
| | *A few times* | 44.00% | | 31.03% | | |
| | *Often* | 20.00% | | 20.69% | | |
| | *very often* | 22.00% | | 27.59% | | |

*Note:* EM: Event memories, OM: Other memories.

[a] This result was replicated using the objective ratings of 'once' and 'more than once' ($\chi^2(1, N=50) = 28.88$, p<0.001).

**Table 3.** Percentage of responses in each category for EMs and OMs, split by species.

| Memory | *Percentage of response* | | |
|---|---|---|---|
| **EM Theme** | **Dog (*N*=26)** | **Cat (*N*=24)** | **Total (*N*=50)** |
| *Escaping/getting lost* | 7.69% | 4.17% | 6.00% |
| *Interaction with an animal and/or person* | **34.62%** | **37.50%** | **36.00**% |
| *Interaction with an object* | 7.69% | 8.33% | 8.00% |
| *Accident or injury and/or vet treatment* | 15.39% | 12.50% | 14.00% |
| *Weather* | 0.00% | 8.33% | 4.00% |
| *Food* | 15.39% | 8.33% | 12.00% |
| *Being bathed or washed* | 0.00% | 12.50% | 6.00% |
| *Locating a hidden or lost object* | 3.85% | 8.33% | 6.00% |
| *A walk or trip* | 11.54% | 0.00% | 6.00% |
| *Other* | 3.85% | 0.00% | 2.00% |
| | | | |
| **OM Theme** | **Dog (*N*=18)** | **Cat (*N*=11)** | **Total (*N*=29)** |
| *Escaping/getting lost* | 22.22% | 9.09% | 17.24% |
| *Interaction with an animal and/or person* | 5.56% | 18.18% | 10.35% |
| *Interaction with an object* | 22.22% | **27.27%** | 24.14% |
| *Accident or injury and/or vet treatment* | 0.00% | 12.50% | 14.00% |
| *Weather* | 0.00% | 0.00% | 0.00% |
| *Food* | 11.11% | 18.18% | 13.79% |
| *Being bathed or washed* | 0.00% | 0.00% | 0.00% |
| *Locating a hidden or lost object* | 0.00% | 0.00% | 0.00% |
| *A walk or trip* | 0.00% | 0.00% | 0.00% |
| *Other* | **38.89%** | **27.27%** | **34.48%** |
| | | | |
| **OM Content** | **Dog (*N*=18)** | **Cat (*N*=11)** | **Total (*N*=29)** |
| *Individual* | 16.67% | 9.09% | 13.79% |
| *Location* | **61.11%** | 36.36% | **51.17**% |
| *Object* | 33.33% | **54.55%** | 41.38% |
| *Food* | 11.11% | 0.00% | 6.90% |
| *Sound* | 0.00% | 18.18% | 6.90% |
| *Activity* | 22.22% | 27.27% | 24.18% |
| *Time* | 5.55% | 18.18% | 10.35% |

*Note*: Bold text indicates the category with the highest response. EM: Event memories, OM: Other memories. Themes were mutually exclusive, whereas multiple selections could be made for OM Content.

**Table 4.** Additional questions used in Study 2 [variable names in brackets].

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**[Status]** Which of the following do/did you regard your dog as? (A domestic animal/ A working animal/ A family member/ A friend).

**[Training]** Has/did your dog receive any form of training or participate in any memory tasks? (Yes/ No/ Don't know)

**[Age at Event]** How old was your dog at the time of the event? If the event occurred more than once, please use the first instance.

**[Longest retention time]** How much time passed since the event first occurred and the most recent occasion in which your dog remembered it?

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*Note:* All multiple-choice questions allowed for only a single response. All instances of "dog" were

replaced by "cat" for participants that chose to answer about a cat.

