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The effect of time left alone at home on dog welfare

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ABSTRACT

The aim of this study was to investigate the effect of time left alone on dog behaviour and cardiac activity. Twelve privately owned dogs, with no history of separation related behaviour problems, were video-recorded on three different occasions when left alone in their home environment. The treatments lasted for 0.5 h ($T_{0.5}$); 2 h (T_2) and 4 h (T_4). Video-recording started 10 min before the owner left the house and continued until 10 min after the owner returned, so that interactions between dog and owner as well as behaviour during separation could be studied. Data on heart rate (HR) and heart rate variability (HRV) were collected within the same time period in each treatment. In addition to analysing behaviours separately, behaviours were also grouped together and defined as new variables; physically active, attentive behaviour, vocal, interaction initiated by owner and interaction initiated by dog. There were no differences in behaviour between treatments at equivalent time intervals until the owner returned, although a number of differences were observed at reunion with the owner. Dogs showed a higher frequency of physical activity ($P < 0.05$) and attentive behaviour ($P < 0.01$) in T_2 (0.37 ± 0.07; 0.52 ± 0.08, mean frequency of occurrence/15 s ± SE) and T_4 (0.48 ± 0.08; 0.48 ± 0.07) compared to $T_{0.5}$ (0.20 ± 0.07; 0.21 ± 0.05). They also showed more tail wagging ($P < 0.01$) and interacted more with their owners ($P < 0.01$) in T_2 (0.27 ± 0.08; 0.47 ± 0.09) and T_4 (0.26 ± 0.04; 0.42 ± 0.09) compared to $T_{0.5}$ (0.09 ± 0.04; 0.14 ± 0.03). After a longer time of separation, the dogs also showed higher frequencies of lip licking ($P < 0.05$) and body shaking ($P < 0.05$) at the owner's return ($T_{0.5} = 0.09 \pm 0.05$; $T_2 = 0.24 \pm 0.08$; $T_4 = 0.27 \pm 0.06$ and $T_{0.5} = 0.03 \pm 0.01$; $T_2 = 0.08 \pm 0.03$; $T_4 = 0.07 \pm 0.01$, respectively). There was a tendency for higher HR ($P < 0.1$) during the first and second minute after reunion in T_2 (127.6 ± 1.25, mean bpm ± SE; 111.3 ± 1.24) compared to $T_{0.5}$ (106.2 ± 1.06; 87.5 ± 1.02). According to the results of this study, the effect of time left alone was shown by a more intense greeting behaviour by the dog towards their owner as well as by a higher frequency of physical activity and attentive behaviour when the owner returned, already after 2 h of separation. Although this study cannot distinguish between whether dogs were aware of the length of time they were alone (but did not signal it) or whether they were unaware until reminded of it by the return of their owner, it does confirm that dogs are affected by the duration of time at home alone.

1. Introduction

In our modern society most dog owners work full time. Many employers do not allow dogs on their premises because some people have allergies or are afraid of dogs. Consequently, many dog owners see no other alternative than leaving their dog at home alone for most of the day. A recent investigation by Norling and Keeling (2010) showed that 73% of Swedish dog owners left their dog at home during working hours. At the same time, modern selection on appearance rather than behavioural traits has led to a higher fearfulness among pet dogs in Sweden (Svartberg, 2006). Fear and anxiety are closely related, so the breeding

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strategies practiced today may increase the risk of separation related behaviour problems and impaired welfare of dogs. Although separation anxiety is one of the most commonly reported behavioural problem (e.g. Bamberger and Houpt, 2006; Voith and Borchelt, 1996), dogs suffering from it still represent a small proportion of the total pet population. There has been little research on how dogs without these behavioural problems are affected by separation from their owner.

Previous studies on dogs without separation related behaviour problems indicate a high level of passive behaviour while left at home alone. Aslaksen and Aukrust (2003) showed that dogs were lying down 95.3% of the time when being left alone at home for between 4 and 9.5 h. In another study (Vestrum, 2009), where dogs were left alone at home together with at least one other dog companion, dogs were lying down for approximately 83% of the time. Puppies that were left alone in their home environment for 1.5 h expressed active behaviour only in the beginning of the period, but then became more passive (77.4% of the time) (Frank et al., 2007). In these studies, the effect of different lengths of time left alone was not taken into consideration. Neither were there any physiological measures taken.

