# Involving caregivers in behavioural research: a SWOT analysis of two citizen science research methodologies to study cat-cat interactions at home

Morgane J.R. Van Belle[a], Noema Gajdoš Kmecová[b], Frank A.M. Tuyttens[a,c], Daniel S. Mills[d], Tiny C.B.M. De Keuster[a]

[a] Ethology and Animal Welfare Research Group, Department of Veterinary and Biosciences, Faculty of Veterinary Medicine, Ghent University, Heidestraat 19, 9820 Merelbeke, Belgium

[b] University Veterinary Hospital – Small Animal Clinic, University of Veterinary Medicine and Pharmacy in Košice, Komenského 73, 041 81 Košice, Slovakia

[c] Animal Sciences Unit, Flanders Research Institute of Agriculture, Fisheries and Food (ILVO), Scheldeweg 68, 9090 Melle, Belgium

[d] Animal Behaviour, Cognition & Welfare group, Dept of Life Sciences, University of Lincoln. Lincoln, Lincs LN6 7DL

Corresponding author: Morgane Van Belle, morgane.vanbelle@ugent.be

Doi: https://doi.org/10.1016/j.applanim.2023.106133

**Abstract**

Citizen science, which involves engaging the general public in research tasks, is increasingly used in animal behaviour studies. In this review we conducted a SWOT analysis (Strengths, Weaknesses, Opportunities, Threats) to evaluate two methodologies of data collection using citizen science in order to study cat-cat interactions: online survey responses and caregiver-recorded home videos analysed by researcher(s).

Using the SWOT-analysis on both methodologies, we listed intrinsic aspects that facilitate (Strengths) or interfere with (Weaknesses) reaching scientific goals, as well as the features that the methodology may be able to capitalise on (Opportunities) or which limit its value (Threats). A major strength of online surveys is the possibility to access caregivers' specific knowledge of their cats, while sampling bias often is a potential weakness. Opportunities of surveys are the methodology´s flexibility and data collection

efficiency, but at the same time suffering from threats related to biases associated with caregiver interpretation of their pet's behaviour. Strengths of caregiver-recorded videos capturing cats' behaviour include that they allow expert behavioural observations and scoring in a systematic manner (e.g. using an ethogram) and thus yielding quantitative data (whose reliability can be tested between and within observers). Furthermore, given the ubiquity of smartphones, filming cats is not a burden for most caregivers, and the collected recordings can potentially contain high-quality data that may otherwise be inaccessible, or subject to bias if a researcher had been present in the home environment. Though, caregivers' influence on and lack of standardisation of the recordings are weaknesses which possibly influence the quality of the collected data. Opportunities include public engagement with science, while possible Threats may be related to privacy of the caregivers participating.

In this review we consider in more detail each of the four SWOT components related to each methodology in order to optimise cat behaviour research in future. The authors suggest strategies for future studies using the research methodologies discussed in this review and give specific recommendations when using caregiver-recorded videos in behavioural studies. Additionally, smart combinations of both online surveys with home videos recorded by caregivers might overcome some limitations of the individual methodologies, and would thus be a potentially stronger approach.

**Keywords**

Citizen science; owner report; video observations; domestic cat; SWOT analysis; social behaviour

## 1. Introduction

"Citizen science broadly refers to the active engagement of the general public in scientific research tasks" (Haklay et al., 2021). Although citizen science has been used most in scientific disciplines such as humanities or ecology, it is recently gaining attention within the field of applied ethology as well (Pongrácz and Camerlink, 2022). Tasks for the general public can be incorporated into each stage of a research project (e.g. formulating hypotheses, data collection or data analysis), however, in behavioural research the methodology is mostly used for collecting data. For companion animals, caregivers are

50 the daily witnesses of their pets and thus potentially a valuable source of information. The most
51 common citizen science methodology currently used in this field relates to the use of caregiver report
52 via online surveys. Concerns about the reliability and validity of such data have been expressed
53 previously (Taylor and Mills, 2006; Gajdoš Kmecová et al., 2021). Both the rise of social media and
54 technical advancements such as the emergence of the smartphone have contributed to evolutions in
55 behavioural research methodologies in the 21st century. The use of caregiver-recorded videos, either
56 by using the available recordings on social media (video mining) (Rault et al., 2013), or by giving
57 recruited participants specific instructions to record their pets, present new opportunities of
58 undertaking citizen science, examining the domestic pet in its home setting rather than in artificial or
59 experimental settings.

60 Social behaviour in cats has an established history of being studied by trained researchers in laboratory
61 settings (e.g. Van den Bos and de Cock Buning, 1994; Van den Bos, 1998), feral or free-roaming
62 conditions (e.g. Dards, 1983; Finkler and Terkel, 2010) or shelter environments (e.g. Kessler and Turner,
63 1999; Gouveia et al., 2011), using direct expert observations of cat-cat interactions (Bateson and
64 Martin, 2021). This approach has been used to a more limited extent for behavioural research of
65 companion cats in their home environment (West, 1974; Bernstein and Strack, 1996; Barry and Crowell-
66 Davis, 1999) which can be linked to various difficulties including practical considerations (e.g. travel
67 times), small study populations and potential observer effects, with many cats notoriously changing
68 their behaviour in the presence of a stranger intruding their safe environment. A growing number of
69 studies are trying to overcome these issues by involving cat caregivers in behavioural research via a
70 citizen science approach in order to systematically study cat-cat interactions and dynamics in the more
71 natural home context (e.g.Gajdoš-Kmecová et al., 2023; Khoddami et al., 2023).

72 In the current review, we explore and evaluate two of the most commonly used methodologies which
73 involve caregivers in research, namely online surveys and caregiver-recorded videos. We chose studies
74 on cat-cat interactions as an example case to illustrate our review for two reasons.

A first reason being the ongoing need for and relevance of further research into cat-cat interactions in the domestic environment. From research in free-ranging conditions, it is known that cats show a certain degree of social flexibility towards conspecifics, i.e. they can both live in social groups and as solitary individuals, depending on resource availability (Bradshaw, 2016). The social opportunities for cats living in households is often largely determined by their human caregivers, since the latter often define the intraspecific social context (multicat or single cat household) and housing conditions (space and resources available) of the cats' living environment. When the social capacities of cats are exceeded (e.g. poor socialisation, conflict over resources, introduction of a new cat in the house), intraspecific social tension may arise and become a cause of stress in cohoused cats (Bradshaw and Hall, 1999; Amat et al., 2016; Finka, 2022). Stress, and more specifically chronic stress, is not only detrimental to cat welfare, but may also impair caregiver wellbeing, by making caretaking more demanding physically, mentally, but also financially. Chronic stress in felines may lower the threshold for development of medical conditions (e.g. gastrointestinal complaints, viral infections (Addie et al., 2009; Amat et al., 2016)) and behavioural problems [e.g. urine marking, compulsive behaviours, increased aggressive displays (Amat et al., 2016)]. Examples showing a direct link between (social) stress and physical health include feline interstitial cystitis (Buffington, 2011), orofacial pain syndrome (Rusbridge et al., 2010) or dermatological conditions (Virga, 2003; see Mills et al., 2014 for a review). Furthermore, behavioural conditions such as house soiling or aggressive behaviours towards conspecifics or people may threaten the cat-caregiver bond and lead to relinquishment (Duarte Cardoso et al., 2022) or euthanasia (Gorodetsky, 1997). Additionally, caregivers with a cat suffering from a stress-related medical or behavioural disorder might encounter difficulties while caring for the diseased animal. Caregiver burden may include increased frustration, stress, anxiety, depression, and social isolation (Spitznagel et al., 2017; Buller and Ballantyne, 2020; Ravenscroft et al., 2021). In conclusion, understanding intraspecific interactions and dynamics of cats living in households, including individual differences (e.g. socialisation), is key for protecting both feline and caregivers' physical and mental well-being.

A second reason is that citizen science methodologies are well-suited to study feline social behaviour. As stated above, studying cat-cat interactions and dynamics in households brings several challenges. When performing behavioural research, spontaneous behaviour is best studied in the natural environment of the animal (Bateson and Martin, 2021). For pet cats – meaning owned or household cats, opposed to feral, street or stray cats (Sparkes et al., 2013) – the natural setting is the environment in and around the human home. Furthermore, the species-typical nature of cats, their territorial characteristics (Bradshaw, 2016) and sensitivity to changes in the environment (Amat et al., 2016) need to be taken into account. Taking companion cats out of their safe environment is thus ill-suited for this type of research, since cats may alter their behaviour over different contexts (Nibblett et al., 2015; Pongrácz and Onofer, 2020), and habituate poorly to the temporary laboratory environment (Uccheddu et al., 2022). Citizen science methodologies are currently often applied to overcome these difficulties.

As a result of the issues above, the aim of this review is to compare citizen science methodologies based on survey versus video-based data, using studies examining cat-cat interactions and the dynamics of multicat households as an example. We explore the issues relating to both established (caregiver report) and innovative (caregiver-recorded videos) methodologies using a SWOT-analysis. Perspectives on and strategies for future research on pet cat behaviour are suggested.

