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The behavioural effects of olfactory stimulation on dogs at a rescue shelter

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ABSTRACT

Many domestic dogs are kept in rescue and rehoming shelters which are frequently stressful and under-stimulating environments. Dog welfare is often compromised within these environments and there is a need to determine new practical and effective methods of improving the welfare of these kennelled dogs. Olfactory stimulation has been demonstrated to have positive behavioural effects in a range of contexts, however this field remains relatively understudied in the domestic dog. This study aimed to investigate the effects of olfactory stimulation via vanilla, coconut, ginger and valerian upon the behaviour of 15 dogs at a rescue shelter. The dogs were simultaneously exposed to six olfactory conditions using scented cloths following a fixed order (cloth control, coconut, vanilla, valerian, ginger and odour control) for 2 h a day for 3 days with an intervening period of 2 days between conditions. The dogs' behaviour was recorded every 10 min throughout the 2 h olfactory conditions using instantaneous scan-sampling. Exposure to ginger, coconut, vanilla and valerian resulted in significantly lower levels of vocalisations and movement compared to the control conditions, while coconut and ginger additionally increased levels of sleeping behaviour. These odours may have application in rescue shelters due to the reduction of behaviours such as barking and activity which may be indicative of stress as well as being traits perceived as undesirable by adopters. This research provides support for the use of olfactory stimulation within the kennel environment.

1. Introduction

Dogs are one of the most commonly kept domestic animals with estimated numbers of eight and a half to nine million dogs being kept as pets in the UK alone (PDSA, 2017; PFMA, 2017). Large numbers of dogs are taken into rescue shelters (Dogs Trust, 2015; RSPCA, 2015) which are often stressful environments for dogs due to the lack of environmental control and behavioural opportunities, inadequate or under-stimulating enclosures, and exposure to a range of psychological and physiological stressors like noise and spatial restriction (Hubrecht, 1995; Tuber et al., 1999; Taylor and Mills, 2007). One common approach to improving welfare in captive animals is through the use of environmental enrichment. Environmental enrichment can be defined as any technique designed to improve the biological functioning of a captive animal via modifications to its environment (Newberry, 1995). The typical aims of environmental enrichment strategies are to improve animal welfare through promoting behavioural diversity, decreasing frequencies of abnormal behaviour, encouraging species-typical patterns of behaviour, increasing the capability to manage challenges and promoting positive use of the environment (Young, 2003).

Olfactory stimulation is a form of sensory enrichment that involves the addition of scents or scented materials to an enclosure in an attempt to stimulate positive behavioural effects (Swaisgood and Shepherdson, 2005; Wells, 2009). Olfactory stimulation such as prey odours, catnip and nutmeg have enhanced behavioural diversity in domestic cats (*Felis catus*) (Ellis and Wells, 2010) and leopards (*Panthera pardus orientalis)* (Yu et al., 2009*)*, and increased activity in black-footed cats (*Felis nigripes)* (Wells and Egli, 2004) and chimpanzees (*Pan troglodytes)* (Struthers and Campbell, 1996). Olfactory stimulation has also been shown to decrease stereotypic pacing in oncilla Cats (*Leopardus tigrinus*) (Resende et al., 2011) and stimulate foraging behaviour in gibbons (*Hylobates moloch*) (Gronqvist et al., 2013). Research on olfactory stimulation in kennelled dogs has explored the effects of essential oils on behaviour, with exposure to lavender and chamomile promoting resting and reducing vocalising. In contrast, dogs spent more time moving and barking upon exposure to peppermint and rosemary (Graham et al., 2005). The paucity of research in this area is surprising considering dogs' highly sensitive olfactory acuity (Krestel et al., 1984; Walker et al., 2006) and that environmental enrichment strategies are proposed to be most effective when targeting the primary sensory ability of the species concerned (Wells, 2009). Further investigation of novel approaches to olfactory stimulation for kennelled dogs is of value in order to widen the choice of odours that can potentially be used as enrichment for shelter dogs. Habituation to olfactory enrichment can be a

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problem (e.g. Wells and Egli, 2004; Ellis and Wells, 2010) so determining additional forms of sensory stimulation that can be used is of value.

There are a number of scents which are easily acquired and have purported positive effects on captive mammals. Vanilla and coconut, delivered in conjunction with other scents, increased exploratory behaviours in wombats (*Lasiorhinus latifrons*) (Hogan et al., 2010), vanilla reduced stereotypic behaviour in sea-lions (*Zalophus californianus*) (Samuelson et al., 2017), and ginger increased activity in lions (*Panthera leo*) (Schuett and Frase, 2001) and foraging in Javan gibbons (*Hylobates moloch*) (Gronqvist et al., 2013). Finally, valerian has been found to have positive stimulatory effects in cats (Bol et al., 2017) and reduce anxiety in laboratory rats (*Rattus norvegicus*) (Murphy et al., 2010). The present study aimed to investigate the effects of olfactory stimulation via vanilla, coconut, ginger and valerian upon the behaviour of dogs at a rescue shelter. Odours were chosen for their safety, ease of acquisition and purported positive influence on the welfare of other captive mammals (e.g. Schuett and Frase, 2001; Hogan et al., 2010; Bol et al., 2017; Samuelson et al., 2017).

