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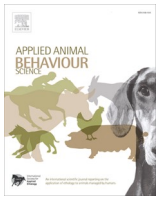

Screen interaction behavior in companion dogs: Results from a dog owner survey

L.K. Donohue [a,1], M. Buesing [a,2], K.D. Peterson [b,3], C. Ersoz [a,4], L.J. Russell [a,5], F.M. Mowat [a,b,*,6]

[a] University of Wisconsin-Madison School of Veterinary Medicine, Department of Surgical Sciences, Madison, WI, USA
[b] University of Wisconsin-Madison School of Medicine and Public Health, Department of Ophthalmology and Visual Sciences, Madison, WI, USA

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ABSTRACT

Despite availability of video content marketed for dog (*Canis familiaris*) entertainment, there is little information on dog behaviors when viewing content, nor describing which content is engaging. The aims of this study were to define demographics of dogs that engage with screens, owner observed behaviors, and perceived content interest. A digital survey was distributed to dog owners (03/2022–03/2023). We collected demographics, home environment, owner-rated behaviors, content interest, and interest in 4 presented videos. We compared the representation of dogs from different purebred dog groups (categorized by job/purpose by the American Kennel Club) with the estimated general purebred dog population. Most respondents (total n=1246) lived in the USA (89%). Median age was 4 years, 54% were purebred, 51% were female. Most (86%, n=1077) stated their dog watched screen content. Excitement behaviors were often described: 78% of dogs approached the screen, 76% vocalized. Many owners played videos for their dogs when left alone. Dogs most frequently engaged with animal content; dogs were the most popular animal. Age and visual status influenced the frequency of perceived interaction; age and breed influenced content interest. Within purebred dogs that were stated to watch content, there was a relative over-representation of "sporting" and "herding"-type breeds. A dog's age, visual status, and breed type may influence their interest in video content at home. Because many owners reported excitement in their dogs in reaction to screen content, owners may wish to determine whether video content would be suitable for use when their dogs are left alone.

1. Introduction

Dogs have been domesticated for several purposes, including to assist humans in working (e.g. herding, hunting, protection), and for human companionship. In 2021, companion dogs were reported to live within an estimated 45% of US households (Larkin, 2021). As many dog owners work outside of the home, dogs are commonly left alone, and owners often seek novel ways to entertain their dogs. In recent years, a variety of video content has been marketed, with the explicit stated purpose of dog entertainment. However, neither dog interest in this content, nor the behavioral responses of dogs to such content have been described in detail.

Vision in dogs is similar to humans in many ways – dogs have a rod photoreceptor-dominated retina, enhancing vision in dim lighting (Miller and Murphy, 1995; Mowat et al., 2008). To enhance diurnal vision, they also possess a cone photoreceptor-rich visual streak and a central region of substantial cone density, with similarities to the human macula (Mowat et al., 2008; Beltran et al., 2014). Despite a higher flicker fusion frequency than humans (meaning that lower resolution screens likely appear to flicker) (Coile et al., 1989), dogs are attentive to movement on screens (Lõoke et al., 2020), and pay greater attention to content that contains subjects with biological relevance (for example if it

* Correspondence to: 1300 University Avenue, Madison, WI 53706, USA.
E-mail address: mowat@wisc.edu (F.M. Mowat).
[1] 0000-0003-0674-8848
[2] 0009-0000-9917-3822
[3] 0000-0003-0128-5282
[4] 0009-0007-5552-9074
[5] 0009-0003-0134-856X
[6] 0000-0002-8726-8768

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represents conspecifics) (Ishikawa et al., 2018). However, the utility of video content as a calming aid for companion dogs is poorly understood, or whether video with or without sound is more calming to dogs. Classical music has a well-defined calming effect in dogs (Wells, 2004; Bowman et al., 2015). Visual stimulation via video presentation (with no sound) had an initial slight calming effect in kenneled shelter dogs, but with rapid habituation of the observed calming effect (increased engagement, reduced movement and vocalization) to repeated presentation of the same videos over a 3-day period (Graham et al., 2005), and a large inter-individual variance in calming effect. Anecdotally and through open-source social media platforms, it is evident that some companion dogs voluntarily engage with video content in the home, yet we do not know the variance in behaviors of such dogs nor how they differ from those that do not engage.

Purebred domesticated dogs have been line bred for many generations to create phenotypically and behaviorally distinct breeds. Dogs belonging to groups of breeds that are expected to be attentive to humans (for example hunting and herding breeds) commonly show behaviors related to cooperation with humans (Barnard et al., 2019), human proximity (Van Poucke et al., 2022), and eye contact (Bognar et al., 2021). In modern domestic dog breeds, grouping by American Kennel Club (AKC) historic working role confirmed distinct behavior traits between dogs in different groups (Morrill et al., 2022), many of which (e.g. biddability, toy directed motor patterns) could be related to visual communication. There is substantial neuroanatomical variation by breed type in the dog brain (Hecht et al., 2019), and retina (McGreevy et al., 2004). It is possible that this neuroanatomical variation affects attentiveness to video content.

The aims of this study were to 1) determine how screen interaction in the home is defined by dog demographics (age, breed, sex, perceived visual status), 2) describe commonly observed behaviors associated with dog screen interaction, and 3) determine the types of screen-based content that dogs are most commonly described to engage with in the home. These findings will help dog owners optimize activities for their dogs when left alone and help researchers to better understand dog visual behavior. We conducted a survey of dog owners, asking them to describe how their dog behaves in response to screen-based content, and what subjects their dog attends to on screens.