Individual dogs respond differently to acute and chronic stress and the arousal has been suggested to be manifested by behaviours such as increased frequency of oral behaviours, vocalization, body shaking, yawning, crouching, increased/repetitive movements, increased auto-grooming and paw-lifting (e.g. Beerda et al., 1997, 2000; Glover, 1992; Hetts et al., 1992; Rooney et al., 2007). Behavioural reactions to stressors can be accompanied by an increase in heart rate (HR) and in saliva cortisol (e.g. Beerda et al., 1998). Cardiac responses may also occur in an anticipatory manner prior to the expression of any alterations in behaviour, as well as persist beyond the behavioural response. Heart rate variability (HRV) is suggested to be a subtle indicator for mental stress load in farm animals (e.g. Von Borell et al., 2007) and has for example been used to assess stress levels of animals under different housing conditions (e.g. Hagen et al., 2005). HRV has also been investigated in dogs and seems to be useful as an indicator of dogs' affective states (Maros et al., 2008).

The main aim of this study was to identify possible differences in dog behaviour and cardiac activity, depending on how long the dog is left alone at home, to assess potential impairment of dog welfare. We hypothesized that even dogs with no known history of separation related behavioural problems would show a higher frequency of indicators of negative stress in the treatments where the dog was left alone for longer periods and that they would express behaviours indicative of an increased arousal when the owner returned.

2. Material and methods

2.1. Subjects

Data for this investigation were based on video-recordings of 12 privately owned dogs. The dogs were of different ages, ranging from 1 to 12 years old (4.3 ± 3.03 (mean $\pm$ SD)), and of different breeds; three Labrador retrievers, two mixed breeds and one of each of the following breeds: Belgian shepherd, English cocker spaniel, German shepherd, Hamilton hound, Hovawart dog, Norwegian elkhound and Nova Scotia duck tolling retriever. The dogs included six females and six males, all intact. Seven dogs had been purchased mainly as companion dogs, two were mainly used for competition and three for hunting purposes. Type of household varied: most dogs lived in apartments of different sizes, a few lived in houses and smaller student accommodations. Participants were recruited by advertisements and personal contacts, and the participation was on a voluntarily basis. The inclusion criteria were that the dogs had no history of obvious separation related behavioural problems, that they were used to being left alone at home for at least 4 h at a time, and that they were being left without any other animal in the home. Most dogs were allowed to roam freely in the entire home and no dogs were kept in cages. The owners were asked to sign an informed consent to participate in the study. This study was approved by the Swedish Ethical Committee and by the Swedish Board of Agriculture for the use of privately owned dogs in research.

2.2. Data collection

All data were collected in the dog's home environment. Reactions of the 12 dogs were recorded during three different treatments when being left alone at home: $T_{0.5} = 0.5$ h alone; $T_2 = 2$ h alone and $T_4 = 4$ h alone. These separation periods were selected because they differed enough in length to answer the research question, related to the effect of time left at home alone, at the same time as they did not exceed the recommended maximum time to leave the dog unattended according to Swedish Animal Welfare Legislation (2008:5 L102). The treatment order was randomly distributed to the dogs according to a Latin square design. Time between treatments varied according to suitable dates for recording (26.3 days (mean) $\pm$ 9.8 (SE), min = 24 h, max = 229 days). Dogs were equipped with a heart rate monitor (Polar® Vantage S810) to which they were accustomed to before the start of the experiment. Dogs were equipped with the monitor and they were considered to be habituated to it when they did not show any behaviour indicating that they were affected by the belt, i.e. did not scratch/bite on the equipment, but that they walked around as usual and were lying down normally with it on. The habituation never needed to exceed 30 min, probably due to the fact that the equipment was very similar to a regular harness. In addition to the previous habituation, the heart rate equipment was strapped onto the dog at least 30 min before each treatment and then the experimenter left the home. Data collection started 10 min before the owner left the house (pre-separation) and continued until 10 min after reunion with the owner (post-separation) (Fig. 1). Owners were asked to use their usual routines when leaving or returning home. Two stationary surveillance cameras (VIVOTEK network camera, PT3124) were placed in the owner's home. One camera was always placed in the entrance area, and the other camera covered the area where the owner thought the

