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Effect of a shelf-furnished screen on space utilisation and social behaviour of indoor group-housed cats (*Felis silvestris catus*)

Emma J. Desforges[a,*], Alexandra Moesta[a], Mark J. Farnworth[b]

[a] WALTHAM® Centre for Pet Nutrition, Freeby Lane, Waltham-on-the-Wolds, Leicestershire LE14 4RT, UK
[b] Plymouth University, A426 Portland Square, Drake Circus, Devon PL4 8AA, UK

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ABSTRACT

The environment of the laboratory cat can be restrictive and may impact their welfare. Enrichment is often provided to alleviate welfare impacts but is seldom assessed or validated for efficacy. This study investigated the effect of novel room furniture (a screen) on the expression of agonistic and affiliative behaviours and space utilisation amongst colony-housed laboratory cats. Video footage of cats ($N = 29$) housed in social rooms ($N = 4$) was collected for 2 days before (baseline phase), 4 days during (test phase) and 2 days following (removal phase) introduction of the novel furniture. Space utilisation data were collected using scan sampling every 10 min and analysed using a generalised linear mixed effects model and Tukey's HSD test. Behavioural data were collected using continuous sampling for 3 h a day in 6×30 min episodes and analysed using a Poisson generalised mixed effects model.

Significantly more agonistic events occurred before the morning feed compared to after feeding within all phases (pre-feed mean = 0.227; post-feed mean = 0.026; $P < 0.0001$). However no significant differences were observed before the morning feed compared to after feeding between phases indicating that the screen had no effect on reducing pre-feed aggression at the morning feed. Agonistic behaviours occurred significantly less following the morning feed during the test phase when compared to the baseline phase (test post-feed mean = 0.011; baseline post-feed mean = 0.029; $P = 0.0342$). Significant differences were also observed on removal of the screen with agonistic behaviour increasing above baseline at the afternoon pre-feed time point, possibly indicative of aggression due to frustration or a rebound effect (removal pre-feed mean = 0.151; baseline pre-feed mean 0.048; $P < 0.0001$). Affiliative interactions between phases were not significantly affected by screen presence. Given the ratio of the screen to existing shelving (0.58:0.42) a statistical significant proportion of cats were found to be on the screen in the test phase of the study ($P < 0.0001$). This study suggests that exploiting the unused vertical space by the addition of stand-alone shelving should be considered a valuable resource for the cat by increasing useable space and reducing agonistic interactions.

1. Introduction

Recent estimates in the United States of America (USA) identified that over 21,000 cats were used in scientific procedures (USDA, 2015). Research environments can be restrictive; however it is recognised that animals in them should be given, where practicable, the opportunity for physical, social and environmental control, and behavioural choice (Broom and Johnson, 1993; FELASA, 2006; Meunier and Beaver, 2013). Limitations for the laboratory cat include the human requirement to house them in colony environments for long periods of time, limited choice over environmental provisions, reduced access to stimulating opportunities and loss of control over social grouping and interactions (Meunier and Beaver, 2013). Such restrictions can result in short and long-term stress and increase the likelihood of disease, which is a concern to both welfare and research quality (Russell and Burch, 1959; Poole, 1997; Balcombe et al., 2004).

In a range of species housed in laboratories, the use of enrichment has been shown to reduce stress and abnormal or undesirable behaviours e.g. dogs (*Canis familaris*) (Coppola et al., 2006); rabbits (*Oryctolagus cuniculus*) (Hansen and Berthelsen, 2000); Sprague-Dawley rats (*Rattus norvegicus*) (Belz et al., 2003) and Guinea baboons (*Papio papio*) (Fagot et al., 2014), as well as to reduce aggression in cats (*Felis silvestris catus*) (Damasceno and Genaro,

* Corresponding author.
E-mail address: emma.desforges@effem.com (E.J. Desforges).

