Applied Animal Behaviour Science 123 (2010) 56–62

Contents lists available at ScienceDirect

Applied Animal Behaviour Science

journal homepage: www.elsevier.com/locate/applanim

The influence of olfactory stimulation on the behaviour of cats housed in a rescue shelter

Sarah L.H. Ellis [a,*], Deborah L. Wells [b,1]

[a] Department of Biological Sciences, University of Lincoln, Riseholme Park, Riseholme, Lincoln, LN2 2LG, UK
[b] School of Psychology, Queen's University Belfast, Belfast, BT7 1NN, Northern Ireland, UK

ARTICLE INFO

Article history:
Accepted 17 December 2009
Available online 18 January 2010

Keywords:
Behaviour
Cats
Enrichment
Rescue shelters
Scent
Olfactory stimulation
Welfare

ABSTRACT

A wide variety of feline species have been shown to gain welfare benefits from the introduction of olfactory stimuli to the captive environment. The effect of this stimulation on the domestic cat, however, has been largely overlooked. This study thus explored the influence of olfactory stimulation on cats housed in a rescue shelter to determine whether it holds any value as a method of enrichment for this species. One hundred and fifty cats were randomly assigned to one of five conditions of olfactory stimulation (control [an odourless cloth]; biologically relevant odour [a cloth impregnated with the scent of rabbit]; biologically non-relevant odours, [a cloth impregnated with lavender, a renowned relaxant, or the scent of catnip, a well known stimulant]). Cats were exposed to the relevant olfactory stimuli for 3 h a day for five consecutive days. Each cat's behaviour was recorded every 5 min on days one, three and five of olfactory exposure, using instantaneous scan sampling. Overall, cats showed relatively little interest in the cloths, spending just over 6% of the total observation time interacting with these stimuli. However, animals exposed to the catnip-impregnated cloths exhibited significantly more interest in the stimulus than animals exposed to the other cloths, spending an average of 11.14% of the observation time interacting with the objects. Across all experimental conditions, interest in the cloths was significantly lower in the second and third hours of stimulus presentation compared to the first, suggesting habituation. Certain components of the cats' behavioural repertoire were influenced by olfactory stimulation. Catnip and prey scent encouraged a significantly higher frequency of behaviours indicative of reduced activity (e.g. more time sleeping, less time standing and actively exploring the environment) in comparison to the control condition. Catnip also encouraged play-like behaviour characterised as the 'catnip response'. Overall, the results suggest that certain odours, notably catnip, may hold potential as environmental enrichment for captive domestic cats.

1. Introduction

Common definitions of environmental enrichment comprise the description of the addition of one or more 'factors' to a relatively impoverished environment to examine the impact of these variables on the physical and psychological welfare of the animal(s) involved (see Chamove, 1989; Newberry, 1995; Shepherdson, 1998; Young, 2003). These 'factors' commonly refer to any physical, social, design, or management features that may improve the behavioural microhabitat of captive animals (Shepherdson, 1998; Young, 2003; Smith and Corrow, 2005). One such 'factor' is the introduction of novel and/or species-specific scents into the captive

* Corresponding author. Tel.: +44 1522 895307; fax: +44 1522 895328.
E-mail addresses: sellis@lincoln.ac.uk (Sarah L.H. Ellis), d.wells@qub.ac.uk (D.L. Wells).
[1] Tel.: +44 28 90 974386; fax: +44 28 90 664144.

0168-1591/$ – see front matter © 2010 Elsevier B.V. All rights reserved.
doi:10.1016/j.applanim.2009.12.011

environment as a popular means of attempting to enrichment the environment by reducing sensory deprivation in a number of species (for review see Wells, 2009). Much of this work has been successfully carried out on zoo-housed wild cats (for review see Clark and King, 2008), with both positive psychological and physiological benefits reported (Powell, 1995; Schuett and Frase, 2001; Pearson, 2002). For example, exposure to the odours of rosemary, chives, lemongrass and allspice has been shown to encourage more active and social behaviours, including allo-play and allo-grooming, in zoo-housed Asiatic lions, *Leo panthera* (Pearson, 2002). Rosemary has also been shown to increase back rolling and head rubbing in these animals, behaviours similar to those produced by catnip (Pearson, 2002). More recently, Wells and Egli (2004) discovered that captive black-footed cats (*Felis nigripes*) showed an increase in species-specific behaviours and a decrease in stereotypic pacing when exposed to cloth-impregnated odourants of nutmeg, catnip and the body odour of a potential prey animal (quail).

Recently, similar investigations have been carried out on domestic species. For example, Graham et al. (2005) found that dogs housed in a rescue shelter exposed to the scents of diffused chamomile and lavender exhibited increased resting and decreased vocalisation, behavioural changes indicative of increased relaxation and improved well-being. Ambient odours of peppermint and rosemary, by contrast, encouraged behaviours more suggestive of agitation (i.e. barking).