## 2. Materials and methods

Given the broad nature of the research question, a qualitative synthesis and analysis of the relevant literature was considered to be an appropriate approach for this literature review (Rother, 2007; Grant and Booth, 2009). The principal investigator (MVB) performed searches via Web of Science, PubMed and Scopus to extract research papers illustrating our example case on intraspecific interactions and dynamics between companion cats in their home environment. Research terms such as “domestic cat”, “social behaviour”, “interaction”, “communication”, ‘’owner report”, “video/observation”, and “questionnaire/survey” were used during the search. Papers were only included if they met four criteria: (1) original research articles, (2) published within the past fifteen years (until 2008) (given the

125 recent development of citizen science – see above), (3) focus on social behaviour of pet cats in the
126 home environment, and (4) used one of the two citizen science methodologies evaluated in the current
127 review. The majority of the search results were excluded since they (1) studied other types of domestic
128 cats (e.g. feral cats), (2) studied interspecific social behaviour (e.g. human-cat) or non-social behaviour,
129 and (3) used non-behavioural measures (e.g. cortisol measurement). Due to the small number of
130 studies remaining (see sections 3.1.1 and 32.1), we added examples of citizen science approaches in
131 other species or topics.

132 The authors combined their years of field experience with the existing literature on other species to
133 evaluate both methodologies using caregiver provided data – survey and video – via a SWOT analysis
134 (Strengths, Weaknesses, Opportunities and Threats). This type of analysis is commonly used to evaluate
135 competing proposals in other fields (e.g. education, agriculture) (Benzaghta et al., 2021), and has also
136 been used to assess research methodologies (Khoshbakht et al., 2017). The four components of SWOT-
137 analysis were used to qualitatively evaluate both citizen science methodologies, using studies on cat-
138 cat interactions and dynamics in households as an example. More specifically, the intrinsic aspects of
139 the methodologies that facilitate (Strengths) or interfere with (Weaknesses) reaching scientific goals,
140 as well as the features of the methodology that may be able to capitalise on (Opportunities) or limit its
141 value (Threats) (Benzaghta et al., 2021). In this instance, the goal is the scientific evidence-base for
142 understanding of cat-cat interactions within the home environment.

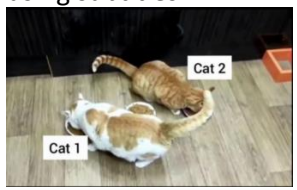
143 The remaining text of this review is structured as follows: the Results section includes subsections for
144 the two citizen science methodologies analysed. d For both the use of caregiver report (see 3.1) and
145 caregiver-recorded videos (see 3.2) the following aspects are discussed: definitions and characteristics
146 of the methodology, examples from literature and a list of considerations relating to the four elements
147 of the SWOT-analysis. In the ensuing Discussion, we formulate strategies for future research to
148 minimise the weaknesses and threats and to maximise the strengths and opportunities of citizen
149 science methodologies in companion animal behavioural studies.

## 3. Results

### 3.1 The use of caregiver report

Caregiver report consists of caregivers observing the behaviour of their pets on a daily basis as part of their co-living and reporting their findings to the researcher(s). A common approach is to use online surveys, but alternatively interview-based studies can be performed. This review focuses on online surveys, since this is a very common quantitative methodology and qualifies best as a citizen science methodology, due to the internet-based spread which makes the involvement of large numbers of citizens possible (Pongrácz and Camerlink, 2022). An overview of different (sub)types of items frequently used in online surveys is given in **Table 1**.

159 ***Table 1*** *Table highlighting different types of data generated by surveys. This table was constructed with adapted terms, descriptions or definitions from Meagher (2009), Battini et al. (2018)*
160 *and Robinson and Leonard (2019).*

| Type | Definition | Examples |
|---|---|---|
| **A – Data categorisation based on the form of the stem question** | | |
| Behavioural description | Participants are given a behaviour or behavioural description and asked to report on the occurrence in their pets. This type of item is commonly used to assess the occurrence of behaviour(al problems) in cats. | Has your cat displayed any aggressive behaviours? If yes, what kind of aggressive behaviour has the cat shown?<br>[] hissing [] scratching [] biting [] other …<br>(Mariti et al., 2017) |
| Behavioural interpretation | Participants are asked about their pet's style of behaving, e.g. integration of behaviour and context by reference to emotions or other internal states (e.g. anxious, content, easy going). This approach can be used within Qualitative Behavioural Assessment (QBA) (Wemelsfelder et al., 2000). This type of item assesses how caregivers interpret the behaviour of their pet (subjective assessment). | On a scale from 1 (not at all) to 5 (very well), please rate how appropriate each of the following descriptions are for the cat. The more fitting you feel the description is for the cat, the higher you rate it. The less fitting the description is for the cat, the lower you would rate it. Description: The cat is sedentary and shy.<br>[] 1 (does NOT describe well) [] 2 [] 3 [] 4 [] 5 (describes very well) [] Not applicable.<br>(Elzerman et al., 2020) |
| Statement | Participants are given a statement and asked to which extent they agree with the given statement. This type of item is commonly used to assess caregivers' beliefs or attitudes towards their pets. | Please indicate your agreement level with the following statements about cats as pets in general (strongly disagree to strongly agree):<br>Cats like to live with another cat in the household.<br>[] Strongly disagree [] Somewhat disagree [] neither agree nor disagree [] Somewhat agree [] Strongly agree<br>(Grigg and Kogan, 2019) |
| Visual representation (video/photo) | Participants are given a visual illustration (e.g., picture, video) of the behaviour of interest to report on the behaviour of their pet. This type of item is commonly used to clarify the visual assessment of behaviour. | You will be shown 10 short (up to 10-seconds) videos without sound.<br>Please watch the videos carefully as you will be asked questions about each video. Any vocalizations from the cats will be displayed using subtitles.<br>  |

| | | |
|---|---|---|
| | | How would you describe the overall interaction between the cats in the video?<br>[] Extremely negative [] Somewhat negative [] Neither positive nor negative [] Somewhat positive [] Extremely positive [] Not sure<br>(Khoddami et al., 2023) |
| **B - Data categorisation based on the response type** | | |
| Open-ended item | Participants are given no response options and can freely provide an answer. There might or might not be a word restriction applied. | How many rooms in your home contain a litter box?<br>(Elzerman et al., 2020) |
| Closed-ended item | Participants are given multiple response options to choose from. Different subtypes of responses include: | |
| *Two options* | Participants are given two opposites to choose from (e.g. yes/no, agree/disagree). Additionally, an option to express insecurity, doubt or inapplicability may be added (e.g. I don't know, not applicable). | Do you see the following behaviour occurring in your cats? Head rubbing:<br>[] Yes [] No [] I don't know.<br>(Van Belle et al., 2023) |
| *Scale* | Participants are given a nuanced set of answer options ranging between two extremes. Options are ordinal numerical scales (Likert, modified Likert) or continuous visual scales (VAS or visual analogue scale). | Overall, how would you rate the relationship between your cats?<br>[] Extremely negative [] Somewhat negative [] Neither positive nor negative [] Somewhat positive [] Extremely positive<br>(Khoddami et al., 2023)<br>How friendly do you think the individual is? Please mark on the line.<br>Unfriendly Friendly<br>I----------I<br>(Meagher, 2009) |
| *Multiple choice* | Participants are given three or more options to choose from (for example time indications to report occurrence of behaviour). Often, options are added to indicate doubt, insecurity or inapplicability (e.g. I don't know, not applicable) or to freely add information (e.g. other: …). | Are the food bowls provided for your cats: (Select all that apply)<br>[] In the same room, side by side [] In the same room, not side by side [] In different rooms [] 1 or less food bowl provided<br>(Khoddami et al., 2023) |

161

### *3.1.1 Example studies and results*

Examples of studies using surveys are easy to find, although studies focussing specifically on social interactions and dynamics between cats are rarer. A first example is the online survey-based study of Elzerman et al. (2020) which examined the occurrence of affiliative behaviours and conflict signs in 2,492 multicat households (6,431 cats). Affiliative behaviours occurred more often than conflict signs, with the most common affiliative sign being physical contact and the most common conflict sign staring. Moreover, the study examined factors affecting cat-cat interactions, including number of cats, available resources, and time spent together. High harmony scores reported by the caregivers were correlated with more affiliative and fewer conflict signs. The study of Elzerman et al. (2020) included multicat households of different sizes, however, the online-survey based study of Khoddami et al. (2023) was based on a more uniform population of two-cat households. Data of 6,529 cat caregivers (13,058 cats) were analysed, using logistic regression models, for factors determining the dynamics between the cats. The relationship between the cats was perceived as more negative by the caregiver if both cats were neutered females or the cats had a large age difference. Moreover, there are other survey-based studies that investigate cat-cat interactions and dynamics as a secondary focus within their research. Examples include studies addressing social behaviour when studying feline personality (Litchfield et al., 2017), or behavioural problems (Kendall and Ley, 2008). Another well-known example is Fe-BARQ (Duffy et al., 2017), an online survey tool which was developed to quantitatively assess behaviour and behavioural problems of pet cats. The questionnaire consists of 85 items which were validated with the responses of 2,608 cat caregivers. Construct validity was tested by correlating item scores for different questions with one another and with predictions based on existing knowledge. With regard to cat-cat sociality, there are some concerns about the sensitivity of Fe-BARQ for assessing breed-differences in cat-cat aggression involving familiar cats (Duffy et al., 2017). The questionnaire was also validated in Spanish, which included testing for caregivers' intra- and inter-observer reliability, internal consistency and construct validity (Menor-Campos et al., 2021). In the Fe-BARQ questionnaire only 7 of 85 items focus on behaviour towards cohoused cats, namely aggressive behaviours (4 items)

and social play (3 items). At the current time the questionnaire has been used in two other studies to assess intraspecific interactions to cohoused cats: the study of Wilhelmy et al. (2016) assessing association with certain breeds or coat colours, and the study of Gajdoš Kmecová et al. (2021) looking for risk factors for cat-cat aggression and playfulness.