2. Material and methods

2.1. Subjects

Fifteen singly-housed dogs (13 males; 2 females) aged between 18 months and 9 years (mean age: 4 years and 4 months) were used in this study. The dogs varied in breed such that one was an American Bulldog cross, one was a collie cross, five were Staffordshire bull terrier crosses, one was a lurcher cross, one was a Jack Russell terrier, one was a lurcher, one was a mastiff-boxer cross, two were Staffordshire bull terriers, one was a terrier and one was an English bull terrier-collie cross. Thirteen of the dogs were medium in size (bull terriers and bull terrier crosses, American bulldog cross, collie cross, mastiff-boxer cross, lurcher and lurcher cross), and two of the dogs were small (terrier, Jack Russell terrier). All dogs were neutered or spayed and deemed healthy by on-site veterinary staff. The dogs had varying origins; four dogs had been relinquished by their owner, three dogs came from another shelter, and eight dogs had strayed and came from local dog wardens. All the dogs had been at the shelter for at least two months (range: 2–21 months; mean length of time: 7.9 months).

The dogs were housed at Gloucestershire Animal Welfare Association and Cheltenham Animal Shelter, Cheltenham, UK. The site consisted of dog kennels, cat kennels and an on-site veterinary clinic and reception centre. The dog kennels were arranged in two rows of opposite-facing blocks (five metres apart), with the observation/walking area in between. There were a total of five blocks, four blocks contained dogs available for rehoming, and an isolation block contained dogs considered by shelter workers to be particularly vulnerable to stress. The dogs in the isolation block were excluded from the study. Blocks one, two and three were in one row with block four and the isolation block on the opposite facing row. Block one had no block opposite it, while block two was opposite block four and block three was opposite the isolation block. There were visually occluding fences between blocks two and four, and block three and the isolation block. The isolation block also had additional fencing preventing physical and visual access so this was accessible only by staff. Each block contained eight standardised individual rectangular kennels and each block was full at the time of study. Not all of the dogs in the kennel blocks were included in the study due to either their young age, their recent arrival at the shelter, or because they were due to be rehomed shortly. The dogs included in the study were located throughout the blocks of kennels, such that five dogs were housed in kennel block one, three dogs were in block two, one dog was in block three and six dogs were in block four. All subjects were housed in the same kennels during the study. Kennels were rectangular and had an access door at either end. Each kennel contained a bed and a water bowl and measured approximately 4 m (length) by 1 m (width) by 2.5 m (height). The kennels were cleaned daily at 8:30 h. Dogs were fed twice daily at 8:15 h and 15:45 h. All dogs were walked twice daily at 10:30 h and 15:30 h for 10 min.

2.2. Olfactory conditions

The dogs were exposed to six different olfactory conditions, four experimental conditions applied with a scented cloth, and two control conditions, one using an unscented cloth (odour control) and one where no cloth was present (cloth control). The odour control condition provided a comparison for the odour conditions by the use of an unscented cloth, while the cloth control condition aimed to control for the potential effects of the cloth as a novel object upon the dogs' behaviour and subsequent results. In the experimental conditions, dogs were exposed to cloths scented with the essential oils coconut (coconut fragrance oil (Code: FOCOCO10); Mystic Moments, UK), vanilla (vanilla fragrance oil (Code: FOVANI10); Mystic Moments, UK), valerian (valerian root essential oil (Code: VAL10); Essential Oils Direct, UK), and ginger (ginger 100% pure essential aromatherapy oil (Code: 5052211003023); Calmer Solutions, UK). For each individual condition, the dogs were simultaneously exposed to the olfactory treatment in order to avoid odours interfering with one another, as the wired mesh doors at the front of the enclosures did not prevent odour transmission.

2.3. Procedure

The four experimental conditions (coconut, vanilla, valerian, and ginger) were presented to the dogs on 35 cm by 30 cm microfiber cloths. These cloths were sterilised using a H2O steam cleaner (H20 × 5, Thane) and latex gloves were worn by the researcher during any cloth-related interaction to avoid odour transmission. For experimental conditions, cloths were scented using a pipette by placing five drops of the relevant essential oil onto the material; one in each corner and one in the centre to ensure even distribution. Post scenting, cloths were placed into sealable plastic bags to prevent contamination from pathogens and other odours. Cloths were scented 60 min prior to being placed in the dogs' kennels.

Cloths were placed into individual dogs' kennels 30 min before the beginning of each recording session and removed at the end of each recording session, with a new freshly scented cloth provided each day. Cloths were placed into the enclosure 30 min before observations to allow habituation to the presence of the cloths. Cloths were placed in the centre of each enclosure to encourage interaction and maximise odour coverage. The dogs were able to touch and interact with the cloths.