**Table 5.** Percentage of participants' responses to the given variables, split by memory type and collapsed across species.

| Variable | Response | Percentage of response by memory type | | | | EM by OM |
|---|---|---|---|---|---|---|
| | | EM (*N*=105) | | OM (*N*=79) | | |
| Event occurrence | *Once* | 80.00% | *p*<0.001[a] | 39.24% | *p*=0.056 | *p*<0.001 |
| | *More than once* | 20.00% | | 60.76% | | |
| Other occasions | *Never* | 27.62% | *p=0.*101 | 20.25% | *p*=0.254 | *p*=0.036[b] |
| | *A few times* | 34.29% | | 20.25% | | |
| | *Often* | 20.00% | | 25.32% | | |
| | *very often* | 19.05% | | 34.18% | | |

*Note*: EM: Event memories, OM: Other memories.

[a] This result was replicated using the author's ratings $\chi^2(1, N=104) = 67.85, p<0.001$.

[b] Non-significant at the corrected significance level of 0.025.

**Table 6.** Percentage of responses in each category for EMs and OMs, split by species.

| Memory | Percentage of response | | |
|---|---|---|---|
| **EM Theme** | **Dog (N=67)** | **Cat (N=37)** | **Total (N=104)** |
| *Escaping/getting lost* | 10.45% | 16.22% | 12.50% |
| *Interaction with an animal and/or person* | **40.30%** | **18.92%** | **32.70**% |
| *Interaction with an object* | 4.48% | 10.81% | 6.73% |
| *Accident or injury and/or vet treatment* | 13.43% | **18.92%** | 15.39% |
| *Weather* | 1.49% | 5.41% | 2.89% |
| *Food* | 15.94% | 13.51% | 15.39% |
| *Being bathed or washed* | 1.49% | 2.70% | 1.92% |
| *Locating a hidden or lost object* | 0.00% | 2.70% | 0.96% |
| *A walk or trip* | 8.96% | 0.00% | 5.77% |
| *Other* | 2.99% | 10.81% | 5.77% |
| | | | |
| **OM Theme** | **Dog (N=40)** | **Cat (N=39)** | **Total (N=79)** |
| *Escaping/getting lost* | 7.50% | 17.95% | 12.66% |
| *Interaction with an animal and/or person* | 10.00% | 7.69% | 8.86% |
| *Interaction with an object* | 20.00% | 25.64% | 22.79% |
| *Accident or injury and/or vet treatment* | 2.50% | 2.56% | 2.53% |
| *Weather* | 0.00% | 0.00% | 0.00% |
| *Food* | 17.50% | 12.82% | 15.19% |
| *Being bathed or washed* | 2.50% | 7.69% | 3.80% |
| *Locating a hidden or lost object* | 5.00% | 0.00% | 2.53% |
| *A walk or trip* | 2.50% | 0.00% | 1.27% |
| *Other* | **32.50%** | **28.21%** | **30.38%** |
| | | | |
| **OM Content** | **Dog (N=40)** | **Cat (N=39)** | **Total (N=79)** |
| *Individual* | 15.00% | 17.95% | 16.46% |
| *Location* | **45.00%** | **35.90%** | **40.51**% |
| *Object* | 27.50% | 25.64% | 26.59% |
| *Food* | 22.50% | 20.51% | 21.52% |
| *Sound* | 7.50% | 5.13% | 6.33% |
| *Activity* | 22.50% | 28.21% | 25.32% |
| *Time* | 5.00% | 12.82% | 8.86% |
| *Action* | 10.00% | 17.95% | 13.92% |