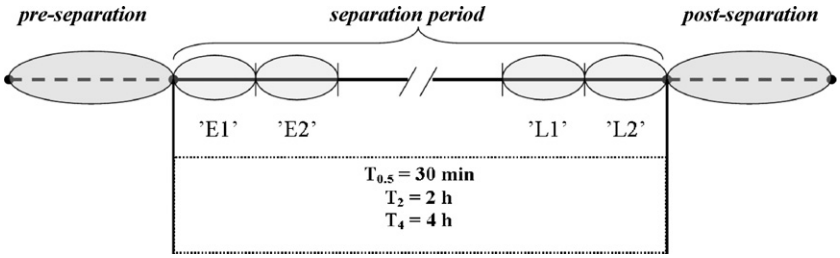

Fig. 1. Reactions of 12 dogs were recorded during 3 different durations (T_x) while left at home alone. Data collection started 10 min before the owner left the home (pre-separation) and continued until 10 min after the owner returned (post-separation). Six different intervals were analysed for differences between treatments (circled areas). Comparisons were based on two 5-min intervals in the beginning ('E1' and 'E2') and two 5-min intervals towards the end of the separation period ('L1' and 'L2'), as well as the 10-min pre- and post-separation periods.

dog would spend most of its time when he/she was absent.

2.3. Behaviour variables

Observations of the behaviour of the dogs were made from the video-recorded material by one trained observer. Videos were scored using the Vivotek software (Vivotek ST3402 version 2.0) and behaviour recorded by hand with paper protocols and pencil, then transferred into excel. If the dog was out of range of the camera, vocalizations were still recorded. The ethogram used in this study is presented in detail in Table 1.

The main behaviour of the dogs was studied instantaneously every 15 s, and variables included were lying (alert or resting), sitting, standing, walking and running. The difference between lying alert and lying resting depended on whether the dog's head was in physical contact with the floor, i.e. resting, or not. Behavioural transitions between lying, sitting, standing, walking and running were inves-

Table 1
Recorded behaviours and their definitions.

Behaviour	Definition
Instantaneous sampling (15 s)	
Lying alert[b]	Dog is lying down but without its head in contact with the floor
Lying resting	Dog is lying down with its head in contact with the floor
Sitting	Dog is sitting with front legs extended and hind legs curved
Standing	Dog is standing up on all four paws
Walking[a]	Dog is walking around, moving
Running[a]	Dog is running around, trotting or galloping
Location	Location of the dog (room/distance to entrance door)
Continuous sampling/one–zero sampling	
Exploring[b]	Motor activity directed towards any physical aspect of the environment, dogs is sniffing/licking/manipulating something (not toys)
Attention towards something[b]	Dog has its ears and eyes pointed in a certain direction (staring >2 s), e.g. towards door, window, etc.
Play[a]	Any vigorous or galloping gaited behaviour directed towards a toy, including chewing, biting, shaking it from side to side, batting with paw (without any interaction with the owner)
Grooming[a]	Dog is cleaning its body surface by licking, nibbling, picking, rubbing, scratching, etc.
Chewing[a]	Dog is chewing an object or eating/drinking
Panting[a]	An increased frequency of inhalation and exhalation with mouth open
Tail wagging[a]	Repetitive wagging movement of the tail
Vocalising[a]	Dog is barking, growling, howling or whining
Yawning[b]	Dog opens its mouth widely and inhales
Lip licking[b]	Dog is snout licking, tongue visible
Body stretching	Dog is extending/stretching a part of or whole body
Body shaking	Dog shakes any part of or whole body from side to side
Following owner[a,c]	Walking behind owner within a distance of 1 m
Physical contact[b,c]	Dog leans, jumps up on and/or nudges/licks the owner
Attention towards owner[b,c]	Dog is focused on the owner, by gazing/staring at the owner (>2 s)
Inviting play[a,c]	Dog initiates play with the owner by standing in play bow position or bringing a toy to the owner (<0.5 m)
Owner physical contact[d]	Owner pets/strokes/scratches the dog
Owner verbal contact[d]	Owner talks to the dog
Owner invites play[d]	Owner offers play, with or without toy
Owner seeks contact[d]	Owner bends down towards the dog or sits/lays down on floor

[a] Behaviours included in new variable 'Physically active'.
[b] Behaviours included in new variable 'Attentive behaviour'.
[c] Behaviours included in new variable 'Interaction initiated by dog'.
[d] Behaviours included in new variable 'Interaction initiated by owner'.

tigated and regarded as a new variable; changing main behaviour, as an indicator of restlessness. Behaviours previously suggested (e.g. Beerda et al., 1997, 2000) to indicate stress or arousal were analysed separately (barking, whining, howling, tail wagging, panting, yawning, lip licking, body stretching and body shaking). Behaviours were also grouped together into new variables; physically active, attentive behaviour, vocal, interaction initiated by owner and interaction initiated by dog (Table 1). The term 'physical activity' was used to describe general activity among the dog and 'attentive behaviour' to mean that the dog was mentally occupied with something, even if it could still be lying down. Lip licking, body stretching, body shaking and yawning were recorded as frequency per 15 s and other behaviours were recorded as present or not at 15 s intervals.