For the odour control condition, cloths were left unscented. For the cloth control condition, dogs were not presented with a cloth. The cloth control condition was applied first followed by coconut, vanilla, valerian, ginger, and the odour control condition. The fixed order of conditions was randomly determined. The dogs were observed within each condition for a 2 h period from 11:00 h to 13:00 h for three consecutive days with two day intervals between conditions. Observations were conducted during this time period, which was outside of feeding and walking times, to prevent food or exercise anticipatory behaviours affecting the dogs' behaviour. This time period also allowed comparison between the dogs' behaviour when the shelter was closed to visitors (11:00 h to 12:00 h) and when the shelter was open to the public (12:00 h to 13:00 h) during visiting hours (12:00 h to 16:00 h). Before each observation period there was a 20 min observer habituation period (10:40 h to 11:00 h). This allowed the dogs to habituate to the observer's presence and observation circuit during the observations.

The dogs' behaviour was recorded by the observer every 10 min for the 2 h observation period using instantaneous scan-sampling. The experimenter recorded the dogs' behaviour during an observation circuit,

Table 1
Ethogram of behaviours utilised in this study (Graham et al., 2005).

Behaviour	Definition
Position	Dog is located in the front half of the kennel.
Standing	Dog is supported upright with all four limbs.
Sitting	Dog is supported by two extended front limbs and two flexed hind limbs.
Moving	Dog is walking, running, trotting or galloping about the kennel.
Resting	Dog is reclining in a ventral or lateral position, eyes open.
Sleeping	Dog is reclining in a ventral or lateral position, eyes closed.
Stereotyping	Dog is performing repetitive, apparently functionless behaviour.
Vocalising	Dog is barking, whining or whimpering.

where the observer walked past each kennel block and recorded the relevant subject's behaviour. At each sampling point (every 10 min) the observer began the observation circuit starting with block 1, proceeding past block 2 and block 3 and then onto block 4. All subjects were sampled within approximately 60 s.

Six scans were conducted each hour and 6 behaviour points were recorded, resulting in 36 behaviour points being recorded over three days per dog for every condition. Behaviours were recorded based on an ethogram used in previous work (Graham et al., 2005) (Table 1). The position of the dog was recorded at each time point in addition to the other variables. In addition, if vocalising occurred alongside another behaviour, both were recorded.

The observer conducted observations during their observation circuit from an open area in the compound located between the rows of kennels. The authors have read and can confirm that this study complies with the ISAE policy relating to animal ethics.

2.4. Data analysis

All fifteen dogs completed the procedure and the data set comprised 12 records per dog. The dogs completed six conditions, each of which was considered for two time periods. The total frequency of each behaviour for each condition was summed, providing an overall count per animal for each hour for each olfactory condition. Where behaviours were exhibited at very low levels across all conditions (mean frequency < 1) they were omitted from analysis as statistical analyses are not robust at such low levels. Otherwise, a linear mixed effects model was used to test for significant effects of time and condition and to identify interaction effects. The linear mixed effects model was used to estimate the effect of olfactory condition (nested within individual) while controlling for the effect of time (nested within condition; within individual). In the model, individual (n = 15) was fitted as a random effect and time (two levels) was fitted as a fixed effect. Condition (six levels) was also fitted as a fixed effect. Interactions were assessed between condition and time. Where significant differences between conditions were identified, multiple comparisons were performed with Tukey adjusted *p*-values reported. All statistical analyses were performed in R version 3.3.2; packages nlme, multcomp and Rmisc (R Core Team, 2016).

3. Results

3.1. Vocalising

There were significant main effects of olfactory condition (X^2 (5) = 24.73 $p < 0.0001$) and time (X^2 (1) = 9.33 $p < 0.01$) upon vocalising behaviour. The mean frequency of vocalisation was higher in the second hour (2.99 ± S.D. 3.53) than the first hour (2.36 ± S.D. 3.41). There was no significant interaction effect between olfactory condition and time (X^2 (5) = 1.55 $p = 0.183$).

Lower levels of vocalising occurred during all four olfactory conditions when compared to the control conditions and lower levels of vocalising occurred in the odour control than the cloth control condition (Fig. 1; Table 2) (coconut versus cloth control: z = 7.95, $p < 0.001$; coconut versus odour control: z = 4.27, $p < 0.001$; ginger versus cloth control: z = 8.88, $p < 0.001$; ginger versus odour control: z = 5.20, $p < 0.001$; valerian versus cloth control: z = −8.34,

