

Understanding Dogs' Engagement with Interactive Games

Interaction Style, Behaviour and Personality

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ABSTRACT

Dogs are being increasingly exposed to interactive technology aiming to entertain them with playful experiences. However, work that investigates how dogs engage with tangible play interfaces, whether they manifest different interaction patterns and how these might relate to their personality has so far been limited. In this paper, we explore how dogs interact with a novel physical game. Our study involved 60 participants, whose personality was assessed using a standard personality test and whose interactions and behaviours during the game were observed. Findings suggest that dogs' engagement with physical games presents with specific interaction styles and behavioural patterns, and that these might correlate with specific personality characteristics. These engagement modalities could provide a criterion to customise the design of interactive games for dogs and optimise their gaming experience. Additionally, findings suggest the possibility that identifying relevant personality characteristics could help predict dogs' preferred engagement modalities.

CCS CONCEPTS

• Animal Computer Interaction • Interaction Design • Interactive Games

KEYWORDS

Dog Centered Design, Dog Game Design, Dog Interaction, Playful Interaction, Dog Personality

1 Introduction

In recent years, the increasing number of dogs who spend time at home alone and their owners' desire to keep them entertained have stimulated a rapidly growing market of mass-produced interactive products [43], with sophisticated games, such as Cleverpet [11],

Ifetch [27] and Puppod [36], becoming available alongside more traditional ones, such as Nina Ottoson's [32]. These mass-produced games tend to be designed for a generic user base. But do all dogs engage with games in the same way or do different dogs engage differently? Does personality play a role in the way dogs engage?

Most ACI work has paid close attention to the individual behavioural responses of dogs during their interaction with devices. However, other research has shown that differences in personality may have an influence on dogs' behaviour [9, 41]. Additionally, ACI studies into the design of interactive systems for dogs usually include a small number of participants. This makes it difficult to identify correlations between interaction and personality in order to extrapolate implications that might be relevant for the large-scale production and adoption of interactive games.

With regards to both designing and choosing interactive gaming experiences for dogs, investigating possible interaction patterns and how these might relate to personality could help provide a middle-ground approach between the individual-focussed approach often found within ACI research and the 'one-fits-all' approach prevalent within the consumer market.

To this end, we investigated the behavioural interactions of a cohort of 60 dogs with a novel game called Spin the Bottle. Dog participants were free to interact however they wanted with the game, with encouragement from, but without the involvement of, their human caretakers. We examined their engagement with the game based on their interaction with the apparatus (e.g. using their paw, snout or mouth) and on other manifested behaviours (e.g. focus, activity, body language); we also assessed their personality traits using the Monash Canine Personality Questionnaire-Revised test (MCPQ-R) [25].

Our findings suggest that dogs' engagement with physical games may indeed conform to specific interaction styles and behavioural patterns, which could potentially inform the design of style-specific interactive games. While there was no statistically significant correlation between interaction styles and broad personality traits, we found statistically significant, or nearly significant, correlations with specific personality aspects. This suggests that aspects of dog personality might influence the way in which dogs approach problem-solving activities during a game. Further, our findings suggest the possibility that identifying relevant personality characteristics could help test for and predict dogs' preferred engagement modalities.

2 Background

2.1 Dog Play, Toys and Games

As a form of positive engagement, it is widely accepted that play is an important part of animal welfare and can be indicative of wellbeing [2]. If an animal's environment meets an animal's basic requirements in terms of provision of food, warmth, comfort, companionship and opportunity to eliminate, then often playful behaviour emerges. In human terms, play is equated with happiness and joy and research has shown that play in animals gives similar effects [2, 49]. While playfulness in domestic dogs may be a result of anthropomorphic selection and a tendency for humans to value paedomorphosis (an animal's retention of juvenile traits into later life) [31], play is an important aspect of dogs' behaviour that continues into adulthood [3]. Dogs engage in locomotor-rotational (running and circling), object (manipulating) and social (interacting with others) play, usually with both conspecifics and humans [39]. As well as being intrinsically pleasurable and self-rewarding [7], play has multiple potential benefits, such as reducing social tension [17] and fostering positive dog-human relationships [33, 38].

Scientific research into the kind of toys and games that dogs prefer and how they interact with them has so far been limited. In their work on dog cognition and problem solving, Kaminiski et al. [22] shed light on dogs' preferences for differently shaped toys. The authors found that, given a choice between an egg-shaped and a ring-shaped toy, dogs tend to prefer the egg-shaped one. While no explanation is given by the authors as to why, we surmise that it could be either because the egg-shape toy was easier to pick up with the mouth or that the egg-shape resembled a ball, a common toy used in dog-human play. Rooney et al. [39] studied object social play, whereby two participants play with an object, as in a game of fetch or tug of war between dog-human and dog-dog dyads. The authors found that in the dog-human dyad, the interaction with the human was more important for the dog than the possession of the object, whereas the opposite was the case for the dog-dog dyad. Although the topic remains widely underexplored, these findings suggest that dogs' have differing playful interactions and gaming preferences.

In recent years, a number of interactive games targeting dogs have appeared on the market. These include products such as Cleverpet [11] and Pup Pod [36]. With the former, in order to obtain a treat, the dog has to remember and tap the pads of a keypad repeating a light sequence of increasing complexity. With the latter, a treat dispenser is activated whenever the dog approaches a separate 'wobbler'; as the dog learns, the game gets harder so that eventually, for a treat to be dispensed, the player has to approach the wobbler only when it emits certain sounds. In a different type of game, instead of releasing a food reward, Ifetch [27] flings a ball for the dog to chase and return to the dispenser, for it to be thrown again.

While these products have proven quite popular among dog owners, research is yet to investigate how different dogs respond to such games and whether different responses might correlate with different dog characteristics; for example, whether and why different dogs might be more or less able to tackle the problem-

solving challenges posed by a game such as Cleverpet [18] and Pup Pod [36]; or whether and why different dogs might develop addictive behaviour when playing a game such as Ifetch [12]. Our study aimed to investigate possible patterns in dogs' interaction with toys and games, the possible relation with personality traits, and what implications there might be for the design and selection of interactive systems for dogs.