2.4. Statistical analyses

To enable comparison of dog behaviour, the separation periods (when dogs were left alone) were divided into intervals in the beginning and at the end of the treatments (Fig. 1). Data were analysed during two 5-min intervals following separation from the owner (*Early*: 'E1' and 'E2'), and the last two 5-min intervals before the owner returned home (*Late*: 'L1' and 'L2'). The 10-min intervals before the owner left the home (pre-separation) and after the owner returned (post-separation) were also analysed and compared between treatments.

Statistical analyses were carried out using SAS® computer package (version 9.1). For analyses of behavioural variables, Kruskal–Wallis tests were used when comparing differences between all treatments. The mean frequencies of behaviours (±SE) shown during the 5-min intervals where the dog was alone at home ('E1', 'E2', 'L1' and 'L2') were compared between the treatments, as well as the 10-min intervals before the owner left and after the owner returned.

Analyses of heart rate data (HR and HRV) were synchronized with the recording of behavioural data, i.e. starting exactly 10 min before the owner left the house. When analysing cardiac activity, 1-min intervals in the pre-separation period, 'E1', 'E2', 'L1', 'L2' and post-separation period were compared between treatments. Mean HR, in beats per minute (bpm) in each interval was analysed. Heart rate variability (HRV) was calculated and analysed as SDRR (the standard deviation of all inter-beat intervals, within one interval) and as RMSSD (root mean square of all successive inter-beat-interval differences in 1 min). HR and HRV were analysed using mixed models, where 'treatment' ($T_{0.5}$, T_2, T_4) was considered as fixed variables and 'dog' was included as a random variable. We used contrasts to examine possible differences in HR and HRV between pairs of treatments.

3. Results

Out of the 90 h of video recorded material, dogs were out of range of the camera view for 4.0% of the time ($T_{0.5}$: 2.3%, T_2: 3.2% and T_4: 5.3% of the time).

3.1. Pre-separation period

There were no differences in behaviour, HR and HRV between the treatments in the period before the owner left the house.

3.2. Separation period

While separated from their owner, all dogs spent most of their total time lying down ($T_{0.5} = 92.0 \pm 2.8$; $T_2 = 96.7 \pm 1.7$; $T_4 = 95.4 \pm 1.9$, $\chi^2 = 0.66$, $P = 0.72$) and to a large extent lying down resting ($T_{0.5} = 78.7 \pm 7.9$; $T_2 = 90.9 \pm 2.7$; $T_4 = 84.8 \pm 6.0$, $\chi^2 = 1.30$, $P = 0.52$), in all treatments. There were no differences between the treatments regarding the dogs' location at home while left alone. The mean percentage of time spent in the entrance area was 50–60% in all treatments ($\chi^2 = 0.30$, $P = 0.86$) and dogs spent approximately 40% of the time near (within 2 m distance) the entrance door in all treatments ($\chi^2 = 0.00$, $P = 1.00$).

There were no differences in behaviour in intervals 'E1', 'E2' or 'L1'. In interval 'L2', the last 5 min before the owner returned, there was a significant difference between the treatments regarding body shaking ($\chi^2 = 8.00$, $P = 0.02$). Dogs separated from their owners for a longer time performed body shaking more often ($T_{0.5} = 0.00 \pm 0.00$; $T_2 = 0.08 \pm 0.08$; $T_4 = 0.12 \pm 0.09$). Dogs also showed a higher level of physical activity ($\chi^2 = 8.19$, $P = 0.02$) in T_2 (0.16 ± 0.08) and T_4 (0.16 ± 0.09) compared to $T_{0.5}$ (0.02 ± 0.01) during 'L2'. This interval was probably influenced by the fact that most dogs could hear or see the owner approaching the home.

Mean HR and HRV did not differ between the treatments in any interval during the separation period.