*Note*: Bold text indicates the category with the highest response. EM: Event memories, OM: Other memories. Themes were mutually exclusive, whereas multiple selections could be made for OM Content.
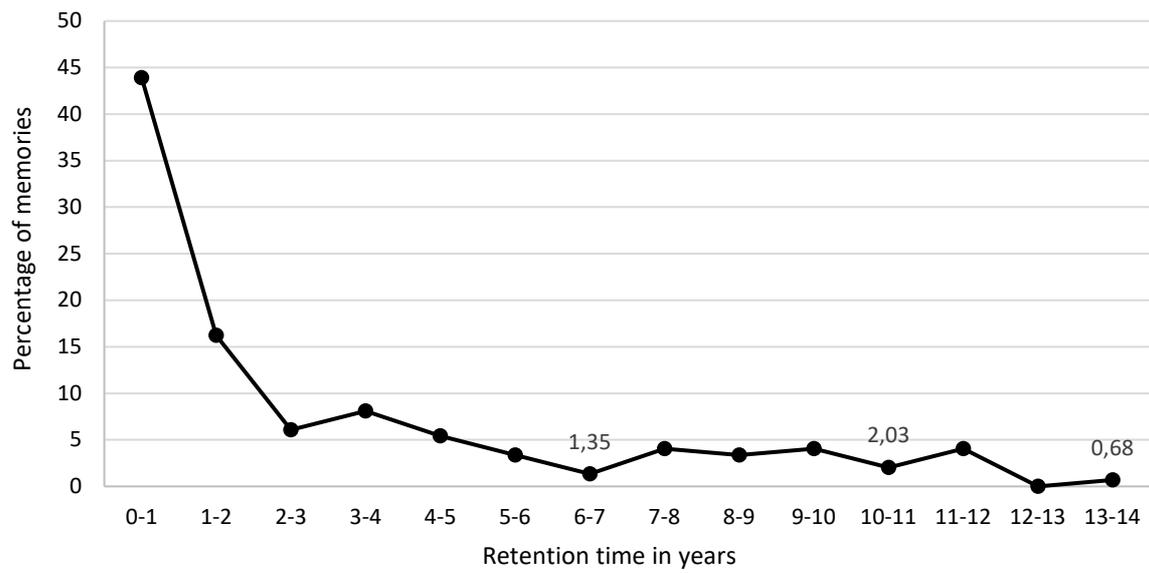
## 9. Figures
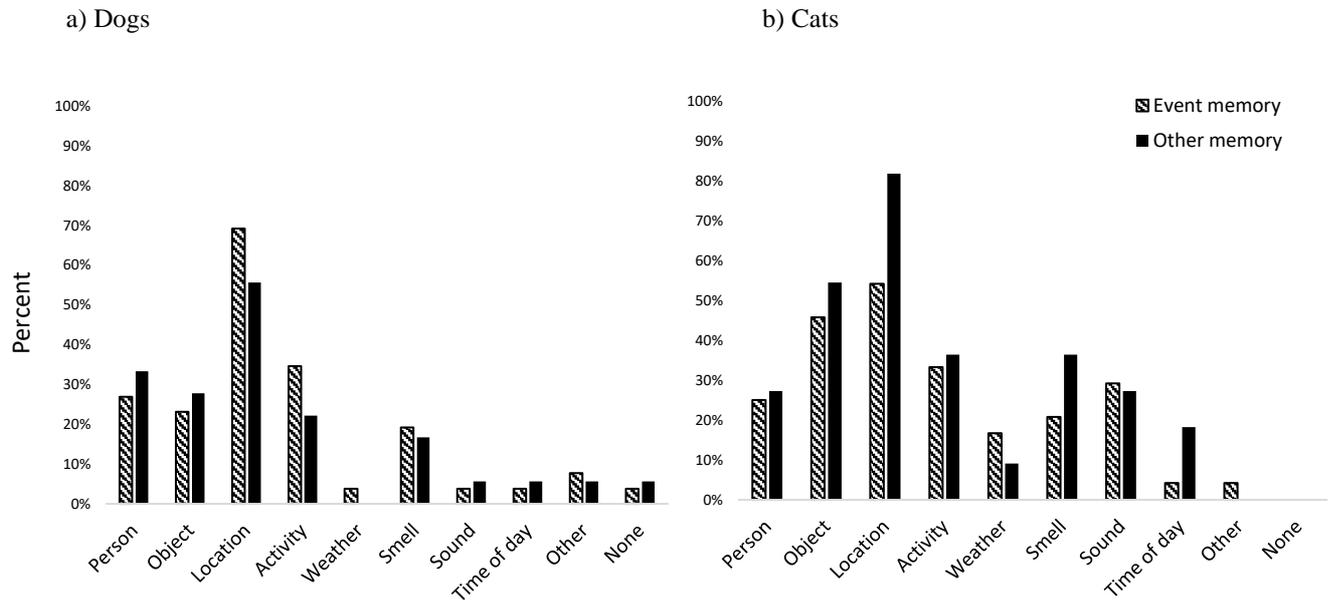
a) Dogs