2.2 Interactive systems for dogs

2.2.1 ACI Research on Playful Interactions. Work within ACI [29] has investigated dogs' interactions with play technology, paying particular attention to dogs' individual responses and preferences. For example, in Wingrave et al. [48]'s game for human-dog pairs, participants interacted with digital projections to worked together through training exercises of increasing complexity. While the authors evaluated the game with various human-dog pairs, assessing each pair's responses, their study does not offer insights into the possible connections between dog behaviour patterns and traits and performance during the game. More recently, Wallis et al. [46] assessed the engagement of a large group of dogs with an interactive touch-screen game with a focus on the effect of the game on their cognitive functions. While the authors considered some breed-specific variables, they did not report observations on the dogs' interaction patterns or the potential influence of their behavioural traits on their interaction with the game. Westerlaken and Gualeni [47] conducted participatory design work with two dogs to iteratively develop a system that would enable their participants to engage in playful interactions. Although the authors described in detail their work with the two individuals during the design and evaluation process, they do not discuss how behavioural differences between the dogs might have influenced their interaction with the prototypes being developed.

In their study of human perceptions of dog-tablet interaction, Zamansky et al. [50] used a previously constructed ethogram [1] to analyse YouTube clips of dogs interacting with tablet-based games. While the authors identified two types of emotional responses to the audio-visual stimuli coming from the tablet (*enjoyable* and *overstimulated*), understanding the role of factors relating to the dogs' behavioural traits was outside the scope of the work. Pons et al. [34] conducted a study with a small group of dogs in a daycare facility, who were allowed to play with a smart toy that either reacted automatically to the dogs' interactions or was remotely controlled by hospitalized children. The authors described the dogs' different response patterns to the situation (*passive*, *alert*, *playful*, *intensely playful*), but did not attempt to relate them to more general behavioural traits.

2.2.2 ACI Research on Interactions for Working Dogs. Much ACI research has focused on working dogs and how technology can better assist them in their roles, with a focus on interface design. For example, Jackson et al. [21] studied wearable communication interfaces, exploring the use of various shapes and positions of sensors-enabled input devices for the dogs to interact with in order to communicate with their handlers. The study showed that some of the dog participants struggled to adapt to 'one size fits all'

interface designs and that differences in anatomy (e.g. size, height, flexibility), breed (border collie vs others) and training experience were contributing factors; but it did not highlight interaction patterns across participants or their possible relation to behavioural traits. Robinson et al. [37] investigated the design of emergency communication systems enabling assistance dogs to call for help on behalf of their assisted humans. The system interface was developed with the participation of and based on the preferences shown by individual dogs interacting with a range of toy-like prototypes; but the authors did not discuss whether and how dog behavioural traits might have informed the dogs' preferences or interaction patterns. Zeagler et al. [51] investigated the interaction of dogs with the touch-screen interface of a prospective alarm system. The authors describe in detail the effect of different training protocols on the dogs' performance, rather than focusing on behavioural differences and similarities between the dogs. Ruge et al. [40] measured mobility assistance dogs' interaction with door-opening controls. Although the study yielded insights into the controls' usability, as with previous studies, the authors did not look for possible interaction patterns or connections with dog behavioural traits. Likewise, Byrne et al. [8] designed a reward delivery robot that dogs could control using different input devices to retrieve a treat. The authors aimed to identify the input device that would allow the dogs to interact with the robot most successfully, but they did not discuss what factors might have affected the dogs' success rate.

With the exception of Wallis et al. [46], the above studies involved small numbers of dogs and, with the exception of Baskin et al. [1] and Pons et al. [40], they focused on dogs' individual responses to interactive systems rather than identify behavioural patterns across research participants. Where researchers identified behavioural patterns, these were not related to more general behavioural traits. However, we were interested in identifying patterns specific to the dogs' interaction with devices and the possible influence of general personality characteristics on the interaction, in order to draw implications for design and selection of playful experiences with interactive games.

2.3 Personality and Capabilities

It is widely accepted that dogs have personality, that is "characteristics of individuals which describe and account for temporally stable patterns of affect, cognition and behaviour" [14]. Research has shown that dogs' physiological responses to different play situations may significantly depend on their personalities [9]. Personality is defined by a number of traits, such as extraversion or neuroticism, each associated with a number of behavioural characteristics. For example, the trait of extraversion is usually associated with being active, energetic, excitable, hyperactive, lively and restless; while the trait of neuroticism is usually associated with being fearful, nervous, submissive and timid. Typically, extravert dogs have a tendency to be sociable, active and attracted to novelty; on the other hand, neurotic dogs tend to be fearful and averse to novelty [41]. It has been shown that these traits can influence dogs' social interactions during play. For example, Carrier et al. [9] found that personality influenced dyadic dog play

in a novel situation, with extravert dogs being more active and sociable than neurotic dogs, and amicable dogs showing more play signals.

Closely related to personality, problem-solving is an essential element of game playing and, at least to a certain extent, requires a dog's persistence in engaging with a task independently [6]. A number of contextual factors may affect how a dog problem-solves, including prior training experience [30], early developmental experiences [45], and current living conditions [10]. Research has also shown that the presence and encouragement of a familiar human may positively influence a dogs' engagement with and performance during problem-solving tasks [44]. However, there is evidence that the role of these contextual factors largely depends on the dogs' personality [5, 41]. Bray et al. [5] found that there is a complex interplay between personality and problem solving. The authors studied temperament (the innate aspects of an individual's personality, such as extraversion and introversion [35]) and problem-solving ability in trainee guide dogs to see which traits were apparent in the most successful dogs. Their results showed that the temperament traits of 'confident flexibility' and 'independent problem solving' were associated with success. However, much of the research that considers both personality and problem-solving has involved working dogs of particular breeds (Labrador Retrievers, German Shepherd Dogs, Springer Spaniels [5, 30, 41]) selected for specific genetic traits in the first place. One study, which involved both pedigree and mix-breed pet dogs to assess personality and problem-solving ability concurrently [4], found a positive correlation between the personality trait motivation and the average level of engagement with a novel game in which the dogs had to spin a bottle around a pivot to extract a food treat. Alongside personality, the study measured three elements, including engagement, performance and ability to learn. Similarly, our study was one of the first to involve a large number of pet dogs of various breeds; however, our aim was to examine the dogs' problem-solving behaviour to identify possible interaction patterns and their relation to personality. Moreover, our study was the first to investigate the role of these behavioural traits in the dogs' interaction with a novel game to draw implications for the design and selection of customizable interactive games.