2. Materials and methods

2.1. Questionnaire design and implementation

A web-based questionnaire ("Qualtrics" Qualtrics XM, Provo, UT, USA) was constructed to survey dog owners regarding the screen interaction behaviors and content interest of companion dogs in the home. The questionnaire took 10–20 minutes to complete and consisted of 41 questions. The first two questions eliminated ineligible dog owners (respondent did not live with their dog, or dog was deemed completely blind per owner response). Questions 3–13 asked demographic information on the dog and the home. Questions 14–24 asked about the screens in the home, and how dogs interacted with screens. Questions 25–29 asked about what content dogs interacted with, question 30 was an open-ended comments question. Owners were given the option (in question 31) to participate with their dogs in watching 4 videos containing horizontal subject movement (dog, traffic, panther, bird). Questions 32–33 asked which screen type was used to present the videos and randomized participants with respect to the order in which the videos were presented. The final 8 questions asked dog owners to rate their dog's interest and tracking response to the 4 videos on a 5-point Likert scale. A blank questionnaire is provided in Supplementary File 1.

The questions were constructed with either a single response option or multiple response options. When multiple response options were presented (for example, lists of content subcategories), they were presented in random order (using the program randomization function) to minimize the impact of primacy effects. Some questions were nested: for example, if an owner selected "no" to a broad content category, the subcategories were not presented. The video presentation order was also randomized to minimize potential effects of dog habituation.

Videos used in this study were obtained open source (pexels.com, Berlin, Germany and pixabay.com, Berlin, Germany). Videos were selected based on video resolution quality (best available), diversity of subject, low camera position (providing a similar viewpoint to a dog standing on the ground), wide horizontal movement of subject, and lack of panning of the camera (static camera) or change of zoom during the video. These criteria were used to allow the videos to represent the closest to a dog visual perspective as possible (Miller and Murphy, 1995), and to allow greater opportunity for the owner to notice how much the dog engaged with the video and tracked movement in the video. The videos were edited (Premiere Pro, Adobe Inc., San Jose, CA) to make each video 10 seconds long and to remove sound if present. Each video started with a one second presentation of a blank screen and a brief (<1 s) sound of a squeaky dog toy to encourage visual orientation to the upcoming video by the dog, which has been shown to occur within 200 ms in dogs (Park et al., 2019). No sound was played during video presentation. Each video was presented twice in succession to give the owner ample opportunity to observe the dog's response. Respondents were asked to make the videos full-screen and present them to their dog seated at arm's length away with the device brightness and sound turned all the way up to maximize visibility of the video, and to allow the reorientation sound to be clearly audible. The 4 videos are provided as supplementary information (Supplementary Files 3–6).

2.2. Ethical note

The final version of the questionnaire was reviewed by the University of Wisconsin-Madison Institutional Review Board (IRB number 22–0205, exempt) and by the University of Wisconsin-Madison Institutional Animal Care and Use Committee and both classified the study as "exempt".

2.3. Inclusion criteria and survey distribution

Consenting dog owners that lived in the same household with their dogs were eligible to participate, provided they considered that their dog had at least some vision. The questionnaire was distributed via direct email to dog owners and veterinarians that had previously participated in research studies at the University of Wisconsin School of Veterinary Medicine, via laboratory social media, by business cards at local dog events and in the University of Wisconsin Veterinary Care animal hospital, posted fliers in Madison, Wisconsin, and local/national news articles. The survey was available from 3/23/2022–3/22/2023.

2.4. Purebred dog population estimates

To determine if dogs bred for specific purpose had varying interest in screen engagement, after survey completion, we assigned each United-States residing purebred dog into one of 7 recognized American Kennel Club (AKC) groups (Herding, Hound, Nonsporting, Sporting, Terrier, Toy and Working).[7] We also analyzed publicly available data of AKC purebred breed popularity statistics (available from 2013 to 2022),[8] which ranks on a yearly basis the popularity of the top approximately 200 purebred dog breeds. Breeds were analyzed if they had 3 or more years of published statistics available. Based on these criteria, we generated median general population popularity ranks for 195 AKC recognized breeds. To do this, each breed was assigned to its designated AKC group, and within each group, the sum of popularity

[7] https://www.akc.org/expert-advice/lifestyle/7-akc-dog-breed-groups-explained/

[8] https://www.akc.org/most-popular-breeds/

ranks for all participating breeds was calculated. To calculate a mean AKC group popularity rank, this sum of ranks was divided by the number of contributing breeds in each group. Groups with a lower numerical AKC group popularity rank were predicted to be more populous than those with a higher numerical rank. Using our USA-based purebred "watcher" dog population information from our survey, we generated a survey population rank based on the numbers of purebred dogs represented in each group. We compared the relative group rankings between our survey population and the general purebred dog population estimated using AKC statistics.

2.5. Post hoc data auditing and statistical analysis

For a response to be classified as complete, the respondent must have answered questions up to and including question 25 (the first content-based question). Incomplete responses were discarded. All complete responses and open-ended comments sections were manually audited to evaluate if the appropriate content selections were made for questions 25–29 (nested questions). Responses were manually corrected if the owner selected a response that was better suited to a different response. Following this auditing, we isolated responses from owners that disclosed that their dog had any specific content interest based on responses to questions 25–29. These responses represented the majority of completed questionnaires, and we designated these dogs as "watchers" as the owners stated that they actively engage with some screen-based content. We also evaluated if some responses came from owners that disclosed that their dog had no interest in any content based on responses to questions 25–29. This group of dogs represented a small minority, designated as "non-watchers". Because of the small number of "non-watchers" responses, statistical analysis comparing "watchers" and "non-watchers" was not performed.

Summary statistics were generated in a spreadsheet (Microsoft Excel for Mac version 16.75.2) for all respondents, for "non-watchers" and for "watchers". Statistics were also generated for purebred and mixed breed dogs separately, and for purebred dogs that resided within the USA, for comparison with AKC statistics. Median, mode, and interquartile ranges are presented, in addition to percentages.