b) Cats



**Fig. 1** Percentage of each commonality type split by memory type and a) dogs, b) cats.
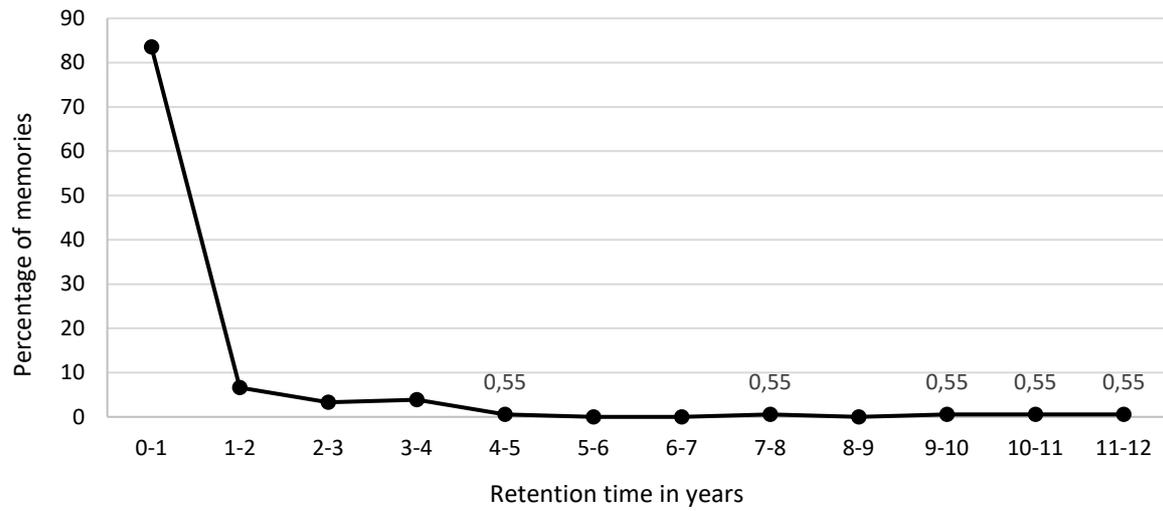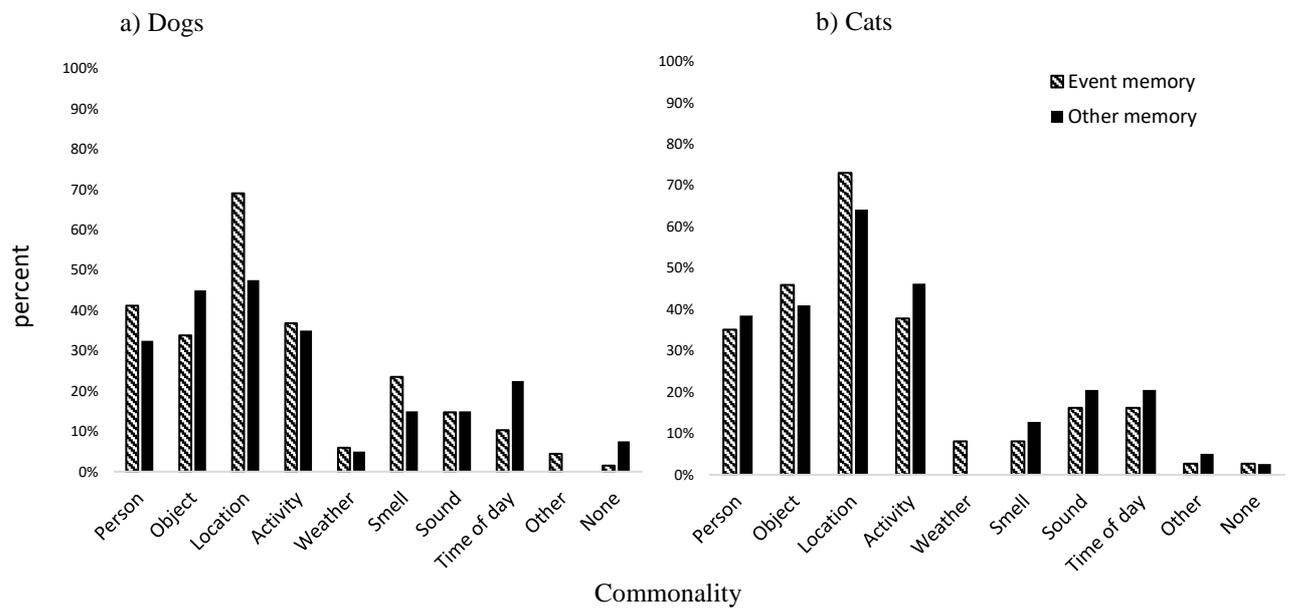
**Fig. 2** Retention time grouped into 1-year periods, collapsed across species and memory type. *Note:*