2.4 Measuring Personality

There are two main methods used to assess personality in dogs: objective test batteries [42] and subjective personality questionnaires [25]. Within the field of personality assessment, it is acknowledged that each method has advantages and disadvantages [13, 31]. On the one hand, test batteries objectively rate dogs' responses to specific stimuli at a given moment in time [42]. However, while some research has shown that these tests can accurately predict personality [42], other research has shown that dogs' responses to test stimuli are not representative of their responses to real life situations. For example, dogs who reacted aggressively towards a test doll were not reported to be aggressive towards small children [16].

On the other hand, questionnaires measure personality by scoring dogs' behavioural traits that present over time. While they

are largely subjective, they have been found to be highly reliable [13]. Indeed, since they are usually completed by the dogs' main caregiver, they can give an overall view of the dogs' personality that is not task or time specific. Furthermore, well-designed questionnaires, such as the Monash Canine Personality Questionnaire, offer a convenient, time-efficient, cost-effective and comparatively rigorous way to assess personality, which reviews and meta-analysis studies have shown to be highly reliable [16]. Some personality questionnaires, such as the Canine Behavioural Assessment and Research Questionnaire (C-BARQ) [20], are designed to identify specific behavioural problems in dogs (e.g. aggression, separation anxiety) and are therefore not always suitable for general research use. In contrast, the Monash Canine Personality Questionnaire Revised (MCPQ-R) is designed to measure a wide range of traits and has shown to be highly predictive of future behaviours in dogs [25].

The MCPQ was revised in 2009 (MCPQ-R) to provide a more succinct questionnaire [25]. The original MCPQ contained 41 items which upon further testing were revised to 26, which showed better stability and internal reliability (Cronbach's alpha 0.74-0.87) [13, 25] and matched mean inter-item correlations of human personality questionnaire subscales (0.37-0.53) [25]. The revised version also showed statistical significance in inter-rater and test retest situations [26]. The MCPQ-R is thus a highly reliable questionnaire designed specifically to assess personality in dogs [25]. Thus, in our study, we used the MCPQ-R to examine possible correlations between personality traits and dogs' behaviour during their interactions with a novel game.

3 The Study

3.1 Methodological approach

We investigated the interactions of 60 dogs with a novel object and game-like experience, in which the dogs endeavoured to achieve an objective relevant to them; in order to do so they had to overcome a challenge that required them to interact with a responsive but unfamiliar set-up. The study took a hybrid approach whereby the experimental procedures were conducted under control conditions within naturalistic settings, in a room within the dogs' habitual environment with only their primary caretaker and the researcher present. Conducting the study in the dogs' own home avoided the stress that a novel environment and novel person might have caused the dogs and that might have affected performance [15]. The dogs were exposed to a game set-up, which they were allowed to interact with freely within a time window. The interaction was video-recorded using a Panasonic FZ150 camera.

Prior to the study the dogs met with the researcher so they could familiarise themselves with her, so that the presence of a novel human would not be a distraction during the study. During this initial meeting, before the dog took part in the game and before any details of the game were revealed, dogs' primary caretakers were asked to complete the MCPQ-R personality questionnaire personality [25].

3.1.1 Research Context and Participants. Considerably larger than previous ACI user studies, our group of participants included 60 pet dogs over the age of 6 months (when puppyhood usually ends) and their owners, who lived within reasonable travelling distance from the research team. The dogs were a mix of pedigree (no=41) and crossbreed (no=19); and male (no=32) and female (no=28). The pedigree dogs included the following breed groups: Gundog (no=24), Terrier (no=10), Hound (no=5), Pastorel (no=1), Toy (no=1). Table 1 provides these details for each individual.

Owners were approached via local veterinary practices, dog walkers and schools, or were reached through word of mouth. Prior to the study, the researcher ascertained that none of the participants had known musculo-skeletal problems; due to the physical activity required to interact with the apparatus. Dogs with arthritic or joint problems were excluded on the assumption that these would impede the use of their limbs.

P	M	S	B	P	M	S	B	P	M	S	B	P	M	S	B
1	36	F	G	16	84	M	G	31	84	M	T	46	120	M	G
2	48	M	X	17	24	F	X	32	60	M	T	47	24	F	G
3	36	M	G	18	12	F	T	33	12	F	X	48	12	M	G
4	108	F	T	19	96	F	T	34	120	F	T	49	48	M	G
5	60	M	G	20	156	F	H	35	72	F	T	50	36	M	G
6	84	M	P	21	132	M	G	36	108	F	X	51	12	F	G
7	72	F	H	22	132	M	G	37	12	F	X	52	12	M	G
8	24	M	X	23	108	F	X	38	72	M	X	53	36	M	H
9	24	F	X	24	132	F	X	39	72	F	T	54	24	F	X
10	60	M	H	25	132	M	G	40	12	M	G	55	72	F	G
11	72	M	X	26	72	F	G	41	72	M	G	56	36	M	X
12	36	F	t	27	60	M	T	42	12	F	X	57	72	F	H
13	12	M	G	28	24	M	G	43	84	F	G	58	12	M	X
14	36	F	X	29	108	F	X	44	24	M	G	59	72	M	X
15	48	M	G	30	96	M	T	45	108	M	G	60	12	M	X

Table 1. Details of participants (P): age in months (M), sex (S) and breed group (B). Breed groups are X (crossbreed), G (Gundog), T (Terrier), H (Hound), P (Pastorel), t (Toy).