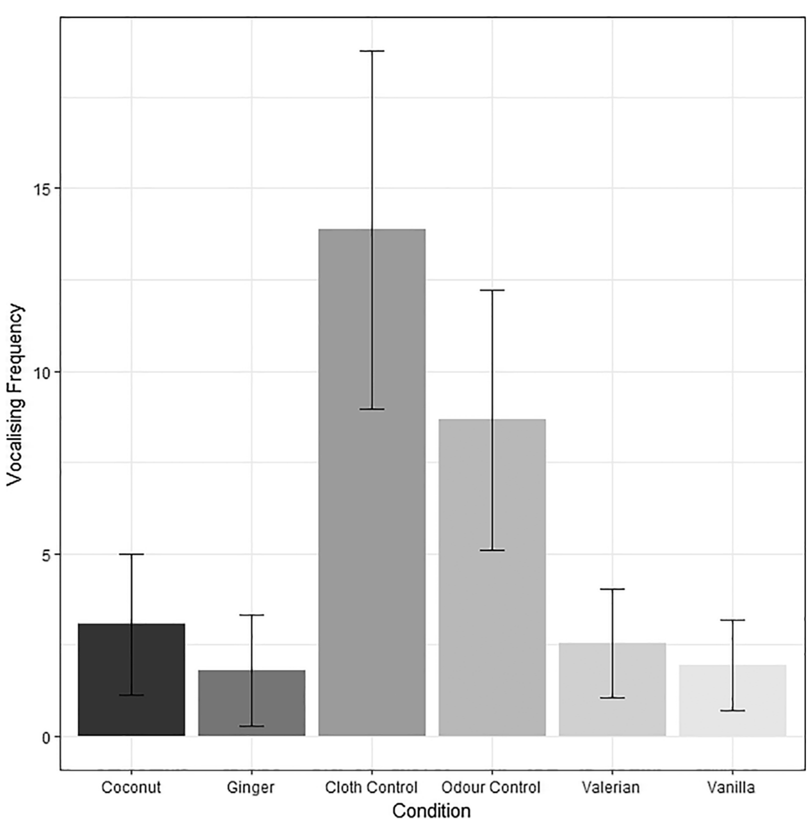

Fig. 1. The frequency of vocalisation displayed within the different odour conditions. Means plus 95% confidence intervals are displayed.

Table 2
The mean (± S.D.) number of times each behaviour was displayed by the dogs (n = 15) in the six olfactory conditions. The mean frequencies presented are for all dogs averaged across the three days of observation for each olfactory condition (mean occurrence/6 h of each condition). Significant contrasts between conditions are indicated via superscript letters.

Behaviour	Odour control	Cloth control	Coconut	Vanilla	Valerian	Ginger
Vocalising	8.67^{b} (6.42)	13.87^{a} (8.84)	3.07^{c} (3.49)	1.93^{c} (2.25)	2.53^{c} (2.70)	1.80^{c} (2.76)
Moving	5.80^{b} (4.41)	12.07^{a} (5.74)	2.20^{c} (1.82)	2.60^{c} (2.47)	1.73^{c} (2.25)	1.27^{c} (1.53)
Resting	$8.13^{a,b}$ (7.07)	4.47^{b} (4.17)	11.13^{a} (6.38)	10.47^{a} (6.31)	9.60^{a} (6.15)	10.60^{a} (6.09)
Sleeping	0.60^{b} (0.91)	0.53^{b} (1.13)	2.73^{a} (1.91)	$1.67^{a,b}$ (1.72)	$1.00^{a,b}$ (1.36)	2.67^{a} (3.27)
Standing	$22.73^{N/A}$ (8.10)	$22.00^{N/A}$ (6.39)	$18.53^{N/A}$ (6.24)	$21.07^{N/A}$ (6.57)	$21.13^{N/A}$ (8.13)	$16.87^{N/A}$ (7.70)
Sitting	$4.67^{N/A}$ (5.04)	$4.20^{N/A}$ (5.07)	$3.13^{N/A}$ (1.92)	$2.73^{N/A}$ (2.93)	$3.80^{N/A}$ (4.23)	$3.93^{N/A}$ (3.92)
Stereotypic	$0.40^{N/A}$ (1.06)	$0.87^{N/A}$ (1.30)	$0.33^{N/A}$ (0.62)	$0.00^{N/A}$ (0.00)	$0.00^{N/A}$ (0.00)	$0.00^{N/A}$ (0.00)
Positioned at front of kennel	15.00^{b} (8.65)	21.73^{a} (7.88)	15.87^{b} (7.12)	$17.47^{a,b}$ (8.40)	$19.80^{a,b}$ (9.36)	15.6^{b} (8.94)

$p < 0.001$; valerian versus odour control: z = −4.66, $p < 0.001$; vanilla versus cloth control: z = −8.78, $p < 0.001$; vanilla versus odour control: z = −5.10, $p < 0.001$; odour control versus cloth control: z = −3.68, $p < 0.01$). No significant differences were found between the remaining pairwise comparisons.

3.2. Moving

There was a significant main effect of olfactory condition (X^2 (5) = 29.10, $p < 0.0001$) but no significant effect of time (X^2 (1) = 0.06, $p = 0.812$) upon movement. The mean frequency of moving was 2.22 (± S.D. 2.48) in the first hour and 2.18 (± S.D. 2.83) in the second hour. There was no significant interaction effect between condition and time (X^2 (5) = 1.73, $p = 0.137$).

Dogs spent less time moving during exposure to all four olfactory conditions when compared to the control conditions and lower levels of moving occurred in the odour control than the cloth control condition (Fig. 2; Table 2) (coconut versus cloth control: z = 8.93, $p < 0.001$; coconut versus odour control: z = 3.02, $p < 0.05$; ginger versus cloth control: z = 10.41, $p < 0.001$; ginger versus odour control: z = 4.50, $p < 0.001$; valerian versus cloth control: z = −9.96, $p < 0.001$; valerian versus odour control: z = −4.05, $p < 0.001$; vanilla versus cloth control: z = −9.13, $p < 0.001$; vanilla versus odour control: z = −3.21, $p < 0.05$; odour control versus cloth control: z = −5.19, $p < 0.001$). No significant differences were found between the remaining pairwise comparisons.