the shortest retention time was 5 minutes.

**Fig. 3** Longest retention time grouped into 1-year periods, collapsed across species and memory type.

*Note*: the shortest retention time was 1 hour.

**Fig. 4** Percentage of each commonality type by species and memory type for a) dogs and b) cats.

5

5

Your participation in this study is completely voluntary. You do not have to participate in this study, and you can quit at any time.

IX. Contact Information
If you have any questions about this research, please contact Amy Lewis (amy_lewis@psy.au.dk)

I have read and understood the above, and I want to participate in this study

○ Yes

○ No

---

**Part 2**

Please select which pet(s) you own/have owned for longer than 6 months?

○ Cat(s)

○ Dog(s)

○ Both cat(s) and dog(s)

○ None of the above

Choice – appears only if "Both cat(s) and dog(s) is selected above

Please select whether you would like to answer the remaining questions about:

○ A dog you own/owned for at least 6 months

○ A cat you own/owned for at least 6 months

---

**Part 3**

What is your gender?

○ Male

○ Female

What is your age in years?

_____

What is your nationality?

_____

Are you a native English speaker?

○ Yes

○ No

How many years of formal education do you have?

_____

**Part 4**

You can choose to answer the following questions about your current dog or about a dog that you had in the past.

The dog you choose must be a dog that you have had (or had) for at least 6 months.

If you have (or have had) multiple dogs, please chose the dog that you have had (or had) the longest and answer all the questions about that dog only.

Please confirm whether you have read and understood the above

○ Yes

○ No

What breed is/was your dog?

_____

What sex is/was your dog?

◯ Male

◯ Female

How long have you had/did you have your dog?

Please enter a number in each box, 0 can be entered if required (e.g. 0 years, 7 months)

Years: _____

Months: _____

Which of the following do/did you regard your dog as?

◯ A domestic animal/pet

◯ A working animal

◯ A family member

◯ A friend

Has/did your dog receive any form of training, or participate in any memory tasks?

◯ Yes

◯ No

◯ Don't know

Next you will be asked questions about your chosen dog's memory of an event. To answer the questions, please think of an occasion when your dog seemed to remember an event from their past. It may be an event that occurred only once, or it may have occurred multiple times. It may be something trivial/mundane or something very unique and unusual.

*Example:* When my puppy was a few months old, he escaped through the garden fence into my neighbour's garden. My neighbour found him in his house eating his cat's food, having snuck in through the cat-flap. Three months later I was sitting with my dog in the garden. He

was barking at me because he was hungry, but I was unable to feed him because he was due at the vets later in the day for an operation. I was trying to get him to stop barking because I could see my neighbour was sitting in his garden next door. Suddenly, my dog ran towards my neighbour and the section of the garden fence where he had previously escaped. He escaped through the fence again and ran to the neighbour's cat-flap (unfortunately for him, the cat-flap was locked).

How did my dog escape?

○ Through the gate

○ Through the garden fence

○ Through the window

Did your dog ever remember an event?

○ Yes

○ No

Describe the occasion when your dog seemed to remember an event.

Please provide 3-4 lines of text as a minimum, so that it is clear what the event was about and when it was remembered.

_____

_____

_____

_____

_____

Was the event your dog remembered a special event for your dog, or was it more of an everyday/common event?