3.1.2 Personality assessment. Personality was assessed using the MCPQ-R (Monash Canine Personality Questionnaire – Revised), which has been found to be a particularly reliable and consistent personality measurement tool [25, 26]. The MCPQ-R measures the traits of extraversion, motivation, training and focus, amicability and neuroticism. In the questionnaire, these traits are associated with adjectives. In particular, the adjectives that qualify each trait are: for *extraversion*, 'active, energetic, excitable, hyperactive, lively, restless'; for *motivation*, 'assertive, determined, independent, persevering, tenacious'; for *training and focus*, 'attentive, biddable, intelligent, obedient, reliable, trainable'; for *amicability*, 'easy going, friendly, non-aggressive, relaxed, sociable'; for *neuroticism*, 'fearful, nervous, submissive, timid'. Caregivers have to score their dog in relation to each adjective on

a Likert Scale from 1 – really does not describe my dog, to 6 – really describes my dog. The overall scores for each personality trait (extraversion, motivation, training and focus, amicability and neuroticism) are obtained by summing up the scores assigned to all the adjectives associated with a particular trait and calculating the percentage against the maximum score available. This is done to ensure scoring consistency, as not all traits are associated with the same number of adjectives and therefore not all traits have the same maximum score. In our study, the order in which the adjectives were presented was randomized to reduce the chance of proximity errors [25]. The questionnaires were printed out and, for each participating dog, the caregiver most familiar with them was asked to complete the questionnaire. The personality questionnaire was completed before any specific details about the game were divulged, to ensure that the caregivers' answers to the questionnaire were not biased either by their anticipation of how their dogs might perform or by their dogs' performance during the experiment. After completion, the paper copies were given a unique number and labelled with the dog's name and owner surname ready for analysis.



Figure 1. Spin the Bottle game apparatus

3.1.3 Experimental set-up. To study dogs' interaction with and behavioural responses to a novel game, we chose to use a low tech, inexpensive set-up that would be easy to construct, that would allow the dogs to engage in a problem-solving activity, and whose tangible 'interface' would enable them to interact in a targeted but unconstrained way, inviting the expression of a range of interactive behaviours without the need for prior training.

Spin the Bottle (see Figure 1) is a food-related game for dogs used in previous canine behaviour research [4]. To ascertain its novelty for the participating dogs, prior to inclusion in the study the research team checked with each owner that their dog had not seen this type of game before. The game's set-up consisted of a 2L plastic bottle, which contained an appetising food treat and which was suspended on and pivoted around a dowel. The dowel passed through holes located half-way up the sides of the bottle and large enough for the bottle to swing freely. The $\frac{3}{4}$ " dowel was fixed at

either end to a wooden frame whose dimensions were approximately 1' x 1' x 1.5' and which supported the suspended bottle. The small heavy-duty nails used to secure the frame had been hammered-in flush and the entire frame had been sanded-down beforehand to prevent any injuries to the dogs.

3.1.4 Experimental task. To get the food treat out of the bottle, the dogs would need to invert the bottle by 180°, so that the neck would point to the floor and the treat could fall out. To entice the dogs to interact with the game, a piece of extra strong mature cheddar cheese was used as a treat, as this type of cheese has a strong smell generally attractive to dogs. Food is an intrinsic motivator for dogs and a valuable resource that we expected they would want to acquire [46]. To ensure that this would be the case, before running the study, we checked with the dog owners that our canine participants were all food-motivated. Prior to the session, owners allowed their dogs to see and smell the cheese, and then placed it in the bottle so the dogs could see where the cheese had gone. The dogs were then given 2 minutes to try to get the cheese out of the bottle. A pilot study had shown that, if dogs had not got the cheese out within 2 minutes, then they were unlikely to and the apparatus was likely to be destroyed. To interact with the game, the dogs could use their paws, mouth or their nose, or all three. The dogs' caregivers were asked to encourage their dogs to interact with the game but were instructed not to touch the apparatus or show the dogs how to get the treat out of the bottle. The game ended either when the treat was obtained or when the 2 minutes were up. The researcher was present for all 60 dogs' interactions with the game and her role was that of passive observer.

3.1.5 Ethical Considerations. The study was carried out under the ethical approval of the hosting institution, in full compliance with the European Directive 2010/63/EU, On the Protection of Animals Used for Scientific Purposes. In addition, the study conformed with current ACI ethical frameworks [28], which require researchers to protect animal participants' welfare and autonomy at all times when working with them. Mediated informed consent for the dogs' participation was obtained in writing from all dog owners, who were given a brief written outline of the study, while contingent consent was garnered directly from the dogs throughout the study.

3.2 Data Analysis

Video recordings of the dogs' behaviours and interactions during the game were analysed in two stages. During the first stage, the videos were watched, and behaviour and interactions were identified, noted down and subsequently grouped into distinct categories. During the second stage of analysis, each video was watched again another three times at half speed using VLC Media player, to verify the correct categorization of behaviours and interactions and to ensure that subtle behaviours that might have occurred simultaneously with other behaviours and interactions were correctly recorded. Since some of these behaviours signal affective states, it was essential to record them accurately within the context of the game, in order to correctly interpret the dogs'

level of engagement. For example, lip licking might have been triggered by the physiological reaction of salivation and might have simply expressed a readiness to consume the cheese; or it might have been a self-comforting behaviour expressing the frustration caused by being unable to get to the cheese. All exhibited behaviours and interactions were quantified, firstly, by behaviour in order to understand behavioural trends during the game (i.e. how many participants exhibited a behaviour) and, secondly, by participant in order to understand individual tendencies (i.e. what behaviours each participant exhibited). Participants' engagement was analysed based on its quality (i.e. the kind of behaviour and interaction), focus (i.e. whether on the game, on a human or elsewhere) and outcome (i.e. cheese or no cheese).