Although the success of olfactory stimulation as a means of environmental enrichment has been scientifically documented for both captive wild cats and sheltered domestic dogs, its value for the domestic cat, whilst advocated (Rochlitz, 2000), remains unknown. This is somewhat surprising since cats are extremely olfactory-orientated animals, making use of odour cues in intra- and inter-specific communication (Robinson, 1990; O'Farrell and Neville, 1994; Nielson, 2008), hunting (O'Farrell and Neville, 1994), feeding (Overall, 1997) and the maintenance of social-cohesion (Macdonald et al., 1987). In addition, detection of scent, in particular, that of the cat's household communal odour (comprised of the individuals residing in the house) often conveys messages of identity, familiarity and security. Such sensitivity to olfactory stimulations has been illustrated in a study investigating domestic felids' behavioural responses to 5 different scents, including, for example, bleach and fish (Nielson, 2008). Whilst discrimination between, and preference for, scents was demonstrated, the cats were only exposed to each odourant for 30 s and therefore their enrichment potential could not be evaluated.

Despite little being documented on their potential enriching properties to the captive cat, olfactory stimulations for cats are readily available on the commercial market (e.g. cat toys containing scents of catnip and valerian). The following study therefore aimed to determine whether olfactory stimulation, in the form of cloths impregnated with a variety of odours, holds any potential as a method of environmental enrichment for captive-housed cats, specifically those housed in rescue shelters.

2. Method

2.1. Study site

Cats Protection Adoption Centre in Co. Antrim, Northern Ireland, was employed as the study site. The cats at this site were housed in two rows of line-block style enclosures which were positioned with the indoor part of the enclosures of one row facing the other. Each cat's enclosure was divided into two sections, referred to hereafter as 'sleeping quarters' and 'exercise area'. The sleeping quarters (90 cm long × 75 cm wide × 108 cm high) contained a plastic bed, blanket and heating apparatus. From the sleeping quarters, the cats could view conspecifics (housed in opposite enclosures) and humans (both staff and visitors) as they walked past the front of the animals' pens. Cats were able to move freely through a flap from their sleeping quarters to the exercise area (187 cm long × 75 cm wide × 216 cm high), which contained a litter tray and water dish. From this location, the cats could view animals in the adjacent exercise areas, but not those in opposite enclosures. Visitors were only permitted to view the cats from a central corridor on the sleeping quarters side of the enclosures, rendering it difficult for them to see animals in the exercise areas.

Compatible cats were kept in pairs or groups, whilst those that were considered unsociable by Cats Protection staff were single-housed in a bid to reduce outbursts of aggression and safeguard welfare. Enclosures were cleaned thoroughly every morning and as needed throughout the course of the day. The animals were fed twice daily, once in the morning and once in the late afternoon. Visitors were able to view the animals between 11:00 h and 15:00 h every day of the week.

2.2. Subjects

One hundred and fifty cats (69 males, 81 females) of mixed breed were randomly chosen as subjects. Most of the cats ($n = 139$, 92.7%) were housed in pairs or groups; the remainder were held singly. All of the cats were physically healthy, and between approximately 4 months to 8 years of age (exact ages were difficult to determine since most of the animals were either relinquished by their previous owners or found as strays). Most of the animals ($n = 131$, 87.3%) had been housed in the shelter for over one month. The sample employed was representative of cats admitted to Cats Protection in terms of breed, age, and sex.

2.3. Olfactory stimulation

Five conditions of olfactory stimulation (one control, four experimental) were developed for the study. These comprised:

(1) *Control environment*: The cats were exposed to no olfactory stimulation other than that arising naturally from their environment, e.g. the odour of the enclosures and their contents, visitors, staff, conspecifics.
(2) *Odourless cloth*: The cats were provided with a cotton cloth (see later), devoid of odour, in addition to

olfactory stimuli naturally present in the animals' environment.

(3) *Lavender* (*Lavandula intermedia*): The cats were exposed to cloths impregnated with the scent of dried lavender flower buds (Norris and Armitage, UK Lavender Distribution). Lavender was chosen for its previously reported calming properties with other species, including humans, pigs and domestic dogs (Bradshaw et al., 1998; Field et al., 2005; Goel et al., 2005; Graham et al., 2005; Lehrner et al., 2005; Wells, 2006).

(4) *Catnip* (*Nepeta cataria*): The cats were exposed to cloths impregnated with the scent of dried catnip (Kookamunga Chataire Catnip, Eight in One Pet Products, USA). Catnip was chosen primarily for its ability to induce pleasurable mental states (known as the 'catnip response') through olfactory detection. Catnip has also been previously reported to have enriching effects on both captive wild (Wells and Egli, 2004), and domestic (DeLuca and Kranda, 1992), cats.

