Thesis

Does dog-directed parenting style influence dog-to-owner attachment?

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1. Abstract

Attachment is an affectional bond that an infant forms with its parents, as a behavioural strategy to maximize chances for survival by maintaining proximity to a caretaker. In the 1970's, Ainsworth developed the "Strange Situation Test" (SST) for assessing attachment styles that infants develop according to their parent's caregiving behaviour and parenting style. Parenting styles are different behavioural strategies parents use to raise children, which influence development and self-reported wellbeing in children. Dogs tend to be regarded as children and treated as such by their owners, and form an attachment bond with their owner alike that between parent and child. Similarly, parenting styles have been found to apply to owner-dog relationships, manifesting as three distinct dog-directed parenting styles that are classified as "authoritarian", "authoritative-intrinsic value" oriented and "authoritative-training" oriented. This raises questions about the consequences of dog-directed parenting for important aspects of the owner-dog relationship, and insights in the effects of dog-directed parenting styles may identify new strategies to improve dog behaviour and welfare.

In the current study, it was investigated if the dog-directed parenting styles adopted by owners associate with dog-to-owner attachment. Owner reports (n=49) on dog-directed parenting, attachment and dog behaviour were combined with the dog's behaviour during the SST to find associations between dog-directed parenting style, owner attachment style and behavioural indicators of dog-to-owner attachment.

Differences in dog behaviour between the 8 episodes of the SST were analysed by linear mixed models to identify indicators of attachment behaviour, and these were tested for associations using a Principal Component Analysis. Resulting behavioural components were interpreted as "outgoing behaviour towards the stranger", grouping tail wagging, being near the stranger, social play with the stranger and, inversely, staring at the owner when the stranger is present and being near the owner's chair when the owner is absent , and as "staring behaviour", grouping staring at the owner during reunions, staring at the door during separation and staring at the stranger. Dog behaviour scores, extracted from owner reports and behaviour tests, were analysed with ANOVA for associations with owner-reported dog-directed parenting style scores and owner-reported adult attachment scores. Both authoritarian dog-directed parenting and insecure adult attachment of the owner towards other people associated with little staring behaviour, high levels of whining during separation from the owner and avoidance of the owner during reunions. These behaviours expressed during the SST are proposed to be indicators of insecure attachment towards the owner. Moreover, authoritative-intrinsic value oriented dog-directed parenting is associated directly with owner-reported separation related distress in dogs in daily life. The authoritative-training oriented dog-directed parenting style seems the preferred parenting style in respect of secure dog-to-owner attachment.

2. Introduction

Parenting styles refer to the different behavioural strategies parents use to raise their children, and which are known to influence the child's development and self-perceived wellbeing (Baumrind, 1967; Baumrind *et al.,* 2010). Dogs are often considered as children and treated as such by their owners (Neidhart & Boyd, 2002), suggesting that owners may follow dog-directed parenting styles when interacting with dogs. Evaluation of over 500 dog owner reports confirmed the existence of dog-directed parenting styles (van Herwijnen *et al.,* 2018), and this raises questions about the consequences of dog-directed parenting for important aspects of the owner-dog relationship, such as the dog's attachment and, subsequently, behavioural problems in dogs. Insights in the effects of dog-directed parenting styles may identify new strategies to improve dog behaviour and welfare by means of improving the owner-dog relationship.

Parenting styles were originally categorized as authoritarian, authoritative, and permissive (Baumrind, 1967), with the uninvolved parenting style being added later to this model (Maccoby & Martin, 1983). The four parenting styles differ in the underlying dimensions of "responsiveness" and "demandingness" (Baumrind *et al.,* 2010; Hughes *et al.,* 2005). Responsiveness relates to what extent parents show affection, involvement, support, and acceptance. Demandingness relates to showing confrontive control, supervision and maturity demands (van Herwijnen *et al.,* 2018; Hughes *et al.,* 2005). Responsiveness and demandingness are independent dimensions, with variation in these dimensions showing as four distinct parenting styles (Baumrind *et al.,* 2010; Hughes *et al.,* 2005). The "authoritative" parenting style is characterized by high responsiveness and high demandingness. The child is expected to behave well and the parent directs the child's activities, but rules are explained. Verbal give-and-take is encouraged and negotiation is possible, as both autonomy of the child and discipline are valued. In the "authoritarian" parenting style low levels of responsiveness and high levels of demandingness are expressed. High levels of control mean that rules are not explained and failure to follow the rules or meet expectations is punished. The "permissive" parenting style is consistent with high levels of responsiveness and low levels of demandingness. The parent is affirmative, warm and acceptant, but there is a lack of monitoring of the child's behaviour and control is exercised minimally (Baumrind, 1967; Baumrind *et al.,* 2010, van Herwijnen *et al.,* 2018; Hughes *et al.,* 2005). Finally, the "uninvolved" parenting style combines low levels of responsiveness and demandingness, leading to little demands, control, and involvement (Baumrind *et al.,* 2010, van Herwijnen *et al.,* 2018; Hughes *et al.,* 2005; Maccoby & Martin, 1983). Authoritative parenting seems to have the best influence on child development, as it results in children that are self-reliant, have good academic achievements, are unlikely to become delinquents, and who report good subjective-wellbeing (Chan & Koo, 2010; Lamborn *et al.,* 1991; Maccoby & Martin, 1983; Simons & Conger, 2007).

Similar to children, juvenile dogs seem to be susceptible to the way they are raised. Twenty-one litters of future guide dogs were videotaped during their first three weeks of life, and after reaching 2.5 years of age associations were found between maternal behaviours of the dam and outcome of the training. High levels of overall maternal behaviour (e.g. time spent with the puppies, grooming, contact, nursing) were associated with a higher likelihood of failing the training program (odds ratio 2.6). In addition, the nursing style of the dam associated with guide dog success, probably due to the different amounts of effort these styles required from the puppies. High levels of ventral nursing were associated with higher chances of program failure, while puppies required to nurse vertically were less likely to fail the program (Bray et al, 2017). There is good evidence for humans having an effect on how dogs behave as well. Dogs react differently to an approaching threatening stranger according to their owners' interaction styles, which varied in levels of "warmth" and "control" (Cimarelli et al., 2016). Interaction styles of owners from 220 pure bred border collies were determined by assessing the owners' interactions with their dogs in 8 different behavioural tests, recording behaviours related to showing enthusiasm, warmth, commands, petting, praises and non-verbal communication. Distinct behavioural components with a total of twenty-one behavioural variables were found, explaining a near third of total variance. Dogs from owners with a high score for "owner

warmth" were more likely to remain passive or hide behind the owner when approached by a threatening stranger, while low owner warmth associated with dogs that approached the stranger at the end of the test in either an appeasing or aggressive way. Signs of aggression tended to be frequent in dogs from owners that scored high for "owner control", a component characterized by commandeering (Cimarelli et al., 2016). The way a dog owner behaves towards his dog and interacts with it, also associates with the prevalence of various behavioural problems. For example, separation related problems associated positively with sleeping close to the owner and first time ownership, and declined with increasing levels of obedience training, as evaluated from 737 dog owner questionnaires (Jagoe & Serpell, 1996). Thus, the (mis)behaviour of dogs seem to associate with the different styles in which owners interact with their dogs and the latter may be conceptualized by the parenting style model that describes parent-child relationships. Three dog-directed parenting styles have been identified from a web based survey under 518 dog-owning parents of at least one child. Dog-directed parenting styles are classified as "authoritarian", characterized by verbal or physical forcefulness and corrections for unwanted behaviour, "authoritative-training" oriented, characterized by training towards desired behaviour, and "authoritative-intrinsic value" oriented, characterized by taking the emotions and needs of the dog as starting point for parenting practices (van Herwijnen et al., 2018). The existence of an uninvolved dog-directed parenting style and a permissive one remains to be determined, as are the effects of different dog-directed parenting styles on the dog-owner bond. Since in humans parenting styles affect the attachment bond an infant develops (Ainsworth *et al.,* 1978), it seems likely that dogs may also adapt their attachment behaviour to the dog-directed parenting style of their owner and this is investigated here.

Attachment is a specific type of affectional bond present in the parent-child relationship (Payne *et al.,* 2016). Affectional bonds are defined as "a relatively long-lasting tie in which the partner is important as a unique individual and is interchangeable with none other" (Ainsworth, 1989). An attachment bond manifests as separation distress, a secure base effect (the presence of the attachment figure gives the attached the confidence to explore the environment), a safe haven effect (returning to the attachment figure leads to a reduction of fear) and proximity seeking (Cassidy, 1999). Infants display attachment behaviour when they are separated from their attachment figure, to promote and restore contact and proximity. This includes vocalising, crying, following, clinging (Ainsworth & Bell, 1970), and assumingly makes up the infant's strategy for survival by maintaining proximity to the attachment figure (Bowlby, 1958; Prato-Previde *et al.,* 2003). Ainsworth developed the "Strange Situation Test" (SST) to assess the attachment style of an infant, by placing the infant in a novel room, introducing an unknown female and separating it from and reuniting it with its mother (Ainsworth & Bell, 1970). The four different styles of attachment in children are secure, avoidant, ambivalent and disorganised (Ainsworth *et al.,* 1978; Main & Solomon, 1986). Attachment styles are partly learnt by the child to fit the caregiving behaviour of the parent, meaning that the parenting style of the parent influences the attachment style a child develops (Main, 1990). Dogs also show attachment behaviour towards their owners in Strange Situation Tests (e.g. Palestrini *et al.,* 2005; Palmer & Custance, 2008; Prato-Previde *et al.,* 2003; Topál *et al,* 1998). They discriminate between their owner and a stranger, especially in reunion behaviour and proximity seeking, and show anxiety and proximity seeking behaviours when they are separated from their owners (e.g. Prato-Previde *et al.,* 2003; Topál *et al,* 1998). Dogs are also reported to show a secure base effect, since play, exploring and interaction with a novel object is increased in presence of their owner (Horn *et al,* 2013; Martini *et al.,* 2013). Owners may provide a safe haven, as dogs that are approached by a stranger in a threatening way show less tachycardia when the owner is present than when alone (Gacsi *et al,* 2013). Such findings support that the attachment bond between a dog and its owner is similar to that between a child and its caretaker. The dog-to-owner attachment bond, as observed in a SST, has been shown to associate with the attachment profile of the owner towards other people, as assessed with the 9 Attachment Profile questionnaire. Dogs of owners with a "confident" attachment profile showed stronger secure base effects than dogs from owners with a "non-confident" attachment style (Siniscalchi *et al.,* 2013). Whether or not dog-directed parenting influences dog-to-owner attachment

is unknown. If parenting styles indeed determine dog-to-owner attachment, owners could be informed on how to improve their dog's welfare by ensuring that their dog becomes securely attached.

The goals of this study were to identify different attachment styles in dogs and to determine if the dog-directed parenting style of the owner is related to dog-to-owner attachment. Owner reports are combined with behavioural tests to find associations between dog-directed parenting style, owner adult attachment style and dog-to-owner attachment. Dogs of authoritative owners are expected to be more securely attached than dogs of authoritarian owners. Dog-directed parenting styles and dog-to-owner attachment are expected to influence the risk of dogs developing unwanted behaviours such as separation related behaviours.

3. Materials & Methods

3.1 General set-up

Owner reports on dog-directed parenting style, attachment and dog behaviour were obtained using a web-based questionnaire. Respondents that showed relatively strong inclinations towards any of the three evaluated dog-directed parenting styles were selected to participate in behavioural tests. After behavioural analysis, the results of the owner reports and behavioural tests were combined to find associations between dog-directed parenting style, owner adult attachment style and dog-to-owner attachment. The questionnaire and tests did not require review by the Wageningen University Medical Ethics Review Committee, as owners participated voluntarily, and no interventions or treatments were administered.