The MCPQ-R questionnaire scores were recorded in an Excel document using a unique identifier. The scores for each dog's personality traits were combined to obtain average scores for the 5 traits for all 60 dogs. Average scores were also calculated for each of the 26 adjectives which made up the 5 traits. Statistical analyses were carried out on the average scores for the personality traits (extraversion, motivation, training & focus, amicability and neuroticism). Further analyses were also carried out on the average adjective scores. Data were checked for normality and the Independent *t*-test was used for the statistical analyses.

4 Findings

4.1 Interaction Styles and Behaviour Patterns

The video analysis revealed three distinct behaviour patterns and three distinct interaction styles. Behaviour patterns can be described as *game-focused*, *human-focused* and *avoidant*.

Game-focused behaviour consisted of an exploratory phase (involving sniffing) and a purposeful phase (involving manipulation). Initially, all but one dog approached the game and explored the apparatus and the bottle, sniffing them and investigating the smell coming from the bottle's opening. After this exploratory phase, some dogs started expressing more purposeful behaviour. For example, 19 dogs started using their mouth to interact with the bottle, 18 also licking the bottle's opening. 16 dogs took hold of the bottle with their molar teeth pulling it up or along and making the apparatus move. 23 dogs pushed the bottle along the dowel with their nose which resulted in slightly swinging the bottle. 13 dogs swung the bottle to a 45° by nudging it with their noses.

Human-focused behaviour involved looking at and approaching the dogs' caretaker and the researcher in the room repeatedly during the game time. Out of the 59 dogs who engaged with the game, 54 dogs looked at or towards their caretaker at some point during the two-minute session. Generally, they alternated between looking at the caretaker and sniffing the bottle, in a typical 'invitation' gesture. Since, as instructed, the caretaker did not help them, 39 of the dogs then tried approaching the caretaker, 17 looking at them and wagging their tail. Given the caretaker's unresponsiveness, 31 of the dogs who had approached their caretaker then looked at the researcher, 26 also approaching her. Of

the 43 dogs who stopped interacting with the game during the two-minute session, 13 went to either sit or lie next to their caretaker.

Avoidant behaviour mainly consisted of sniffing the floor around and away from the apparatus, and wandering off to do something else, such as looking out of a window or fetching a toy. The behaviour persisted even when the dogs were being encouraged to interact with the game by their human.

Interaction styles can be described as *strategic*, *contact* and *no-contact*. Although this was not always the case, interaction styles and behaviour patterns tended to overlap to some extent: dogs who manifested a *strategic interaction style* also tended to express more *game-focused behaviour*, dogs who manifested a *contact interaction style* also tended to express more human-focused behaviour, and dogs who manifested a *no-contact interaction style* also tended to express more *avoidant behaviour*. The following sections discuss interaction styles and how they tended to overlap with behaviour patterns.

The *strategic interaction style* was manifested in the use of paw(s), snout or mouth, or all of these to rotate the bottle around the dowel, in a more or less steady and coordinated way. The dogs who manifested this style also exhibited more game-focused behaviours, and after the initial exploratory phase, their interactions became more purposeful and, in some cases, very effectively so. In particular, 15 dogs engaged with the apparatus in a more strategic way than the other 45 participants, using their snout and mouth to manipulate the bottle, with 5 dogs also using one or two paws, thus spinning the bottle (unless they missed their target). Of these 15 dogs, only 8 managed to invert the bottle by 180° and hold it in position. They did so by initially taking hold of the bottle with one side of their mouth and pulling it round in a downward movement using their molar teeth. They then used their noses to control the bottle's movement with enough steadiness and precision to keep it in the upside position long enough for the cheese to fall out. The other 7 dogs kept using their mouths, holding it by the molar teeth, but did not manage to turn it to the required 180° angle, instead making the apparatus move as they pulled the bottle up or moved it along the dowel.

The *contact interaction style* involved exploratory sniffing as well as the purposeful use of snout and mouth, or both, to tap and nudge the bottle to swing or move it. Dogs who manifested this style showed some *game-focused behaviour* but overall tended to show more *human-focused behaviour*. In particular, the 25 dogs in this group begun by sniffing the bottle and the apparatus, before interacting with the bottle using their snout, their mouth, or both. They tapped or nudged the bottle with their snout making it swing slightly on the dowel but not enough to invert it. They also pushed the bottle along the dowel with their noses. Some licked or bit the bottle top, sometimes attempting to pull the bottle upwards or sideways without managing to rotate it, but instead making the apparatus move. Although these participants were interested in the game, their interaction style was not sophisticated enough to allow them to get the cheese. They also tended to take their focus off the game to focus on the humans in the room instead.

The *no-contact interaction style* involved exploratory sniffing of the bottle and apparatus but no physical interaction. Dogs who

manifested this style showed some human-focused behaviour and, after initially sniffing the bottle opening or the apparatus, they also expressed various avoidant behaviours. Since these dogs did not physically touch the apparatus, for them only possible outcome was that they did not manage to get the cheese.

Invariably, the 8 dogs who managed to get the cheese out of the bottle presented with a strategic interaction style and a game-focused behaviour that begun with an exploratory phase and quickly progressed to a sophisticated purposeful phase. However, not all dogs who manifested a strategic interaction style always expressed game-focused behaviour. For example, 7 dogs in the group that manifested a strategic interaction style showed more human-focused behaviour than the other 8, while showing strategic interaction which nearly allowed them to get the cheese. Similarly, dogs who manifested a contact interaction style also expressed avoidant behaviour in addition to game-focused behaviour, although to a lesser extent compared with dogs who manifested a no-contact interaction style. In other words, the behaviour pattern groupings only partially overlapped with interaction style groupings and the dogs in each interaction style group tended to show more than one particular behaviour pattern. Figure 2 shows the interplay between the different behavioural focus and interaction styles.