*3.1.2 SWOT-Analysis*

A summary of the SWOT-analysis for online survey-based methodology is displayed in **Table 2**. The current analysis is an overall assessment not discriminating between the variety in survey designs described in **Table** 1, although the different SWOT-elements listed below might be more or less applicable to individual cases.

A Strength of the usage of online surveys with caregivers is their daily witnessing of their cats' behaviour, and their potential to describe behaviours well (Kendall and Ley, 2008). They are familiar with the history (behavioural and medical) and personalities of their pets. Therefore, it is generally assumed that caregivers are well placed to provide reliable insights into their cats' behaviour, and provide information which may otherwise be inaccessible for researchers. Survey-based research is often quick, low-cost and low-effort (in comparison with behavioural observations by expert). Furthermore, a standardised instrument (Fe-BARQ) is available, which shows structural validity (Duffy et al., 2017), and the reliability of caregiver reports on a Spanish version of the scale established (Menor-Campos et al., 2021), however, it only includes a very limited number of items on social interactions.

By contrast, a Weakness of online questionnaires is the convenience sampling and biases in respondents often inherent to the sampling methodology; respondents do not reflect the intended population due to a self-selection bias (e.g. internet access or social media activity required, special interest in the research topic), which can be increased according to the type of survey (e.g. longer surveys recruit a particularly keen demographic) (Fenner et al., 2020). Differences in sampling population may jeopardise the generalisability of the obtained results. An additional weakness is the

potential for pseudoreplication and nonindependence in the data with the same caregiver filling out the questionnaire multiple times (for the same cat or several cats in the household) (see Gajdoš Kmecová et al., 2021 as an example), especially when data collection is anonymous.

On the other hand, one of the opportunities related to the survey-based methodology is the potential for online surveys to collect large quantities of data, which are less subject to effect of small systematic biases and facilitate more powerful statistical analysis (Khoshbakht et al., 2017). The methodology is also not field-specific, and can be applied in a large number of contexts (e.g. behaviour, welfare, management) and species (e.g. cats, dogs, horses).

A Threat to the integrity of the data generated related to the survey-based approach is the growing criticism of the limited accuracy of caregiver report, and biases that might be created by caregivers' misinterpretation of behaviour (Taylor and Mills, 2006; Hall and Wynne, 2012). These are not necessarily a problem, depending on the design of the study and inclusion of adequate controls, and so are not an inherent weakness (for examples see Gajdoš Kmecová et al., 2021; Ines et al., 2021). In the literature, different forms of bias are discussed, including caregivers failing to remember past events (recall bias) (Fenner et al., 2020) or giving answers that are socially desirable (social desirability bias) (Meagher, 2009), positively reflect their care for the cats (self-enhancement bias) (Meagher, 2009), or show consistency with their personal beliefs (confirmation bias) (Fenner et al., 2020). Furthermore, the way caregivers see their pets tend to change with their demographics, including their gender (in many studies of companion animals there is a large female bias among respondents) or educational level (often more educated respondents) (Pongrácz and Szapu, 2018), individual bond with their cat (Ines et al., 2021), and personal characteristics, such as temperament or expectations (Taylor and Mills, 2006). Certain topics such as behavioural differences related to breed or coat colour might also be biased by pre-existing cultural factors, beliefs or assumptions. Importantly, our recent study comparing caregiver report on cat-cat interactions in a survey with expert behavioural observations with videos (Van Belle et al., 2023) found that up to 33.3% of caregivers underreported at least one of

the surveyed cat-cat interactions, especially head rubbing and allogrooming. A notable proportion of caregivers (4/42, 9.5%) were also unsure about whether or not certain interactions occurred between their cats, which further indicates caregivers' limitations even for evaluating behaviours that are described to them (Van Belle et al., 2023). Similar issues have also been reported in relation to caregiver-report in other species (Grigg et al., 2021) or self-report in humans (Martin et al., 2019). Furthermore, when collecting data from cat caregivers, privacy regulations need to be taken into account. Collecting data anonymously implies individual respondents cannot be identified in any way (including e.g. not collecting IP-addresses or identification of respondents through combining their responses on different questions) and may be favoured from a data protection perspective; however, this might be challenging in specific studies, for example if caregivers need be traced to clarify their responses, give additional information or provide them with feedback. By contrast, when individuals can be identified, participants must be informed appropriately (informed consent) and measures should be taken to ensure confidentiality of the provided data (Robinson and Leonard, 2019), which increases workload.

252 ***Table 2*** *Summary of the Strengths, Weaknesses, Opportunities and Threats (SWOT) of online survey-based research.*

| Helpful | | Harmful | |
|---|---|---|---|
| **Strengths** | References | **Weaknesses** | References |
| Involving caregivers in research makes inaccessible information accessible: caregivers can describe their cats' behaviour and are flexible in time and place. | (Kendall and Ley, 2008) | Convenience sampling results in sampling bias and difficulties to generalise results. | (Fenner et al., 2020) |
| Validated questionnaires for behavioural analysis available: e.g. Fe-BARQ. | (Duffy et al., 2017) | Pseudoreplication in case of anonymous data collection. | (Taylor and Mills, 2006; Meagher, 2009; Hall and Wynne, 2012; Pongrácz and Szapu, 2018; Martin et al., 2019; Fenner et al., 2020; Grigg et al., 2021; Van Belle et al., 2023) |
| The methodology is low-cost, low-effort and quick. | | | |
| **Opportunities** | | **Threats** | |
| Online surveys collect large quantitates of data, implying fewer statistical errors. | (Khoshbakht et al., 2017) | Various biases due to caregiver misinterpretation:<br>• Confirmation bias;<br>• Self-enhancement bias;<br>• Social desirability bias;<br>• Influence of caregiver demographics;<br>• Cat-caregiver bond and caregiver personality. | Meagher, 2009; Hall and Wynne, 2012; Pongrácz and Szapu, 2018; Martin et al., 2019; Fenner et al., 2020; Grigg et al., 2021; Van Belle et al., 2023) |
| Flexible research methodology applicable for a wide variety of research topics. | | Considerations when (not) collecting caregivers' personal data. | (Robinson and Leonard, 2019) |

253

## 3.2 Videos provided by cat caregivers

An alternative methodology of citizen science involves expert behavioural observations based on videos of cat-cat interactions provided by cat caregivers, referred to as caregiver-recorded videos in this review. The terminology used is explained in **Table 3**. These caregiver-recorded videos – filmed in the home-environment of the cats - might be recorded by the caregiver with their own device (smartphone or camera) or with a device provided by the researcher (fixed or animal-borne camera). This includes the use of data available on internet (YouTube, social media) or databases – also called video mining (Rault et al., 2013) – or by asking caregivers directly to record videos, or to provide videos recorded in the past ('family archive').

***Table 3*** *Table on the use of audio-visual media (video) in research. Two types with different subtypes are identified: caregiver-recorded and researcher-recorded videos. The current review focuses on the first type. The table was constructed with the use of terms and adapted definitions from Jewitt (2012), Rault et al. (2013), Zappella et al. (2015) and Huck and Watson (2019).*

| Type | Definition |
|---|---|
| **Caregiver-recorded video** | The use of video footage of behaviour of companion animals recorded by non-scientists, i.e. members of the lay audience (animal caregivers).<br>Subtypes include: |
| Participatory video | The use of videos recorded by participants (animal caregivers) specifically for research purposes, preferably after specific training (e.g. instructions or guidelines from the researcher). Participants may use their own device (smartphone or camera) or a device provided by the researcher (camera). |
| Use of existing video (video mining) | The use of a video recorded by the lay audience which were not recorded specifically for research purposes. This includes the use of publicly available data (e.g. videos on social media, webcam streams, existing archives, or films/documentaries) or private data (e.g. videos of the 'family archive' which are provided to the researcher). |
| **Researcher recorded video** | The use of video footage of behaviour of companion animals recorded by scientists for research purposes.<br>Subtypes include: |
| Fixed position video | The use of a video recorded by a fixed position camera installed and controlled by a researcher. The researcher may be present or absent while filming (e.g. camera traps). |
| Animal-borne video | The use of a video recorded by a small video camera attached to the collar around the neck of the pet. |