3.2 Subjects

For this study, records on 49 dog-owner dyads were used. The participants owned their dog since it was a puppy (maximum of 16 weeks old) and cared for their dog for more than half of the time. The dog owners ranged between 18 and over 65 years of age with a median age group of 45-54 years, and comprised of 7 men and 42 women. The sample of dogs consisted of 27 males and 22 females, ranging between half a year and 12 years of age with a median age group of 4-5 years. The main purpose of 48 dogs was companionship and 1 dog was kept primarily for assistance tasks. Secondary purposes of the dogs were: exercise (30 dogs), participating in dogs sports (18 dogs), feeling safe (8 dogs), guarding, hunting or herding (7 dogs), assistance (6 dogs) and breeding (5 dogs). The subjects were 6 mixed bred and 43 pure bred dogs (1 Australian Shepherd, 1 Beagle, 2 Beaucerons, 2 Berger Blanc Suisses, 1 Border Collie, 2 Briards, 2 Dutch Patridge Dogs, 2 English Cocker Spaniels, 2 Flat-Coated Retrievers, 1 German Pinscher, 2 Golden Retrievers, 1 Grand Basset Griffon Vendéen, 1 Hovawart, 1 Hungarian Vizsla, 2 Labradoodles, 2 Labrador Retrievers, 1 Lagotto Romagnolo, 1 Landseer ECT, 2 Scotch Collies, 1 Malinois Dog, 1 Maltese Dog, 1 Old German Herding Dog, 1 Old German Shepherd Dog, 1 Portuguese Podengo, 3 Rottweilers, 1 Shetland Sheepdog, 1 Siberian Husky, 1 St. Bernard, 1 Staffordshire Bull Terrier, 1 Tervueren Shephard Dog, and 1 Welsh Springer Spaniel).

3.3 Questionnaire

A web based questionnaire ran from August 2017 till March 2018, which was completed by a total of 2,202 respondents. The questionnaire contained parts of the “Ten-Item Personality Inventory” (TIPI) (Gosling *et al.,* 2003), “Experiences in Close Relationships Scale” (ECR) (Brennan *et al.,* 1998), “Canine Behavioral Assessment & Research Questionnaire (C-BARQ)” (Hsu & Serpell, 2003), “Monash Canine Personality Questionnaire-Revised”(MCPQ-R) (Ley *et al.,* 2007), the “32-Parenting Style and Dimensions Questionnaire” (32-PSDQ) (Robinson *et al.,* 1995) and the “20-Dog-directed Parenting Style and Dimensions Questionnaire” (20-D-PSDQ) (van Herwijnen *et al.,* 2018). Owners could indicate to what extend the statements applied to them or their dog on a Likert-type scale of 1-5 or 1-7, where 1 stood for never/strongly disagree and 5 or 7 stood for always/strongly agree. At the end of the questionnaire, owners indicated whether they were willing to participate in behavioural tests with their dogs.

3.4 Procedure

All behavioural tests were performed in a standardized and controlled environment at the dog testing facilities of Wageningen University. Tests were performed in a test room of approximately 7 by 7 metres. In each corner, an Axis M10 network camera hung from the ceiling and these recorded the room during the tests. Next to the test room, an observation room was present from where the tests were observed. Instructions to the owner were provided via a microphone in the observation room and a sound box in the test room. For safety reasons, dogs were attached to a long leash after having explored the room. On leash, the dog was not able to reach the front part of the room, where the exits

to the hall and observation room were. In this way, the owner or experimenter could always move out of reach from the dog when feeling unsafe. Owners signed an informed consent form, giving permission to be filmed during the tests for the purpose of behavioural video analysis. Four tests were performed, being an adapted strange situation test (SST), intrinsic input test, altruism test and parenting style validation test. Only the findings from the SST test are presented and this procedure is described below. Full test sessions took less than 1.5 hours including walks and breaks.

The SST is frequently used to assess attachment behaviour in both infants and dogs. During the SST, the heart rate in beats per minute was determined in part of the sample (n=12). A "Zephyr BioHarnass™ 3" strap was sent a week in advance to owners who were willing to let their dog wear a heart monitor during the test, to habituate the dogs to wearing a strap prior to the tests. Before the start of the experiment a BioHarnass strap with a "Zephyr puck" heart rate monitor was attached around the dog's torso after consulting the owner about consent and safety of handling the dog. Water and transmission gel were used to improve transmission between the electrodes in the strap and the dog's torso. If a dog showed one or more responses to the strap after a 5 minute habituation period, such as scratching, biting, shaking, scraping against objects, and stress behaviours, or when transmission between the dog and the Zephyr BioHarnass proved too poor to measure the heart rate consistently, the strap was removed. Otherwise, the heart rate monitor was worn during the SST. Then, the owner received instructions for the SST, the cameras and heart rate recorder were activated and the owner was led to the test room. The SST room contained a long leash attached to the wall (4.25 metres), two chairs (numbered "1" and "2"), a water bowl, and a basket with toys (two balls on a rope, two tug-of-wars and a squeaky duck). A female experimenter acted as the "stranger". The entire protocol of the SST lasted approximately 15 minutes and consisted of 8 episodes (episode 0 to 7). The episodes are described in Table 1.

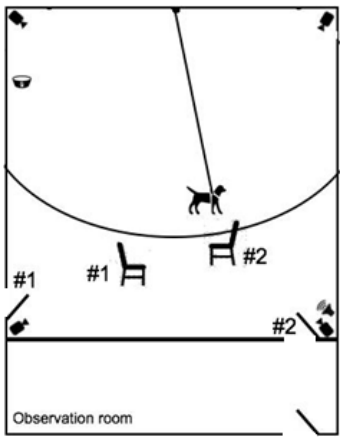

Figure 1: Experimental setup SST (from Jager, Smit & van Woensel, 2017)

Table 1: Dogs were tested for attachment to their owners using a Strange Situation Test protocol, and the 8 subsequent episodes are described

Episode	Duration	Description
0: owner and dog	2 minutes	The owner and dog explored the room off leash
1: owner and dog	1 minute	The owner attached the dog to the leash, sat down on chair 2 and acted as a non-participant
2: owner, dog and stranger	2 minutes	The stranger entered and sat on chair 1 as a non-participant. After half a minute, the stranger started casual conversation with the owner. After a minute of talking, the stranger started playing with the dog, while the owner sat on chair 2 as a non-participant. After half a minute, the owner was instructed to leave
3: stranger and dog	2 minutes	The stranger continued to interact with the dog by trying to elicit play and calling its name. After a minute, the stranger sat down on chair 1 as a non-participant
4: owner and dog	2 minutes	The owner re-entered the test room and the stranger left. The owner greeted the dog and was allowed to play with it
5: dog	2 minutes	The owner left the test room, while the dog remained by itself
6: stranger and dog	2 minutes	The stranger entered the test room and interacted with the dog by trying to elicit play and calling its name. After a minute, the stranger sat down on chair 1 as a non-participant
7: owner and dog	2 minutes	The owner re-entered and greeted the dog, while the stranger left. The owner was allowed to play with the dog

3.5 Data collection and analysis

Results from the web based questionnaire were organised using "Microsoft Access 2016" software and behavioural analyses were based on video recordings of the dogs during the SST, aided by "Observer XT version 10.5" software. From the four recorded videos of a test, i.e. angles on the test room, the two most useful ones were loaded in Observer XT for analysis. Continuous sampling was used to record play behaviour, locomotion, staring and closeness to persons/objects, while 3 second point sampling was used to record stress behaviour and other events. The complete ethogram used for analysing the dog's behaviour during the SST is shown in appendix 8.1. Behaviours were expresses in percentage of the observation time or in rate per minute. The heart rate was recorded every 2.5 seconds and expressed in beats per minute. Statistical tests were performed using "GenStat 7th edition" statistical package. Restricted Maximum Likelihood (REML) linear mixed models were used to test differences in the expressed behaviours between episodes of the SST, using the model $Y_{xy} = u + Episode_x + Dog_y + e_{xy}$, with episode (0 to 7) as fixed effect and the dog (n=49) as random component. The outcomes guided the selection of behavioural parameters, constituting combinations of behaviour and episode(s), that might reflect attachment and which were tested for associations with a Principal Component Analysis (PCA) following procedures described by van Herwijnen *et al.* (2018). PCA components were thus assumed to reflect dimensions of attachment with variation in it being captured in component scores that integrated original behaviour scores with loadings as weighting factors. Associations between measures of dog-to-owner attachment and dog-directed parenting styles (authoritarian, authoritative-training oriented, authoritative-intrinsic value oriented), or dimensions of owner adult attachment style (anxious, avoidant), were tested with ANOVA. Two separate models were ran for parenting style scores as independent variables and for adult attachment style scores. Statistical models included main effects and two-way interactions and independent variables were included as co-variates, expressed on scales of 0 to 100% of the possible maximum.

4. Results

4.1 Dog-to-owner attachment

Dog-to-owner attachment was assessed with a Strang Situation Test (SST) that consisted of 8 different episodes. Differences between episodes of the SST in expressed behaviours in 49 dogs were analysed by linear mixed models. Behaviours that occurred frequently, i.e. at least more than 50% of the records, are presented in Table 2, including predicted means (± standard error) and p-values for SST episode (EP) effects. The relatively rare behaviours were looking away from the owner, freezing, sneezing, urogenital check, yelping, biting the leash, manipulation of the environment, staring at the owner chair and staring at the stranger chair, and behaviours that seemed irrelevant in terms of attachment after analysis were petting by the owner, pulling the leash, tongue flicking, soliciting attention and being near the stranger chair. These behaviours are not further discussed here, though a complete overview of the mean predicted values per episode for each behaviour and significant differences between episodes (EP 0 to EP 7) per behaviour can be found in appendix 8.2.

The general behaviour of the dogs indicated a degree of stress during the SST, and more detailed analyses revealed how this was true especially in episodes when the owner was absent. Due to weather conditions during testing, many dogs panted near continuously during the test, likely obscuring any effects panting might have as a stress indicator during the SST.

In the following explanation of the SST episode effects on the dogs' behaviour a division is made according to whether behaviours were expressed especially during separation from the owner or in the presence of the owner. The latter is subdivided further in behaviours expressed during reunions with the owner and other behaviours expressed with the owner and/or stranger present. Mean scores per SST episode are presented as rate per minute, except for scores expressed as percentage of the observation time. Significant differences between episodes existed for a given behaviour, when means do not share a superscript letter.

Table 2: Dogs (n=49) were tested for attachment behaviour in a Strange Situation Test composed of 8 episodes. Presented are the overall predicted means (± s.e.) in percentage of the observation time or rate per minute and linear mixed model p-values of the episode effects.