4.2 Interaction styles and Personality Aspects

To identify any possible correlations between interaction style and personality, we compared average personality trait scores for dogs in the *strategic interaction style* group to the average personality trait scores for dogs in the other two groups (*contact and no contact*). As previously mentioned, the dogs in the *strategic* group all interacted using their paw(s), snouts and mouths and managed to either fully invert the bottle (and get the cheese) or almost invert the bottle (nearly getting the cheese) which was the aim of the game. However, when testing for personality trait differences, we did not find statistically significant results.

Then, to identify any possible correlations between interaction styles and specific personality aspects, we tested the average scores for the 26 individual adjectives that make up the traits. We found a statistically significant result for the *strategic* group for the adjective ‘active’ (from the extraversion trait). This means that dogs in the *strategic* group, who used their paw(s), snouts and mouths, scored on average significantly higher for the adjective ‘active’ than dogs in the other groups:

$$t_{58} = 1.74, P = 0.04$$

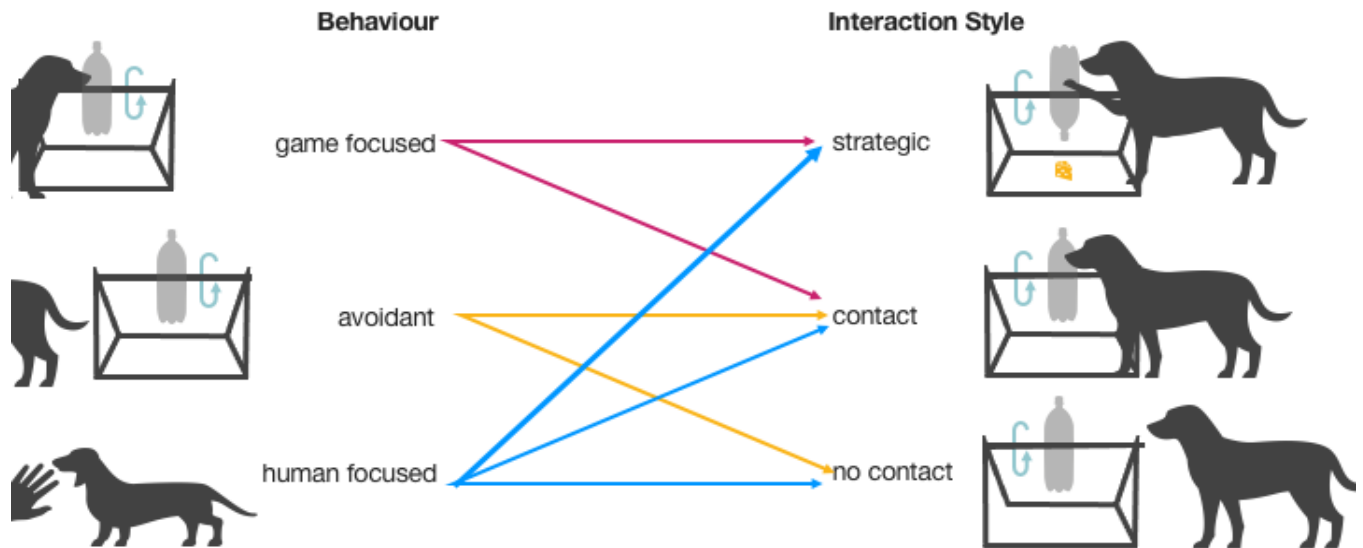


Figure 2: Interplay between the different behavioural focus and the interaction styles

We found two other adjectives to be close to significance for the *strategic* group: ‘hyperactive’ (from the extraversion trait) and ‘assertive’ (from the motivation trait). This means that on average dogs in the *strategic* group scored higher than dogs in the other groups on ‘hyperactive’ and ‘assertive’:

$t_{58} = 1.56$, $P = 0.06$ (hyperactive)

$t_{58} = 1.44$, $P = 0.08$ (assertive)

We also compared the averages of the 26 individual adjectives between the *contact* group (snout and mouth users) and the *no contact* group (no physical contact with game) to look for any statistical differences.

We found a statistically significant result for the adjectives ‘persevering’ and ‘tenacious’ (from the motivation trait). This means that dogs in the *contact* group scored on average higher for these adjectives than dogs in the *no contact* group:

$t_{43} = 1.85$, $P = 0.03$ (persevering)

$t_{43} = 2.61$, $P = 0.00$ (tenacious)

Although not statistically significant, the analyses showed that dogs in the *no contact* group scored on average higher on 3 adjectives:

‘fearful’ (from the neuroticism trait) and ‘excitable’ and ‘hyperactive’ (from the extraversion trait). This means that dogs in the *no contact* group scored on average higher for these adjectives than dogs in the *contact* group:

$t_{43} = -1.44$, $P = 0.08$ (hyperactive)

$t_{43} = -1.10$, $P = 0.14$ (fearful)

$t_{43} = -0.84$, $P = 0.21$ (excitable)

5 Discussion

Our study investigated how dogs would interact with a novel game and what variations there might be in the way the different dogs interacted with it and whether any interaction patterns would emerge. We considered how the behaviours the dogs exhibited during the game might relate to their engagement with the game. We also looked for possible connections between the dogs’ personality traits, the adjectives that are used to describe personality traits and interaction patterns. Our findings shed light on a range of issues, discussed below.

5.1 Understanding engagement

All the dogs in our study (except one) showed exploratory behaviour towards the game. As dogs have been found to have a pre-disposition to investigate novel objects [23], this is perhaps unsurprising. However, such behaviours varied between individuals, ranging from sniffing the bottle or the apparatus without touching it to purposely touching the bottle or moving it during sniffing. Kaulfuß and Mills [23] identified similar behaviours in a study in which dogs were presented with a novel object. However, in our study, after the initial exploratory phase, the majority of dogs chose not to continue exploring the game. This is in contrast to observations made in a study by Lazzaroni [24], which tested pet dogs, captive dogs and free ranging dogs’ persistence when trying to extract food hidden in a bottle or ball, and in which pet or captive dogs were found to be more persistent than free ranging dogs. It is possible that the presence of the dogs’

owners in our study influenced the dogs’ decision to abandon the game after an initial exploration, although findings from a study by Brubaker and Udell [6] suggest that the presence of a familiar human might not be relevant to dogs’ interactions with a novel game. It is also possible that for many of the dogs in our study the game did not hold interest. However, given the fact that an appetizing treat was on offer, it is perhaps more likely that the game did not afford the kind of interaction that would have been appropriate for those dogs.