### *3.2.1 Example studies*

Research on cat-cat interactions using caregiver-provided videos is presently uncommon in the literature. A notable exception is the study of Gajdoš-Kmecová et al. (2023) on playful and aggressive interactions in cats (N = 210). The researchers used a combination of video mining (YouTube, 102 videos) and participatory videos (63 videos). The study found evidence to extend the classification of interactions beyond the previously recognised affiliative (social mutual play) and agonistic ones (fight/aggression) to include an intermediate form. The previously mentioned study on cat-cat interactions using caregiver report and participatory videos of 84 cats living in 42 two-cat households (Van Belle et al., 2023) has also provided important advances in our understanding of cat-cat interactions and their recognition, especially because of the large sample that can be gathered using this methodology. They had instructed caregivers to videotape their cats in predefined contexts in which interaction was expected (a feeding event, a sleeping event, a (play)fight, an encounter, allogrooming and a free context). In total 775 videos were collected, and analysed by the researcher for the occurrence of social interactions. Expert behavioural observations were compared with caregivers' report, and indicated underreporting of cat-cat interactions by one on three caregivers (Van Belle et al., 2023), with most underreporting of behaviours like head rubbing and allogrooming. To the best knowledge of the authors, there is currently no other research available using a similar home video-based approach for analysing cat-cat interactions and dynamics, although the methodology has been used for other research topics in cat behavioural research including cognition (Smith et al., 2021) and communication (Fukimoto et al., 2023). Videos recorded by lay people have also been used in behavioural research in other species, including dogs (e.g. Burn, 2011; Stewart et al., 2015; McLennan, 2023), horses (Nelson and Fijn, 2013) and parrots (Acharya and Rault, 2020); as well as wild animals such as elephants (Pokharel et al., 2022) and birds (Tryjanowski et al., 2020; Marziliano et al., 2022), and human children (e.g. Zappella et al., 2015; Boonzaaijer et al., 2017; Martin et al., 2019).

*3.2.2 SWOT-Analysis*

A summary of the SWOT-analysis of the methodology using caregiver-recorded videos is displayed in **Table 4.**

A major Strength of using videos is that it allows expert behavioural observations, thus facilitating some of the gold standards of traditional ethological research (Bateson and Martin, 2021). Videos can capture subtle details of cat-cat interactions (e.g. complex interactions, simultaneous behaviours), and can be watched repeatedly, which facilitates multiple applications of the data including the inclusion of intra-/inter-observer reliability testing, and use in different research projects or for educational purposes (Asan and Montague, 2014). Furthermore, observer effects (i.e. the visual presence or other stimuli (e.g. odour) of the observer result in changes in animals' behaviour (Lehner, 1996)) linked to researchers visiting the home setting of the cats are potentially minimised, since caregivers are part of the normal safe environment of the cats and their presence is thus less intrusive (Nelson and Fijn, 2013; Asan and Montague, 2014). Avoiding home visits also implies less direct contact between caregiver and researcher, thus potentially reducing expectation bias and possibly increasing the objectivity of the study by blinding assessors (Tuyttens et al., 2014; Tuyttens et al., 2016). As many caregivers often enjoy making, watching and sharing pictures and videos of their cats (O'Meara, 2014; Maddox, 2021), the need for habituation of the cats is limited, and video mining or participant recruitment should be reasonably easy. Boonzaaijer et al. (2017) also reported that caregivers found it relatively easy to make videos specifically for research purposes. Moreover, caregivers' smartphones provide high-quality video footage, comparable to or even better than cameras commonly used in research. Involving caregivers to video allows collecting data flexibly, and evidence can be collected varying in time [e.g. recording outside working hours, documenting rare behaviours (Pokharel et al., 2022)], and place (e.g. following highly mobile interactions while moving the smartphone).

A Weakness of collecting videos from caregivers is the lack of standardisation. The collected videos are typically fragmented (Zappella et al., 2015) or data are missing due to caregivers' absence or limited availability (e.g. caregivers are sleeping or away from home), limited observational skills [e.g. missing

(the initiation) of interactions (Nelson and Fijn, 2013; Van Belle et al., 2023), or other reasons (e.g. selectively recording more positive interactions (Zappella et al., 2015)]. Consequently, the collection of video recordings may not be representative. When recruiting caregivers specifically for research, differences in their commitment, skills and time-schedule could also reflect in differences in the quality of the collected data between subjects (sampling bias) (Dickinson et al., 2010), such as the chances of capturing rare interactions, visibility of interactions, camera-angle or the total amount of video material recorded. Standardisation when using video mining is even more problematic, since caregivers will record without instructions. Variance in video quality might also be increased given differences in the devices used by different caregivers, if they are not provided with a camera by the researcher. Marschik and Einspieler (2011) suggest therefore that the methodology might be more useful for qualitatively rather than quantitative studies, as no definitive conclusions can be drawn about specific rate of occurrence of behaviours (e.g. missing interactions do not imply absence in the household, limited information about how common or exceptional behaviours are). Another Weakness is that the methodology is highly labour-intensive and time consuming, which might be underestimated by researchers. In the cases of the caregivers, this might result in a poor subject recruitment to data provision ratio. Not only is the resulting behavioural coding known to be labour-intensive for researchers, but there are also hidden additional tasks related to the citizen science methodology (e.g. participant recruitment, communication with (possible) participants, data quality control etc) (Miklósi et al., 2005). As with caregiver report, but potentially even more pronounced than in online surveys, a bias is created in the study population (sampling bias) towards highly motivated, well-informed and technically skilful caregivers.

Opportunities provided by the methodology include the potential to collect large amounts of data in a cost- and time-efficient manner. Actively involving caregivers in collecting data for research also increases public awareness and engagement with science, making science potentially more accessible to the general public, with opportunities for training and learning for the lay audience (Nelson and Fijn, 2013). Ongoing technical advancements – e.g. latest versions of smartphones, 'pet cameras' – will

continue to improve the quality of home videos in future. Furthermore, with ongoing innovations in artificial intelligence, computers may soon be trained to analyse (caregiver-recorded) video efficiently in a wide range of circumstances (see for examples Bailey et al., 2014; Feighelstein et al., 2023; Ipek et al., 2023), thus decreasing workload for researchers and possibly improving accuracy and objectivity of the results. The methodology is also highly flexible, and can be applied to various research topics, as shown by the existing evidence displayed above.

Threats, however, include potential observer effects due to the caregivers' presence (if not setting up a fixed camera). The caregiver might alter the interactions between the cats accidently (e.g. due to previous interventions during interactions, attention seeking behaviour of the cats) or deliberately (e.g. distracting the cats, manipulating or intervening with interactions). Additionally, when collecting video footage within caregivers' personal space, a range of ethical and legal considerations related to privacy of participants need to be considered by the researchers (Giersberg and Meijboom, 2022). When using video mining, creative commons licensing status and copyright need to be taken into account. A well-designed data management plan and GDPR record are crucial to ensure safe storage and treatment of large amounts of possibly sensitive data (Miklósi et al., 2005).

359 ***Table 4*** *Summary of the Strengths, Weaknesses, Opportunities and Threats (SWOT) of research using caregiver-recorded video's.*

| Helpful | | Harmful | |
|---|---|---|---|
| **Strengths** | References | **Weaknesses** | References |
| Good practice in applied ethological research can be applied to data analysis. Expert behavioural observations as the gold standard can be applied to the research and a range of specific advantages related to the use of video recordings:<br>▪ Capturing subtle details;<br>▪ Observer reliability testing:<br>▪ Reuse in different studies;<br>▪ Use for other purposes (e.g. education). | (Asan and Montague, 2014; Bateson and Martin, 2021) | Lack of standardisation in the collected data:<br>• Fragmented data;<br>• Missing data;<br>• Sampling bias;<br>• Variation in image quality;<br>• Qualitative > quantitative validity. | (Dickinson et al., 2010; Marschik and Einspieler, 2011; Nelson and Fijn, 2013; Zappella et al., 2015; Van Belle et al., 2023) |
| Avoidance of home visits leads to:<br>▪ Limited observer effects (familiar person);<br>▪ Minimum expectation bias;<br>▪ Blinding assessors. | (Nelson and Fijn, 2013; Asan and Montague, 2014; Tuyttens et al., 2014; Tuyttens et al., 2016) | Labour-intensive and hidden workload (e.g. caregiver communication). | (Miklósi et al., 2005) |
| Low-effort for participants<br>▪ Limited need for habituation of cats;<br>▪ Easy and fun for caregivers to participate in research. | (O'Meara, 2014; Boonzaaijer et al., 2017; Maddox, 2021) | Sampling bias in study population, e.g. highly motivated, well-informed, technically-skilled cohort. | |
| Additional strengths related to caregiver involvement are:<br>• High quality of smartphone cameras;<br>• Collecting data flexible in place and time. | (Pokharel et al., 2022) | | |
| **Opportunities** | | **Threats** | |
| Reasonable to large quantity of data relatively easily harvested. | | Observer effects related to caregiver's presence, including accidental influence (e.g. previous intervention during cat-cat interactions, cats´ attention seeking) and deliberate influence (e.g. distracting cats). | |

| | | | |
|---|---|---|---|
| Involvement of caregivers results in:<br>• Increase in public awareness, training and education;<br>• Connecting scientists with the general public. | (Nelson and Fijn, 2013) | Privacy of participants and ethical considerations. | (Miklósi et al., 2005; Giersberg and Meijboom, 2022) |
| Technical advancements might lead to:<br>• Improvement in video quality;<br>• Use of AI for video analysis. | | | |
| Flexible research methodology applicable for a wide variety of research topics. | | | |

360

## 4. Discussion

Research on cat-cat interactions and dynamics in the home setting is increasingly using a citizen science approach. We conducted a SWOT analysis to systematically identify possible strengths, weaknesses, opportunities and threats associated with caregiver report (survey) versus caregiver video. This systematic approach also highlights the potential strategies that can be formulated to minimise the weaknesses and threats and to maximise the strengths and opportunities to optimise outcomes in future research (Van Wijngaarden et al., 2012). Suggestions to optimise future behavioural research are discussed below.