3.3. Post-separation period

Following the two longer periods of time that the dogs were left alone at home, the dogs more frequently initiated interactions with their owners at reunion ($T_{0.5} = 0.14 \pm 0.03$; $T_2 = 0.47 \pm 0.09$; $T_4 = 0.42 \pm 0.09$, $\chi^2 = 12.48$, $P = 0.002$) (Fig. 2). Interactions initiated by the owners at reunion did not differ between treatments ($T_{0.5} = 0.60 \pm 0.20$; $T_2 = 0.67 \pm 0.18$; $T_4 = 0.81 \pm 0.18$, $\chi^2 = 2.87$, $P = 0.24$). These findings showed that dogs displayed different frequencies of initiating contact according to the time separated from their owners, regardless of the owner's behaviour.

Dogs showed a higher frequency of tail wagging ($P = 0.005$) after a longer time of separation (Table 2). The level of 'attentive behaviour' and 'physical activity' were higher ($P = 0.005$ and $P = 0.026$, respectively) in T_2 and T_4 compared to $T_{0.5}$. Dogs showed a higher frequency of behavioural transitions ($P = 0.039$) in T_2 and T_4 compared to $T_{0.5}$. Lip licking and body shaking were also expressed more ($P = 0.046$ and $P = 0.022$, respectively) in T_2 and T_4.

Due to the memory storage limits in the receiver, HR data were only available for three dogs in T_4 and we therefore excluded this treatment from the statistical analysis. A comparison between $T_{0.5}$ and T_2 showed a tendency for a higher HR during the first minute after reunion in T_2 ($T_{0.5} = 106.2 \pm 1.06$, mean bpm ± SE; $T_2 = 127.6 \pm 1.25$, *F*-

Table 2
Mean frequency of observed behaviours, standard error (SE), χ^2-statistics and *P*-values for variables tail wagging, 'attentive behaviour, 'physical activity', 'changing main behaviour', lip licking, and body shaking during the post-separation period ($n = 12$).

Variable	$T_{0.5}$	T_2	T_4	χ^2	*P*-value
Tail wagging	0.09 ± 0.04	0.27 ± 0.08	0.26 ± 0.04	10.49	0.005
Attentive behaviour[b]	0.20 ± 0.05	0.52 ± 0.08	0.48 ± 0.07	10.53	0.005
Physical activity[a]	0.20 ± 0.07	0.37 ± 0.07	0.48 ± 0.08	7.31	0.026
Changing main behaviour[c]	0.14 ± 0.04	0.27 ± 0.04	0.26 ± 0.04	6.51	0.039
Lip licking	0.09 ± 0.05	0.24 ± 0.08	0.27 ± 0.06	6.16	0.046
Body shaking	0.03 ± 0.01	0.08 ± 0.03	0.07 ± 0.01	7.60	0.022

[a] Physical activity includes walking, running, playing and invitation to play, grooming, vocalising, chewing, panting, tail wagging and following owner.
[b] Attentive behaviour includes lying alert, exploring, attention towards something in the surroundings/owner, yawning, lip licking, physical contact with owner.
[c] Changing main behaviour refers to the number of behavioural transitions between lying, sitting, standing, walking and running.

value = 3.4, $P = 0.1$) as well as during the second minute ($T_{0.5} = 87.5 \pm 1.02$; $T_2 = 111.3 \pm 1.24$, *F*-value = 4.6, $P = 0.06$). No differences in HRV were observed in the post-separation period.

4. Discussion

Dogs were lying down resting most of the time when left alone at home in all treatments and no behaviour differences between the treatments were observed before the dog detected that the owner was returning home. After longer times of separation, dogs interacted more with their owners at reunion and showed more tail wagging, lip licking and body shaking. Dogs were therefore affected by the time left home alone, although they did not express it until the owner returned home.

In the following sections we discuss the pre-separation, separation and post-separation periods as well as greeting behaviour.

4.1.1. Pre-separation

No differences were observed in behaviour, HR or HRV in the 10-min period before the owner left the dog, which was to be expected, since the dogs probably could not predict how long the time of separation from the owner was going to be. The reason for investigating this period was to see whether any dog showed behaviours related to anticipatory distress, which is common in the period preceding the owner's departure among dogs suffering from separation anxiety (Lund and Jørgensen, 1999).