The dogs who chose to continue investigating the game went on to show what seemed more purposeful interactions, such as persistently sniffing the bottle opening, nudging the bottle round the dowel with their nose, taking hold of the bottle with their mouths to turn it over, and even using their paws to manipulate the bottle. In particular, we identified three interaction patterns, which we described as *strategic*, *contact* and *no-contact*. Dogs in both the *strategic* and *contact* groups showed decidedly more purposeful interactions than the dogs in the *no-contact* group, however, there was a difference in the interactions of these two groups. Although dogs in both groups primarily used their mouths and noses, dogs in the *strategic* group showed much better motor control and used their noses to invert the bottle, instead of trying to do so with their mouth. It is unclear why some dogs used their noses to manipulate the bottle while others used prevalently used their mouth or their paws. Other studies that have challenged dogs with similar games [6, 23, 30] have not detailed which physical interactions resulted in which outcomes, therefore comparisons are difficult to make.

The different interaction styles shown by both the *strategic* and *contact* groups also resulted in different outcomes for the dogs. Within the *strategic* group, those dogs who primarily controlled the bottle with their noses obtained the cheese reward whereas the dogs who primarily used their mouths did not. Only half of the dogs in this group managed to use their noses with enough control to hold the bottle in position allowing the cheese to drop. The dogs in the *contact* group also interacted with their mouths and noses but they did not show the same amount of skill as the dogs in the *strategic* group, which meant that they were unable to effectively invert the bottle. It is unclear why some dogs were able to manipulate the bottle with better control than others and future research should aim to better understand this.

We found that dogs who continued to engage with the game and showed purposeful behaviour also focused less on the humans in the room (looking at or approaching the owner or researcher). Indeed, dogs in the *strategic* group seemed to score lower on human-focused behaviours than dogs in the *contact* and *no-contact* groups. A study by Marshall-Pescini et al. [30], which measured how long dogs spent gazing at their humans during a task, found that dogs who had undertaken training (i.e. agility) involving greater coordination with a human partner gazed for longer than dogs trained for more independent work (i.e. search and rescue). Thus, it seems that training experience might influence dogs’ interaction with a game, and could possibly increase or decrease their problem-solving focus and chances of a positive outcome. This would be consistent with observations we made with some of our participants. For example, P39 and P57, who had done agility

training and obedience training respectively were much more human focused than the 13 other dogs in the *strategic* group. They spent the full 2 minutes interacting with the game, encouraged by their caretakers, but their interaction skill was not enough to gain them the cheese reward. In contrast P1, who had done formal gundog training was the least human focused and the quickest to invert the bottle and gain the reward. P41, P42 and P54 also scored low on human focus but had only done basic dog training. All 3 managed to get the cheese reward however they took longer than P1. On the other hand, we found that dogs who had no training at all, for example P47 in the *no-contact* group, showed a greater tendency to focus on their human; they also showed more avoidance behaviours (wandering away from the game, lip licking, looking elsewhere in the room and sniffing the floor away from the game) compared to the trained dogs. These dogs might have been less equipped to deal with the situation and might therefore have been unable to focus on the task. Generally, dogs in the *no-contact* group showed more avoidance behaviours than dogs in the *strategic* and *contact* groups. Both human-focused behaviours and avoidance behaviours suggest that the dogs might have felt helpless and frustrated. Future research could better explore the manifestation and transition between purposeful interactive behaviours and avoidance behaviours during different gaming interactions both digital and tangible, and the influence of human-related practices, such as training, on dogs' willingness and ability to engage with a game.

5.2 Personality and interaction

We assessed our participants' personality using the MCPQ-R questionnaire to understand whether there might be a relation between interaction styles and personality traits, which might be exploited to inform the customization and selection of mass-produced interactive games for dogs. Whilst we did not find any correlations between interaction styles and personality traits, we did find correlations between interaction styles and some of the adjectives used to describe the traits. Dogs in the *strategic* group, who used their paw(s), snouts and mouths, scored more highly on the adjectives *active*, *hyperactive* (from the trait 'extraversion') and *assertive* (from the trait 'motivation') in their personality profile. These dogs also showed the least human-focused behaviour which suggests that they may have been more independent compared to the dogs in the *contact* and *no-contact* groups. However, we could identify no correlation that could explain why 8 of the dogs in the *strategic* group manipulated the bottle with their noses and achieved enough control to gain the cheese reward, while the other 7 dogs in this group did not.

As mentioned above, dogs in the *contact* group who interacted with their mouths and noses did not show the same amount of skill shown by the dogs in the *strategic* group, which meant that they were unable to invert the bottle and get the cheese reward. For the *contact* group our results showed a correlation with the adjectives *persevering* and *tenacious* (from the trait 'motivation') suggesting that these dogs wanted to get the cheese but did not have the skills to obtain it. These dogs also scored highly on human-focused

behaviour, which could indicate that they needed or wanted human intervention when engaging with the challenge posed by the game.

Dogs in the *no-contact* group tended to score more highly on the adjectives *fearful* (from the trait 'neuroticism'), *excitable* and *hyperactive* (from the trait 'extraversion'). Although none of these correlations were statistically significant, the higher scores on those adjectives could suggest that these dogs might have been intimidated by the novelty of the apparatus, while also finding it more difficult to focus on the challenge posed by the game. Indeed, these dogs also showed the least game-focused behaviour, many simply sniffing the bottle opening and the apparatus; they also showed more human-focused and avoidance behaviour. For example, some of the participants in this group (P32 and P36) spent most of the session running about, jumping at or on either the researcher or their caretaker, and even fetching other toys to try to engage play. This suggests that the game was perhaps too challenging for them or did not hold enough interest.