Comments received in the single, optional open ended comments question (question 30) were manually reviewed and dog behaviors (actions) and owner perceived emotions were counted, when they specifically related to the dog's screen interaction. Behaviors were classified into one of 12 predetermined categories (attention, tracking, ear or head movement, vocalization, unspecified reaction, tail wagging, movement toward the screen, movement away from the screen, attacking/lunging, waiting/sitting/lying, relaxing/sleeping, or standing). All behaviors contained within a comment were coded even if multiple were described. Similarly, comments were separately coded for perceived emotions as either positive (example: like, love, enjoy) or negative (example: fear, hate, dislike, anxiety).

A logistic regression was performed (R version 4.2.3) to estimate the difference in proportion of engagement between purebred and mixed breed dogs across all categories. Fisher's exact tests were performed to determine relationships between questionnaire responses and age, sex, purebred breed status, visual status, number of screens available in the home, and for comparisons between breed group and stated content interest and presented video interaction. Significance was determined a priori with alpha set to 0.05 for all tests.

3. Results

3.1. Response characteristics

Four participants did not consent. A further 7 were ineligible based on exclusion criteria. A total of 1600 eligible responses were received; 354 responses contained incomplete data and were excluded from analysis. Of the remaining 1246 responses, 75 respondents acknowledged that their dog had no interest in any of the described content categories (animals, ball sports, non-ball sports, vehicles, other, classified as "non-watchers"), and 94 respondents either acknowledged no interest or did not know if their dog had interest in the described content categories. Because the main focus of this research was to describe qualities of dogs that do engage with some screen-based content, the unknown interest responses were excluded, and "non-watcher" responses are only included in aggregate demographic data (in Table 1) and relationships between age, breed, sex, visual status, and response characteristics (Table 2) were excluded from the remainder of the analyses. Responses from owners that disclosed specific content interest (n = 1077, 86% of responses; described in the manuscript as "watchers") are mostly described.

3.2. Demographics

The population demographics describing owner responses for all dogs and those for "watchers" (owners who disclosed their dog interacted with some content type) and "non-watchers" (owners who disclosed their dog did not interact with any content) are outlined in Table 1. The owner's subjective vision assessment indicated that vision was most commonly rated as "excellent", but a smaller percentage of

Table 1
Summary of demographics of dogs owned by study respondents. "All respondents" were those that were not excluded and answered at least one question on screen-based content interaction of their dog. "Watchers" were dogs whose owners stated that their dog interacted with at least one type of content category (animals, ball sports, non-ball sports, vehicles, other). "Non-watchers" were dogs whose owners stated their dog did not interact with any content category. Percentages are followed by n-numbers in parentheses.

Demographic	Group	All respondents (n = 1246)	"Watchers" (n = 1077)	"Non-watchers" (n = 75)
Age (years)	median (IQR)	4 years (2–7) 1 year (188)	4 years (2–7)	5 years (3–8)
	Mode	24% (300)	1 year (170)	5 years (13)
	≥8 years	6% (70)	24% (257)	28% (21)
	≥12 years		5% (56)	8% (6)
Sex	Female	51% (630)	51% (547)	49% (37)
	Male	49% (615)	49% (529)	51% (38)
Neutering/ spay status	Neutered/ spayed	83% (1037)	82% (887)	93% (70)
	Intact	17% (208)	18% (190)	7% (5)
Breed	Purebred	54% (674)	56% (606)	43% (32)
	Mixed breed	43% (539)	41% (441)	57% (43)
	Unknown	3% (33)	3% (30)	0% (0)
Owner perceived visual status	Excellent	82% (1024)	84% (910)	65% (49)
	Good	15% (196)	14% (152)	29% (22)
	Fair	2% (24)	1% (14)	5% (4)
	Poor	0% (2)	0% (1)	0% (0)
Home location	**US**	**89% (1106)**	**90% (965)**	**80% (60)**
	Wisconsin	42% (462)	48% (399)	37% (22)
	Minnesota	6% (61)	6% (55)	5% (3)
	California	5% (58)	5% (54)	3% (2)
	Illinois	5% (50)	5% (47)	2% (1)
	Florida	4% (46)	4% (40)	2% (1)
	Other	39% (429)	38% (370)	50% (30)
	Non-US	**11% (140)**	**10% (112)**	**20% (15)**
	Canada	30% (42)	28% (31)	40% (6)
	United Kingdom	20% (28)	21% (26)	0% (0)
	European Union	19% (27)	21% (24)	47% (7)
	Australasia	16% (22)	17% (19)	13% (2)
	Other	15% (21)	11% (12)	7% (1)
Estimated human population density	Urban	21% (257)	20% (211)	28% (21)
	Suburban	60% (744)	60% (645)	60% (45)
	Rural non-farm	12% (145)	12% (134)	9% (7)
	Rural farm	8% (100)	8% (87)	3% (2)

Table 2
Fisher's exact test analysis of age, purebred status, sex and visual status on owner perception of dog screen interactions.

		All dogs	Age (years)		Breed		Sex		Visual status	
			<= 4	> 4	Purebred	Mixed breed	Male	Female	Excellent	Good/fair/ poor
How often the dog interacts with active screen	At least once/day	68%	71%	65%	71%	66%	67%	70%	71%	54%
	At least once/week	18%	19%	16%	16%	20%	19%	17%	16%	24%
	At least once/ month	6%	6%	5%	6%	5%	6%	6%	6%	5%
	A few times per year	8%	4%	14%	7%	10%	9%	8%	7%	16%
	p value	NA	**<0.0001**		0.09		0.78		**<0.0001**	
Distance (feet) from screen when dog interacts	0–1	11%	10%	12%	11%	11%	11%	11%	11%	9%
	1–2	15%	15%	14%	14%	15%	15%	15%	15%	12%
	2–4	28%	27%	30%	29%	27%	29%	26%	27%	30%
	4–8	37%	39%	34%	36%	38%	35%	38%	36%	41%
	>8	10%	9%	11%	10%	10%	9%	10%	10%	7%
	p value	NA	0.28		0.97		0.74		0.35	
Duration (minutes) of dog interaction	<1	22%	21%	23%	21%	22%	22%	22%	20%	30%
	1–5	48%	50%	45%	49%	47%	48%	48%	48%	46%
	5–20	19%	18%	19%	18%	18%	19%	18%	20%	14%
	20–60	6%	7%	6%	6%	7%	6%	7%	6%	5%
	>60	5%	4%	7%	5%	6%	5%	5%	5%	5%
	p value	NA	0.16		0.93		0.95		**0.03**	
Content interest	Animal	89%	90%	87%	90%	87%	88%	90%	91%	81%
	Other	33%	34%	33%	36%	31%	35%	32%	33%	35%
	Ball sports	26%	29%	22%	27%	23%	27%	25%	26%	24%
	Vehicle	17%	21%	12%	19%	14%	16%	19%	18%	11%
	Non-ball sports	16%	17%	15%	19%	11%	15%	16%	16%	13%
	p value	NA	**0.03**		**0.02**		0.48		0.23	