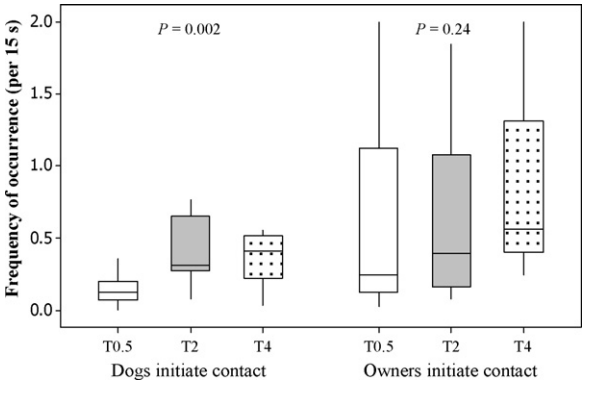

Fig. 2. Frequencies (medians with 95% CI) of dog–owner interaction initiated by dogs (left three boxes, include the behaviours: following owner, physical contact, play invitation and attention towards owner) and by the owner (right three boxes, include the behaviours: physical contact, verbal contact, owner invites to play, bending down, sitting/lying on the floor) in the post-separation period in $T_{0.5}$, T_2 and T_4.

4.1.2. Separation period

During separation, dogs were lying down resting for most of the time. This aligns with other studies on dogs left alone at home (Aslaksen and Aukrust, 2003; Frank et al., 2007; Vestrum, 2009). It was not unexpected that we did not see any treatment differences in 'E1' and 'E2', since these intervals occurred at the same time after separation from the owner in all treatments. More surprisingly though, we did not see any treatment differences in 'L1', which suggests that the dogs were unaffected by the time left alone at home, as long as the owner was not present or there was no indication that they were returning home. The higher level of physical activity during 'L2' in T_2 and T_4 just before the owner actually entered the house, suggests that dogs showed a higher arousal prior to the expected reunion after being left alone for longer periods of time.

Dogs are good at interpreting human signals and seek human attention for communicative interaction (Miklósi et al., 2000, 2003). One could suggest that dogs are less motivated to send out signals while alone, since the cost of producing the signals probably outweighs the potential benefit of them when there is no receiver. Nevertheless, dogs suffering from separation anxiety express their discomfort through excessive vocalization, destructive behaviour, elimination in the house, pacing, salivating and trembling (McCrave, 1991; Overall, 1997; Voith and Borchelt, 1996). None of these behaviours were shown by the problem-free dogs in this study.

4.1.3. Post-separation

Dogs interacted more with their owners after a longer time of separation and showed higher frequencies of behaviour indicative of increased arousal (lip licking and body shaking). They were also more attentive and physically active during this phase in T_2 and T_4 compared to $T_{0.5}$. Interactions initiated by the owners at reunion did not differ between the treatments. Thus, dogs' behaviour when owners returned differed according to the time

separated from their owners and not according to the owners' behaviour. HR tended to differ between $T_{0.5}$ and T_2 immediately after reunion with the owner (min 1 and 2), probably reflecting the greater physical activity and supporting an increased arousal after a longer time of separation.

4.2. Greeting behaviour

Reunion with the owner after a longer time of separation seemed to result in an increased arousal in dogs, where they showed higher frequencies of lip licking, body shaking, tail wagging, physical activity, behavioural transitions and increased attention towards the surrounding environment. That dogs initiated more contact with the owner when they had been separated for 2 or 4 h, compared to after 0.5 h, may indicate that dogs needed to reinstate the relationship to a greater extent after longer periods of separation. Lip licking is related to submissive behaviour, contact seeking and conflict signalling in wolves and dogs (e.g. Beaver, 1999; Fox, 1970; Harrington and Asa, 2003) and has been proposed to be an indicator of negative stress, even in non-social situations (Beerda et al., 1998). The current study shows that a higher frequency of lip licking may also be related to an increased positive arousal or act as a reinstatement behaviour. Active submission is a key component of greeting behaviour between canids and includes behaviours such as lip licking and tail wagging. Expressing active submission has been suggested to be an attempt to promote an affiliative and friendly harmonic social interaction and often occurs as ritualised behaviour between individuals that are attached to each other and where a clear hierarchical differentiation is already established (Schenkel, 1967). Body shaking may be performed to rearrange the fur after lying down for a longer time, but it has also been suggested to be an expression of relief after a stressful event (Beerda et al., 1998). Body shaking has furthermore been proposed to be involved in play soliciting gestures between canids (Bekoff, 1974; Fox, 1970). This could suggest that either dogs experienced the longer times of separation as more stressful (or at least negative), hence showing a higher frequency of body shaking when it was over, or the increased solicitation gestures were a part of the more intense greeting procedure following longer separation. Intense greetings of long duration (>2–3 min) and following the owner around excessively have been reported by owners to dogs suffering from separation anxiety (Flannigan and Dodman, 2001) and are symptoms often included when establishing a diagnosis for this disorder (e.g. McCrave, 1991). However, Parthasarathy and Crowell-Davis (2006) did not observe any differences between dogs with separation anxiety and dogs without any separation related behavioural problems regarding the level of physical contact or proximity to owners when being reunited with their owners after a short period of separation (2 min). When evaluating dogs with separation problems, other aspects of the dog's behaviour are probably more informative than assessing their greeting intensity towards the owner upon reunion, for example specific features of greeting behaviour.