(5) *Prey scent*: The cats were exposed to cloths impregnated with the faecal and body odour of the domestic rabbit *Oryctolagus cuniculus*. The rabbit is a common prey item for domestic cats (Courchamp et al., 1999; Woods et al., 2003) and was thus chosen for its species-relevant stimulating properties.

Each of the experimental stimuli was presented to the cats using two square cotton cloths (15 cm × 15 cm), one placed on the floor of the pen area and one on the floor of the exercise area within the enclosures. For both lavender and catnip, the cloths were submerged into the dried plant matter for the 24-h period before the condition commenced. Twenty grams of catnip and lavender was employed per cloth. For the condition 'prey scent', the cloths were rubbed over the rabbit's scent glands twenty times and then left in contact with dried rabbit faeces for the 24-h period before testing commenced. Gloves were always worn by the experimenter (SLHE) when handling any of the cloths to reduce the likelihood of odour transmission.

2.4. Procedure

The cats were randomly assigned to one of the five conditions (30 animals per condition) in a between-subjects design. It was ensured that there was a roughly equal distribution of animals across conditions according to age, sex and length of time in the rescue shelter.

Each cat was exposed to its allocated condition for five days, between 12:00 h and 15:00 h, totalling 15 h of exposure per animal. The cats were always presented with the olfactory stimuli at the same time of day to prevent any inconsistent exposure to extraneous events in the shelter environment, e.g. feeding, enclosure cleaning. In addition, it was ensured that all of the cats included in the study at the same time received the same olfactory stimulation to prevent cross-contamination of scents. Cloths were removed immediately after observation on each day of presentation with enclosures being cleaned the following morning before the introduction of a new cloth, thus preventing an increase in scent intensity across the five days or exposure. In addition, the minimum time between the removal of a one type of scented cloth and the introduction of another was 60 h (Friday p.m. to Monday a.m.) and during this time three full cleans of the enclosure took place allowing extensive cleaning to remove any traces of the original scent.

The behaviour of each cat was recorded on 3 of the 5 days of presentation to the olfactory stimulation. The days on which the cats were studied were not always the same between conditions due to uncontrollable events in the shelter environment (e.g. veterinary visits, husbandry disruptions). Cats were only studied on the days on which there were no disruptions in the environment. Observations of the animals' behaviour commenced as soon as the cloths were placed in the enclosures. Prior to this time, the experimenter spent 10 min within the visitor corridor to let the animals habituate to her presence. The experimenter then approached the front of each subject's enclosure and recorded the cat's behaviour as soon as she saw the animal. Each cat's behaviour was recorded every 5 min over the recording period using an instantaneous scan-sampling technique (e.g. Martin and Bateson, 1993), providing 36 observations of each animal's behaviour per day. For each condition, at every sample point, the behavioural state of each individual was recorded according to an ethogram devised from pilot studies and existing work in this area (UK Cat Working Group, 1995, see Table 1). In addition, for all the experimental conditions which incorporated the addition of a cloth,

Table 1
The ethogram of cat behaviours recorded in this study (adapted from the U.K. Cat Behaviour Working Group, 1995).

Behaviour	Description
Interact with cloth	Cat interacts with cloth, e.g. sniffs, touches, plays with, lays or rolls on, the cloth
Sitting	Cat is positioned with its front legs extended straight, front paws and rump on the ground
Standing	Cat is positioned with four paws in contact with the ground
Resting	Cat is positioned with its legs in a crouched position and body held ventrally close to the ground. Cat is generally inactive, with its eyes open or partially closed
Sleeping	Cat is in resting position, with eyes constantly closed. Paws may or may not be in contact with the ground
Moving	Cat walks, runs, trots or climbs through the environment
Grooming	Cat licks, chews or scratches its own body
Playing	Cat manipulates an object with its paw(s) in an apparently playful manner. It may pat at the object with claws retracted, throw an object in the air, pounce upon it, wrestle with it or chase it. Playing can also occur without an object where cat may jump, pounce or chase as if it was interacting with an imaginary object.
Socialising	Cat interacts (i.e. grooms, plays) with conspecific/s
Exercise area	Cat is located in exercise area of enclosure

the number of times that cats were observed interacting with the cloths was also recorded.

2.5. Data analysis

The total number of times each cat in each condition was observed performing each behaviour on the ethogram was summed, providing an overall frequency count per animal per behaviour (the single-housed cats were excluded from analysis of the behaviour *socialising*). Kruskal–Wallis tests were subsequently carried out to determine whether there were any significant differences in the behaviour of the cats between conditions of olfactory stimulation.