3.3. Resting

There were significant main effects of olfactory condition (X^2 (5) = 6.75, p < 0.0001) and time (X^2 (1) = 4.35, p < 0.05) upon resting behaviour. Higher levels of resting behaviour occurred in the first hour (4.84 ± S.D. 3.9) than the second hour (4.14 ± S.D. 3.0). There was no significant interaction effect (X^2 (5) = 1.00, p = 0.422) between condition and time.

Dogs spent more time resting during exposure to coconut, ginger, valerian and vanilla when compared to the cloth control condition (Fig. 3; Table 2) (coconut versus cloth control: z = −4.91, p < 0.001; ginger versus cloth control: z = −4.70, p < 0.001; valerian versus cloth control: z = 4.20, p < 0.001; vanilla versus cloth control: z = 4.65, p < 0.001). All remaining pairwise comparisons were non-significant.

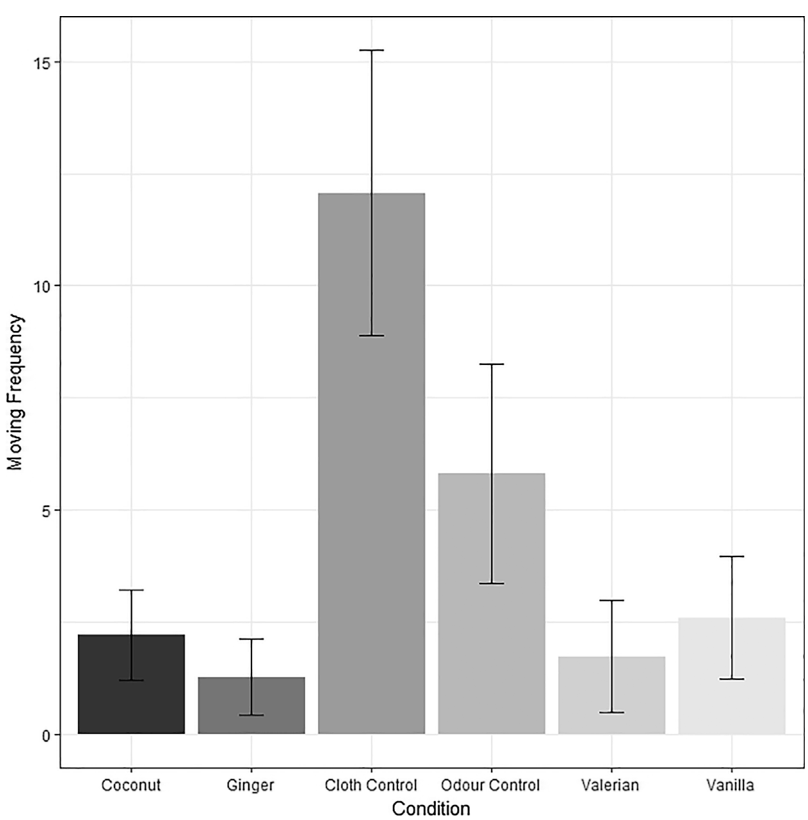

Fig. 2. The frequency of movement displayed within the different odour conditions. Means plus 95% confidence intervals are displayed.

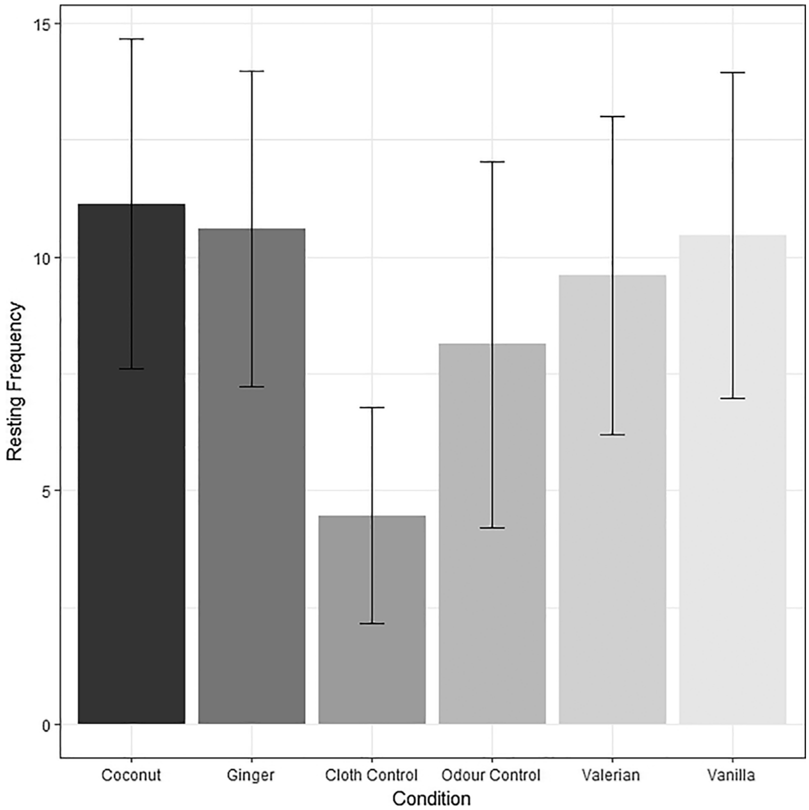

Fig. 3. The frequency of resting displayed within the different odour conditions. Means plus 95% confidence intervals are displayed.