### 4.1 Strategies to optimise research methodology

#### *4.1.1 Survey – Essential reliability and validity testing*

The main threats relating to online surveys for the study cat-cat interactions focus on the reliability and validity of caregiver report as a data source. Reliability relates to whether or not the results of a methodology contain errors (e.g. are results consistent, can they be reproduced or are there biases?), while validity considers whether or not a methodology is appropriate for studying the topic of interest (e.g. does the test measure what it should measure, is it what needs to be measured in order to test the hypothesis of interest?) (Taylor and Mills, 2006). Various forms of both reliability and validity testing are applicable to survey instruments. Reliability testing preferably includes testing test-retest or intra-observer reliability (e.g. does the same caregiver gives consistent answers over time), inter-observer reliability (e.g. do different caregivers of the same pet give similar responses, or observing equivalent behaviours in different cats provide similar responses) and internal consistency (e.g. do questions measuring the same behaviour give similar outcomes) (Meagher, 2009). For measuring the validity of an online survey, three aspects should be considered: content validity (i.e. does the survey consist of relevant items for studying the topic), criterion validity (i.e. do the items in the survey relate directly to phenomenon of theoretical interest in a meaningful way), and construct validity (i.e. are the results consistent with existing knowledge) (Meagher, 2009). Existing surveys studying cat-cat

interactions and dynamics are poorly tested for all these aspects, especially criterion validity in relation to the accurateness of caregivers in their reporting is crucial. Consistency with gold standard measures (behavioural observations) has been tested in surveys of other species, e.g. dogs (Wright et al., 2012), horses (Momozawa et al., 2003) and parrots (Mellor et al., 2022). This approach should also be possible for cats, but recent work suggests this should not be assumed (Van Belle et al., 2023). Caregivers' capacity to perform behavioural observations could be tested by implementing (audio-)visual illustrations (e.g. video, picture) of the behaviours/interactions of interest to check whether or not they are able to recognise these (see also **Table 1**).

*4.1.2 Video – Need for standardisation.*

Although collecting caregiver-recorded videos gives researchers visual evidence of the occurrence of behaviours or interactions thus enabling analysis using gold standard behavioural methods, the lack of standardisation in the collected data can be a weakness. When performing video mining as a data collection methodology, recommendations have been formulated by Rault et al. (2013) and can be applied in studies on cat-cat interactions. These include performing video selection in accordance with pre-set quality requirements and strict inclusion/exclusion criteria. Availability of adequate data for a specific research hypothesis should be tested via pilot testing. Quality requirements should be clearly articulated and could include visibility e.g. lighting requirements and blur, full body in view, and both interacting animals visible. Further inclusion and exclusion criteria might be based on content (e.g. type of interaction/behaviour), video type (e.g. edited or not edited), and caregiver's role (e.g. interfering, interacting). For clarification of these guidelines and further recommendations we refer to the review of Rault et al. (2013). Our recommendations for setting up a project which actively recruits caregivers to record videos, are listed in **Table 5** and summarised below. When collecting caregiver-recorded videos specifically for research purposes, the quality requirements and inclusion/exclusion criteria can be explained to participants and incorporated in a standardised protocol (see also Van Belle et al. (2023) for an example). Detailed instructions for caregivers could include requirements for

content (e.g. which (spontaneous) interactions/behaviours to film), video quality (e.g. length, lighting, camera angle/position) and their own role (e.g. whether or not to interact with their pet). Proper caregiver guidance during the process of video recording (e.g. answering questions, providing advice/assistance to improve video quality) and rigorous control of the provided videos (quality, inclusion/exclusion) means that caregivers interference with the quality of the provided videos can be minimised.

***Table 5*** *Recommendations when setting up a research project using caregiver-recorded videos. Recommendations are formulated for all stages related to the citizen science aspect of using caregiver-recorded videos.*

| Strategies for using caregiver-recorded videos in your research project |
|---|
| **Before data collection**<br>▪ Check local ethical and legal requirements when collecting videos from caregivers. Caregivers' informed consent might be needed if videos (might) contain personal data.<br>▪ Set up a data management plan which includes a strategy for collecting, storing and archiving the collected data safely (e.g. responsibilities, access, anonymisation, long-term plan).<br>▪ Create detailed, comprehensive instructions for caregivers, which can be preferably delivered in an attractive and accessible way to possible participants. These instructions should preferably answer the following questions:<br>o What to film? (e.g. which interactions, animals, situations)<br>o When to film? (e.g. specific moments within the day or within a certain period)<br>o How to film? (e.g. own device or provided device, how to manipulate camera)<br>o How long to film? (e.g. x minutes, specific start- and end points)<br>o What are minimum criteria for image quality and inclusion? (e.g. what needs to be visible (lighting, camara angle etc.))<br>o How should caregivers and other persons behave? (e.g. interference desired or not)<br>▪ Define inclusion and exclusion criteria for the quality and content of the videos.<br>▪ Piloting the study design and video instructions with a limited number of participants is recommended to evaluate feasibility and compensability for citizen scientists and suitability of the collected videos for the research project.<br>▪ Set up a strategy to ensure the group of participating caregivers is sufficiently large and representative of the study population of interest.<br>**During data collection**<br>▪ Consider the need for ongoing caregiver communication and guidance, both when recruiting participants and when collecting videos with them.<br>▪ Evaluation of the collected videos with pre-set inclusion/exclusion criteria with adjustments if needed.<br>▪ Use creative solutions to keep participants motivated – filming their pets is generally more labour-intensive then filling out a survey about a pet. Strategies may include e.g. checklists to track progress, sharing information about the study or other work in the field, and rewarding participants.<br>**After data collection**<br>▪ Data management including storage, processing and handling of (large) video files.<br>▪ Communicating results with research participants as a learning opportunity for both researcher and caregiver. |

### *4.1.3 Room for improvement - combining methodologies?*

When we focus on the strengths and opportunities both methodologies possess, a third strategy can be suggested. Caregiver-report via an online survey makes it possible for researchers to access the wide knowledge they hold by living on a daily basis with their pet (e.g. medical and behavioural history, personality, environmental conditions), while caregiver-recorded videos allow researchers to see for themselves how the animals behave and interact in their safe environment. The latter may be used to validate the definition of behaviours which may be rated using the former methodology, thus potentially increasing the validity of quantitative reports. Thus both methodologies may be complementary and could provide researchers with a fuller view of the phenomenon of interest, e.g. social interactions and dynamics of pet cats. Close collaboration with caregivers, with implementation of their report in research and checking it with visual video evidence, will not only be beneficial for improving the quality of research output but also increases public awareness of and involvement in science.

Other opportunities arise with technical developments, which might be possibly incorporated in future study designs investigating cat-cat interactions and dynamics. Innovative methodologies include the use of animal-borne cameras (see Huck and Watson, 2019 as an example) or the use of commercially available fixed cameras (e.g. PetCam®, PetCube®). Researchers have been using cameras in the home setting previously (e.g. Palestrini et al., 2010; Zhang and McGlone, 2020), and the devices already owned by caregivers might create new opportunities. Moreover, GPS-trackers have been applied in research studying free-roaming cats (Roetman et al., 2018; Bischof et al., 2022), and future developments might make it possible to track cats' activity patterns within the home, as has been reported with livestock (Hansson et al., 2023). In conclusion, many possibilities are currently available – and might be available in the near future – to study cat behaviour in their home environment.

Therefore, researchers have increasingly fewer limitations when it comes to examining companion cats, which should result in a better understanding of cats' social lives.

### 4.2 Pros and cons of a SWOT analysis

To the best knowledge of the authors, this paper is the first to evaluate both online surveys and caregiver-recorded videos as citizen science methodologies for companion animal behaviour research. We chose cat-cat interactions and dynamics in the home setting as an example case and applied the SWOT analysis as a framework for evaluating the research methodologies. This sort of structured analysis of strengths, weaknesses, opportunities and threats is not common in behavioural research. However, we believe it offers a useful approach to highlight the pros and cons of various approaches, which allows researchers to make an informed choice concerning the preferable methodology for an intended study. SWOT is mostly used in economy and management, where the approach has been criticized as being too superficially descriptive, non-quantitative, and often subjective (Vlados and Chatzinikolaou, 2019). However, since the method has been used for a long time and is widely applied in various fields – including the analysis of research strategies – its value should not be underestimated (Khoshbakht et al., 2017; Benzaghta et al., 2021). The current approach should help scientists choose and optimise an appropriate approach to their research project, and to generate valuable research output to increase understanding of behaviour and welfare of companion animals.