For the experimental conditions, a Friedman ANOVA was conducted to determine whether the amount of time that the cats interacted with the cloths differed significantly across the three hours of presentation, i.e. hours 1, hours 2, hours 3. All post-hoc tests (Mann–Whitney *U*-tests, Wilcoxon tests) were carried out using a Bonferroni adjusted alpha level of 0.01.

3. Results

3.1. Interaction with cloths

Overall, the cats spent 6.25% of the observation time interacting with the cloths (i.e. 6.75 times out of 108 sample points).

The amount of time that the cats were recorded interacting with the cloths was significantly ($\chi^2 = 17.17$, df = 4, $P < 0.01$) related to the condition of olfactory stimulation (see Table 2). Post-hoc Mann–Whitney *U*-tests showed that cats exposed to *catnip* spent significantly more time interacting with the cloths than animals exposed to any of the other olfactory conditions (*odourless cloth* [$Z = -3.006$, $P < 0.01$], *prey scent* [$Z = -3.794$, $P < 0.001$], *lavender* [$Z = -3.110$, $P < 0.01$]). The amount of time that the cats were observed interacting with the cloths did not differ significantly, however, between the *odourless cloth* and the *prey scent* ($Z = -0.756$, $P = 0.45$) or *lavender* ($Z = -0.374$, $P = 0.71$) conditions. A break down of interaction with cloth revealed three specific behaviours directed towards the cloth; sniff cloth, body (or body part) resting on cloth and play with cloth.

The amount of time that the cats were observed interacting with the cloths (in the conditions in which cloths were present) differed significantly across the 3 h of daily presentation ($\chi^2 = 43.08$, df = 2, $P < 0.001$). The animals spent significantly more time interacting with the cloths during their first hours of presentation (mean number of observations = 0.99, ± 0.11), compared to their second ($Z = -5.127$, $P < 0.001$; mean number of observations = 0.61, ± 0.12) or third ($Z = -3.424$, $P < 0.01$; mean number of observations = 0.68, ± 0.12) hours of presentation. There was no significant difference in the amount of time the cats were witnessed interacting with the cloths between hours 2 and 3 of presentation ($Z = -0.849$, $P = 0.40$).

3.2. The effect of olfactory stimulation on cat behaviour

Analysis revealed a significant effect of olfactory stimulation on some of the cat behaviours recorded, namely standing, resting, sleeping, moving, grooming, socialising and in exercise area (see Table 2). However, Bonferroni corrections on the pairwise comparisons using an adjusted alpha level of 0.01 reduced the number of significant effects.

Olfactory stimulation had a significant effect on the sedentary behaviours of sleeping ($\chi^2 = 16.78$, df = 4, $P < 0.01$), standing ($\chi^2 = 17.39$, df = 4, $P < 0.01$) and resting ($\chi^2 = 16.34$, df = 4, $P < 0.01$). Post-hoc tests revealed that cats exposed to *catnip* ($Z = -3.181$, $P < 0.01$) and *prey scent* ($Z = -3.476$, $P < 0.01$) showed a significantly higher occurrence of sleeping, and significantly less standing ($Z = -3.564$, $P < 0.001$ [*catnip*], $Z = =3.199$, $P < 0.01$ [*prey scent*]) and resting ($Z = -3.117$, $P < 0.01$ [*catnip*], $Z = 3.221$, $P < 0.01$ [*prey scent*]) than cats in the control environment condition.

Olfactory stimulation also had a significant effect on the more active behaviours. Moving was significantly influenced by olfactory stimulation ($\chi^2 = 13.34$, df = 4, $P < 0.05$), with cats exposed to *catnip* ($Z = -2.799$, $P < 0.01$) and *prey scent* ($Z = -2.764$, $P < 0.01$) showing significantly less active exploration in comparison to those in the *control environment*. Grooming was also found to be significantly influenced by olfactory stimulation ($\chi^2 = 10.00$, df = 4, $P < 0.05$), with significantly fewer occurrences of this behaviour pattern observed in cats exposed to *catnip*

Table 2
The mean number of times (expressed in percentage terms) cats in each condition of olfactory stimulation were observed performing each of the behaviours on the ethogram averaged across the three days of observation.