Behaviour	Mean ± s.e.	*P*-value episode
Non-social play	0.00% ± 0.30	*P*<0.001
Social play owner	1.88% ± 2.36	*P*<0.001
Petting owner	4.42% ± 2.88	*P*<0.001
Social play stranger	0.00% ± 1.40	*P*<0.001
Lying	0.08% ± 3.42	*P*<0.001
Sitting	2.25% ± 2.57	*P*<0.001
Moving	66.28% ± 2.66	*P*<0.001
Standing	31.39% ± 3.94	*P*<0.001
Near owner	32.36% ± 3.01	*P*<0.001
Near owner chair	20.17% ± 1.77	*P*<0.001
Near stranger	0.00% ± 2.70	*P*<0.001
Staring at stranger	0.00% ± 1.40	*P*<0.001
Staring at owner	18.00% ± 2.00	*P*<0.001
Staring at owner chair	0.00% ± 0.40	*P*<0.006
Staring at door	0.32% ± 2.28	*P*<0.001
Panting	3.86 ± 0.78	*P*=0.416
Paw lifting	0.03 ± 0.03	*P*=0.862
Yawning	0.02 ± 0.03	*P*=0.084
Stretching	0.01 ± 0.01	*P*=0.700
Tongue flicking	0.84 ± 0.12	*P*=0.003
Shaking	0.03 ± 0.02	*P*=0.339
Sniffing	0.08 ± 0.03	*P*=0.313
Barking	0.01 ± 0.30	*P*=0.211
Whining	0.22 ± 0.65	*P*<0.001
Jumping	0.16 ± 0.09	*P*<0.001
Growling	0.00 ± 0.10	*P*=0.003
Avoid stranger	0.00 ± 0.00	*P*=0.013
Avoid owner	0.00 ± 0.00	*P*<0.001
Looking away from stranger	0.05 ± 0.02	*P*<0.001
Shake	0.13 ± 0.03	*P*<0.001
Soliciting attention	0.25 ± 0.10	*P*<0.001
Pulling leash	0.13 ± 0.14	*P*<0.001
rooming	0.05 ± 0.03	*P*=0.176
Sniffing environment	7.71 ± 0.22	*P*<0.001
Tail wagging	3.67 ± 0.52	*P*<0.001

4.1.1 Separation behaviour

Dogs in isolation showed high levels of whining, staring at the door, being near the chair of the owner and being inactive. Dogs whined (p <0.001) more when they were alone (EP5=4.7±0.6^{A}) than during any other episode. Otherwise, they whined the most when alone with the stranger (EP3=3.1±0.6^{B} and EP6=3.0±0.6^{BC}) and the least when the owner was present (EP2=1.7±0.6^{CD} to EP0=0.2±0.6^{E}). Staring at the door (p <0.001) was expressed the most when dogs were alone (EP5=47.1±3.0%^{A}), the second most when only the stranger was present (EP3=33.4±3.0%^{B} and EP6=31.8±3.0%^{B}) and the least when the owner was present (EP4=3.0±3.0%^{C} to EP0=0.3±3.0%^{C}). Dogs spent more time near the chair of the owner (p <0.001) when the owner was absent (EP3=44.7±4.9%^{A}, EP5=53.9±4.9%^{A} and EP6=49.2±4.9%^{A}) than when the owner was present (EP4=7.0±4.9%^{B} to EP0/EP1=0±4.9%^{B}). Dogs moved (p <0.001) the least when the owner was absent (EP3=13.7±3.4%^{E}, EP5=10.8±3.4%^{E} and EP6=12.1±3.4^{E}), as compared to 66.3%±3.4^{A} in EP0. Consequently, stationary behaviours (sitting, lying, standing, all p <0.001) occurred most during separation episodes.

4.1.2 Reunion behaviour

During reunions with their owners in episodes 4 and 7, dogs showed high levels of tail wagging, jumping, staring at their owner and social play with their owner. Likewise, avoiding the owner, non-social play, body shake and growling were expressed most frequently during reunion episodes. The level of tail wagging (p <0.001) was highest during owner reunions (EP4=6.2±0.5^{A} and EP7=7.0±0.5^{A}), and the second highest when dogs were with their owners in non-reunion episodes (EP0=3.7±0.5^{B}, EP1=3.9±0.5^{B} and EP2=4.2±0.5^{B}). Tail wagging was rare when only the stranger was present (EP3 and EP6, both 2.5±0.5^{C}) and occurred the least when the dog was alone (EP5=0.4±0.5^{D}). Jumping (p <0.001) occurred the most during reunion episodes (EP4=0.4±0.1^{A} and EP7=0.5±0.1^{A}) compared to other episodes (EP0=0.2±0.1^{BC} to EP 0.012±0.1^{C}). Dogs stared at their owners (p <0.001) the most during reunions (EP4=34.0±2.6%^{A} and EP7=32.1±2.6%^{A}), the second most during the exploratory episodes with the owner (EP0=28±2.6%^{B} and EP1=20.5±2.6%^{B}) and the least when both the owner and stranger were present (EP2=11.4±2.6%^{C}). Social play with the owner (p <0.001) was highest during the second reunion episode (EP7=34.2±3.2%^{A}), compared with the first reunion episode (EP4=27.5±3.2%^{B}). Non-social play (p <0.001) was highest during the reunion episodes as well (EP4=1.6±0.5%^{A} and EP7=2.1±0.5%^{A}), compared to all other episodes (EP2=0.3±0.5%^{B} to EP0/EP5=0±0.5%^{B}). Avoiding the owner (p <0.001) was significantly higher during the first reunion episode (EP4=0.07±0.02^{A}) than in all other episodes (EP7=0.03±0.02^{B} and 0±0.02^{B} in all non-reunion episodes). Dogs also expressed shake (p <0.001) most during reunions and the exploratory episode (EP0=0.13±0.04^{A}, EP4=0.17±0.04^{A} and EP7=0.15±0.04^{A}), compared to other episodes (EP1=0.05±0.04^{BC} to EP6=0±0.04^{C}). Growling (p=0.003) was highest during reunion episodes and the first separation episode when the dog remained with the stranger (EP3=0.16±0.09^{AB}, EP4=0.17±0.09^{AB} and EP7=0.31±0.09^{A}), but only the second reunion episode differed significantly from the other episodes (EP2=0.0270±09^{B} to EP0/EP1/EP5/EP6=0009^{B}).

4.1.3 Behaviour during exploration and presence of the stranger

In the presence of the owner, dogs expressed the highest levels of staring at the stranger, spending time near the stranger, and the lowest levels of looking away from the stranger, although social play with the stranger was not influenced by the presence of the owner. During exploration (EP0), dogs moved the most and spent the least time near the owner. Dogs stared the most at the stranger (p<0.001) when their owner was present and when the stranger entered after the dogs had been alone (EP2=28.4±1.8%^{A} and EP6=26.6±1.8%^{A}), and the least after the owner left the dog with the stranger (EP3=17.2±1.8%^{B}). Dogs looked away from the stranger (p <0.001) more when they were alone with the stranger for the first time (EP3=0.2±0.1^{A}), compared to when both owner and stranger are present (EP2=0.04±0.1^{B}). There was no difference in avoiding the stranger when the owner was absent or present. Dogs spent the most time near the stranger (p <0.001) when the owner was also present (EP2= 32.6±3.6%^{A}), and the least when the dog was alone with the stranger (EP3=25.8±3.6%^{AB} and EP6=24.5±3.6%^{B}). Dogs were the most near their owner (p <0.001) during reunion episodes and when

the owner sat on a chair without the stranger present (EP1=78.7±3.9%^{A}, EP4=73.1±3.9%^{A} and EP7=80.3±3.9%^{A}). Dogs spent less time near their owner when the stranger was also present (EP2=48.9±3.9%^{B}), and were the least near the owner during exploration off leash (EP0=32.4±3.9%^{C}). Social play with the stranger did not differ significantly when the owner was present or absent. Sniffing the environment (p <0.001) decreased over time, as it was displayed most in EP0 (7.7±0.3^{A}), the second most in EP1 (2.4±0.3^{B}), even less in EP2 (1.4±0.3^{C}) and barely in all other episodes (EP3=0.5±0.3^{D} to EP6=0.3±0.3^{D}).

4.2 Associations between expressed behaviours during the SST

Based on differences in the dogs' behaviours across the SST episodes, a total of 28 behavioural parameters were identified and tested for associations using Principal Components Analysis (PCA) on 49 records (see appendix 8.3). The number of behavioural parameters were reduced stepwise by omitting those that did not fit in the main components, resulting in a final analysis on 8 behavioural parameters (see Table 3). The first behavioural component indicated "outgoing" behaviour during the SST, and explained 31.8% of the variation. It grouped "tail wagging during owner reunions and when alone with stranger" (loading of 0.64), "being near stranger" (0.73), "social play stranger" (0.70) and, inversely, "being near owner chair when owner was absent" (-0.72) and "being near owner when both stranger and owner were present" (-0.69). High positive component scores reflected an outgoing style of engaging with the stranger. The second behavioural component indicated "staring" behaviour and explained 23.7% of the variation. This component consisted of "staring at the door when the owner was absent" (-0.55), "staring at owner during reunions" (-0.86) and "staring at stranger" (-0.71). High positive component scores identified dogs who stared above average at the door, owner and stranger. Details on components scores per dog can be found in appendix 8.4.

Table 3: Dogs (n=49) were tested for attachment to their owner in a Strange Situation Test that was constructed of 8 episodes. Presented is the loadings pattern of 8 behavioural parameters, calculated across Strange Situation Test episodes, determined with a Principal Component Analysis. Significant loadings (above 0.5 or below -0.5) are indicated with an asterisk. Percentage of variation explained by the first 3 main components are indicated in the first row.

Behaviour	Component 1 (31.8%) "Outgoing"	Component 2 (23.7%) "Staring"	Component 3 (12.0%)
Tail wagging mean episode 3, 4, 6, 7	* 0.64	-0.16	-0.46
Near stranger mean episode 2, 3, 6	* 0.73	0.36	-0.07
Social play stranger mean episode 2, 3, 6	* 0.70	0.35	-0.21
Near owner chair mean episode 3, 5, 6	* -0.72	0.27	-0.03
Near owner episode 2	* -0.69	0.00	-0.37
Staring at door mean episode 3, 5, 6	-0.17	* -0.55	* -0.66
Staring at owner mean episode 4, 7	0.13	* -0.86	0.08
Staring at stranger mean episode 2, 3, 6	0.27	* -0.71	0.36

4.3 Dog-directed parenting styles

Dog owners reported on the way they parented their dogs in daily life by filling out an online questionnaire. The 49 participating owners had a mean dog-directed parenting score of 83.7±10.9% for authoritative-training oriented, 64.7±18.1% for authoritative-intrinsic value oriented, and 26.6±17.7% for authoritarian parenting. A total of 20 parameters, including the 2 aforementioned principal components, 16 behavioural SST parameters and 2 owner-reported scores for dog attachment and separation related distress obtained from C-BARQ, were tested for associations with dog-directed parenting style scores (n=49) using an ANOVA. A complete overview of p-values for the associations between the analysed behaviours and behavioural components and dog-directed parenting styles, and estimated means for these parameters and components, can be found in

appendix 8.5. In the following, predicted means (± s.e.) are presented as rate per minute, but for percentages of the observation time.

ANOVA analyses with parenting style scores as independent variables, including two-way interactions were ran to evaluate the dogs' SST behaviours. Interactions between authoritarian and authoritative-training oriented dog-directed parenting affected whining when separated from the owner (mean 4.3±1.0 when the dog was alone and 2.9±0.8 when the dog was alone with the stranger), jumping during reunions (0.5±0.1) and avoiding the owner during reunions (0.1±0.02). Strong authoritarian parenting in combination with weak training oriented dog-directed parenting associated with dogs that whined a lot during separation from the owner (p=0.084 for EP5 and p=0.012 for EP3,6), showed avoidance of the owner (p=0.018 for EP4,7) and little jumping (p=0.004 for EP4,7) during reunions. For the behaviours whining and avoiding these interactions are illustrated by figure 2.A and 2.B.

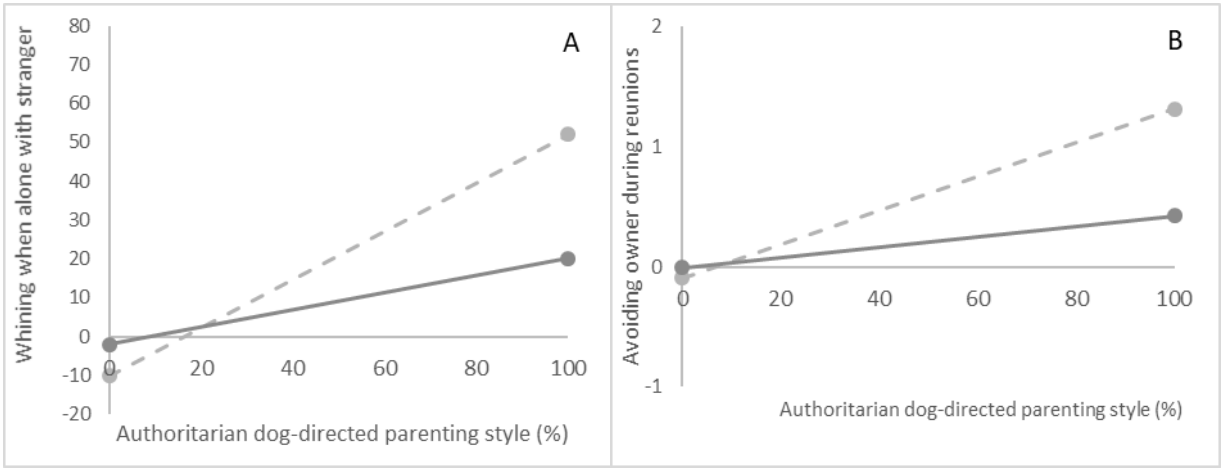

Figure 2: Dog-directed parenting styles (n=49) were tested for associations with 20 behavioural parameters. Presented are the associations between the interaction of authoritarian and training-oriented dog-directed parenting and whining when the dog is alone with the stranger (ANOVA p=0.012) in figure 2.A, and avoiding the owner during reunions (ANOVA p=0.018) in figure 2.B. Authoritarian parenting is expressed from 0 to 100% on the X-axis, and the interactions with 30% and 70% authoritative-training oriented parenting are shown respectively with the dashed and solid lines.