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2014); primates (Honess and Marin, 2006) and African clawed frogs (*Xenopus* spp.) (Chum et al., 2013). The provision of enrichment can only be considered as such, if it provides positive consequences and improves the welfare of the cat (Rochlitz, 2000; Ellis, 2009; Baumans and Van Loo, 2013). Enrichment can promote desirable and species-typical behaviours and is believed to provide a welfare benefit by enhancing physical and psychological well-being (Ellis, 2009; Baumans and Van Loo, 2013). It may also contribute to the maintenance of behavioural stability in confined groups of cats. Despite benefits of enrichment within single and group-housed cats in residential (Herron and Buffington, 2012; Heath and Wilson, 2014) and shelter environments (Gourkow and Fraser, 2006; Kry and Casey, 2007; Dantas-Divers et al., 2011; Moore and Bain, 2013) being well documented, limited research is available for laboratory cats in stable colony environments (Morris et al., 2011).

Mandatory standards for care and accommodation of laboratory cats in the UK are specified within the Animal Scientific Procedures Act, 1986 Codes of Practice (ASPA, 2014) and include the provision of appropriate enrichment to reduce stress-induced behaviour and a floor space allowance of 0.5 m^2 per cat >3 kg when group housed. However, enrichment specifications are not clearly defined and consequently subjective; in addition it is unknown whether the enforced space requirement is adequate for all group housed cats in research environments. It is possible that cats that live in a confined environment may not utilise all of the available space, due to limited or restricted access to provisions. For those reasons, in addition to the ASPA guidelines, effective utilisation of the space and consideration of the dynamics within the cat group may require further attention.

The social structure of cat groups can be complex, especially within research environments whereby group numbers and dynamics can frequently change. Affiliative and agonistic behaviours can be observed in social groups with relatedness, familiarity, gender, age and bodyweight all contributing to the relationship type, ranking order and priority over resource access (Crowell-Davis et al., 2004; Bonanni et al., 2007; Damsceno and Genaro, 2014). Submissive and agonistic interactions are frequently a result of arousal and competition relating to feeding strategy (Knowles et al., 2004; Bonanni et al., 2007; Finkler et al., 2011), though they can often be ritualised (Crowell-Davis et al., 2004). The time of feeding and food availability often increase the frequency of agonistic interactions in species such as pigs (*Sus scrofa domesticus*) (Bench et al., 2013); cows (*Bos taurus*) (DeVries et al., 2004); seatrout (*Cynoscion nebulosus*) (Manley et al., 2015); and zoo housed animals (Young, 1997). Kasanen et al. (2010) described the behavioural need for a carnivore to perform species-specific feeding behaviours such as foraging and hunting, which may not be fulfilled in artificial feeding environments such as confinement and may contribute to agonistic behaviour around feed times within the research environment.

Shelving and the use of vertical space is one form of enrichment recognised as important for cats in confinement with the majority of the cats' time spent on shelves and off the floor (Hart, 1980; Podberscek et al., 1991; Meunier and Beaver, 2013). Raised areas provide additional opportunities for space use, areas for seclusion, vantage points and a sense of environmental control necessary to minimise bullying and to help cats cope with and alleviate social stress (Carlstead et al., 1993; Barry and Crowell-Davis, 1999; Ottway and Hawkins, 2003; Stella et al., 2014; Vinke et al., 2014).

We hypothesised that the provision of novel room furniture comprising a screen with additional shelves would reduce agonistic behaviour by increasing opportunities for individual cats housed in colonies to physically separate themselves, if desired. In addition, the sizeable screen would provide additional opportunities for space use within a spatially restricted environment.

Fig. 1. The screen developed by partitioning one IKEA® Kallax shelving unit into two giving two vertical columns of eight horizontal shelves on each side.