3.4. Sleeping

There was a significant main effect of olfactory condition (X^2 (5) = 4.56, $p < 0.01$) upon sleeping behaviour. There was no significant effect of time (X^2 (1) = 0.34, $p = 0.559$). The mean frequency of sleeping was 0.79 (± S.D. 1.21) in the first hour and 0.71 (± S.D. 1.19) in the second hour. There was no significant interaction effect (X^2 (5) = 2.18, $p = 0.064$) between condition and time.

Dogs spent more time sleeping during exposure to coconut and ginger than the control conditions (Fig. 4; Table 2) (coconut versus cloth control: z = −3.34, $p < 0.05$; coconut versus odour control: z = −3.24, $p < 0.05$; ginger versus cloth control: z = −3.45, $p < 0.01$; ginger versus odour control: z = −3.34, $p < 0.05$). No significant differences were found between the remaining pairwise comparisons.

3.5. Position

There were significant main effects of olfactory condition (X^2 (5) = 4.41 $p < 0.01$) and time (X^2 (1) = 13.18 p < 0.001) upon how often the dogs were located at the front of the kennel. The mean frequency of being positioned at the front of the kennel was lower in the first hour (8.24 ± S.D. 4.68) than the second hour (9.38 ± S.D. 4.35). There was no significant interaction effect between condition and time (X^2 (5) = 1.55 $p = 0.182$).

Dogs spent more time at the front of the kennel in the cloth control condition than during the odour control condition and exposure to coconut and ginger (Fig. 5; Table 2) (coconut versus cloth control: z = 3.54, $p < 0.01$; ginger versus cloth control: z = 3.49, $p < 0.01$; odour versus cloth control: z = −3.88, $p < 0.01$). No significant differences were found between the remaining pairwise comparisons.

3.6. Other behaviours

There was a significant main effect of time (X^2 (1) = 6.82, $p < 0.05$) but no significant effect of condition (X^2 (5) = 2.30, $p = 0.054$) on standing behaviour. The mean frequency of standing was higher in the second hour (10.80 ± S.D. 3.79) than the first hour (9.83 ± S.D. 4.39). There was no significant interaction effect between condition and time (X^2 (5) = 1.16, $p = 0.3362$).

There was no significant effect of condition (X^2 (5) = 0.95, $p = 0.457$) or time (X^2 (1) = 0.002, $p = 0.96$) on sitting behaviour. The mean frequency of sitting was 1.87 (± S.D. 2.07) in the first hour and 1.88 (± S.D. 2.39) in the second hour. There was also no significant interaction effect between condition and time (X^2 (5) = 0.91, $p = 0.48$).

Stereotypic behaviours were performed at very low levels and were therefore omitted from the statistical analyses.

4. Discussion

This study aimed to determine the effects of olfactory stimulation via vanilla, coconut, ginger and valerian on the behaviour of shelter dogs. The findings indicate that exposure to ginger, coconut, vanilla and valerian significantly influences the behaviour of kennelled dogs in this shelter. Exposure to all the olfactory conditions investigated resulted in lower levels of vocalisations and movement compared to the control conditions, while dogs also showed increased levels of sleeping behaviour during the coconut and ginger conditions compared to the control conditions. The experimental set-up caused olfactory condition to be entangled with order of presentation, but since the two control conditions were presented either first or last we feel confident that our findings do reflect the effects of olfactory stimulation. Time was also found to affect the dogs' behaviour with higher levels of vocalisation and standing, as well as lower levels of resting occurring in the second hour when the shelter was open to visitors. The dogs were also positioned at the front of their kennel more often in the second hour when the shelter was open to the public.

Exposure to coconut, vanilla, valerian and ginger reduced vocalisations in the dogs which may be suggestive of reduced stress. Excessive