owners of "non-watchers" graded vision as excellent. Very few dog owners overall described their dog's vision as fair or poor. The median age of "watchers" was 4 years (interquartile range 2–7 years) whereas the median age of "non-watchers" was slightly older (5 years (IQR 3–8 years)). The frequency distribution of "watchers" was skewed towards young age, with the mode at 1 year old, whereas the plot for "non-watchers" had a less skewed distribution shape, with the mode at 5 years. A small proportion of "watcher" dogs were aged 8 years or older and very few were aged 12 years or older. A slightly higher proportion of "non-watchers" were aged 8 or older or aged 12 or older. There was equal representation of sexes between male and female in both "watchers" and non-watchers" and most dogs were spayed or neutered, although a greater proportion of "non-watchers" were spayed or neutered. There was a slight over-representation of purebred dogs in the "watchers" population, whereas the opposite was true for "non-watchers". Most dogs and their owners lived in the United States; the most common US State of residence was Wisconsin and most dogs resided in a suburban home location.

We performed statistical analysis to determine whether there were differences in response characteristics between owners of dogs of different demographics (age less than or greater than median age of all dogs, breed purebred or mixed breed, sex male or female) or based on subjective visual status (excellent versus good/fair/poor). We included data from "watchers" and "non-watchers" in this analysis. Significant effects were identified for age on frequency of screen interaction (younger dogs watched significantly more frequently) and in relation to content interest (younger dogs had greater overall content interest). A significant effect of purebred breed status was also identified for content; purebred dogs had greater overall content interest (Table 2). There were no significant effects of age, breed, or sex on the perceived duration of screen interaction, or relating to the distance from which dogs were perceived to watch screens. Subjective visual status significantly influenced the frequency of screen interaction, and the duration of screen interaction, whereby dogs with better rated vision interacted with screens more frequently, and for longer duration (Table 2).

Because purebred breed appeared to relate to interaction, we determined if the survey purebred group was comprised of a "typical" population of dogs representing different breed groups. We estimated the population size of each of the breed groups in the USA, using published AKC breed popularity statistics, and ranked each AKC group from predicted most populous (1) to least populous (7; Table 3). The most populous group was predicted to be the Toy group, and the least populous the Hound group. We assigned each of our USA-based purebred "watchers" from our survey to an AKC group and ranked groups from most to least populous. Within our population, the most populous were Sporting dogs, and the least populous were Hounds. There were some notable differences between the predicted general purebred group population ranks (using AKC statistics) versus our survey "watcher" population ranks (Table 3). Most notably, Herding and Sporting groups were ranked 3 places higher in our survey population than the predicted general population. In contrast, Nonsporting and Working groups were ranked 3 places lower in our survey population than the predicted general population. Within the Herding group, the 3 most populous breeds in our survey were Australian Shepherd (n = 26, AKC rank 2 within group), Border Collie (n = 22, AKC rank 6 within group) and German Shepherd Dog (n = 13, AKC rank 3 within group). Within the Sporting group, the 3 most populous breeds in our survey were Labrador Retriever (n = 58, AKC rank 1 within group), Golden Retriever (n = 56, AKC rank 2 within group), and Cocker/Springer Spaniel (n = 5 each, AKC rank 6 and 5 respectively within group). Further examination of specific breeds was precluded by low n-numbers for each breed.

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3.3. Screen access, interaction, and content

The general details of dog screen access for "watchers" are described in Supplementary Table S1. Most "watcher" dogs had access to between 1 and 4 active (defined as often "switched on") screens (97%). Television was the most common screen (98%) followed by "other" (not specified), laptop, and tablet. Most dogs paid attention to screens at least once a day (72%). Most dogs paid attention to screens for 1–5 minutes during a watching event (50%), although relatively equal numbers of dogs either attended for 5–20 minutes or less than 1 minute. Very few dogs paid attention for more than 20 minutes, although owners occasionally commented that dogs would sit and watch a whole movie and appeared to actively engage with content and react to certain parts of the plot. Most dogs watched screens from between 2 and 8 feet away. Statistical analysis using Fisher's exact test (1 screen available in the home versus

Table 3
US-based purebred dog characteristics of "watchers" compared with AKC popularity statistics. *AKC mean popularity score was calculated by dividing the sum of the median rank for all breeds contributing to each group (for all years with statistics) by the number of contributing breeds within each group. A low score corresponds to a more popular dog breed. Breeds were included for AKC popularity ranking if they had ≥3 years of statistics represented.