2. Materials and methods

2.1. Subjects and housing conditions

Twenty-nine neutered domestic short-haired cats participated in the study; 16 male and 13 females, mean age was 4.5 yrs ± 1.8 yrs. The study was conducted at the WALTHAM® Centre for Pet Nutrition, UK. The cats were housed in four social groups: group 1: $N = 8$, m:f = 6:2; group 2: $N = 7$, m:f = 3:4; group 3: $N = 7$, m:f = 5:2; group 4: $N = 7$, m:f = 2:5. The floor area of each social room was 2.9 m × 12.9 m. Eight areas of approximately 0.75 m × 1.5 m were drawn on the floor of the room with wax crayon to facilitate assessment of space utilisation. Permanent wall-mounted unheated shelves were available on all perimeter walls of the rooms (positioned at 79 cm from the floor; length varied between 40 and 290 cm, width = 30.5 cm, height = 4.0 cm). All four rooms were adjacent to one another and cats could see into each room via large windows which spanned the width/length of each room. The daytime schedule was consistent for each cat and included group and individual socialization. Each cat was individually housed for 30–60 min in the morning and afternoon for feeding. All cats were fed to their estimated Metabolic Energy Requirement (MER). Water was available *ad libitum* throughout the study via two wall mounted water drinkers located within each room. Number and location of beds, scratch posts, ladders and litter boxes was standardised and distributed equally across the eight areas of each room. The cats were housed under a natural twenty-four hour light-dark cycle. Temperature and ventilation was regulated as per UK Home Office requirements and consistent across rooms.

The study design was approved by the University of Edinburgh Veterinary Ethics Review Committee and the WALTHAM® Animal Welfare Ethical Review Board.

2.2. Experimental protocol

Baseline measures of space utilisation and behaviour were made over a two day period (days 1 and 2). Following the baseline period a shelf-furnished partition screen (Fig. 1) (hereafter referred to as 'screen') was added to the room and behavioural and space utilisation measures repeated for a four day test period (days 3–6).

Table 1
Ethogram of behavioural measures recorded in each phase.

	Definition
Agonistic behaviour	
Paw	A cat strikes another cat with a forepaw
Mount	A cat places its sternum against the back of another cat, maintaining its hind limbs on the ground, without bite
Fight	A cats engages in physical contact with another cat, attacking and rolling over
Bite	A cat snaps its teeth at or in contact with another cat
Pounce	A cat launches itself at another cat
Flinch	A cat draws back with a quick backward movement
Body arch	A cat curves its back upwards and stands rigidly. The tail is usually pointing upright (though can be down) and the fur may be piloerected
Submissive crouch	A cat crouches down and lowers body to the floor: the body is tense with the ears back or flat and the tail may swish or twitch
Stare	A cat gives a fixed gaze at another cat for at least 2 s; has ears erect and forward or erect and rotated sideways
Block cat	A cat walks in the direction of another cat while staring at it
Deviate	A cat has to deviate from its path or position in response to another cat's stare or block
Raise paw	A cat lifts its forepaw as if to cuff another cat but contact is not made
Chase	A cat chases another cat for at least 3 strides. Chaser has ears forward or rotated to the side, may have tail base high and remainder of tail dropped
Growl	A cat makes a low-pitched rumbling noise, usually with mouth closed
Yowl	A cats makes a long-drawn out vocalization for more than 2 s with mouth open
Hiss	A cats makes a drawn out SSSS sound with mouth open
Spit	A cats makes a sudden, short, explosive exhalation
Affiliative behaviour	
Walk with cat	A cat travels side by side with another cat often with tails entwined
Rest with cat	A cat rests (sit, lay) with one or more other cats making body contact or body part within 5 cm proximity
Touch noses	A cat touches/sniffs the nose of another cat often performed while standing and facing one another
Allogroom	A cat uses its tongue to groom another cat, usually on the head and neck. The recipient of the allogrooming is highly co-operative, may tilt and rotate itself to provide access to the groomer
Rub cat	A cat rubs a body part (normally head, body or tail) onto another cat
Social roll	A cat rolls on the ground in a relaxed manner (may be slow motion, ears forward) in the presence of another cat
Chirrup	A cat makes a high pitched BRRRP sound, as a contact call between cats

Contents adapted from Bradshaw et al. (1995) and Dantas-Divers et al. (2011).