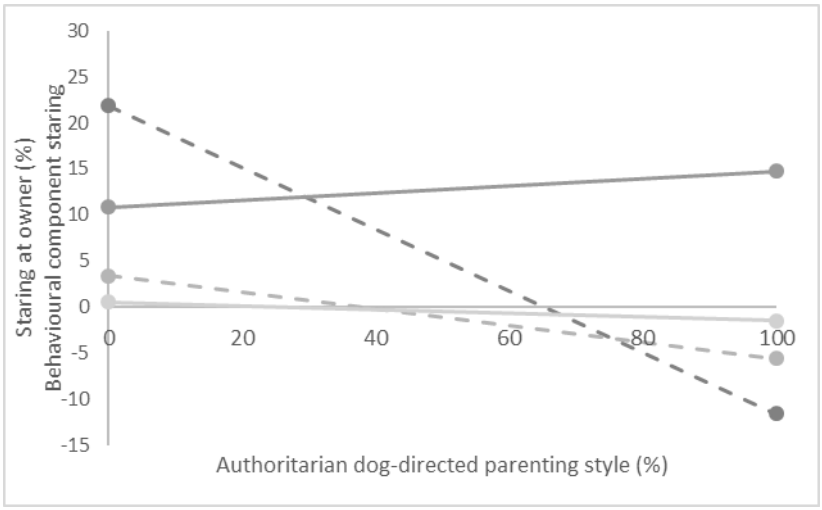

Figure 3: Dog-directed parenting styles (n=49) were tested for associations with 20 behavioural parameters. Presented are the associations between the interaction of authoritarian and intrinsic-value oriented dog-directed parenting styles and staring at the owner when the stranger is present in percentage of observation time (ANOVA p=0.012) with the dark lines and the principal component of staring at the door, owner and stranger (ANOVA p=0.001) with the light lines. Authoritarian parenting is expressed from 0 to 100% on the X-axis, and the interactions with 30% and 70% authoritative-intrinsic value oriented parenting are shown respectively with the dashed and solid lines.

Interactions between authoritarian and authoritative-intrinsic value oriented dog-directed parenting explained variation in staring at the owner when both owner and stranger were present (mean 12.0±1.2%) and the principal component of staring behaviour (0.1±0.2). When the owner had a strong authoritarian dog-directed parenting style and a weak intrinsic value oriented one, dogs stared little at their owner when the stranger was present (p=0.012), at the owner during reunions, at the door when the owner was absent and at the stranger (behavioural component staring, p=0.001). These associations are shown in figure 3.

Authoritarian dog-directed parenting (p=0.072) showed a tendency towards explaining variation in the principal component score for outgoing behaviour towards strangers (0.01±0.2). When authoritarian parenting increased from 30% to 70%, the component score for outgoing behaviour towards the stranger decreased from -0.08±0.25 to -1.07±0.66.

Owner-report based scores for problem behaviour in the dogs were analysed for effects of the three parenting style scores for only 43 records due to missing reports. The mean C-BARQ score for separation related distress was 5.3±8.8%. Dog-directed parenting styles associated with separation related distress, as a significant effect for the intrinsic value oriented (p=0.044) and statistical trends for the authoritarian (p=0.072) and training oriented (p=0.086) dog-directed parenting styles were found. Both a strong intrinsic value oriented and authoritarian style are associated with a high owner-reported separation related distress score, while a strong training oriented style associated with low owner-reported separation related distress, as shown in figure 4.

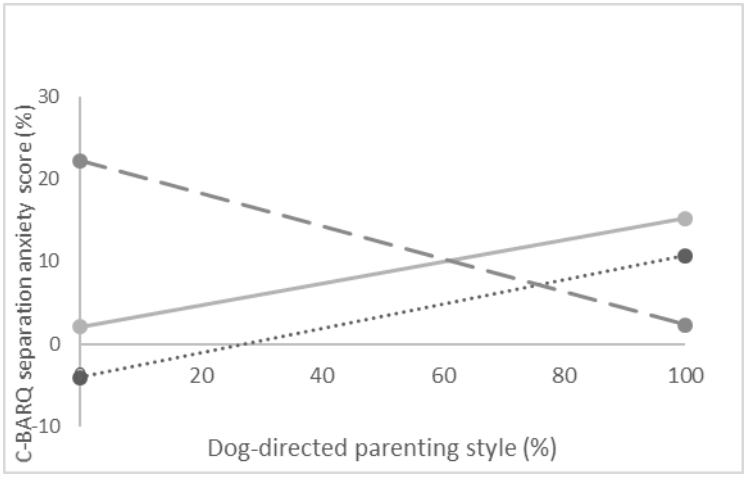

Figure 4: Dog-directed parenting styles were tested for associations with 20 behavioural parameters. Presented are the associations between the three dog-directed parenting styles and owner-report based scores for separation related distress (n=43) (ANOVA, authoritative-intrinsic value oriented p=0.044, authoritative-training oriented p=0.086 and authoritarian p=0.072). The level of dog-directed parenting is expressed from 0 to 100% on the X-axis, and the different parenting styles are expressed with a solid line (authoritarian), dashed line (authoritative-training oriented) and a dotted line (authoritative-intrinsic value oriented).

The heart rate of 12 dogs was determined during the STT. The mean heart rate during the test over all dogs was 113±28 beats per minute (BPM). A significant association between the authoritative-intrinsic value oriented dog-directed parenting style and the mean heart rate during the SST was found (ANOVA p=0.028). The mean heart rate decreased from 128.8±16.0 to 105.6±9.9 BPM over the range of 30% to 70% for authoritative-intrinsic value oriented parenting.

4.4 Adult attachment style

Dog owners reported on their adult attachment style towards other people by filling out an online questionnaire. The 43 owners that filled in the Experiences in Close Relationships Scale (ECR) questionnaire (Brennan *et al.,* 1998), had mean scores of 45%±18% for the "avoidant" and 43%±19% for "anxious" dimensions of adult attachment. Again the 2 principal components, 16 behavioural SST parameters and 2 owner-reported scores for dog attachment and separation related distress obtained from C-BARQ, were tested for associations with adult attachment scores for anxiousness and avoidance on 43 records using an ANOVA. All associations of these dimensions with the analysed behaviours, behavioural components and owner reported parameters are described in detail in appendix 8.6. In the following, predicted means (± s.e.) are presented as rate per minute, but for scores expressed as percentage of the observation time.

The dimension anxiousness of the owners' adult attachment explained variation in the scores for owner-reported dog-to-owner attachment (mean 53.9±3.4%) and the behavioural component staring (-0.1±0.2). The more anxious an owner reported to be, the higher the self-reported attachment of his dog was (p=0.043), with an increase from 48.3±4.2% to 64.9±6.1% of the maximum score over a range of 30% to 70% anxiousness. The same strong anxiousness associated with dogs that stared little at the owner during reunions, at the door during separation from the owner and at the stranger (behavioural component staring, p=0.032). Over a range of 30% to 70% of anxiousness, the component score for staring behaviour decreased from 0.2±0.2 to -0.8±0.4.

Both the anxious and avoidant dimensions of the adult attachment style associated with the amount of whining when the owner is absent (4.8±1.04 when the dogs were alone, and 3.1±0.9 when dogs were alone with the stranger) and showed a trend towards affecting avoidance of the owner during reunions (0.1±0.02), without interacting with each other. During separation, dogs whined more when the owner has a more anxious attachment style (p=0.035) and a tendency towards less whining was found when the owner is avoidant (p=0.063). Dogs whined less when they were alone with the stranger, when the owner has a more avoidant attachment style (p=0.015), as shown in figure 5.

During reunions with the owner, trends were found towards more avoiding the owner when the owner is anxious (p=0.055), increasing from 0.02±0.03 to 0.12±0.04 over a range of 30% to 70% for anxious attachment, and little avoidance when the owner is avoidant (p=0.054), decreasing from 0.09±0.03 to -0.01±0.05 over a range of 30% to 70% for avoidant attachment.

Finally, the interaction between the anxious and avoidant dimensions showed a tendency towards explaining variation in the principal component of outgoing behaviour towards strangers (-0.04±0.3), allowing for an interpretation of the effect of the adult attachment styles "secure" (low in both dimensions), "anxious" (high in only the anxious dimension), and "avoidant" (high in only the avoidant dimension). Dogs tended to be the most outgoing in their behaviour (p=0.068) when their owner had an secure attachment style, and owners with an anxious or avoidant style tended to have dogs that showed less outgoing behaviour, as shown in figure 6.

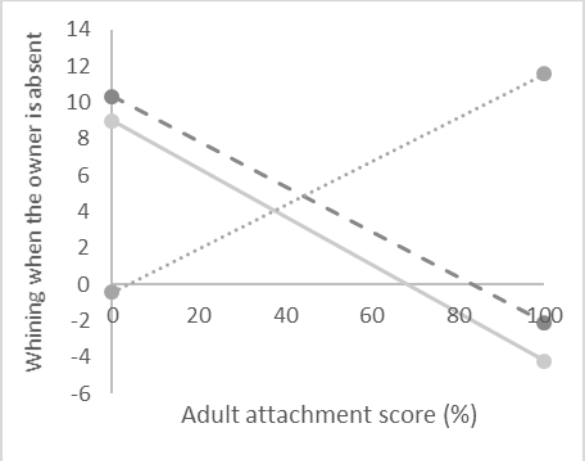

Figure 5: Dimensions of the owners' adult attachment style (n=43) were tested for associations with 20 behavioural parameters. Presented are the associations between the owner-reported avoidant and anxious dimension of adult attachment and the dogs' whining when separated from the owner. The level of adult attachment style dimensions is expressed from 0 tot 100% on the X-axis, and the found associations are represented with a solid line (avoidant, with stranger, ANOVA p = *0.015), a dashed line (avoidant, alone, ANOVA* p=*0.063) and a dotted line (anxious, alone,* p=*0.035).*

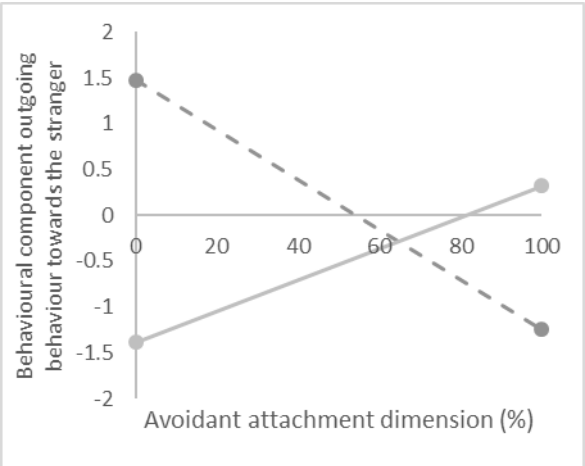

Figure 6: Dimensions of the owners' adult attachment style (n=43) were tested for associations with 20 behavioural parameters. Presented is the association between the interaction of the anxious and avoidant dimensions of owner-reported adult attachment and the dog's behavioural component score for outgoing behaviour towards the stranger (ANOVA, p=*0.068). Avoidant attachment score is expressed from 0 to 100% on the X-axis, and the interactions with 30% and 70% anxious attachment are shown respectively with the dashed and solid line.*

5. Discussion

Dog-to-owner attachment shares similarities with child-to-parent attachment, and Strange Situation Test (SST) protocols are commonly used to measure attachment in both children and dogs. Here, SST procedures on 49 privately owned dogs were performed with the aim to test associations between dog-to-owner attachment and dog-directed parenting styles. Parenting styles supposedly affect attachment bonds children have with their caretakers (Ainsworth *et al.,* 1978), and parenting styles have been reported to exist also in the owner-dog relationship (van Herwijnen *et al.,* 2018). The attachment system was successfully activated during the STT in the tested dogs, as shown by proximity seeking behaviours and several behaviours indicative of secure base effects. Reunion behaviour in the dogs, after having been separated from the owner, may be the most revealing of attachment type. Authoritarian dog-directed parenting related inversely with the test dogs staring at the door, owner and stranger and related directly with whining during separation and avoidance of the owner during reunions. This suggests an insecure attachment style in dogs of authoritarian owners. Interestingly, authoritative – intrinsic value oriented dog-directed parenting related directly to owner-reported separation related distress that dogs expressed in daily life. Apparently, dog-directed parenting styles have consequences for a dog's attachment to its owner and the problem behaviours that associate with it. With respect to secure dog-to-owner attachment, the authoritative-training oriented style seems the preferred dog-directed parenting style.