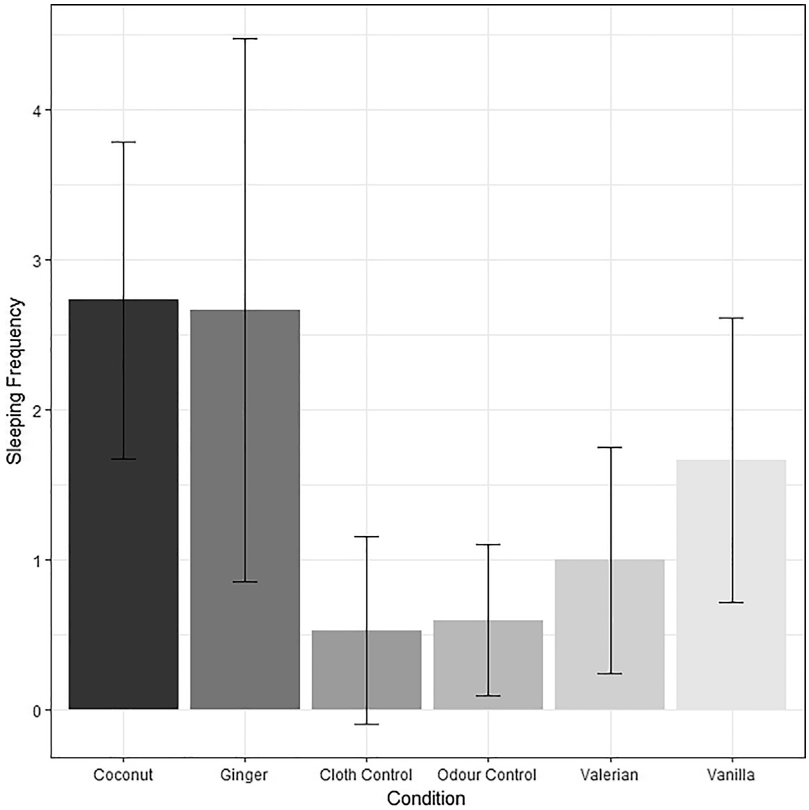

Fig. 4. The frequency of sleeping displayed within the different odour conditions. Means plus 95% confidence intervals are displayed.

vocalisation is frequently used as an indicator of stress in dogs (Hetts et al., 1992; Stephen and Ledger, 2005; Taylor and Mills, 2007). Vocalising (such as barking, growling, whining and yelping) is displayed by dogs during periods of acute and chronic stress, alongside other indicators suggestive of stress such as lowered posture and repetitive behaviour (Beerda et al., 1997; Beerda et al., 1999). These increased vocalisations are also displayed by spatially restricted and socially isolated dogs alongside behaviours suggested to indicate stress such as

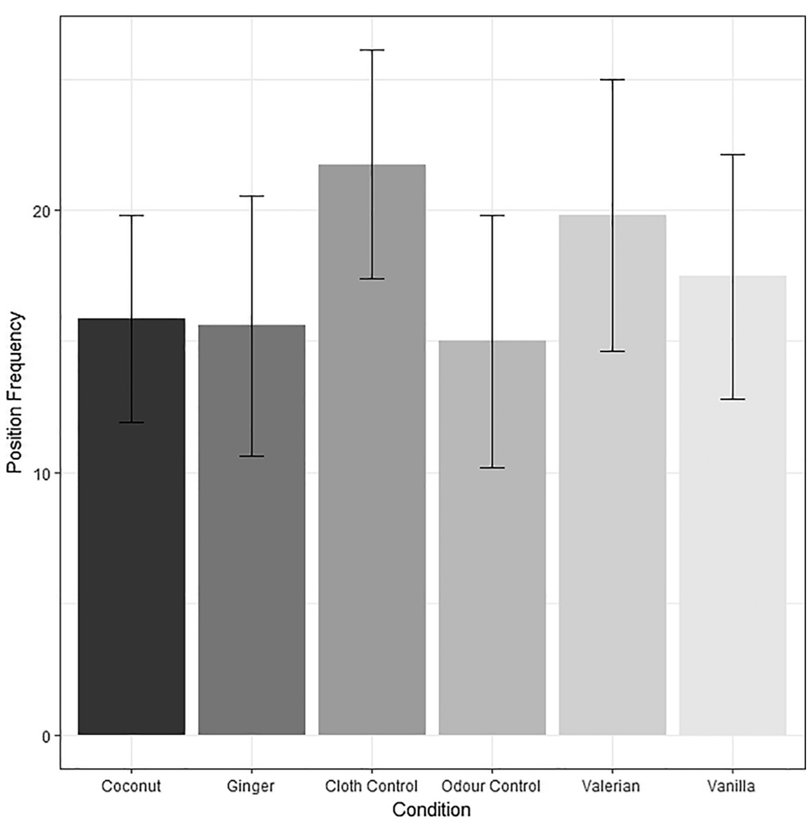

Fig. 5. The frequency that the dogs were located at the front of the kennel displayed within the different odour conditions. Means plus 95% confidence intervals are displayed.

pacing and paw lifting (Hetts et al., 1992; Beerda et al., 1999). Phobic dogs can also display increased vocalisations (e.g. barking and whining) in stressful contexts such as thunderstorms (Dreschel and Granger, 2005). While concerns can be raised about the use of vocalisations as a stress indicator in dogs, as deciphering the affective state of dogs can be challenging and increased vocalisations can also be displayed to attract human attention or in positive contexts such as play (Yin, 2002; Yin and McCowan, 2004), the aversive contexts in which excessive vocalisations are often displayed by dogs and the associated behaviours are supportive that excessive vocalisation may indicate stress in dogs. Excessive vocalisation is also considered undesirable by potential adopters (Wells and Hepper, 1992; Wells and Hepper, 2000), and the high noise levels caused by these vocalisations may have welfare implications such as potential damage to dogs' hearing (Sales et al., 1997). Since all four odour conditions tested (coconut, vanilla, valerian, and ginger) significantly reduced vocalisation behaviours, this is suggestive that exposure to these odours may hold potential to reduce stress in shelter dogs.