The screen (1.47 m × 1.47 m × 0.39 m) was developed by partitioning one IKEA® Kallax shelving unit (IKEA®, Leiden, Netherlands) into two giving two vertical columns of eight horizontal shelves on each side. Following removal of the screen a further two days of measurements were taken (days 7 and 8). Each of the 4 rooms went through the 8 day experimental cycle sequentially rather than simultaneously with a non-experimental day in between to allow for equipment cleaning to minimise odour contamination.

During the test periods, the screen was placed in the same location within the centre of each room.

Video footage was collected for all 32 days of the experiment (8 days per room). Footage was recorded from 08:00 h to 16:00 h via two ceiling mounted video cameras (GoPro Hero 3+; GoPro; USA) located in adjacent top corners of each room enabling each side of the screen to be viewed. Video data were recorded to a 1TB hard drive (Atomos; Australia) located on the outside of the social room.

2.3. Space utilisation measurements

Scan samples were collected every 10 min for each study day and space utilisation was measured using the eight discrete areas created within the room. A cat was considered to be occupying the sector in which its head was located. Cats were recorded as either 'on ground', 'off ground' (on any item of furniture except the screen) or 'on screen'. The results were recorded in an Excel spreadsheet (Microsoft Office Professional Plus 2010, Redmond, Washington, United States of America).

2.4. Behavioural measurements

All occurrences of individual agonistic and affiliative behaviours were measured as events (ethogram—see Table 1). The frequencies of agonistic or affiliative events were recorded in 30 min continuous sessions both immediately before and after the provision of food, which was provided both in the morning and in the afternoon. These four time periods were assessed for each day across the experimental period.

2.5. Statistical analyses

Space and behavioural measures were recorded during the two days of the baseline and removal phases and the last two days of the test phase (day 5 and 6) to minimise the effect of novelty on screen use.

2.5.1. Space utilisation

The primary analysis investigated was the space utilisation of the cats when the screen was introduced into a room. In addition, the cats utilisation of different areas, given the resources available, within a room was explored as a secondary analysis

Firstly, the proportion of cats off the ground (including on screen for the test phase) was analysed by a generalised linear mixed effects model for repeated proportional measures, with a fixed effect of experimental phase (baseline, test, removal) and a random effects structure of day within phase within room. Between phase comparisons were made using Tukey's HSD test at an overall level of 5%. Secondly, the proportion of cats on the screen (given they were off ground) was analysed for the test phase. An average proportion and 95% confidence interval (CI) are reported