Overall our results suggest that the MCPQ-R test maybe too coarse and unspecific a tool to reflect which aspects of a dog's personality might be important for game interaction and which personality characteristics might be relevant in those dogs who managed to extract the food reward from the game. Additionally, the test does not reflect circumstantial aspects of a dog's personality. For example, our findings suggest that training might play a role in a dog's ability to get the reward from the game, but that this might depend on the kind of training the dogs have undertaken and the skills they have developed as a result. Another issue with the MCPQ-R test might be that, although it has been found to be a highly reliable tool for assessing a dog's personality [29, 30], it still reflects the perception caregivers have of their dogs and might therefore not be objective, not least because different people may interpret the meaning of the adjectives used by the test differently. For example, the adjective *reliable* (from the trait 'training and focus') might be interpreted as referring to a dog's behaviour in specific circumstances or to their temperament more generally; the adjective *intelligent* (also from the trait 'training and focus') carries connotations that might make scoring it objectively problematic, as a care-taker's perception of their own dog's intelligence might be biased. Finally, adjectives that might be useful for describing personality characteristics relevant to the interaction with games, such as *curiosity* or *playfulness*, are not included in the MCPQ-R test. We suggest that a test could be developed to capture finer-grained characteristics of dogs' personality that might be relevant for capturing their *gaming personality*.

5.3 Designing and selecting for interaction styles

For our study we used a low-tech, inexpensive apparatus that, in spite of - and partly thanks to - its simplicity enabled us to observe different and more or less effective interaction patterns. While dog games based on complex digital technology [11, 36] represent a growing market trend, these mass-produced devices hardly take into account the different ways in which dogs might prefer or be able to interact with games. As a result, dog owners might buy, sometimes at significant cost, and offer to their dogs games that

provide a less than optimal experience and that fail to provide the entertainment and enrichment for which they are acquired.

In this regard, we argue that better understanding dogs' interaction styles and the influence that relevant personality characteristics and relevant experience might have on these, could help inform the development of playful experiences that are relevant to and enjoyable for dogs with different gaming requirements. In particular, using interaction styles as a criterion for designing different playful experiences could provide a middle-ground approach to customization between the individual-centred focus typical of ACI research and the 'one-fits-all' solutions typical of mass-produced toys and games. Unlike the apparatus used in our study, digital technology would afford the adaptation of interaction modalities to different players' interaction styles, by providing adjustable settings or - for more sophisticated and costly applications - by automatically adjusting their interactivity at the beginning of a game or on the fly. For example, a mobile input device could afford greater resistance to the limb of a confident 'pawer' thus enabling them to better control the effect of their interaction; or it could afford more sensitive responsiveness thus enabling the snout of a hesitant 'noser' to control a game with less effort.

Such adaptability to different interaction styles could help dogs engage more effectively using their preferred mode of interaction, maintain interest and focus on a problem-solving task, and ultimately achieve satisfaction in a gaming challenge whose purpose would ultimately be to provide them with a positive experience. Additionally, while many games are designed, sold and purchased for dogs who spend a lot of time alone, our findings suggest that some dogs might want or need interaction with a human during a game. This raises the question as to whether games for home alone dogs can replicate the benefit of having their caregiver present or whether the need for the involvement of a human might be due to some dogs' lack of confidence in approaching a task independently. In this regard, customization options could include the possibility of adapting a game to enable a human player to participate in the game. Alternatively, the game's interactivity could be designed and progressively customized to help a dog increase their level of confidence in order to enable them to play more independently over a period of time.

The work presented here aims to contribute to this area of research concerned with designing adaptive games for companion animals [34] by highlighting a possible approach to customization, based on interaction styles and factors that might influence them. However, in order to identify dogs' interaction styles and the factors that might influence them, so that appropriate game experiences can be provided for the player, there is a need to develop reliable predictive tools. In this regard, tests analogous to the MCPQ-R but specifically tailored to capturing dogs' gaming personality could be used to predict their interaction styles and select games that provide a suitable match.

5.4 Limitations of the study

We recognise that our study had some limitations. For example, the cheese reward might have been more motivating for some dogs than for others. Although the researcher checked with the dogs' caretakers that they were food motivated and liked cheese, we cannot know how cheese-motivated individual dogs actually were, which could have affected their engagement and performance. It is also worth noting that, because the researcher had to work around caregivers' commitments, the sessions were not carried out at the same time of day for all 60 participants, which could have affected the dogs' performances. For example, a participant might have been tired after a walk and less motivated to engage with a novel game. While the aim of the study presented here was to consider dogs' spontaneous interactive behaviours with a novel game, it might be interesting to see whether repeating the test would make a difference to the level, kind and outcome of the interaction that some of the dogs showed.

6 Conclusions

Our study investigated how different dogs interact with a novel game and whether their interaction presents any patterns and whether these might relate to their personality. Our findings suggest that dogs present with a variety of interaction styles when engaging with a game, although it is unclear why some dogs prefer to use their paw, some their mouth and some their nose. Also, the behaviour of many dogs participating in our study suggested that they would prefer some human involvement when playing games. Differing interaction styles and a preference for human involvement could be due to subtle differences in personality traits or they could be due to prior training or other experiences and future research should consider further investigation in this regard. The development of games that are fulfilling and enjoyable from a dog and human point of view remains a challenging domain. However, technological advances are opening new possibilities for the development of gaming experiences that could be customized or that could adapt to different players' interaction styles and preferences according to relevant behavioural characteristics. To identify dogs' interaction styles and provide them with optimal gaming solutions, tests specifically tailored to capturing dogs' gaming personality could be developed based on relevant behavioural characteristics.

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