Behaviour	Control environment mean frequency (%)	Odourless cloth mean frequency (%)	Lavender mean frequency (%)	Catnip mean frequency (%)	Prey scent mean frequency (%)	*P*
Interact cloth	n/a	5.4	3.8	10.8	4.3	<0.01*
Sitting	10.9	9.9	10.4	9.0	7.6	0.19
Standing	4.1	3.2	3.3	1.6	2.0	<0.01*
Resting	19.3	14.1	16.2	13.6	13.5	<0.01*
Sleeping	55.6	64.8	61.8	68.3	72.5	<0.01*
Moving	5.3	3.8	5.2	2.5	2.5	<0.05
Grooming	5.0	5.6	5.0	3.3	4.6	<0.05
Playing	3.0	1.1	1.1	0.7	1.2	<0.05
Socialising	2.6	2.6	2.1	1.4	1.4	0.08
Exercise area	17.5	10.8	14.0	10.0	5.2	<0.01*

P values arising from the Kruskal–Wallis tests are presented.
* Significant result using Bonferroni adjusted alpha level of 0.01.

scented cloths than in animals exposed to the *odourless cloth* ($Z = -3.131$, $P < 0.01$). The activity of playing was also significantly influenced by olfactory stimulation ($\chi^2 = 11.51$, df = 4, $P < 0.05$), with cats exposed to the *catnip* scented cloths playing significantly less than those in the control condition ($Z = -2.896$, $P < 0.01$). However the behaviour 'playing' does not include any playing directed specifically at the cloth (which instead is measured as a component of 'interaction with cloth'). Finally, position in the enclosure was also significantly influenced by olfactory stimulation ($\chi^2 = 20.50$, df = 4, $P < 0.01$). Cats in the *prey scent* condition frequented the sleeping area significantly more than cats in all the other conditions (*odourless cloth*, $Z = -3.045$, $P < 0.01$; *lavender*, $Z = -2.844$, $P < 0.01$; *catnip*, $Z = -3.045$, $P < 0.01$; *control environment*, $Z = -4.080$, $P < 0.01$).

4. Discussion

Overall, the findings from this study demonstrate that olfactory stimulation can influence the behaviour of sheltered cats, and that certain olfactory interventions, in this case the addition of catnip, may hold potential as an environmental enrichment strategy for such animals.

The cats in this investigation spent, on average, across the four conditions in which the cloths were present, just over 6% of their time interacting with the stimuli. Whilst this appears a relatively small percentage of time, a recent study investigating the effect of visual stimulation on the behaviour of cats housed in a rescue shelter found similar results; the cats in this study exhibited interest in television screens depicting various moving images for 6.10% of the observation time (Ellis and Wells, 2008). It is possible that cats in a shelter environment only respond to novel stimuli for a relatively small proportion of time, regardless of the nature of this stimulus, e.g. visual or olfactory. It is very difficult to deduce from frequency (or duration) of behaviour alone how important a stimulus is to an animal's well-being, thus highlighting one of the methodological problems of utilising behavioural measures to assess the welfare implications of potential enrichment strategies. For example, behaviour such as drinking can occur at low frequencies in comparison to other behaviours such as resting, yet is of vital importance to an animal's survival. The relatively low occurrence of interaction with the cloths cannot therefore be used alone to determine their enrichment potential. Other factors, such as the nature of the behaviours expressed, should also be taken into account when considering the welfare implications of an environmental intervention.

The cats' interest in the cloths differed significantly between the conditions of olfactory stimulation. Cats exposed to catnip showed significantly more interest in this stimulus than animals exposed to other odours, spending on average 11.4% of their time interacting with the scent-impregnated cloths. Although not explored for statistically in light of the low daily frequency of behaviours witnessed within individuals, the catnip-impregnated cloths appeared to encourage particularly playful behaviour specifically directed at those cloths, for some individuals, for example, pawing at, wrestling with and rolling on the cloths (total interaction time across individuals and summing the three days of observation revealed 103 play behaviours directed at the catnip-impregnated cloths versus only 36 play interactions directed at the control cloth). These play behaviours may well reflect elements of the 'catnip response' which is known to consist of four components: (1) sniffing, (2) licking and chewing with head shaking, (3) chin and cheek rubbing and (4) head-over rolling and body rubbing (Tucker and Tucker, 1988). This invariable automatic response often additionally includes digging, pawing, scratching, salivating and grooming (Tucker and Tucker, 1988). Although none of these individual behaviours are exclusive to the catnip response, their combination in the mentioned sequence is unique to the catnip response, and is believed to indicate intrinsic reward or pleasure (Hatch, 1972; Tucker and Tucker, 1988).