## 5. Conclusion

Survey-based research using caregiver report has already been applied extensively in behavioural research, although some surveys might lack validity. Collecting caregiver-recorded videos, on the other hand, is a more innovative development which uses expert behavioural observations, but is in its infancy and may need greater standardisation. Carefully combining these methodologies might overcome some of the limitations discussed, and the application of other technical developments (e.g. animal-borne cameras, GPS trackers) should be explored further.

**Acknowledgements**

The authors would like to thank prof. dr. Christel Moons for her suggestion to use the SWOT-analysis to evaluate the research methodologies.

**References**

Acharya, R. & Rault, J. L., 2020. Risk factors for feather-damaging behavior in companion parrots: A social media study. J Vet Behav 40**,** 43-49. https://doi.org/10.1016/j.jveb.2020.07.003.

Addie, D., Belak, S., Boucraut-Baralon, C., Egberink, H., Frymus, T., Gruffydd-Jones, T., Hartmann, K., Hosie, M. J., Lloret, A., Lutz, H., Marsilio, F., Pennisi, M. G., Radford, A. D., Thiry, E., Truyen, U. & Horzinek, M. C., 2009. Feline Infectious Peritonitis: ABCD guidelines on prevention and management. J Feline Med Surg 11**,** 529-529. https://doi.org/10.1016/j.jfms.2009.05.008.

Amat, M., Camps, T. & Manteca, X., 2016. Stress in owned cats: behavioural changes and welfare implications. J Feline Med Surg 18**,** 577-586. https://doi.org/10.1177/1098612X15590867.

Asan, O. & Montague, E., 2014. Using video-based observation research methods in primary care health encounters to evaluate complex interactions. Informatics in Primary Care 21**,** 161-170. https://doi.org/10.14236/jhi.v21i4.72.

Bailey, D., Thomas, D., Cho, M. & Al-Souti, S., 2014. Automating monitoring of cat feeding behaviour. 2014 IEEE Sensors Applications Symposium, SAS 2014 - Proceedings**,** 299-304. https://doi.org/10.1109/SAS.2014.6798965.

Barry, K. J. & Crowell-Davis, S. L., 1999. Gender differences in the social behavior of the neutered indoor-only domestic cat. 64**,** 193-211. https://doi.org/10.1016/S0168-1591(99)00030-1.

Bateson, M. & Martin, P., 2021. Measuring Behaviour: An Introductory Guide*, 4.* Cambridge, Cambridge University Press.

Battini, M., Barbieri, S., Vieira, A., Can, E., Stilwell, G. & Mattiello, S., 2018. The use of qualitative behaviour assessment for the on-farm welfare assessment of dairy goats. Anim 8(7)**,** 123. https://doi.org/10.3390/ani8070123.

492 Benzaghta, M. A., Elwalda, A., Mousa, M., Erkan, I. & Rahman, M., 2021. SWOT analysis applications:
493 An integrative literature review. Journal of Global Business Insights 6**,** 55-73.
494 https://doi.org/10.5038/2640-6489.6.1.1148.
495 Bernstein, P. L. & Strack, M., 1996. A game of cat and house: Spatial patterns and behavior of 14
496 domestic cats (Felis catus) in the home. Anthrozoos 9**,** 25-39.
497 https://doi.org/10.2752/089279396787001572.
498 Bischof, R., Hansen, N. R., Nyheim, Ø. S., Kisen, A., Prestmoen, L. & Haugaasen, T., 2022. Mapping the
499 "catscape" formed by a population of pet cats with outdoor access. Sci Rep 12**,** 1-9.
500 https://doi.org/10.1038/s41598-022-09694-9.
501 Boonzaaijer, M., Van Dam, E., Van Haastert, I. C. & Nuysink, J., 2017. Concurrent validity between live
502 and home video observations using the Alberta infant motor scale. Pediatric Physical Therapy
503 29**,** 146-151. https://doi.org/10.1097/PEP.0000000000000363.
504 Bradshaw, J. W. S., 2016. Sociality in cats: A comparative review. J Vet Behav 11**,** 113-124.
505 https://doi.org/10.1016/j.jveb.2015.09.004.
506 Bradshaw, J. W. S. & Hall, S. L., 1999. Affiliative behaviour of related and unrelated pairs of cats in
507 catteries: A preliminary report. Appl Anim Behav Sci 63**,** 251-255.
508 https://doi.org/10.1016/S0168-1591(99)00007-6.
509 Buffington, C. a. T. 2011. Idiopathic cystitis in domestic cats-beyond the lower urinary tract.
510 Buller, K. & Ballantyne, K. C., 2020. Living with and loving a pet with behavioral problems: Pet
511 owners' experiences. J Vet Behav 37**,** 41-47. https://doi.org/10.1016/j.jveb.2020.04.003.
512 Burn, C. C., 2011. A vicious cycle: A cross-sectional study of canine tail-chasing and human responses
513 to it, using a free video-sharing website. PLoS ONE 6.
514 https://doi.org/10.1371/journal.pone.0026553.
515 Dards, J. L., 1983. The behaviour of dockyard cats: interactions of adult males. Appl Anim Ethol 10**,**
516 133-153.

517 Dickinson, J. L., Zuckerberg, B. & Bonter, D. N., 2010. Citizen science as an ecological research tool:
518 Challenges and benefits. Annu Rev Ecol Evol Syst 41**,** 149-172.
519 https://doi.org/10.1146/annurev-ecolsys-102209-144636.
520 Duarte Cardoso, S., Da Graça Pereira, G., De Sousa, L., Faraco, C. B., Piotti, P. & Pirrone, F., 2022.
521 Factors behind the Relinquishment of Dogs and Cats by their Guardians in Portugal. J Appl
522 Anim Welf Sci. https://doi.org/10.1080/10888705.2022.2087183.
523 Duffy, D. L., De Moura, R. T. D. & Serpell, J. A., 2017. Development and evaluation of the Fe-BARQ: A
524 new survey instrument for measuring behavior in domestic cats (Felis s. catus). Behav
525 Processes 141**,** 329-341. https://doi.org/10.1016/j.beproc.2017.02.010.
526 Elzerman, A. L., Deporter, T. L., Beck, A. & Collin, J. F., 2020. Conflict and affiliative behavior frequency
527 between cats in multi-cat households: a survey-based study. J Feline Med Surg 22**,** 705-717.
528 https://doi.org/10.1177/1098612X19877988.
529 Feighelstein, M., Henze, L., Meller, S., Shimshoni, I., Hermoni, B., Berko, M., Twele, F., Schütter, A.,
530 Dorn, N., Kästner, S., Finka, L., Luna, S. P. L., Mills, D. S., Volk, H. A. & Zamansky, A., 2023.
531 Explainable automated pain recognition in cats. Sci Rep 13**,** 1-16.
532 https://doi.org/10.1038/s41598-023-35846-6.
533 Fenner, K., Hyde, M., Crean, A. & Mcgreevy, P., 2020. Identifying sources of potential bias when using
534 online survey data to explore horse training, management, and behaviour: A systematic
535 literature review. Vet Sci 7**,** 140. https://doi.org/https://doi.org/10.3390/vetsci7030140.
536 Finka, L. R., 2022. Conspecific and Human Sociality in the Domestic Cat: Consideration of Proximate
537 Mechanisms, Human Selection and Implications for Cat Welfare. Anim 12.
538 https://doi.org/10.3390/ani12030298.
539 Finkler, H. & Terkel, J., 2010. Cortisol levels and aggression in neutered and intact free-roaming
540 female cats living in urban social groups. Physiology & Behavior 99**,** 343-347.
541 https://doi.org/10.1016/j.physbeh.2009.11.014.

542 Fukimoto, N., Albuquerque, N. & Savalli, C., 2023. Synchronous citizen science: A new method for cat
543 behavior research. J Vet Behav 62**,** 18-21. https://doi.org/10.1016/j.jveb.2023.02.001.
544 Gajdoš-Kmecová, N., Peťková, B., Kottferová, J., Halls, V., Haddon, C., De Assis, L. S. & Mills, D. S.,
545 2023. An ethological analysis of close-contact inter-cat interactions determining if cats are
546 playing, fighting, or something in between. Sci Rep 13**,** 92-92.
547 https://doi.org/10.1038/s41598-022-26121-1.
548 Gajdoš Kmecová, N., Pet'ková, B., Kottferová, J., Wannell, R. S. & Mills, D. S., 2021. Potential Risk
549 Factors for Aggression and Playfulness in Cats: Examination of a Pooling Fallacy Using Fe-
550 BARQ as an Example. Front Vet Sci 7**,** 545326. https://doi.org/10.3389/fvets.2020.545326.
551 Giersberg, M. F. & Meijboom, F. L. B., 2022. Caught on Camera: On the Need of Responsible Use of
552 Video Observation for Animal Behavior and Welfare Research. Front Vet Sci 9:864677.
553 https://doi.org/https://doi.org/10.3389/fvets.2022.864677.
554 Gorodetsky, E., 1997. Epidemiology of dog and cat euthanasia across Canadian prairie provinces. Can
555 Vet J 38**,** 649-652.
556 Gouveia, K., Magalhães, A. & De Sousa, L., 2011. The behaviour of domestic cats in a shelter:
557 Residence time, density and sex ratio. Appl Anim Behav Sci 130**,** 53-59.
558 https://doi.org/10.1016/j.applanim.2010.12.009.
559 Grant, M. J. & Booth, A., 2009. A typology of reviews: An analysis of 14 review types and associated
560 methodologies. Health Information and Libraries Journal 26**,** 91-108.
561 https://doi.org/10.1111/j.1471-1842.2009.00848.x.
562 Grigg, E. K., Chou, J., Parker, E., Gatesy-Davis, A., Clarkson, S. T. & Hart, L. A., 2021. Stress-Related
563 Behaviors in Companion Dogs Exposed to Common Household Noises, and Owners'
564 Interpretations of Their Dogs' Behaviors. Front Vet Sci 8**,** 1-10.
565 https://doi.org/10.3389/fvets.2021.760845.