	AKC popularity ranking per registration statistics 2013–2022		Survey "watchers"		AKC population rank minus survey population rank
	Mean popularity score*	Estimated population rank	% (n)	Population rank	
Herding	107	5	21% (103)	2	**+3**
Hound	128	7	4% (20)	7	0
Nonsporting	87	3	9% (45)	6	**-3**
Sporting	92	4	28% (142)	1	**+3**
Terrier	109	6	11% (54)	4	+2
Toy	66	1	16% (82)	3	-2
Working	74	2	10% (51)	5	**-3**

Because there were differences in group distribution in our watcher group, we performed analysis to establish if breed group influenced the frequency, duration, or distance of perceived dog screen interaction. There were group differences in the perceived frequency of screen interaction ($p<0.001$, Fisher exact test), duration of interaction ($p= 0.004$, Fisher exact test), but not the distance at which dogs observed screens ($p = 0.43$, Fisher exact test). Graphs demonstrating the different groups for these outcomes are presented in Appendix A.

>1 screen available) determined that there were differences in how long dogs interacted with screens based on the number of available screens in the home ($p < 0.0001$). Most notably, dogs with access to <=1 screen in the home were reported to watch for more than 1 hour by only 6% of owners, whereas dogs with access to 2 or more screens were reported to watch for more than 1 hour by 14% of owners.

Because video content often contains both visual and auditory stimuli, we asked questions to attempt to determine whether one sensory stimulus on screens was perceived to be more engaging for dogs. Owners more commonly reported that their dog was attracted by movement (90%, n = 949) compared with sound (78%, n = 818). Owners were given the option in this question to select both sound and movement, but some owners selected only one option. If owners selected only one option, they more commonly selected movement (23%, n = 237) versus sound (10%, n = 108, $p < 0.001$, Fisher's exact test). Many owners also acknowledged that their dog would watch content on screens with the sound muted (55%, n = 581), and a much smaller proportion answered that their dog would not watch if the sound was muted (17%, n = 186) with the remainder unsure (29%, n = 309).

Dogs exhibited a variety of behaviors in response to screen-based content (Table 4). The most commonly selected behaviors were to turn the head to the side or move the ears, approach the screen, and vocalization. Less commonly, owners selected options that their dog would touch the screen with the nose or look around the screen to view a perceived object. A small proportion of owners indicated that their dogs ran away from the screen. Some owners described dog behaviors and perceived emotions in the optional open-form question (question 30). This question did not specifically ask about their dog's reaction to content. We reviewed all comments to identify contextual words that were interpreted to relate to dog behaviors (actions), or owner interpreted dog emotions in response to screen-based content (Table 4). A total of 616 comments were received from the responses that were analyzed. A total of 670 dog behaviors in response to screens were described in 455 individual comments, and a total of 179 perceived dog emotions in response to screens were described in 173 individual comments. The most common behaviors described were attention (watching, looking, staring) and vocalization (barking, howling, whining, growling, Table 4). Movement-related behaviors (movement towards or away from the screen, attacking) were described more frequently than sedentary-related behaviors (standing, waiting/sitting, relaxing/sleeping; 101 comments contained movement behaviors = 16.4% of all comments, 59 comments contained sedentary behaviors = 9.6% of all comments). Owners described more perceived positive dog emotions in reaction to screen content (like, love, enjoy) than negative emotions (fear, dislike, hate; Table 4).

Owners disclosed that their dogs spent a median of 2 hours (interquartile range 0–5 hours) per day alone in the home, and dogs spent a similar amount of time outside of the home (median 2, interquartile

Table 4
Screen interaction behavior and use of screens for entertainment in the home. †Respondents selected all answers that applied.

Category	Subcategory	Watchers % (n)
Behaviors exhibited when interacting with screens†	Turn head to side or prick ears	78% (832)
	Approach the screen	78% (830)
	Vocalize	76% (813)
	Touch the screen with nose	29% (309)
	Look behind or to the side of screen	27% (291)
	Touch the screen without nose	17% (182)
	Other	14% (149)
	Bring toys to screen	6% (65)
	Run away from the screen	5% (55)
Question #30 phrase analysis	**Behaviors:**	**Percentage of phrases (n):**
	Attention (watch, look, stare)	54% (334)
	Vocalization	19% (114)
	Movement towards screen	13% (79)
	Wait/sit/lie	8% (48)
	Reaction (not described)	7% (42)
	Ear/head movement	3% (18)
	Attack/lunge	3% (16)
	Tracking movement	2% (11)
	Standing	1% (8)
	Movement away from screen	1% (6)
	Relax/sleep	1% (3)
	Tail wagging	0% (2)
	Perceived emotions:	**Percentage of phrases (n):**
	Positive emotions (e.g. like, love, enjoyment)	22.1% (136)
	Negative emotions (e.g. fear, anxiousness, hate)	7.0% (43)
Amount of time on an average day spent alone in the home (hours)		2 (IQR 0–5)
Amount of time on an average day spent outside the home (hours)		2 (IQR 1–3)
Entertainment provided at home when dog is alone†	Provide interactive toys	57% (454)
	General television/video content	48% (387)
	Sounds or music	47% (373)
	Dog-specific television/video content	17% (138)
	Any video content	*50% (404)*
	Exclusively video content	*15% (124)*
	Use interactive pet camera to communicate with dog	14% (112)
	Other	3% (22)

range 1–3 hours; Table 4). When owners left their dog alone in the home, they commonly provided interactive toys for their dog, and many played general television or video content or played sounds or music. Less commonly, owners played dog-specific television or video content. Half of owners selected at least one video content option. Some owners exclusively played video content for their dogs when they were left alone and did not report using other methods to entertain their dog.

The subjects contained in video content that owners described their dogs to find engaging is summarized in Table 5. The most engaging subjects were animals and within the animal category, dogs were the most popular animal. However, multiple animal subjects were frequently selected per response in the animal category, indicating that dogs had broad animal interest. Interestingly, humans did not rank highly in interest among animals (37%, n = 377, the 9th most popular animal subject). The next most popular broad content categories were "other", in which cartoons or animation was the most popular option and ball sports, in which basketball and soccer were most common. Less popular categories were vehicles in which cars/trucks were the most popular, and non-ball sports, in which two animal sports: dog sports and horse events were the most popular.