It must be noted that whilst catnip produces the same response in cats of any sex, sexual status, colour or breed (Holmes, 1993; Barry, 2005), only 50–70% of cats exhibit the documented catnip response, its reaction being one determined by genetics (Hart, 1977). In addition, it has previously been reported that a number of factors, including environmental (e.g. sounds and routines of the habitat) and psychological (e.g. adjustment to the habitat), qualitatively influence the catnip response (Tucker and Tucker, 1988), although it is not documented in what way. The cats in the current study were randomly allocated to the catnip condition and were therefore not tested prior to the study to see if they exhibited the catnip response. The results may therefore have been somewhat 'diluted' due to the likelihood that only 15–21 (50–70%) of the cats would, proportionally, have had the genetic ability to behaviourally react to this herb. That said, certain cats exposed to catnip did show behaviour indicative of improved well-being, for example, increased play (directed towards the impregnated cloth), a behaviour associated with a positive welfare state (Leyhausen, 1979; Friend, 1991). Previous research has also shown that potential owners are more likely to re-home cats with certain behavioural traits (e.g. a playful nature [Vandenbussche *et al.*, 2002]). Thus, the addition of catnip to the enclosures of cats known to have the genetic basis for the catnip response may have the potential to improve both the short- and long-term welfare of such animals.

Interestingly, cats exposed to the odourants of lavender and prey scent spent less time interacting with the cloths (3.86% and 4.41% of the total observation time, respectively) than animals exposed to the unscented cloths (5.59% of total interaction time). Since previous studies have reported beneficial effects of lavender (Bradshaw et al., 1998; Graham et al., 2005; Wells, 2006) and prey scents (Baker et al., 1997; Wells and Egli, 2004) on captive animals, including wild cats, the relatively low level of interest exhibited by the cats in the present investigation is somewhat surprising. Further research is needed to explore whether this result represents a simple lack of interest in these particular odour cues, or whether such stimuli are simply of no biological value or interest (or are perhaps even aversive), to domestic cats.

Whilst the cats in this study showed some interest in the odour-impregnated cloths, they were also observed interacting with the control cloths (i.e. those with no scent impregnated). On average across the three days of observation and across individuals, cats interacted with the control cloths for 5.4% of the observations but only for 4.3% and 3.8% of the observations for prey scent and lavender respectively. Thus, it appears the novel object of the cloth itself held some interest to the cats as well as causing changes in general behaviour. The novelty of an object is an important feature in terms of initiating exploration and investigation of it (Trickett et al., 2009). Further investigation into the use of cloths (without odour) over the longer term would help identify whether the cloth itself has potential enriching value or it is simply the case of a novel object within the environment eliciting short-term interest.

In addition, the novelty of the scented cloths may also have some impact on their ability for behavioural change. For example, the amount of attention that the animals directed towards the odour-impregnanted cloths decreased significantly between the first and second hours of daily presentation, suggesting a degree of habituation. It is known that cats rapidly habituate to play objects (Hall et al., 2002) and visual stimulation in the form of televised moving images (Ellis and Wells, 2008). It is thus of little surprise that habituation was also witnessed with the olfactory stimulation explored here. As with other types of enrichment strategy, rotation of odours may be required to maintain novelty and facilitate an enriching effect (see Wells, 2009).

A number of factors must be considered if using olfactory stimulation in the captive environment. For instance, one must consider the optimum strength of olfactory stimulus to use. Some authors have reported unwanted physical side effects (e.g. vomiting, skin irritation) in pet cats exposed to potpourri (Richardson, 1999; Foss, 2002), and thus care needs to be taken to ensure that the type, and concentration, of olfactory stimulus utilised is safe to employ.

Individual variation in response to olfactory information also needs to be considered. Differences in feline personality (e.g. Lee et al., 2007; McCune, 1992) may give rise to differences in response to olfactory stimulation, with some animals perhaps gaining more benefits from this type of sensory input than others or some animals showing preference over one type of scent over others.

Although this study focused on the value of odour *introduction* for captive feline welfare, the avoidance of natural odour *removal* also needs to be mentioned. Routine husbandry practices can remove important olfactory information, both regarding the self and others in the group. Many species (e.g. non-human primates, felids) scent mark in a bid to demarcate territories, advertise reproductive state, signal resource ownership and convey information on social status (e.g. Drea and Scordata, 2008). The natural scents left behind through elimination (both urination and defecation), hair and sweat glands can also provide cues that are both informative, and potentially enriching, in their own right (Wells, 2009). As a solution to the problem of odour removal, Clark and King (2008) recommend cleaning half of an animal's enclosure at a time, thus allowing the retention of some meaningful odour cues.

This research was carried out using an opportunistic sample of sheltered animals, the majority of which (92.7%) were pair- or group-housed. Social interactions between pen-mates were seldom witnessed during the testing periods. Nonetheless, it cannot be ignored that the presence of another animal in the same living quarters can exert an influence on felid behaviour and may effect the amount of attention directed towards an enrichment item. The low number of single-housed cats in this study ($n = 11$) prevented any statistical comparison of enrichment-directed behaviour between solitary and pair-housed animals. Such a comparison, however, would be interesting in any future investigations of this nature.