This finding is also supported by the decreased movement shown by the dogs in these conditions, as excessive activity is also used as an indicator of stress in kennelled dogs (e.g. Hetts et al., 1992; Beerda et al., 2000), as well as being considered undesirable by adopters (Protopopova et al., 2014; Protopopova and Wynne, 2014). In addition, increased sleeping behaviour was also shown in the coconut and ginger conditions. Enhanced sleeping behaviour has been suggested to be indicative of relaxation and improved welfare in kennelled dogs (Kogan et al., 2012; Brayley and Montrose, 2016) and comparable to the increased resting behaviour found from use of enrichment in other kennelled dog studies (e.g. Wells et al., 2002a; Graham et al., 2005). It is important to note though that while enhanced resting and sleeping are often utilised as an indicator of increased welfare in dogs (e.g. Wells et al., 2002a; Graham et al., 2005; Kogan et al., 2012), inactivity is not a simple indicator of wellbeing. Increased inactivity may indicate apathy, boredom or learned helplessness (Wells et al., 2002b; Stephen and Ledger, 2005; Burn, 2017). Interpreting the emotional state underlying these behaviours is challenging and with the ethogram used in this study it is not possible to draw conclusions about the emotional state underlying these behaviours.

Our findings suggest that olfactory stimulation via vanilla, valerian, ginger and coconut may have application in rescue shelters due to reducing behaviours such as barking and excessive activity. While there are limitations with the use of these measures which should be considered, these findings may be suggestive of reduced stress in the dogs. The effects of the odours were seen both when the shelter was open and when it was closed to visitors. The use of these odours may also have indirect benefits as by reducing behaviours, such as vocalising and activity, that are deemed undesirable by potential adopters (e.g. Wells and Hepper, 1992; Protopopova and Wynne, 2014), this may also have the potential to positively influence public perceptions of dog desirability and their subsequent likelihood of rehoming.

One behaviour which is attractive to potential adopters, the dog being at the front of the kennel (Wells and Hepper, 1992), was greatest in the cloth control condition, compared to both the other control and the coconut and ginger conditions. While this could suggest that consideration may be warranted regarding the use of olfactory stimulation during public viewing times, it is important to note that the dogs being positioned at the front of the kennel was also observed most during times when the shelter was open to the public suggesting that visitors may in themselves stimulate this behaviour (Wells and Hepper, 2000). If shelters do choose to mediate potential trade-offs between visibility of dogs to potential adopters and environmental interventions, it is important that consideration of the welfare of the dogs remains paramount, particularly as higher levels of vocalisation and lower levels of resting were seen in the dogs when the shelter was open to visitors.

While the findings of this study suggest that olfactory stimulation may have application in rescue shelters, it is important to be cautious when considering the conclusions drawn in this study. In addition to the concerns highlighted earlier regarding the use of barking and activity as indicators of stress in dogs, and the difficulties with interpreting the dogs' underlying emotional state, there are also concerns related to the study design and sample. Limitations include the sample size, which was relatively small compared to previous work in this field (e.g. Graham et al., 2005), the relatively limited ethogram used, the potential impact of order and observer effects and concerns with generalising these findings to the shelter dog population, as well as the relatively limited duration of exposure of dogs to the olfactory conditions. A further limitation is that the design of the experiment caused the olfactory treatment to be entangled with the order of presentation. Due to the difficulties of preventing odour transmission between the dogs' enclosures, the dogs were simultaneously exposed to each olfactory treatment. The conditions were therefore applied in a fixed order which meant that treatment effects were entangled with order effects. In addition, in this study a number of repeated observations were made from a single small group of individuals that lacked spatial independence. This may have caused concerns with pseudoreplication and social facilitation of behaviour. While this does not disqualify the study or render the findings not of potential value, it is important to note that this may raise concerns when generalising conclusions from this sample across all shelter dogs.

Overall, the findings from this study suggest that use of odours such as coconut, ginger, vanilla and valerian affect the behaviour of kennelled dogs at this shelter. All odours used influenced the dogs' behaviour by reducing activity and vocalisations. Coconut and ginger additionally increased sleeping behaviour in the kennelled dogs. While the use of behaviours such as barking and activity to indicate stress in dogs need to be viewed with caution due to the difficulties in interpreting the emotional states underlying these behaviours, barking and excessive activity may be indicative of stress in shelter dogs (Hetts et al., 1992; Beerda et al., 2000), as well as being traits perceived as undesirable by adopters (e.g. Wells and Hepper, 1992; Protopopova and Wynne, 2014).

Further investigation using a larger sample size, use of video to record behavioural observations and longer durations of olfactory exposure would be of value. Use of physiological stress indicators, such as cortisol or infrared thermography, alongside behavioural indicators would also be beneficial. In addition, examining the effects of olfactory stimulation on visitors to animal shelters may also be valuable. Odours can affect human emotional state (Ehrlichman and Halpern, 1988; Diego et al., 1998; Weber and Heuberger, 2008) and have been utilised in supermarkets to attempt to influence consumer behaviour (Spangenberg et al., 1996; Chebat and Michon, 2003). Investigating the effects of olfactory stimulation on the length of time that visitors spend at the shelter, and on their perceptions of the dogs' traits and adoptability may be of value.

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