We asked dog owners to show their dogs 4 short videos containing a variety of subjects moving in a horizontal direction. Out of the total respondents (n = 1246), 672 owners completed this section. We asked owners to rate how much of the video the dog watched ("watching"), and separately, to rate how much they noted their dog tracking horizontal movement ("tracking"). The most common screen that was used to present the videos was a smartphone (43%, n = 289), followed by laptop (25%, n = 166), tablet (12% n = 81), computer with external monitor (11%, n = 75) and other (9%, n = 59). The results of this video presentation corroborated the findings from the survey regarding content interest (Table 5). There was significant variance in dog "watching" ($p < 0.001$, Fisher's exact test) and "tracking" response ($p < 0.001$, Fisher's exact test) between the 4 presented videos (percentages of respondents that watched and tracked the videos are shown in Supplementary Figs. S4 and S5). The most consistently attended to and tracked video was the video of a dog. Dog owners often reported that their dog "watched" or "tracked" all, or most of the dog video. Dogs were moderately and similarly interested in the videos of a hopping bird, and a walking panther. About half of dog owners acknowledged that their dog "watched" or "tracked" all or most of these videos. The least popular video was the video of traffic. Only about a third of dog owners acknowledged that their dog "watched" or "tracked" all or most of this video. We performed statistical analysis (Fisher's exact test) to evaluate if owners' responses to the content interest questions earlier in the questionnaire were related to how they perceived their dog's reaction to similar, presented videos. Dog owners that had previously stated their dog had interest in watching conspecifics were more likely to rate their dog as interested in the presented dog video (high level of "watching"), those that stated their dog had interest in watching birds (any type) were more likely to rate their dog as interested in the bird video, those that stated their dog had interest in watching wild animals were more likely to rate their dog as interested in the panther video, and those that stated their dog had interest in watching vehicles (any type) were more likely to rate their dog as interested in the traffic video (all comparisons $p < 0.001$, Fisher's exact test).

Table 5
Content interacted with the most by "watchers". The top 5 subcategories or responses that >50% respondents selected are listed for each category.

Category	Watchers % (n)
Animals	**95% (1026)**
Dogs	*93% (942)*
Wild animals (e.g., nature documentaries)	*65% (655)*
Cats	*64% (647)*
Livestock (not horses)	*64% (643)*
Horses	*63% (640)*
Squirrels	*56% (568)*
Other	**36% (373)**
Cartoons	*76% (279)*
Other	*34% (124)*
Video games	*18% (65)*
Abstract movement (e.g. screensaver)	*14% (53)*
Moving water	*10% (37)*
Ball sports	**28% (294)**
Soccer	*50% (144)*
Basketball	*50% (143)*
American Football	*44% (127)*
Tennis	*32% (93)*
Baseball/softball	*26% (76)*
Vehicles	**18% (194)**
Car/truck	*82% (154)*
Bicycle	*51% (95)*
Motorcycle/moped	*42% (79)*
Skateboard	*32% (60)*
Bus	*26% (49)*
Non-ball sports	**17% (179)**
Dog sports	*63% (112)*
Horse events	*53% (94)*
Ice hockey	*35% (62)*
Hunting	*24% (43)*
Winter sports (skiing, ice-skating etc.)	*22% (40)*

3.4. Content interest and purebred group relationships

We isolated responses from "watcher" dog owners in the United States, to compare with published American Kennel Club purebred dog statistics. We first investigated if mixed breed or purebred dogs showed different interest in categories of subject (Table 6). Compared with mixed breed dogs, purebred dogs were rated by their owners to have greater subject category interest, a difference which was statistically significant for overall content interest irrespective of category (mean ± 95% proportion for mixed breed was 33.4 ± 0.02% and for purebred was 40.8 ±0.03%, odds ratio of reporting interest in purebred dogs versus mixed breed dogs is 1.38 ± 0.16, $p < 0.001$; Table 6). Considering the categories, purebred dogs also had higher proportion of interest rated by their owners than mixed breed dogs for animals ($p < 0.001$), other ($p = 0.004$), non-ball sports ($p < 0.001$) and vehicles ($p = 0.004$) but not for ball sports ($p = 0.08$). For the presented videos, the USA-based purebred dogs were also frequently rated to have a higher interest than mixed breed dogs (Table 6).

We determined if differences in content interest between purebred and mixed breed dogs were being driven by over-representation of purebred dogs belonging to specific breed groups, originally bred for specific working purpose. When purebred dogs were separated into groups based on AKC classification, no significant differences in content interest (animal, sports, vehicles, other) were identified (Fisher exact test p = 0.88), nor did owners report different breed group proportions of watching of the 4 presented videos (p = 0.99, hound group was not included in analysis for video interaction as it included only 8 individuals; summary data presented in Supplementary table S2).

4. Discussion

This survey of dog owners identified features of dogs that engage with screen-based video content in the home environment. Dogs described to engage with screens the most were typically young, had good visual status, and although purebred dogs and mixed breed dogs were equally reported, there was over representation of specific types of purebred dogs compared with the predicted general population of dogs. This indicates that purebred dog breed "purpose" may influence motivation to engage with screens in the home. Reported behavioral responses to screens were variable, with signs of excitement frequently reported either in multiple choice responses, or in written comments.

We described certain demographic features of dogs that reportedly

Table 6
US-based "watcher" dog content interest and comparison between purebred and mixed breed content interest. For category selection, the percentage of respondents that selected "yes" is presented, for video presentation, the percentage of respondents that selected watched/tracked "all" or "most" is presented. Percentages for each category within purebred groups is bolded if ≥5% greater than the overall purebred percentage. [a-d] indicates that the percentage of "yes" responses were significantly different comparing mixed breed and purebred dogs using Fisher exact test analysis.