Finally, as with all studies investigating the impact on animal welfare a change in the animals environment has, there are many methodological problems to tackle with a common understanding that there is no perfect way of measuring animal welfare (e.g. see Newberry, 1995; Newberry and Estevez, 1997). A combination of several types of measures (behaviour, physiological and cognitive for example) is likely to provide the most accurate assessment. However, each of such measures should be appropriately validated and assessed for reliability to ensure its value in an animal welfare assessment. For the domestic cat, in particular in an animal shelter situation, there are a number of practical and methodological constraints. For example, group housing can cause difficulties if trying to collect physiological data from urine or faecal samples from shared litter trays. Thus, investigations developing novel methods of assessing physiology and cognition which could be used alongside behavioural measure would greatly improve the assessment that potential enrichment strategies have on feline welfare.

5. Conclusions

Overall, the results from this study suggest that olfactory stimulation in the form of scent-impregnated cloths, notably that of catnip, may be enriching for domestic cats housed in rescue shelters. Authors have highlighted the potential use of olfactory stimulation for confined cats (e.g. Rochlitz, 2000) as a means of improving welfare. The present study suggests the olfactory scent of catnip may indeed hold some merit as a method of environmental enrichment for certain individuals within the domestic cat population. Further long-term studies in this area which investigate the catnip response in more detail are highly advocated, however, before generalised conclusions can be drawn.

Acknowledgements

The authors would like to thank the staff at Cats Protection for facilitating this research. Funding for this work was part of a DEL funded PhD studentship.

References

Baker, W.K., Campbell, R., Gilbert, J., 1997. Enriching the pride: scents that make sense. Shape Enrich. 6, 1–3.