How to best assess dog-to-owner attachment from SST behaviour is subject of ongoing investigation and in the current study candidate indicators of attachment are identified from a total of 392 records on 49 dogs that were analysed with linear mixed models for effects of the 8 SST episodes, which varied in the presence of owner and stranger. Attachment theory assumes that attached individuals want to be close to their attachment figure (Bowlby, 1958), which can be observed as proximity seeking and separation distress. Proximity seeking when separated from the owner was mainly expressed in the current study by an increase in whining, spending time near the chair of the owner and staring at the door. Whining and staring at the door were expressed less when the stranger was with the dog compared to when the dog was alone, but still significantly more than when the owner was present. Dogs moved around the experimental room minimally in absence of the owner. These findings are in line with literature, where proximity seeking in dogs during the SST is previously described as approaching, being oriented towards and following the attachment figure, while in absence of the owner vocalising and searching, like scratching the door, orienting towards the door and the attachment figure's chair, are displayed (Prato-Previde *et al.,* 2003). Dogs make a clear distinction between the attachment figure and a stranger, as proximity seeking is displayed more towards the owner (Fallani *et al.,* 2006; Prato-Previde *et al.,* 2003; Rehn *et al.,* 2013; Topál *et al.,* 1998). It is important to note that proximity seeking behaviour may be subject to training, as guide dogs display these behaviours less than companion dogs even though their heart rate suggests activation of the attachment system (Fallani *et al.,* 2006).

Secure base effects and safe haven effects may not be recorded properly in dogs using a common SST design, as order effects influence exploratory behaviour, the motivation to play varies between dogs, and well-socialized dogs may not at all be wary of the stranger. The dog's behaviour during reunions with the owner may be a more appropriate feature of the SST to determine attachment type. A secure base effect constitutes that the presence of the attachment figure gives the attached individual the confidence to explore the environment (Cassidy, 1999). In the presence of the owner, dogs from the current study looked away from the stranger less than in the owner's absence. Dogs spent more time staring at the stranger and being near the stranger when the owner was present or when the owner had left the dog with the stranger, as compared to when the stranger entered the test room after the dog had been alone. In contrast, no effect of the presence of the owner on social play with the stranger was found. Though, both the time spent in social play with the owner and non-social play in the owner's presence was much higher compared to time spent in social play with the stranger. Dogs stared at their owner the least when both the owner and stranger were present, and

they spent the least time near their owner when they were exploring the novel environment off leash. Studies using the SST in dogs generally use exploration and play behaviour as indicators of a secure base effect of the owner (Mariti *et al.,* 2013; Palmer & Custance, 2008; Prato-Previde *et al.,* 2003). Even though play behaviour is expressed more in the presence of the attachment figure (Palestrini *et al,* 2005; Palmer & Custance, 2008), the amount of play and the effect of the attachment figure on the dog's play behaviour shown during the SST may be dependent on the age and previous experiences of the dog (Rehn *et al.,* 2013; Velsecchi *et al.,* 2010). Play behaviour needs to be displayed at a level high enough to determine a difference in play behaviour with and without the attachment figure present (Pamer & Custance, 2008; Rehn *et al.,* 2013). Moreover, in the SST order effects distort the effect of the attachment figure's presence on exploration behaviour, as exploration behaviour decreases during the test (Fallani *et al.,* 2006; Palestrini *et al.,* 2005; Palmer & Custance, 2008; Prato-Previde *et al.,* 2003). This order effect showed in this study as decreased sniffing of the environment in subsequent episodes. In laboratory dogs, there was no difference in exploratory behaviour upon entering the novel room where the SST took place when they were accompanied by a known handler or a stranger (Rehn *et al.,* 2013). However, companion dogs did show more exploratory behaviour and non-social play in the presence of the owner in a counterbalanced version of the SST (Palmer & Custance, 2008). In this counterbalanced SST, dogs were randomly placed in one of two conditions in which the order of the presence of the owner and stranger were opposite to each other. After dogs had been left alone in the test room, exploration increased in the presence of the stranger as well as in the presence of the owner, suggesting an ameliorative effect of human presence in general on exploration (Palmer & Custance, 2008). The SST design used in the current study was not counterbalanced, and effects of owner presence cannot be entangled from those of habituation. In the current study many behaviours directed towards the stranger, such as staring, looking away, and being near were significantly influenced by the presence of the owner. It cannot be ruled out that the differences between expressed behaviours with and without the owner present are due to novelty of the stranger when she first entered with the owner present and a reduced interest hereafter. Nevertheless, these observations in relation to the stranger may provide useful additional tools to investigate a secure base effect in a counterbalanced SST design. Future research could also include gaze shifting between the owner and a stressor (e.g. stranger) in order to detect secure attachment in dogs, as securely attached children have a higher attention flexibility than insecurely attached children (Rehn *et al.,* 2017). However, dogs and infants do react differently to a stranger entering during the SST. Whereas infants return to their mother's side or look at their mother, well socialized dogs generally greet the stranger or continue with their activities, suggesting less stranger wariness in socialized dogs than in most infants (Palmer & Custance, 2008).

The safe haven effect means that proximity to the attachment figure reduces the attached individual's fear (Cassidy, 1999). Given that the SST does not seem to induce the stranger related fear in dogs that has been reported for infants, there is only indirect support that the owner gives the dog a sense of security (Palmer & Custance, 2008; Prato-Previde *et al.,* 2003). Direct support of a safe haven effect in dogs is shown by a decrease in cortisol levels due to stress associated with a novel environment by the presence of a familiar human (Tuber *et al.,* 1996), and the presence of the owner having an ameliorative effect on the increase in heart rate and decrease in heart rate variability when dogs are approached by a stranger in a threatening way (Gasci *et al.,* 2013). In future research, the use of tests other than the SST should also be considered, as secure base and safe haven effects can be more easily interpreted in tests involving challenging or novel situations, specifically designed to measure these effects.

Reunion behaviour towards the owner, as measured during a SST, may be especially indicative of attachment type. Dogs displayed contradictory behaviours during the reunions with the owner, which fits attachment theory in that avoidant or resistant behaviours during reunions reflect insecure attachment styles (Rehn & Keeling, 2016). During the reunions with the owners, dogs were excited as illustrated by high levels of jumping and tail wagging. Over different SST studies in dogs, reunion behaviour is consistently more intense during reunion with the owner compared to the stranger

(Prato-Previde *et al.,* 2003, Topál *et al.,* 1998). The dogs also expressed body shake most during reunions and during the first exploration episode. In this context shake seems a tension releaser, which indicates that some dogs may have experienced conflict prior to reunions. During reunions dogs stared at their owners the most, although dogs also avoided their owner the most during the first reunion. Reunions were furthermore characterized by relatively high levels of social play and non-social play. Frequent growling during reunions and the first episode alone with the stranger, is probably due to the fact that in these episodes play was elicited. Especially during "tug-of-war" playing dogs growled without displaying signs of aggression. In children, reunion behaviours are used to identify the attachment style of the attached individual (Ainsworth *et al.,* 1978; Marinelli *et al.,* 2007; Rehn *et al.,* 2013, Rehn & Keeling, 2016). Securely attached children protest departure and actively greet their caregiver upon return, whereas insecurely attached children either show lots of distress during departure and reluctance upon reunion or display very little reaction to both events (see Table 4).

Table 4: Relations between attachment style, caregiving style, parenting style and possible owner attachment styles (adapted from Rehn & Keeling, 2016[a]; Ebrahimi et al., 2017[b]; Siniscalchi et al., 2013[c]; Doinita & Maria, 2015[d])

Attachment style (child)	**SST attachment behaviour (child)** [a]	**Caregiving style** [a]	**Parenting style** [b]	**Suggested owner/parent attachment style** [cd]
Secure	Protest departure of attachment figure, active greeting upon reunion, flexible attention to threat and play	Sensitive and responsive to signals and needs	Authoritative	Confident
Insecure avoidant	Shows little distress during departure, little response upon reunion, attention is shifted away from attachment figure and threat	Little response and discouragement to distress, encourages independence	Authoritarian	Non-confident
Insecure ambivalent/ resistant	Distressed during departure attachment figure, reluctance upon reunion, shows either angry resistance upon contact or clinging behaviour, attention is mainly on attachment figure	Responsiveness is inconsistent between neglect and comfort giving	Permissive	Non-confident
Disorganized	No clear behavioural pattern, contradictory behaviour, does not approach attachment figure upon reunion, unable to focus attention on both environment and attachment figure	Behaviour that is frightening, intrusive or abusive, withdrawal	Uninvolved	-

Attachment theory discriminates the main attachment types "secure", "avoidant" or "ambivalent", apart from "disorganized" in situations of child neglect. Such dimensions could not be identified from the behaviours that dogs showed during the SST, as tested by a principal components analysis (n=49) on 28 behavioural parameters that were constructed of behaviours across SST episodes. Rather, behavioural components indicating outgoing behaviour towards strangers and staring at the door, owner and stranger were found. Previously, behavioural components indicating a dog's "anxiety", "acceptance of the presence of the stranger" and "attachment" during the SST were found (Topál *et al.,* 1998). Acceptance of the presence of the stranger was defined by long lasting physical contact with the stranger and a high level of contact seeking towards the stranger upon entering (Topál *et al.,* 1998). The current component of outgoing behaviour towards strangers includes spending time near the stranger and in social play with the stranger, indicating similarities between these components. As the behaviours directed towards the stranger are not dependent on the presence of the owner, the component indicating outgoing behaviour towards the stranger cannot be interpreted as an indicator of a secure base effect. Since well-socialized dogs are less wary of the stranger than most infants are during the SST (Palmer & Custance, 2008), remaining in the test room with the stranger might not stress well-socialized dogs enough to activate the attachment system and display secure base effects in relation to contact with the stranger. Training may also influence outgoing behaviour towards strangers. In guide dogs, the amount of training explained differences in behaviour towards a stranger during the SST, when the same dogs were tested as a pre-training custody dog and as a year-post-training guide dog (Fallani *et al.,* 2007). Therefore, outgoing behaviour

towards the stranger may not be an appropriate indicator of dog-to-owner attachment. This in contrast to the PCA component indicating staring behaviours, as it includes both a proximity seeking and a reunion behaviour. Little staring at the door in absence of the owner, little staring at the owner during reunions combined with little staring at the stranger suggests an either an insecure avoidant or ambivalent attachment style.