566 Grigg, E. K. & Kogan, L. R., 2019. Owners' attitudes, knowledge, and care practices: Exploring the
567 implications for domestic cat behavior and welfare in the home. Anim 15;9(11):978.
568 https://doi.org/10.3390/ani9110978.
569 Haklay, M., Dörler, D., Heigl, F., Manzoni, M., Hecker, S. & Vohland, K., 2021. What Is Citizen Science?
570 The Challenges of Definition. In: Vohland, K., Land-Zandstra, A., Ceccaroni, L., Lemmens, R.,
571 Perelló, J., Ponti, M., Samson, R. & Wagenknecht, K. (eds.) The Science of Citizen Science.
572 Cham, Springer International Publishing, pp. 13-33.
573 Hall, N. J. & Wynne, C. D. L., 2012. The canid genome: Behavioral geneticists' best friend? Genes
574 Brain Behav 11**,** 889-902. https://doi.org/10.1111/j.1601-183X.2012.00851.x.
575 Hansson, I., Silvera, A., Ren, K., Woudstra, S., Skarin, A., Fikse, W. F., Nielsen, P. P. & Rönnegård, L.,
576 2023. Cow characteristics associated with the variation in number of contacts between dairy
577 cows. Journal of Dairy Science 106**,** 2685-2699. https://doi.org/10.3168/jds.2022-21915.
578 Huck, M. & Watson, S., 2019. The use of animal-borne cameras to video-track the behaviour of
579 domestic cats. Appl Anim Behav Sci 217**,** 63-72.
580 https://doi.org/10.1016/j.applanim.2019.04.016.
581 Ines, M., Ricci-Bonot, C. & Mills, D. S., 2021. My cat and me—a study of cat owner perceptions of
582 their bond and relationship. Anim 11(6), 1601. https://doi.org/10.3390/ani11061601.
583 Ipek, N., Van Damme, L. G. W., Tuyttens, F. a. M. & Verwaeren, J., 2023. Quantifying agonistic
584 interactions between group-housed animals to derive social hierarchies using computer
585 vision: a case study with commercially group-housed rabbits. Sci Rep 13**,** 1-14.
586 https://doi.org/10.1038/s41598-023-41104-6.
587 Jewitt, C., 2012. An Introduction to Using Video for Research. National Centre for Research Methods
588 Working Paper**,** 1-25.
589 Kendall, K. & Ley, J., 2008. Owner observations can provide data for constructive behavior analysis in
590 normal pet cats in Australia. J Vet Behav 3**,** 244-247.
591 https://doi.org/10.1016/j.jveb.2008.03.001.

592 Kessler, M. R. & Turner, D. C., 1999. Effects of Density and cage size on stress in domestic cats housed
593 in animal shelters and boarding catteries. Anim Welf 8**,** 15-26.
594 Khoddami, S., Kiser, M. C. & Moody, C. M., 2023. Why can't we be friends? Exploring factors
595 associated with cat owners' perceptions of the cat-cat relationship in two-cat households.
596 Front Vet Sci 10: 1128757. https://doi.org/10.3389/fvets.2023.1128757.
597 Khoshbakht, M., Gou, Z. & Dupre, K., 2017. Cost-benefit Prediction of Green Buildings: SWOT Analysis
598 of Research Methods and Recent Applications. Procedia Engineering 180**,** 167-178.
599 https://doi.org/10.1016/j.proeng.2017.04.176.
600 Lehner, P. N., 1996. Handbook of ethological methods*, 2nd.* Cambridge, UK, Cambridge University
601 Press.
602 Litchfield, C. A., Quinton, G., Tindle, H., Chiera, B., Kikillus, K. H. & Roetman, P., 2017. The 'Feline
603 Five': An exploration of personality in pet cats (Felis catus). PLoS ONE 12**,** 1-17.
604 https://doi.org/10.1371/journal.pone.0183455.
605 Maddox, J., 2021. The secret life of pet Instagram accounts: Joy, resistance, and commodification in
606 the Internet's cute economy. New Media and Society 23**,** 3332-3348.
607 https://doi.org/10.1177/1461444820956345.
608 Mariti, C., Guerrini, F., Vallini, V., Bowen, J. E., Fatjó, J., Diverio, S., Sighieri, C. & Gazzano, A., 2017.
609 The perception of cat stress by Italian owners. J Vet Behav 20**,** 74-81.
610 https://doi.org/10.1016/j.jveb.2017.04.002.
611 Marschik, P. B. & Einspieler, C., 2011. Methodological note: Video analysis of the early development
612 of Rett syndrome-one method for many disciplines. Developmental Neurorehabilitation 14**,**
613 355-357. https://doi.org/10.3109/17518423.2011.604355.
614 Martin, M., Rosales, G., Sandoval, A., Lee, H., Pugach, O., Avenetti, D., Alvarez, G. & Diaz, A., 2019.
615 What really happens in the home: A comparison of parent-reported and observed tooth
616 brushing behaviors for young children. BMC Oral Health 19**,** 1-9.
617 https://doi.org/10.1186/s12903-019-0725-5.

618 Marziliano, M., Zoratto, F. & Alleva, E., 2022. Using videos from social media to study the begging
619 behaviour of peregrine falcon (Falco peregrinus) nestlings. Rendiconti Lincei 34**,** 217-225.
620 https://doi.org/10.1007/s12210-022-01129-x.
621 Mclennan, T., 2023. Does the attention a dog pays to their owner increase after the dog engages in
622 activities that mimic the predatory preferences of that dog ( Canis familiaris )? Appl Anim
623 Behav Sci 263**,** 105944-105944. https://doi.org/10.1016/j.applanim.2023.105944.
624 Meagher, R. K., 2009. Observer ratings: Validity and value as a tool for animal welfare research. Appl
625 Anim Behav Sci 119**,** 1-14. https://doi.org/10.1016/j.applanim.2009.02.026.
626 Mellor, E. L., Mendl, M., Mason, G., Davison, C., Van Zeeland, Y. & Cuthill, I. C., 2022. Validating
627 owner-reporting of feather condition of pet Psittaciformes using photographs. Anim Welf 31**,**
628 163-173. https://doi.org/10.7120/09627286.31.2.001.
629 Menor-Campos, D. J., Ruiz-Soriano, C. & Serpell, J., 2021. Spanish validation of the Fe-BARQ
630 questionnaire: A replication study. J Vet Behav 46**,** 101-114.
631 https://doi.org/10.1016/j.jveb.2021.09.002.
632 Miklósi, Á., Pongrácz, P., Lakatos, G., Topál, J. & Csányi, V., 2005. A comparative study of the use of
633 visual communicative signals in interactions between dogs (Canis familiaris) and humans and
634 cats (Felis catus) and humans. J Comp Psychol 119**,** 179-186. https://doi.org/10.1037/0735-
635 7036.119.2.179.
636 Mills, D., Karagiannis, C. & Zulch, H., 2014. Stress - Its Effects on Health and Behaviour: A Guide for
637 Practitioners. Vet Clin North Am Small Anim Pract 44**,** 525-541.
638 https://doi.org/https://doi.org/10.1016/j.cvsm.2014.01.005.
639 Momozawa, Y., Ono, T., Sato, F., Kikusui, T., Takeuchi, Y., Mori, Y. & Kusunose, R., 2003. Assessment of
640 equine temperament by a questionnaire survey to caretakers and evaluation of its reliability
641 by simultaneous behavior test. Appl Anim Behav Sci 84**,** 127-138.
642 https://doi.org/10.1016/j.applanim.2003.08.001.