Barry, D., 2005. Catnip. Chem. Eng. News 83, 39.
Bradshaw, R.H., Marchant, J.N., Meredith, M.J., Broom, D.M., 1998. Effects of lavender straw on stress and travel sickness in pigs. J. Altern. Comp. Med. 4, 271–275.
Clark, F., King, A.J., 2008. A critical review of zoo-based olfactory enrichment. In: Hurst, J.L., Beynon, R.J., Roberts, S.C., Wyatt, T.D. (Eds.), Chemical Signals in Vertebrates, vol. 11. Springer, New York, pp. 391–398.
Chamove, A.S., 1989. Environmental enrichment: a review. Anim. Tech. 40, 155–178.
Courchamp, F., Langlais, M., Sugihara, G., 1999. Control of rabbits to protect island birds from cat predation. Biol. Conserv. 89, 219–225.
DeLuca, A.M., Kranda, K.C., 1992. Environmental enrichment. Lab. Anim. 21, 38–44.
Drea, C.M., Scordata, E.S., 2008. Olfactory communication in the ringtailed lemur (Lemur catta): form and function of multimodal signals. In: Hurst, J.L., Beyon, R.L., Roberts, S.C., Wyatt, T.D. (Eds.), Chemical Signals in Vertebrates 11. Springer, New York, pp. 91–102.
Ellis, S.L.H., Wells, D.L., 2008. The influence of visual stimulation on the behaviour of cats housed in a rescue shelter. Appl. Anim. Behav. Sci. 113, 166–174.
Field, T., Diego, M., Hernandez-Reif, M., Cisneros, W., Feijo, L., Vera, Y., Gil, K., 2005. Lavender fragrance cleansing gel effects on relaxation. Int. J. Neurosci. 115, 207–222.
Foss, T.S., 2002. Liquid potpourri and cats-essence of trouble. Vet. tech. 23, 686–689.
Friend, T.H., 1991. Symposium: response of animals to stress. J. Dairy Sci. 74, 292–303.
Goel, N., Hyungsoo, K., Lao, R.P., 2005. An olfactory stimulus modifies night-time sleep in young men and women. Chronobiol. Int. 22, 889–904.
Graham, L., Wells, D.L., Hepper, P.G., 2005. The influence of olfactory stimulation on dogs housed in a rescue shelter. Appl. Anim. Behav. Sci. 91, 143–153.
Hall, S.L., Bradshaw, J.W.S., Robinson, I.H., 2002. Object play in adult domestic cats: the roles of habituation and disinhibition. Appl. Anim. Behav. Sci. 79, 263–271.
Hart, B.L., 1977. Feline behaviour: olfaction and feline behaviour. Feline Pract. 7, 8–10.
Hatch, R.C., 1972. Effects of drugs on catnip-induced pleasure behaviour in cats. Am. J. Vet. Res. 33, 143–155.
Holmes, R.J., 1993. Environmental enrichment for confined dogs and cats. The TG Hungerford Refresher Course for Veterinarians. In: Proceedings from the Postgraduate Committee in Veterinary Science, University of Sydney, vol. 214. pp. 191–197.
Lee, C.M., Ryan, J.J., Kreiner, D.S., 2007. Personality in domestic cats. Psychol. Rep. 100, 27–29.
Lehrner, J., Marwinski, G., Lehr, S., Johren, P., Deecke, L., 2005. Ambient odors of orange and lavender reduce anxiety and improve mood in a dental office. Physiol. Behav. 86, 92–99.
Leyhausen, P., 1979. Cat Behaviour: the Predatory and Social Behaviour of Domestic and Wild Cats. Garland STPM Press, London/New York.
Macdonald, D.W., Apps, P.J., Carr, G.M., Kerby, G., 1987. Social dynamics, nursing coalitions and infanticide among farm cats. Advances in Ethology 28, 1–64.
Martin, P., Bateson, P., 1993. Measuring Behaviour: An Introductory Guide. Cambridge University Press, Cambridge.
McCune, S., 1992. Temperament and the welfare of caged cats. PhD Thesis, University of Cambridge, Cambridge.
Newberry, R.C., 1995. Environmental enrichment: increasing the biological relevance of captive environments. Appl. Anim. Behav. Sci. 44, 229–244.
Newberry, R.C., Estevez, I., 1997. A dynamic approach to the study of environmental enrichment and animal welfare. Appl. Anim. Behav. Sci. 54, 53–57.
Nielson, J., 2008. Scent preferences in the domestic cat. In: Proceedings of the Joint Scientific Veterinary Behaviour Meeting of the American College of Veterinary Behaviourists and the American Veterinary Society of Animal Behaviour, New Orleans, USA, July 18, 2008.
O'Farrell, V., Neville, P., 1994. The BSAVA Manual of Feline Behaviour. British Small Animal Veterinary Association, Cheltenham, UK.
Overall, K.L., 1997. Clinical Behavioural Medicine in Small Animals. Mosby, London.
Pearson, J., 2002. On a roll: novel objects and scent enrichment for Asiatic lions. Shape Enrich. 11, 7–10.
Powell, D.M., 1995. Preliminary evaluation of environmental enrichment techniques for African lions (*Panthera leo*). Anim. Welf. 4, 361–370.
Richardson, J.A., 1999. Potpourri hazards in cats. Vet. Med. 94, 1010–1012.
Robinson, I., 1990. Olfactory communication in the Felidae. Bull. Feline Advis. Bureau 27, 45–48.
Rochlitz, I., 2000. Recommendations for the housing and care of domestic cats in laboratories. Lab. Anim. 34, 1–9.
Schuett, E.B., Frase, B.A., 2001. Making scents: using the olfactory senses for lion enrichment. Shape Enrich. 10, 1–3.
Shepherdson, D.J., 1998. Tracing the path of environmental enrichment in zoos. In: Shepherdson, D.J., Mellen, J.D., Hutchins, M. (Eds.), Second Nature: Environmental Enrichment for Captive Animals. Smithsonian Institution Press, Washington, DC, pp. 1–12.
Smith, A.L., Corrow, D.J., 2005. Modifications to husbandry and housing conditions of laboratory rodents for improved well-being. ILAR J. 46, 140–147.
Tucker, A.O., Tucker, S.S., 1988. Catnip and the catnip response. Ecol. Bot. 42, 214–220.
Trickett, S.L., Guy, J.H., Edwards, S.A., 2009. The role of novelty in environmental enrichment for the weaned pig. Appl. Anim. Behav. Sci. 116, 45–51.
U.K. Cat Behaviour Working Group, 1995. An Ethogram for Behavioural Studies of the Domestic Cat (*Felis silvestris catus* L.), UFAW Research Report No. 8. Universities Federation of Animal Welfare, Hertfordshire.
Vandenbussche, S., Casey, R.A., Bradshaw, J.W.S., 2002. Factors influencing the selection of domestic cats from a rescue shelter. In: Proceedings of the BSAVA Congress, 2002, Birmingham, U.K.. BSAVA Publications, Gloucester, p. 610.
Wells, D.L., 2009. Sensory stimulation as environmental enrichment for captive animals: a review. Appl. Anim. Behav. Sci. 118, 1–11.
Wells, D.L., 2006. Aromatherapy for travel-induced excitement in dogs. JAVMA 229, 964–967.
Wells, D.L., Egli, J.M., 2004. The influence of olfactory enrichment on the behaviour of captive black-footed cats, *Felis nigripes*. Appl. Anim. Behav. Sci. 85, 107–119.
Woods, M., Mcdonald, R.A., Harris, S., 2003. Predation of wildlife by domestic cats *Felis catus* in Great Britain. Mammal Review 33, 174–188.
Young, R., 2003. Environmental Enrichment for Captive Animals. Universities Federation for Animal Welfare (UFAW) Series. Blackwell Publishing, Oxford.