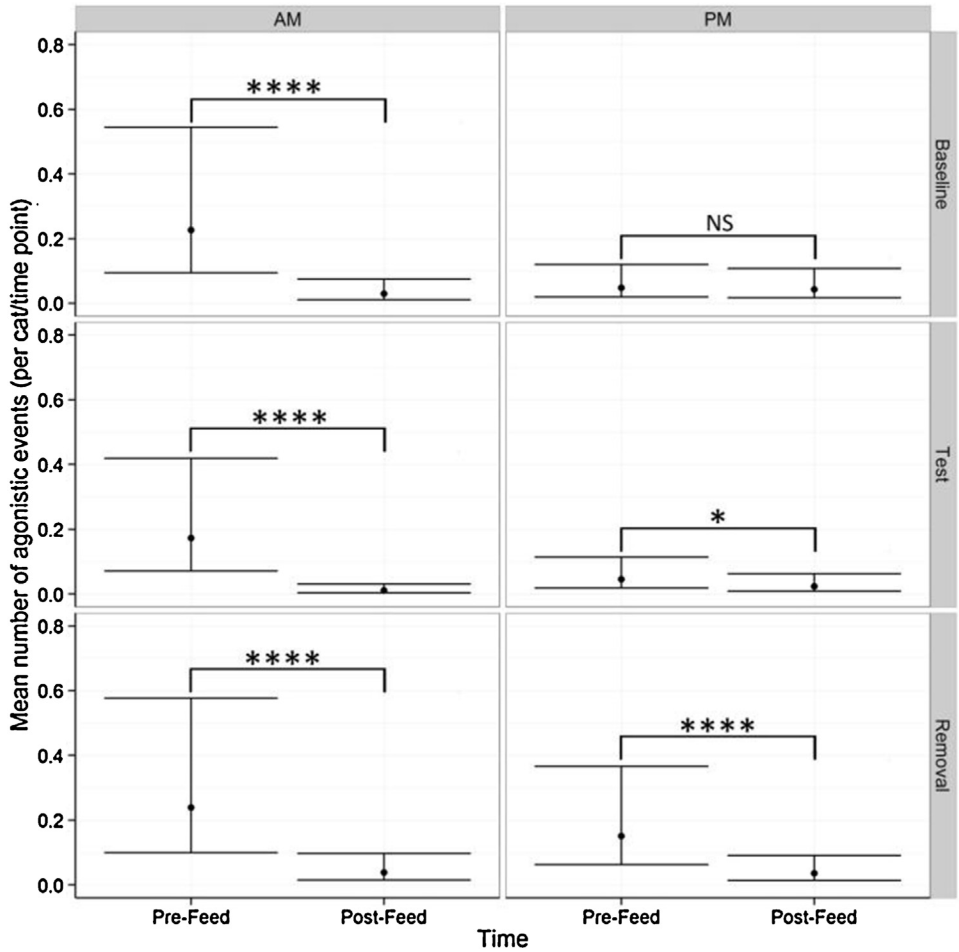

Fig. 2. Comparison between the mean number of agonistic events per cat within a 30 min time point before and after feeding in the morning and afternoon, before (baseline), during (test) and following (removal) provision of a shelf furnished screen, with 95% confidence intervals. *P*—value; NS > 0.05; *≤0.05; **≤0.01; ***≤0.001; ****≤0.0001.

Secondly, the proportion of cats in an area with each resource were analysed by generalised linear mixed effects models for repeated proportional measures. As the location of the screen bordered across multiple areas during the test phase, analysis of area usage was only reliable during the baseline and removal phase. A model was fitted for each of the six resources (bed, water, corridor door, internal door, shelf and litter). A random effects structure of day, phase and room was used. To test for significant differences in the proportion of cats within an area containing a particular resource, the estimated proportion and it's 95% confidence interval was compared to the probability that cats would be present in the area by chance given the availability of the resource within the room

2.5.2. Behaviour

A Poisson generalised mixed effects model was used with phase (baseline, test, removal), time point and their interaction as fixed effects, and with day nested in phase nested in room as random effects. To take into account the different measurement times and the different number of cats in each room at each time point, an offset term of the (log) total number of minutes recorded for cats within a room at a time point was incorporated into the model. Contrasts were then performed between phases at the same time point, between times within phases and between morning and afternoon pre and post feed time points between phases. Means and fold changes are reported with 95% family wise confidence intervals (CI). R version 3.1.1 packages 'lme4' and 'multcomp' were used.

Table 2
The estimated proportion of cats off ground during each phase of the study (with 95% confidence intervals).

Phase	Estimated proportion of cats off the ground	CI (95%)
Baseline	0.18	(0.14,0.24)
Test	0.41	(0.33,0.49)
Removal	0.20	(0.15,0.26)

Table 3
The odds ratio of cats being off ground in one phase compared to another phase of the study (with 95% confidence intervals).

Contrast	Odds Ratio	CI (95%)	*p*-value
Removal-Baseline	1.08	(0.79,1.49)	0.8360
Test-Baseline	3.05	(2.23,4.19)	<0.0001
Test-Removal	2.82	(2.06,3.87)	<0.0001

3. Results

3.1. Space utilisation

The estimated proportion of cats (N = 4 rooms) off the ground were higher during the test phase than baseline and removal phases (see Table 2). When a screen was introduced into a room, cats were approximately three times more likely to be off the ground compared to when no screen was present during baseline and removal phases (see Table 3). Given the ratio of the screen to existing shelving (0.58:0.42) a significantly larger proportion of cats were found to be on the screen when off the ground in the test phase of the study than would be expected by chance 0.75 (95% CI: 0.66, 0.82), $P < 0.0001$.