643 Nelson, X. J. & Fijn, N., 2013. The use of visual media as a tool for investigating animal behaviour.
644 Anim Behav 85**,** 525-536. https://doi.org/10.1016/j.anbehav.2012.12.009.
645 Nibblett, B. M., Ketzis, J. K. & Grigg, E. K., 2015. Comparison of stress exhibited by cats examined in a
646 clinic versus a home setting. Appl Anim Behav Sci 173**,** 68-75.
647 https://doi.org/10.1016/j.applanim.2014.10.005.
648 O'meara, R., 2014. Do Cats Know They Rule YouTube? Surveillance and the Pleasures of Cat Videos.
649 M/C Journal 17(2). https://doi.org/https://doi.org/10.5204/mcj.794.
650 Palestrini, C., Minero, M., Cannas, S., Rossi, E. & Frank, D., 2010. Video analysis of dogs with
651 separation-related behaviors. Appl Anim Behav Sci 124**,** 61-67.
652 https://doi.org/10.1016/j.applanim.2010.01.014.
653 Pokharel, S. S., Sharma, N. & Sukumar, R., 2022. Viewing the rare through public lenses: Insights into
654 dead calf carrying and other thanatological responses in Asian elephants using YouTube
655 videos. Royal Society Open Science 9:211740. https://doi.org/10.1098/rsos.211740.
656 Pongrácz, P. & Camerlink, I., 2022. Reaching out to the public – the increase of citizen science
657 projects in applied ethology. Appl Anim Behav Sci 247(4):105561.
658 https://doi.org/10.1016/j.applanim.2022.105561.
659 Pongrácz, P. & Onofer, D. L., 2020. Cats show an unexpected pattern of response to human ostensive
660 cues in a series of A-not-B error tests. Anim Cogn 23**,** 681-689.
661 https://doi.org/10.1007/s10071-020-01373-4.
662 Pongrácz, P. & Szapu, J. S., 2018. The socio-cognitive relationship between cats and humans –
663 Companion cats (Felis catus) as their owners see them. Appl Anim Behav Sci 207**,** 57-66.
664 https://doi.org/10.1016/j.applanim.2018.07.004.
665 Rault, J. L., Elmore, M. R. P., Biehl, D. J., Russell, M. A. & Garner, J. P., 2013. The world is a natural
666 laboratory, and social media is the new petri dish. Ethology 119**,** 803-806.
667 https://doi.org/10.1111/eth.12125.

668 Ravenscroft, S. J., Barcelos, A. M. & Mills, D. S., 2021. Cat-human related activities associated with
669 human well-being. Human-animal interaction bulletin 2021**,** 79-95.
670 https://doi.org/10.1079/hai.2021.0006.
671 Robinson, S. B. & Leonard, K. F., 2019. Designing Quality Survey Questions*,* California, SAGE
672 Publications Inc.
673 Roetman, P., Tindle, H. & Litchfield, C., 2018. Management of pet cats: The impact of the cat tracker
674 citizen science project in South Australia. Anim 8**,** 1-14. https://doi.org/10.3390/ani8110190.
675 Rother, E. T., 2007. Systematic literature review X narrative review. ACTA Paulista de Enfermagem 20**,**
676 7-8. https://doi.org/10.1590/s0103-21002007000200001.
677 Rusbridge, C., Heath, S., Gunn-Moore, D. A., Knowler, S. P., Johnston, N. & Mcfadyen, A. K., 2010.
678 Feline orofacial pain syndrome (FOPS): A retrospective study of 113 cases. J Feline Med Surg
679 12**,** 498-508. https://doi.org/10.1016/j.jfms.2010.03.005.
680 Smith, G. E., Chouinard, P. A. & Byosiere, S. E., 2021. If I fits I sits: A citizen science investigation into
681 illusory contour susceptibility in domestic cats (Felis silvestris catus). Appl Anim Behav Sci
682 240**,** 105338-105338. https://doi.org/10.1016/j.applanim.2021.105338.
683 Sparkes, A. H., Bessant, C., Cope, K., Ellis, S. L. H., Finka, L., Halls, V., Hiestand, K., Horsford, K.,
684 Laurence, C., Macfarlaine, I., Neville, P. F., Stavisky, J. & Yeates, J., 2013. ISFM Guidelines on
685 Population Management and Welfare of Unowned Domestic Cats (Felis catus). J Feline Med
686 Surg 15**,** 811-817. https://doi.org/10.1177/1098612X13500431.
687 Spitznagel, M. B., Jacobson, D. M., Cox, M. D. & Carlson, M. D., 2017. Caregiver burden in owners of a
688 sick companion animal: A cross-sectional observational study. Vet Rec 181**,** 1-6.
689 https://doi.org/10.1136/vr.104295.
690 Stewart, L., Maclean, E. L., Ivy, D., Woods, V., Cohen, E., Rodriguez, K., Mcintyre, M., Mukherjee, S.,
691 Call, J., Kaminski, J., Miklósi, Á., Wrangham, R. W. & Hare, B., 2015. Citizen science as a new
692 tool in dog cognition research. PLoS ONE 10**,** 1-16.
693 https://doi.org/10.1371/journal.pone.0135176.

694 Taylor, K. D. & Mills, D. S., 2006. The development and assessment of temperament tests for adult
695 companion dogs. J Vet Behav 1**,** 94-108. https://doi.org/10.1016/j.jveb.2006.09.002.
696 Tryjanowski, P., Hetman, M., Czechowski, P., Grzywaczewski, G., Sklenicka, P., Ziemblińska, K. &
697 Sparks, T. H., 2020. Birds drinking alcohol: Species and relationship with people. a review of
698 information from scientific literature and social media. Anim 10(2):270.
699 https://doi.org/10.3390/ani10020270.
700 Tuyttens, F. a. M., De Graaf, S., Heerkens, J. L. T., Jacobs, L., Nalon, E., Ott, S., Stadig, L., Van Laer, E. &
701 Ampe, B., 2014. Observer bias in animal behaviour research: Can we believe what we score,
702 if we score what we believe? Anim Behav 90**,** 273-280.
703 https://doi.org/10.1016/j.anbehav.2014.02.007.
704 Tuyttens, F. a. M., Stadig, L., Heerkens, J. L. T., Van Laer, E., Buijs, S. & Ampe, B., 2016. Opinion of
705 applied ethologists on expectation bias, blinding observers and other debiasing techniques.
706 Appl Anim Behav Sci 181**,** 27-33. https://doi.org/10.1016/j.applanim.2016.04.019.
707 Uccheddu, S., Miklósi, Á., Gintner, S. & Gácsi, M., 2022. Comparing Pears to Apples: Unlike Dogs, Cats
708 Need Habituation before Lab Tests. Anim 12**,** 1-14. https://doi.org/10.3390/ani12213046.
709 Van Belle, M. J. R., Gajdoš Kmecová, N., Tuyttens, F. a. M., Moons, C. P. H., Mills, D. S. & De Keuster, T.
710 C. B. M., 2023. What caregivers don't tell you ... A comparison between survey responses
711 and home videos of cat-cat interactions. Appl Anim Behav Sci 265**,** 105993-105993.
712 https://doi.org/10.1016/j.applanim.2023.105993.
713 Van Den Bos, R., 1998. The Function of Allogrooming in Domestic Cats (Felis silvestris catus); a STudy
714 in a Group of Cats Living in Confinement. Journal 16**,** 109-110.
715 https://doi.org/10.1007/bf02896348.
716 Van Den Bos, R. & De Cock Buning, T., 1994. Social Behaviour of Domestic Cats ( Fezis Zybica f . cattrs
717 L .): a Study of Dominance in a Group of Female Laboratory Cats. 1613**,** 14-37.

718 Van Wijngaarden, J. D. H., Scholten, G. R. M. & Van Wijk, K. P., 2012. Strategic analysis for health care
719 organizations: The suitability of the SWOT-analysis. International Journal of Health Planning
720 and Management 27, 34-49. https://doi.org/10.1002/hpm.1032.
721 Virga, V., 2003. Behavioral dermatology. Vet Clin Small Animal 33, 231-251.
722 https://doi.org/10.1016/S0195-5616(02)00102-X.
723 Vlados, C. & Chatzinikolaou, D., 2019. Towards a Restructuration of the Conventional SWOT Analysis.
724 Business and Management Studies 5, 76-76. https://doi.org/10.11114/bms.v5i2.4233.
725 Wemelsfelder, F., Hunter, E. A., Mendl, M. T. & Lawrence, A. B., 2000. The spontaneous qualitative
726 assessment of behavioural expressions in pigs: First explorations of a novel methodology for
727 integrative animal welfare measurement. Appl Anim Behav Sci 67, 193-215.
728 https://doi.org/10.1016/S0168-1591(99)00093-3.
729 West, M., 1974. Social Play in the Domestic Cat. 430, 427-430.
730 Wilhelmy, J., Serpell, J., Brown, D. & Siracusa, C., 2016. Behavioral associations with breed, coat type,
731 and eye color in single-breed cats. J Vet Behav 13, 80-87.
732 https://doi.org/10.1016/j.jveb.2016.03.009.
733 Wright, H. F., Mills, D. S. & Pollux, P. M. J., 2012. Behavioural and physiological correlates of
734 impulsivity in the domestic dog (Canis familiaris). Physiology and Behavior 105, 676-682.
735 https://doi.org/10.1016/j.physbeh.2011.09.019.
736 Zappella, M., Einspieler, C., Bartl-Pokorny, K. D., Krieber, M., Coleman, M., Bölte, S. & Marschik, P. B.,
737 2015. What do home videos tell us about early motor and socio-communicative behaviours
738 in children with autistic features during the second year of life - An exploratory study. Early
739 Human Development 91, 569-575. https://doi.org/10.1016/j.earlhumdev.2015.07.006.
740 Zhang, L. & Mcglone, J. J., 2020. Scratcher preferences of adult in-home cats and e ff ects of olfactory
741 supplements on cat scratching. Appl Anim Behav Sci 227, 104997-104997.
742 https://doi.org/10.1016/j.applanim.2020.104997.