_____

_____

_____

_____

_____

Please indicate using the scale how emotional the event was <u>for your dog</u>?

|                  | 1 | 2 | 3 | 4 | 5 |                  |
|------------------|---|---|---|---|---|------------------|
| Very<br>negative | ○ | ○ | ○ | ○ | ○ | Very<br>positive |

How many times did the <u>event occur</u> before your dog remembered it?

○ Once

○ More than once

How old was your dog at the <u>time of the event</u>?

If the event occurred more than once, please use the first instance.
Please enter a number in each box, 0 can be entered if required.

Years: _____

Months: _____

How old was your dog when it <u>remembered the event</u>?

If your dog remembered the event more than once, please use the first instance.
Please enter a number in each box, 0 can be entered if required

Years: _____

Months: _____

When your dog remembered the event, approximately how much time had passed since the event first occurred and the first time your dog remembered it ?

Please enter a number in each box, for instance, if 2 months had passed, put 2 in the months box and 0 in the other boxes.

Minutes: _____

Hours: _____

Weeks: _____

Months: _____

Years: _____

Please select option 1 to continue

○ Option 1

○ Option 2

○ Option 3

Think about the occasion in which your dog remembered the event. Were they any similarities between the event and the occasion in which your dog remembered the event? (e.g., in the example, the event and the memory of the event occurred in the same location and the neighbour was present in both situations)

Please select any commonalities, if there were no commonalities, select none:

☐ Person(s)

☐ Object(s)

☐ Location(s)

☐ Activity(s)

☐ Weather

☐ Smell(s)

☐ Sound(s)

☐ Time of day

☐ None

☐ Other (please specify below)

If you selected other, please specify here:

_____

Please briefly describe any commonalities that you selected above. If you selected "None", please write "N/A"

_____

Has your dog remembered the event on other occasions that you are aware of?

○ Never

○ A few times

○ Often

○ Very often

How much time has passed since the event first occurred and the most recent occasion in which your dog remembered it? (e.g., if your dog remembered the event on 4 occasions and on the 4th occasion 1 year had passed since the event first occurred, put 1 in the year box and 0 in the other boxes).

Hours: _____

Weeks: _____

Months: _____

Years: _____

Any comments you would like to add about this study:

_____

**Examples of participants' event descriptions.**

Example of a dog owner's description of an event that was coded as an EM:

*"One Christmas when my dog was two years old, I had wrapped two medium sized stuffed animals and placed them under the tree. Not traditional dog toys or anything that smelled. On Christmas day, when we sorted out the presents, we told her that those were her gifts and we "helped her open them" by peeling back the paper slowly. She loved those stuffed animals (rabbit and squirrel). Next Christmas, again I bought her a new stuffed animal or similar size and feel, wrapped it and placed it under the tree. I used the same doggie Christmas wrapping paper as the previous year. When we came down on Christmas morning the second year, we found her holding the gifted "frog" stuffed animal. She had found and opened her own gift and only that one. It was actually unbelievable. I stopped using her doggie gift wrap and started hiding her gifts in the back of the tree so she couldn't get to them. I would not have believed it if not seen it myself."*

Example of a dog owner's description of an event that was coded as an OM:

*"My ex boyfriend moved out of our house and the dog stayed with me. months later when they saw each other, the dog remembered him immediately. The dog ran into his arms like there had not been any time they spent apart. It was very heart warming to see and made me smile tremendously. The dog saw him and didn't want to leave his side for quite a while after that!"*

Example of a cat owner's description of an event that was coded as an EM:

*"Cat remembers the one time when I put his food bowl in the bathroom (so the other cat wouldn't finish his left overs). Even months later, whenever I use that bathroom during the day, cat still jumps up and tries to run into the bathroom before I close the door. If he gets in, he looks around desperately for that food that was there once."*

Example of a dog owner's description of an event that was coded as an OM:

*"when we had a dog I used to feed the cat upstairs since the dog couldn't get upstairs. After the dog passed away I began feeding the cat downstairs. A few months ago I got a puppy and now when I prepare the food the cat runs upstairs to eat but I no longer feed him up there. I still feed the cat downstairs even tho I got a puppy but he still goes upstairs every morning thinking I'm going to feed him up there because theres a dog in the house again."*