Attachment behaviour of the attached, and the caregiver's adult attachment style and parenting style are related to each other (Rehn & Keeling, 2016). The attachment style of an infant is adjusted to the caregiving style of its parent. Later in life, attachment styles are transferred to new relationships as adult attachment styles, and adult attachment styles may influence several aspects of human social behaviour, among which caregiving and parenting (Main, 2000; Rehn & Keeling, 2016). Questionnaires on attachment styles, responsive caregiving towards the partner and parenting styles from 125 couples with children of 7-8 years old showed that responsive caregiving links attachment and parenting. Responsive caregiving to the partner was negatively associated with attachment avoidance, attachment anxiety, authoritarian and permissive parenting styles, whereas it was positively associated with authoritative parenting (Millings *et al.,* 2013). In addition, records on 74 parents with children of 4-8 years of age who filled out the Adult Attachment Questionnaires and Parental Styles Questionnaires, showed a significant correlation between a secure adult attachment style and authoritative parenting (Doinita & Maria, 2015). Therefore, adult attachment style of dog owners was expected to be related to both dog-directed parenting and dog-to-owner attachment. Indeed, both dog-directed parenting styles and adult attachment dimensions, modelled as independent variables in two separate ANOVA's (n=49), associated with indicators of attachment as observed in the SST. ANOVA revealed interaction effects of dog-directed parenting styles on how dogs behaved during SST. Strong authoritarian dog-directed parenting is directly related to the dogs' whining during separation from the owner and avoidance of the owner during reunions, and indirectly related to staring behaviour (i.e. at the owner, door and stranger) and outgoing behaviour towards strangers. Authoritative-intrinsic value oriented parenting is related directly to separation related distress, inversely related to mean heart rate during the SST in dogs and increases staring behaviour in dogs from authoritarian owners. Authoritative-training oriented parenting is related to lower levels of whining and avoidance in dogs from authoritarian owners. The opposite relationships of authoritarian and authoritative parenting styles with the dog's whining, avoidance and staring behaviours during separation and reunions, suggest these behaviours may not only be indicative of attachment, but also of attachment style, provided that attachment styles of children are affected by parenting styles. In addition, the anxious dimension of adult attachment related directly to whining in absence of the owner and avoidance of the owner during reunions, and related inversely to staring behaviour. Outgoing behaviour towards strangers seems to be highest in dogs from owners with a secure adult attachment style and lowest in dogs from owners with anxious or avoidant styles.

Taking into account the findings from both this study and previous literature, the strongest indicators of attachment style are whining during separation, avoidance of the owner during reunions and staring behaviour. Both whining when separated from the owner and avoiding the owner upon return fit well with the separation distress and possible resistance upon reunion that define the insecure ambivalent attachment style. However, avoiding the owner would also fit an avoidant attachment style. The direct relationship with authoritarian parenting, inverse relationship with authoritative-training oriented parenting, and the fact that the levels of both behaviours associate positively with the caregiver's anxious dimension of attachment, supports the assumption that high levels of whining during separation and avoidance during reunions indicate an insecure attachment style. These findings are not standalone, as an increase in vocalizing during separation and a less intense greeting towards the owner during reunion in dogs from owners with a non-confident attachment style towards other people has been described previously (Siniscalchi *et al.*, 2013). Staring behaviour contains elements of proximity seeking (staring at the door during separation), reunion behaviour (staring at the owner during reunion) and attention towards a possible stressor (staring at the stranger). Displaying little of the combination of these behaviours could fit both insecure avoidant

and ambivalent attachment style, while displaying these behaviours in higher levels resembles secure attachment in children. As staring behaviour is inversely related to authoritarian parenting and anxious adult attachment of the owner, and directly related to authoritative-intrinsic value oriented parenting, the amount of displayed staring behaviour indeed seems to enable differentiation between securely and insecurely attached dogs. Secure attachment in dogs is expected to associate with an authoritative dog-directed parenting style and owners with a secure adult attachment style (Table 4). There was some evidence for this, assuming that securely attached dogs actively engage in social interactions with strangers. In contrast, a previous study found that dogs from owners with a non-confident attachment style towards other people explored more, especially in presence of the stranger, and played more with the stranger in absence of the owner (Siniscalchi *et al.*, 2013). The inconsistence in these findings supports that outgoing behaviour towards the stranger may be an inappropriate attachment indicator.

In children, separation related distress fits an insecure attachment style. Separation related distress score of the dogs (n=43) from owner-reports obtained with the C-BARQ questionnaire associated significantly with the authoritative-intrinsic value oriented dog-directed parenting style and trends were found for the other two dog-directed parenting styles. The more intrinsic value oriented an owner is, the more likely will his dog be to score high on self-reported separation related distress. A statistical trend in the same direction was found for the authoritarian dog-directed parenting style. Separation related distress showed a trend towards decreasing when the training oriented style increased. Previous research found that separation related distress in dogs is higher when the owner scores higher on attachment avoidance on the Adult Attachment Scale (Konok *et al.,* 2015), although this effect was not found in the current study. It was suggested that dog owners may experience separation related distress as affirming of the dog-to-owner attachment bond (McGreevey & Bennet, 2010), and it seems reasonable to assume this statement might more readily apply to owners with an insecure attachment style than secure owners. In addition, a positive association was found between the anxious dimension of adult attachment of the owner and owner-reported dog-to-owner attachment. The questions measuring the attachment score in the C-BARQ questionnaire are not related to expressed behaviour in situations where the attachment system is activated, but acquire information about following, contact seeking and jealousy when the owner is present. Scoring high on the majority of these questions, would suggest clingy and intrusive behaviour of the dog in the presence of the owner. Extreme clinging behaviour disagrees with secure attachment, as securely attached individuals are able to move away from their attachment figure. Therefore, the relationship between an insecure adult attachment style and a high score for the C-BARQ's attachment score seems credible. Also, it is important to note that some owners may not experience an anxious relationship as a disadvantage. In assistance dog owners, a higher anxious attachment to the dog predicted a higher quality of life for the dog owner. In disabled people owning an assistance dog, anxious attachment may be inherent to the awareness of the benefits of independence derived from the assistance dog (White *et al.,* 2017), although it is also plausible that an anxious adult attachment style leads to higher "attachment-like" behaviour from the dog such as following and contact seeking, making the relationship more affirming for the owner.

Finally, observed behaviour during the SST may be combined with physiological parameters, such as cardiovascular responses, to improve the reading of the dog's reactions (Fallani *et al.,* 2006; Gácsi *et al.,* 2013; Palestrini *et al.,* 2005; Valsecchi *et al.,* 2010). In the current study, the predicted mean heart rate (n=12) during the SST of the dog was related inversely to authoritative-intrinsic value oriented dog-directed parenting. Previous research showed that mean heart rate during SST episodes is higher in episodes characterized by a high level of physical activity (Palestrini *et al.,* 2005). Even though during separation of the owner dogs showed little physical activity, heart rate remained above baseline, likely due to the stress of separation. An increase in heart rate can indicate excitement, but whether the dog is stressed or positively excited cannot be distinguished (Palestrini *et al.,* 2005). As both stress and

activity can increase the mean heart rate, changes in mean heart rate are difficult to interpret (Fallani *et al.,* 2006; Palestrini *et al.,* 2005). In contrast, no effect of the presence of a familiar person was found on the heart rate of laboratory dogs, in which all changes in mean heart rate could be explained by physical activity (Rehn *et al.,* 2013). Therefore, the most likely explanation for a lower mean heart rate during the SST in dogs from authoritative-intrinsic value oriented owners is that these dogs simply moved less, perhaps due to resistant behaviour during reunions in comparison with other dogs. Even though one might expect dogs from intrinsic value oriented owners to be more stressed during separation, as the intrinsic oriented style is related to self-reported separation related distress using C-BARQ, negative psychological states do not necessarily affect heart rate (von Borell *et al.,* 2007; Rehn *et al.,* 2013). Heart rate variability (variations of heart beat intervals) is a more sensitive parameter of stress and emotional states than mean heart rate, as it reflects changes in the sympatho-vagal balance. Even when psychological states do not affect the mean heart rate, changes in heart rate variability may be present (von Borell *et al.,* 2007; Gásci *et al.,* 2013). In future studies, measuring heart rate variability may give additional insights in the emotional states of dogs during testing.

The goals of this study were to identify different attachment styles in dogs and to determine whether the dog-directed parenting style of the owner associates with dog-to-owner attachment. Little staring behaviour, high levels of whining during separation from the owner and avoidance of the owner during reunions are indicative of an insecure dog-to-owner attachment bond. The study population did not allow further differentiation into insecure avoidant and ambivalent attachment styles. Research in a larger sample of dogs and owners, with a normally distributed representation of all parenting and adult attachment styles, is required to really determine whether a differentiation into distinct insecure attachment styles in dogs is appropriate. Authoritative-training oriented dog-directed parenting seems the preferred parenting style for dog owners, as this style related inversely with several behaviours indicative of insecure attachment and separation related distress dogs showed in daily life. Dogs owned by authoritarian owners showed several behaviours indicative of an insecure dog-to-owner attachment style, while the authoritative-intrinsic value oriented dog-directed parenting style related directly to separation related distress in dogs. In future research, analysis of the behaviour of the owner may be included in behavioural tests, as information on the dog-owner behavioural dynamic should give more information on the interplay of adult attachment style, parenting style of the owner, and the dog-to-owner attachment style.

6. Conclusions

A Strange Situation Test is a useful tool to assess behaviours during separation from the owner and reunion with the owner, which are potentially interesting to distinguish between different attachment styles in dogs. In the current study, identified indicators of insecure attachment towards the owner were little staring at the door during separation, owner during reunions or the stranger (principal component of staring behaviour), high levels of whining in absence of the owner, and avoiding the owner during reunions. Authoritarian dog-directed parenting is associated with these behaviours indicative of insecure attachment in dogs, and intrinsic value oriented dog-directed parenting is associated with self-reported separation related distress in dogs. Therefore, the authoritative-training oriented dog-directed parenting style seems the preferred parenting style with respect to secure dog-to-owner attachment.