	Category selection: % "yes" (n respondents who answered the question)					Video presentation: interest, tracking, % of dogs rated all/most (n respondents who answered the question)			
	Animals	Other	Ball Sports	Non-ball sports	Vehicles	Dog video	Bird video	Panther video	Traffic video
All USA-based "watchers" (n = 1004)	91% (993)	33% (965)	26% (981)	16% (978)	17% (974)	63%, 58% (662)	51%, 45% (662)	49%, 42% (663)	38%, 30% (665)
USA-based mixed breed (n = 477) or unknown (n = 27)	87%[a] (495)	29%[b] (476)	24% (485)	12%[c] (484)	14%[d] (481)	60%, 56% (257)	48%, 41% (257)	45%, 38% (260)	35%, 26% (257)
USA-based purebred (n = 500)	95%[a] (498)	38%[b] (489)	29% (496)	21%[c] (494)	21%[d] (493)	70%, 65% (274)	57%, 52% (274)	55%, 49% (274)	42%, 33% (275)

engage with screen-based content at home. Male and female dogs in our sample were equally represented, and most dogs were neutered or spayed. Sex did not significantly influence any characteristics of screen engagement that we analyzed. Dogs were typically juveniles or young adults, with fewer senior or geriatric dogs described. Age was related to screen interaction characteristics; younger dogs were reported to interact more frequently and with a broader range of subjects. Whether this is a feature of reduced older dog perception (visual function), motivation, or behavior is unclear. It is possible it is at least in part, a feature of perception, as we have shown that older dogs have reduced retinal function (Salzman et al., 2023). Our finding in this study that subjective owner perception of dog visual ability also influenced the frequency of screen interaction also supports this. Motivation and behavior likely also contribute; attentiveness in dogs is subject-dependent and declines with age (Wallis et al., 2014), visually mediated behavioral activities are reduced in older dogs (Snigdha et al., 2012; Wallis et al., 2016; Rogers et al., 2023), and older dogs are described to form eye contact more slowly than younger dogs (Bognar et al., 2021). We also hypothesize that habituation to screen-based content occurs as dogs mature, whereby the lack of realism of content impacts novelty and motivation. At least on novel presentation, video images appear "real" to a dog, as 2-dimensional and 3-dimensional objects are processed in similar brain regions in dogs as assessed by functional brain imaging (Prichard et al., 2021). However, studies in many species have found that a lack of social interaction impacts animal learning using video content due to a lack of real-time feedback (for a review see (D'eath., 1998)) and a study in kenneled dogs showed rapid habituation to biologically relevant video content (Graham et al., 2005). A dog's home environment may also influence screen interaction motivation – if the environment is highly enriched (for example with frequent interactions with friendly humans and other animals, environmental enrichment in the form of training, walks and play), we hypothesize that dogs may interact at a different frequency or with different behavioral responses. This is an important subject for future research.

We noted that certain types of purebred dogs were over-represented in our population. Purebred dogs were slightly over-represented in the "watchers" group, compared with the 49.2% purebred dog population in a recently published large-scale dog study from the United States (Morrill et al., 2022). We did not obtain sufficient responses from non-watching dog owners to compare demographics statistically, but our small population of "non-watchers" contained a smaller proportion of purebred dogs (43%) than the larger "watchers" group. Within our population of "watchers", purebred dogs were reported to interact significantly more broadly with screen-based content than mixed breed dogs. Both findings support some potential for inherent breed-related traits that increase dog interaction with screens. We found over-representation within our purebred population of 2 breed groups: sporting and herding dogs. The AKC group descriptions indicate that these two groups perform visually mediated "tasks" cooperatively with humans. Sporting dogs "assist hunters in the capture and retrieval of feathered game" whereas herding dogs were "developed for moving livestock".[9] Both breed groups are highly human cooperative compared with other breeds (Barnard et al., 2019), and might therefore be anticipated to pay attention to items (such as television) that humans attend to. Retrieval requires visual perception as a primary sense, as there is often minimal sound to indicate location of the item for retrieval. Genetic studies have defined that behaviors related to motor patterns are more heritable than other behaviors, and the most heritable trait is that of retrieving (53% heritable) (Morrill et al., 2022). Therefore, dogs line bred for retrieval have higher likelihood of retrieval ability. Herding behavior also requires substantial visual attention to both to the livestock and the handler (although auditory commands are frequently also utilized by handlers). Herding dogs exhibit significantly greater orientation behavior than working or non-sporting dogs (Arons and Shoemaker, 1992), and engage eye contact with humans more than other breeds (Konno et al., 2016; Van Poucke et al., 2022), Herding behavior traits are desired and selected for in the breeding of herding dogs. Several genes have been associated with herding behavior by genome-wide association (Shan et al., 2021). Whether dogs in these groups have differences in their visuomotor activities has not been described although in general, behavior traits in dogs are related to neuroanatomic differences in the brain (Hecht et al., 2019).

We determined that owners perceive that most dogs are attracted to watch content on screens based on movement, or a combination of movement and sound. More owners noted their dogs were attracted to movement than sound, and a slight majority of owners noted their dogs watched with the sound muted. Eye tracking experiments with trained dogs have demonstrated that dogs will follow movement on a screen (Abdai and Miklósi, 2022; Volter and Huber, 2022) and anticipate onward movement of an interesting subject (Volter et al., 2020). Our study further confirms that many untrained companion dogs attend to and react to visible content on screens per subjective owner assessment. A combination of vision and auditory stimuli were often reported by owners in our study to attract their dog to the screen, with some owners commenting that the sound of a familiar song, voice, or jingle incited their dog to begin watching. This has also been shown in laboratory studies where targeting behavior was more frequently observed when auditory and visual stimuli were presented compared with a single sensory stimulus (Gibsone et al., 2021). However in the same study, individual dogs showed preference for one stimulus type over another. It is possible that our population of "watchers" prefer visual stimuli over auditory. We found that dogs in the home are typically perceived to interact for short periods of time, similar to a laboratory-based study where unrestrained dogs were given the option whether or not to watch presented videos (Hirskyj-Douglas et al., 2017).