4.3. Implications for welfare

Whereas reduced activity or little exercise does not necessarily mean impaired welfare, level of activity has been used to measure the effects of social enrichment, feeding enrichment and space allowance in laboratory dogs (e.g. Hubrecht, 1993; Schipper et al., 2008). The high proportion of inactivity during separation in this study may therefore have implications for dog welfare. Furthermore, a joint body of research shows that increased social contact, either with other dogs or with humans has a positive effect on the welfare of laboratory dogs or dogs in shelters (e.g. Hetts et al., 1992; Hubrecht et al., 1992; Wells and Hepper, 2000) even if specific studies on the impact of human company on pet dogs are scarce. The resting behaviour during separation from the owners in our study could indicate acceptance of the situation by these dogs, although long term and repetitive isolation may have welfare consequences if the owner does not compensate the lack of stimulation in other ways.

While the dogs were alone, no differences in behaviour were shown, irrespective of the length of separation. The behavioural differences according to time in this study appeared when the owners returned. It could be argued that the differences in behaviour when the owners return are normal, merely reflecting a more intense greeting behaviour after a longer time of separation to reinstate the bond. This would imply that dogs are able to estimate the length of time the owners have been away. The ability to estimate time intervals has been investigated in a number of species, e.g. rats (Roberts, 1981), pigeons (Roberts et al., 1989) and domestic hens (Taylor et al., 2002) but not, to our knowledge, in dogs. On the other hand, the findings in this study may imply that dogs were unaware of the passing of time, and what they were missing, until they were reminded of it by the return of their owner. Petherick et al. (1990) showed that hens, with previous experience of dustbathing, had the capacity to relate a neutral stimulus (coloured cue) with access to peat even when the peat was out of sight. Their findings indicate that hens have the cognitive ability to associate to a rewarding resource even when they do not see it.

So, do dogs think about their owner while they are separated and might welfare be at risk due to dogs 'missing' their owner? The question whether or not animals have an episodic memory, i.e. have the ability to recall events from the past along with relevant spatial and temporal details (Tulving, 2002), is under debate (e.g. Roberts et al., 2008; Suddendorf and Busby, 2003; Zentall, 2006). Studies have shown that e.g. scrub jays (Clayton et al., 2003), rats (Babb and Crystal, 2006) and chimpanzees (Martin-Ordas et al., 2010) are able to connect a specific event to a specific time and place, but these experiments still do not give evidence for a conscious experience of recollection and so whether episodic-like memory systems have an impact on emotional states. But considering Duncan's (1996) view that an animal's welfare depends on how the animal feels, this is an important area to investigate further. Irrespective of whether dogs were 'missing' their owner, or whether it is a case of 'out of sight is out of mind' while they were at home alone, the differences between treatments in this study do

show that dogs are capable of estimating time, once it has ended.

5. Conclusions

Dogs showed more greeting behaviour (tail wagging, lip licking), body shaking and initiated more physical contact with their owners upon reunion after a longer time of separation. This implies that they were affected by time, and that they were able to perceive the length of time, once it was over. There was no behavioural evidence that the welfare of dogs was reduced, even during the longest period of separation, but studies of whether dogs remember their owner in his/her absence would help give insight into the welfare implications of being separated. The low activity levels during separation might be normal because the dogs did not have anyone to interact with, but the possible indirect negative effects on welfare resulting from repeated, long term absence of both physical and mental stimulation should be born in mind.

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