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8. Appendices

8.1 Ethogram

Behaviour type	Behaviour	Sampling type	Definition
Play	No Play	Continuous sampling	No play was shown
	Non-social play	Continuous sampling	Any energetic behaviour, usually directed toward a toy, when clearly detached from social interaction
	Social play owner	Continuous sampling	Any energetic behaviour performed when interacting with owner, often including a toy
	Petting owner	Continuous sampling	The owner is petting the dog, either while social play occurs or not
	Social play stranger	Continuous sampling	Any energetic behaviour performed when interacting with stranger, often including a toy
Locomotion	Lying	Continuous sampling	Sternum touching ground and hind limbs on either side (bent or stretched out the back) OR side of dog touching the ground fully OR Back of dog touching the ground
	Sitting	Continuous sampling	Front legs straight, rear end lowered, and resting on “hocks” and perineum
	Moving	Continuous sampling	Dog is moving (any direction)
	Standing	Continuous sampling	Upright on all 4 legs, no locomotion
Being near	Owner	Continuous sampling	The dog is near the owner (within 1 meter)
	Owner chair	Continuous sampling	The dog is near the owner’s chair while the owner is not sitting on it (within 1 meter), starting from episode 3
	Stranger	Continuous sampling	The dog is near the stranger (within 1 meter)
	Stranger chair	Continuous sampling	The dog is near the stranger’s chair while the stranger is not sitting on it (within 1 meter), starting from episode 2
	Not being near	Continuous sampling	The dog is not within 1 meter of the owner, stranger or either chair
Staring	No staring	Continuous sampling	No staring at below specified directions is shown
	At stranger	Continuous sampling	Staring fixedly at stranger either in close proximity or from a distance
	At stranger chair	Continuous sampling	Staring fixedly at empty stranger chair
	At owner	Continuous sampling	Staring fixedly at owner either in close proximity or from a distance
	At owner chair	Continuous sampling	Staring fixedly at empty owner chair
	At door	Continuous sampling	Staring fixedly at the door towards the hallway or observation room either in close proximity or from a distance

Behaviour type	Behaviour	Sampling type	Definition
Stress behaviour	Panting	Point sampling	Mouth wide open with tongue protruding, often moving in and out of the mouth
	Freezing	Point sampling	When all movement of the body is stopped
	Paw lifting	Point sampling	A fore paw is lifted into a position of approximately 45°
	Yawning	Point sampling	Inhalation of air and stretching of the eardrums, followed by an exhalation of breath
	Stretching	Point sampling	Extend either forelegs or hind legs and hold for 1-2 s
	Tongue flicking	Point sampling	Part of the tongue is shown and moved along the mouth
	Shaking	Point sampling	Rotation of the body for a prolonged period of time
	Sniffing	Point sampling	Nose to ground/air/object and sides of body moving rapidly in and out
	Sneezing	Point sampling	Expulsion of air from the lungs through the nose and mouth
	Barking	Point sampling	Head and lips forward, mouth opening, and shutting repeatedly while vocalising.
	Urogenital check	Point sampling	Checking urogenital area
	Whining	Point sampling	Soft, high pitched vocalisations
	Yelping	Point sampling	Loud (relative to whining) high pitched vocalisations
	Jumping	Point sampling	Pushing off with and land on hind legs, or land or forelegs
	Growling	Point sampling	Low pitched threatening vocalisations
Events	No event	Point sampling	Any activity not included in the event listing below
	Avoid stranger	Point sampling	Obvious avoidance of interaction with stranger by moving away
	Avoid owner	Point sampling	Obvious avoidance of interaction with owner by moving away
	Looking away from stranger	Point sampling	Obvious avoidance of interaction with stranger by looking away
	Looking away from owner	Point sampling	Obvious avoidance of interaction with owner by looking away
	Shake	Point sampling	Rotation of the body starting at the head and moving caudally, lasting only 1-2 seconds
	Soliciting attention	Point sampling	Approach or accost the owner or stranger
	Pulling leash	Point sampling	Pulling while on leash
	Biting leash	Point sampling	Biting on leash
	Grooming	Point sampling	Behaviours directed towards the subject's own body, like scratching, licking and biting-self
	Aggressive behaviour	Point sampling	Growling, barking, baring teeth, snapping, attacking, either in a high or low posture

	Sniffing environment	Point sampling	Sniffing directed toward physical environment
	Manipulation environment	Point sampling	Playful or stereotyped interactions with elements from the environment
	Tail wagging	Point sampling	Repetitive wagging movements of the tail

8.2 Attachment behaviour

Table 5: Estimated means per behaviour for each episode of the Strange Situation Test

Behaviour type	Behaviour	P-value	Differences between episodes (in mean % of the time)
Play	Non-social play	*P* <0.001	Group A: episode 4 (1.6251%), 7 (2.1296%) Group B: episode 0 (0%), 1 (0%), 2 (0.3393%), 3 (0.1189%), 5 (0%), 6 (0.032%)
	Social play owner	*P* <0.001	Group A: episode 7 (34.211%) Group B: episode 4 (27.479%) Group C: episode 0 (1.878%), 1 (1.767%), 2 (0%), 3 (0.05%), 5 (2.445%), 6 (0.898%)
	Petting owner	*P* <0.001	Group A: episode 4 (22.32%), 7 (25.03%) Group B: episode 1 (17.91%), 4 (22.32%) Group C: 0 (4.42%), 2 (10.05%), 3 (4.08%), 5 (2.04%), 6 (2.04%)
	Social play stranger	*P* <0.001	Group A: episode 2 (6.906%), 3 (7.864%), 6 (5.98%) Group B: episode 0 (0%), 1 (0%), 4 (0.078%), 5 (0%), 7 (0.126%)
Locomotion	Lying	*P* <0.001	Group A: Episode 5 (25.37%), 6 (33.09%) Group B: Episode 2 (13.26%), 3 (15.53%), 4 (7.96%), 7 (11.4%) Group C: Episode 1 (3.58%), 4 (7.96%), 7 (11.4%) Group D: Episode 0 (0.08%), 1 (3.58%), 4 (7.96%)
	Sitting	*P* <0.001	Group A: Episode 3 (13.448%), 4 (8.92%), 5 (14.361%), 6 (11.02%) Group B: Episode 1 (7.725%), 3 (13.448%), 4 (8.92%), 6 (11.02%) Group C: Episode 1 (7.725%), 2 (6.946%), 4 (8.92%), 6 (11.02%), 7 (5.951%) Group D: Episode 0 (2.251%), 1 (7.725%), 2 (6.946%), 7 (5.951%)
	Moving	*P* <0.001	Group A: Episode 0 (66.28%) Group B: Episode 4 (38.04%), 7 (39.73%) Group C: Episode 1 (31.58%), 4 (38.04%) Group D: Episode 1 (31.58%), 2 (26.84%) Group E: Episode 3 (13.66%), 5 (10.77%), 6 (12.12%)
	Standing	*P* <0.001	Group A: Episode 1 (57.12%), 2 (52.96%), 3 (57.36%), 5 (49.5%) Group B: Episode 2 (52.12%), 4 (45.07%), 5 (49.5%) Group C: Episode 4 (45.07%), 5 (49.5%), 6 (43.77%), 7 (42.92%) Group D: Episode 0 (31.39%)
Being near	Owner	*P* <0.001	Group A: Episode 1 (78.69%), 4 (73.14%), 7 (80.28%) Group B: Episode 2 (48.89%) Group C: Episode 0 (32.36%) Group D: Episode 3 (2.04%), 5 (4.92%), 6 (2.19%)
	Owner chair	*P* <0.001	Group A: Episode 3 (44.73%), 5 (53.86%), 6 (49.2%) Group B: Episode 0 (0%), 1 (0%), 2 (1.71%), 4 (6.99%), 7 (4.86%)
	Stranger	*P* <0.001	Group A: Episode 2 (32.64%), 3 (25.84%)

			Group B: Episode 3 (25.84), 6 (24.53%) Group C: Episode 0 (0%), 1 (0%), 4 (2.17%), 5 (0%), 7 (0.36%)
	Stranger chair	*P* <0.001	Group A: Episode 5 (9.339) Group B Episode 0 (0%), 1 (0%), 2 (0.319%), 3 (0.196%), 4 (1.184%), 6 (0.709%), 7 (0.131%)
Staring	At stranger	*P* <0.001	Group A: Episode 2 (28.428%), 6 (26.627%) Group B: Episode 3 (17.198%) Group C: Episode 0 (0%), 1 (0%), 4 (0.341%), 5 (0%), 7 (0.087%)
	At stranger chair	*P* <0.037	Group A: Episode 5 (1.4083%) Group B: Episode 0 (0%), 1 (0%), 2 (0%), 3 (0.0347%), 4 (0.3463%), 6 (0%), 7 (0.0202%)
	At owner	*P* <0.001	Group A: Episode 4 (33.97%), 7 (32.1%) Group B: Episode 0 (28%), 1 (20.49%) Group C: Episode 2 (11.43%) Group D: Episode 3 (0.48%), 5 (0.35%), 6 (0%)
	At owner chair	*P* <0.006	Group A: Episode 2 (0.8248%), 5 (1.832%) Group B: Episode 0 (0%), 1 (0%), 2 (0.0251%), 3 (0.8248%), 4 (0.0023%), 6 (0.5293%), 7 (0%)
	At door	*P* <0.001	Group A: Episode 5 (47.05%) Group B: Episode 3 (33.42%), 6 (31.79%) Group C: Episode 0 (0.32%), 1 (2.21%), 2 (1.85%), 4 (2.95%), 7 (2.51%)
Stress behaviour	Panting	*P*=0.416	-
	Freezing	*P*=0.113	-
	Paw lifting	*P*=0.862	-
	Yawning	*P*=0.084*	Trend towards: Group A: Episode 1 (0.076), 2 (0.118), 4 (0.031), 6 (0.088), 7 (0.061) Group B: Episode 0 (0), 1 (0.076), 3 (0.013), 4 (0.031), 6 (0.088), 7 (0.061) Group C: Episode 0 (0), 1 (0.076), 3 (0.013), 4 (0.031), 5 (-0.01), 7 (0.061)
	Stretching	*P*=0.700	-
	Tongue flicking	***P*=0.003**	Group A: Episode 0 (1.111), 1 (1.022), 4 (1.061), 7 (0.942) Group B: Episode 1 (1.022), 4 (1.061), 5 (0.731), 7 (0.942) Group C: Episode 1 (1.022), 2 (0.667), 5 (0.731), 7 (0.942) Group D: Episode 2 (0.667), 5 (0.731), 6 (0.654), 7 (0.942) Group E: Episode 2 (0.667), 3 (0.525), 5 (0.731), 6 (0.654)
	Shaking	*P*=0.339	-
	Sniffing	*P*=0.313	-
	Sneezing	*P*=0.262	-
	Barking	*P*=0.211	-
	Urogenital check	*P*=0.893	-
	Whining	***P* <0.001**	Group A: Episode 5 (4.653) Group B: Episode 3 (3.059), 6 (2.952) Group C: Episode 2 (1.686), 6 (2.952) Group D: Episode 1 (0.683), 2 (1.686), 4 (0.901), 7 (1.18)

			Group E: Episode 0 (0.223), 1 (0.683), 4 (0.901), 7 (1.18)
	Yelping	0.300	-
	Jumping	***P* <0.001**	Group A: Episode 4 (0.37), 7 (0.498) Group B: Episode 0 (0.159), 4 (0.37) Group C: Episode 0 (0.159), 1 (0.041), 2 (0.12), 3 (0.048), 5 (0.012), 6 (0.111)
	Growling	***P=0.003***	Group A: Episode 3 (0.16), 4 (0.17), 7 (0.31) Group B: Episode 0 (0), 1 (0), 2 (0.027), 3 (0.16), 4 (0.17), 5 (0), 6 (0)
Events	Avoid stranger	***P*=0.013**	Group A: Episode 2 (0.0166), 3 (0.05), 6 (0.041) Group B: Episode 0 (0), 1 (0), 2 (0.0166), 4 (0), 5 (0), 7 (0)
	Avoid owner	***P* <0.001**	Group A: Episode 4 (0.069) Group B: Episode 0 (0), 1 (0), 2 (0), 3 (0), 5 (0), 6 (0), 7 (0.028)
	Looking away from stranger	***P* <0.001**	Group A: Episode 3 (0.235), 6 (0.123) Group B: Episode 2 (0.04), 6 (0.123) Group C: Episode 0 (0), 1 (0), 2 (0.04), 4 (0), 5 (0), 7 (0)
	Looking away from owner	*P*=0.065*	Trend towards: Groups A: Episode 0 (0.008), 4 (0.027), 7 (0.027) Group B: Episode 0 (0.008), 1 (0), 2 (0), 3 (0), 5 (0), 6 (0), 7 (0.009)
	Shake	***P* <0.001**	Group A: Episode 0 (0.12546), 4 (0.16723), 7 (0.14934) Group B: Episode 0 (0.12546), 1 (0.05349) Group C: Episode 1 (0.05349), 2 (0.01857), 3 (0.0124), 5 (0.01529), 6 (0)
	Soliciting attention	***P* <0.001**	Group A: Episode 1 (0.5898), 2 (0.3801) Group B: Episode 0 (0.246), 2 (0.3801), 4 (0.3308), 7 (0.2976) Group C: Episode 0 (0.246), 4 (0.3308), 6 (0.1005), 7 (0.2976) Group D: Episode 0 (0.246), 3 (0.0107), 5 (0), 6 (0.1005)
	Pulling leash	***P* <0.001**	Group A: Episode 2 (1.4178) Group B: Episode 1 (0.6357), 3 (0.5981), 4 (0.61), 6 (0.3941), 7 (0.3871) Group C: Episode 0 (0.1314), 5 (0.196), 6 (0.3941), 7 (0.3871)
	Biting leash	*P*=0.518	-
	Grooming	*P*=0.176	-
	Aggressive behaviour	-	-
	Sniffing environment	*P* <0.001	Group A: Episode 0 (7.709) Group B: Episode 1 (2.351) Group C: Episode 2 (1.364) Group D: Episode 3 (0.471), 4 (0.354), 5 (0.371), 6 (0.322), 7 (0.345)
	Manipulation environment	*P*=0.563	-
	Tail wagging	*P* <0.001	Group A: Episode 4 (6.229), 7 (7.017) Group B: Episode 0 (3.666), 1 (3.862), 2 (4.184) Group C: Episode 3 (2.47), 6 (2.455) Group D: Episode 5 (0.43)

8.3 Original PCA loadings pattern

Table 6: Original loadings pattern of 28 initial behavioural parameters across Strange Situation Test episodes determined with a Principal Component Analysis.