[9] https://www.akc.org/expert-advice/lifestyle/7-akc-dog-breed-groups-explained/

Dogs in our study subjectively demonstrated preference for subject types when presented on screens in the home. Animals were a strong preference, and within animals, conspecifics were attended to by almost all dogs that interact with screen content. Even within other subjects such as non-ball sports, animal-related content was preferred (dog sports, horse events). Dogs have been shown to recognize conspecifics in images (Autier-Dérian et al., 2013), and on video screens in laboratory-based studies, particularly when paired with relevant contextual sounds (Hirskyj-Douglas et al., 2017; Mongillo et al., 2021). We were surprised at the interest of many dogs in our study to cartoons or animations. However, the rapid and animated movement, colors and contrast contained within cartoons are likely to be detectable to dogs, based on their visual system (Miller and Murphy, 1995). Many owners commented that cartoon animals were watched by their dogs. Point-light depictions of moving humans and dogs are attended to by dogs in a laboratory setting (Ishikawa et al., 2018), therefore it appears that animal-like movement is sufficient to attract attention in dogs.

Owners described several dog behaviors and perceived emotions in response to video content. Reactions were complex, with a mixture of attentiveness, excitement, and anxious-type behaviors described. Further studies will be needed to determine whether video content can be consistently adopted as a calming aid for dogs, and whether the environmental context (human present or absent) modifies this. Hirskyj-Douglas et al. (2017) studied the natural behavior of 2 dogs in an environment (without their owners present) where 3 screens continuously presented short segments of video content. One dog showed more calm behavior and settled to watch, whereas the other, (younger) dog paced and exhibited more signs of anxious behavior. Both dogs were sporting dogs (Labrador Retrievers). Another study in 50 kenneled shelter dogs presented video content, showed that there was a small aggregate increase in calm behavior (resting, reduced vocalization) which was short-lived. Graham et al. (2005) Inter-individual variance in that study appeared high. Based on the range of described actions and behaviors we identified in our open-ended question, dogs appear diverse in their reactions to content, and there are likely nuances in terms of content and context. We did not ask owners if their dogs reacted differently to different content, but as an example, the diversity of real-world dog reactions to other dogs would allow us to assume that a similar diversity exists in reaction to video depictions of dogs. If video-based entertainment is to be effective for a diverse range of dogs, it should be dog-centered (i.e. represent content that dogs, not just humans enjoy), and perhaps involve other dogs, as proposed by one study hypothesizing on how a “dog internet” might be constructed (Hirskyj-Douglas and Lucero, 2019).

Our study had several limitations. The respondents were self-selected based on social media and news reports of the study; therefore, we very likely oversampled responses from owners that cohabited with “watchers” and cannot estimate what overall proportion of dogs are “watchers”. In terms of demographics, it is unclear if there was any bias in sampling, for example from purebred dogs due to different exposure of purebred dog owners (as opposed to mixed breed dog owners) to information on the study. Information provided by owners was subjective and was not verified with objective data. The estimates of US dog populations were based on published rankings, versus actual purebred dog registration numbers and over-representation of herding and sporting dogs in engagement with screens requires independent verification. There is likely bias in what access dogs have to screen-based content – dogs are more likely to watch what humans watch on screens and are potentially interested in other content that the owners do not expose them to. Dog owners also likely carry bias about the anticipated behavioral traits of their dog and may overestimate interest that aligns with predefined ideas of interest, particularly in purebred dogs. Similarly, the owners that showed their dogs the 4 videos in real-time had previously responded to questions in the same questionnaire regarding content interest, and this may have biased the owners to answer about their dog’s engagement with the presented videos. Future studies where objective assessment of content interest is made would help to confirm our findings. From our study design, it was not possible to determine the exact contribution of audible versus visible stimuli on screens to dog attention. Future studies could be designed to test this, for example by presenting videos with and without sound to dogs. Although screen technology is improving exponentially, the most common screen that dogs interacted with was television, which has a range of refresh rates available, most commonly between 60 Hz and 120 Hz. The critical fusion frequency at which dogs no longer perceive individual images on screens is higher than in humans, and peaks at approximately 70–90 Hz (Coile et al., 1989; Miller and Murphy, 1995). It is therefore possible that lower refresh rate television screen content is unappealing or unrealistic to dogs and may have affected owner’s perceptions of interest. In support of this, one owner commented that their dog showed greater interest after they upgraded the television to a newer model and two owners commented that their dogs had different reactions to high definition vs. low-definition videos. Laboratory-based studies of video interactions should consider this factor when selecting presentation methods for dogs.

A future goal of our research is to develop and optimize video-based methods to assess changes in visual attention as dogs age. Reliability of, and habituation to such a test will be important to assess, as repeated examination in longitudinal studies will be necessary. However, as proof-of-principle, using our four presented videos, we have shown that dogs will engage (albeit subjectively assessed) with novel, randomly presented video content, and that interest matches subjective owner perceptions of overall subject interest (i.e., dogs show the most interest in dogs in both contexts). These preliminary studies will need objective verification, but this is a promising future direction for our research.

CRediT authorship contribution statement

L.K. Donohue: Conceptualization, Data curation, Formal analysis, Investigation, Writing – original draft, Writing – review & editing; **M. Buesing:** Conceptualization, Methodology, Writing – review & editing; **K.D. Peterson:** Data curation, Formal analysis, Methodology, Software, Writing – review & editing; **C. Ersoz:** Conceptualization, Methodology, Writing – review & editing; L.J. Russell: Conceptualization, Methodology, Writing – review & editing; **F.M. Mowat:** Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing – review & editing.

Declaration of Competing Interest

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

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.applanim.2023.106151.

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