Behavioural parameters	Load 1	Load 2	Load 3	Load 4	Load 5
Whining episode 5	0.1529	0.554	-0.2784	0.4765	0.2617
Whining mean episode 3 & 6	0.1980	0.458	-0.4962	0.4523	0.2337
Shake mean episode 4 & 7	0.0322	-0.250	-0.3882	0.5024	-0.0047
Tail wagging mean episode 4 & 7	-0.4684	-0.253	0.2383	0.3011	0.1708
Tail wagging mean 3 & 6	-0.6420	-0.036	0.0233	0.1317	0.0281
Jumping mean episode 4 & 7	-0.1553	-0.121	0.0235	0.1158	0.3831
Avoiding owner mean episode 4 & 7	0.2231	0.214	-0.3652	0.4350	-0.2222
Avoiding stranger mean 2, 3 & 6	0.3769	0.095	0.2368	0.2547	-0.3354
Looking away from stranger episode 3 & 6	0.4191	0.195	0.3622	-0.1189	-0.3853
Looking away from stranger episode 2	0.3495	-0.090	0.4277	0.2015	-0.0711
Pulling leash episode 2	-0.4245	0.347	-0.1447	0.0385	0.0397
Near owner chair mean episode 3, 5 & 6	0.5650	0.316	-0.2405	-0.3665	0.2183
Staring at door episode 5	0.0506	-0.458	-0.3212	0.2503	0.5072
Staring at door mean episode 3 & 6	0.0636	-0.530	-0.0799	-0.0980	0.6562
Moving mean episode 0, 1, 2, 4 & 7	0.0585	0.364	0.3130	0.6235	0.0638
Moving mean episode 3, 5 & 6	-0.3469	0.250	-0.0471	0.2816	0.1093
Near owner mean episode 1, 4 & 7	0.2043	-0.141	0.0177	-0.3735	0.3375
Near owner episode 2	0.5385	0.059	0.3799	-0.1147	0.5017
Near stranger episode 2	-0.6391	0.063	-0.3617	-0.2709	-0.2254
Near stranger mean episode 3 & 6	-0.8685	-0.027	-0.0743	-0.1039	0.0120
Staring at owner episode 2	0.3910	-0.337	-0.1180	0.2611	-0.3012
Staring at owner mean episode 4 & 7	0.0744	-0.745	-0.0591	0.2880	-0.0370
Staring at stranger episode 2	-0.0715	-0.745	0.0036	0.1382	-0.0725
Staring at stranger episode 3 & 6	-0.0577	-0.478	0.2763	0.2746	-0.3968
Social play stranger mean 2, 3 & 6	-0.7025	0.188	0.1493	0.1076	-0.0242
Non-social play mean episode 4 & 7	-0.3340	0.261	0.2906	-0.1024	0.1194
Social play owner mean episode 4 & 7	-0.2460	0.122	0.7925	0.2027	0.2460
Petting owner mean episode 4 7	0.0099	-0.124	-0.4663	-0.2295	-0.2844

8.4 Component scores per dog

Table 7: Component scores for the behavioural components from Principal Component Analysis (in component 2 "Staring" the direction of the component scores are turned around)

Dog	sc1 "Outgoing"	sc2 "Staring"	sc3 -
1	-2.313	-0.742	0.8910
2	0.481	1.043	-0.2454
3	-1.050	-3.952	0.0383
4	2.928	-2.249	-1.8738
5	1.822	-0.484	0.7174
6	0.590	-1.115	1.2405
7	0.337	-2.258	-0.2426
8	3.271	0.088	0.4394
9	0.870	-1.640	0.0663
10	3.236	0.161	0.1463
11	0.074	-1.315	1.5104
12	1.166	-1.005	-0.8182
13	4.163	-1.545	0.7367
14	-2.177	-1.113	-1.4822
15	-1.349	-0.113	0.7391
16	-0.475	0.596	-0.1397
17	1.133	3.213	-0.8885
18	-2.441	-2.148	-0.6328
19	0.804	1.827	-0.7602
20	-1.071	-0.489	0.2653
21	-1.974	0.630	0.4250
22	-0.763	0.469	0.9675
23	-1.817	-0.503	0.0184
24	-0.006	0.056	-0.9181
25	1.409	0.992	-0.4427
26	-1.316	1.670	-0.0198
27	-1.515	1.317	1.5588
28	-1.046	1.466	-0.3459
29	-0.222	0.171	1.9241
30	1.559	1.375	-0.2150
31	0.410	1.252	1.4769
32	-1.735	0.825	0.7317
33	-0.360	-1.101	-0.5617
34	0.778	0.227	-1.0338
35	-0.074	0.974	-1.0794
36	-0.756	0.001	0.4801
37	-2.713	1.095	0.2784
38	-1.298	-0.597	1.0393
39	-0.112	0.765	-1.1689
40	-2.565	-1.203	-2.3213
41	0.377	-0.675	-1.1462

42	0.436	2.990	-0.9554
43	0.978	0.888	-0.3161
44	0.078	-0.721	-0.2104
45	2.585	-0.136	0.4108
46	0.296	0.968	0.9424
47	0.268	-1.563	0.4872
48	-1.032	1.195	-1.5636
49	0.129	0.414	1.8504

8.5: Dog-directed parenting styles

Table 8: Effects of dog-directed parenting styles on expressed behaviours during the SST and owner-reported components

Behaviour	***P*-value**	**Estimated means**
Dog attachment (C-BARQ)	All: *P*=0.397-0.819	-
Separation related distress (C-BARQ)	**I: *P*=0.044** A: *P*=0.072 T: *P*=0.086	I: 0%=-4.1 and 100%=10.8 A: 0%=2.1 and 100%=15.2 T: 0%=22.3 and 100%=2.3
Whining ep 5	A*T *P*=0.084	T0%, A0%=-12.6, T0%, A100%=58.8 T100%, A0%=6.6, T100%, A100%=-3.4
Whining mean ep 3, 6	**A*T *P*=0.012**	T0%, A0%=-16.1, T0%, A100%=76.1 T100%, A0%=2.4, T100%, A100%=-5.5
Shake mean ep 4, 7	All: *P*=0.156-0.909	-
Jumping mean ep 4, 7	**A*T *P*=0.004**	T0%, A0%=5.1, T0%, A100%=-10.4 T100%, A0%=-0.5, T100%, A100%= -2.9
Avoiding owner mean ep 4, 7	**A*T *P*=0.018**	T0%, A0%=-0.2, T0%, A100%=2.0 T100%, A0%=0.1, T100%, A100%=-0.2
Avoiding stranger mean ep 2, 3, 6	All: *P*=0.225-0.967	-
Looking away from stranger ep 3, 6	All: *P*=0.142-0.913	-
Looking away from stranger ep 2	All: *P*=0.127-0.590	-
Pulling leash ep 2	I*T *P*=0.060	T0%, I0%=14.0, T0%, I100%=-8.8 T100%, I0%=-1.7, T100%, I100%=3.5
Moving mean ep 0, 1, 2, 4, 7	A: *P*=0.060	A: 0%=37.8 and 100%=50.9
Moving mean ep 3, 5, 6	All: *P*=0.415-0.979	-
Near owner mean ep 1, 4, 7	All: *P*=0.136-0.907	-
Staring at owner ep 2	**I*A: *P*=0.012**	A0%, I0%=30.1, A0%, I100%=2.6 A100%, I0%=-31.3, A100%, I100%=34.5
Non-social play mean ep 4, 7	All: *P*=0.363-0.713	-
Social play owner mean ep 4, 7	All: *P*=0.389-0.875	-
Petting owner mean 4, 7	**I*T: *P*=0.034**	T0%, I0%=-185.4, T0%, I100%=130.4 T100%, I0%=54.3, T100%, I100%=10.1
Behavioural component: outgoing	A: *P*=0.072	A: 0%=0.7 and 100%=-1.8
Behavioural component: staring	**I*A: *P*=0.001**	A0%, I0%=5.5, A0%, I100%=-1.6 A100%, I0%=--8.7, A100%, I100%=1.6
Mean HR during SST	**I: *P*=0.028**	I: 0%=146 and 100%=88

8.6: Adult attachment style

Table 9: Effects of adult attachment styles on expressed behaviours during the SST and owner-reported components

Behaviour	***P*-value**	**Estimated means**
Dog attachment (C-BARQ)	Anxious ***P*=0.043**	Anxious 0%=35.9, 100%=77.3
Separation related distress (C-BARQ)	All: *P*=0.219-0.627	-
Whining ep 5	Avoidant *P*=0.063	Avoidant 0%=10.3, 100%=-2.1
	Anxious ***P*=0.035**	Anxious 0%=-0.4, 100%=11.6
Whining mean ep 3, 6	Avoidant ***P*=0.015**	Avoidant 0%=9.0, 100%=-4.2
Shake mean ep 4, 7	All: *P*=0.141-0.633	-
Jumping mean ep 4, 7	All: *P*=0.294-0.960	-
Avoiding owner mean ep 4, 7	Avoidant *P*=0.054	Avoidant 0%=0.2, 100%=-0.1
	Anxious *P*=0.055	Anxious 0%=-0.1, 100%=0.2
Avoiding stranger mean ep 2, 3, 6	All: *P*=0.580-0.903	-
Looking away from stranger ep 3, 6	Avoidant*Anxious *P*=0.096	Avoidant *anxious 0%,0%=-0.6, 0%,100%=0.6 100%, 0%=1.8, 100%,100%=0.6
Looking away from stranger ep 2	All: *P*=0.430-0.895	-
Pulling leash ep 2	All: *P*=0.131-0.925	-
Moving mean ep 0, 1, 2, 4, 7	All: *P*=0.279-0.978	-
Moving mean ep 3, 5, 6	All: *P*=0.735-0.973	-
Near owner mean ep 1, 4, 7	All: *P*=0.108-0.968	-
Staring at owner ep 2	All: *P*=0.333-0.952	-
Non-social play mean ep 4, 7	Avoidant*Anxious *P*=0.088	Avoidant *anxious 0%,0%=-6.3, 0%,100%=11.7 100%, 0%=5.7, 100%,100%=-0.6
Social play owner mean ep 4, 7	Avoidant*Anxious *P*=0.084	Avoidant *anxious 0%,0%=66.0, 0%,100%=-40.9 100%, 0%=13.2, 100%,100%=69.9
Petting owner mean 4, 7	All: *P*=0.160-0.572	-
Behavioural component: outgoing	Avoidant*Anxious *P*=0.068	Avoidant *anxious 0%,0%=3.6, 0%,100%=-3.5 100%, 0%=-2.4, 100%,100%=1.5
Behavioural component: staring	Anxious: ***P*=0.032**	Anxious 0%=1.0, 100%=-1.5
Mean HR during SST	All: *P*=0.417-0.548	-