The estimated proportion of cats within an area containing a particular resource can be seen in Table 4. A significantly higher proportion of cats utilised areas containing bed and shelf resources than would be expected by chance, based on their availability within the rooms. A lower proportion of cats utilised the areas containing the internal door, corridor door and litter resources than would be expected by chance, given the availability in the rooms.

3.2. Behaviour

The planned contrasts of the mean number of events for affiliative and agonistic behaviours with fold changes and 95% confidence intervals can be seen in Table 5.

Fewer affiliative events occurred per cat at the afternoon pre-feed compared to post-feed during both the baseline and removal phases of the study. The changes in events between pre and post afternoon feed were less in the test phase than the removal phase of the study. No significant differences of affiliative behaviour were observed between phases at the time points investigated.

At the morning feed times, pre-feed agonistic events were higher than post-feed for baseline, test and removal phases of the study as shown in Fig. 2. At the afternoon feed times, pre-feed agonistic events were higher than post-feed in the test and removal phases as shown in Fig. 2. Agonistic events were higher at the morning pre-feed than afternoon pre-feed across baseline, test and removal phases as shown in Fig. 3. Agonistic events were higher at the morning post-feed at the removal than the test and at the baseline than the test phases as shown in Fig. 4. Agonistic events were higher at the afternoon pre-feed in the removal phase compared to the and test phases as shown in Fig. 5. The change in events between the morning pre and post-feed and afternoon pre and post-feed were less in the test phase than the removal phase of the study.

4. Discussion

The results of this study have demonstrated that the screen presence increases space utilisation within a spatially restricted environment and that it has a complex impact upon the expression of agonistic behaviour.

Agonistic events occurred significantly more before the morning feed compared to after feeding within all phases, however no significant differences were observed between phases suggesting that the screen had no positive effect on agonistic interactions before the morning feed. This could have been due to the effective value of the food at that time, for example due to overnight fast (Bench et al., 2013). Alternatively, it could support a strong internal motivation for the cats to perform the agonistic behaviour. A possible cause of elevation of pre-feed agonistic interactions could be due to the high frequency of general activity (D'Eath et al., 2009) and behaviours such as walking, running and jumping which were noted during the video observations. Podberscek et al. (1991) reported similar observations in laboratory cats between 08:00–09:00, though the frequencies of agonistic interactions were rare. Therefore it is conceivable that behaviours associated with heightened arousal could have contributed to agonistic interactions between cats.

Agonistic behaviours occurred significantly less in the test phase following the morning feed than in either the baseline or removal phases, suggesting that the screen had a positive effect in reducing agonistic interactions once feeding had occurred. An explanation could be that the screen provided a benefit to the cat (such as a visual barrier and withdrawal opportunity) which resulted in limited opportunities for agonistic interactions to be fulfilled

In the afternoon, agonistic events occurred significantly more before feeding in the removal phase compared to other phases, and significantly more before compared to following the afternoon feed in the test and removal phases of the study. One explanation is that the cats were in a process of recovery, and as only two days following the screen removal were observed, it is conceivable that the agonistic behaviours would return to a similar level to baseline over a longer observation period. The increase of the agonistic behaviour could be explained by a build up of motivation created by the absence of opportunity to perform behaviours (such as hiding) which are only achievable when the screen was present. For example, the screen provided more opportunities to hide and resulted in less aggressive interactions, the absence of the screen resulted in less opportunity to solve conflict by hiding and aggressive interactions were increased.

An alternative explanation could be evidence of a rebound effect in cats. The rebound effect in animals has been described as an increase in the occurrence of specific behaviours after a period of prevention, often demonstrated with an increase in the duration or frequency of a highly motivated behaviour when given the opprtunity (Manning and Dawkins, 1998) and has been observed in other species, for example horses (*Equus caballus*) (Christensen et al., 2002) and rabbits (*O. cuniculus*) (Dixon et al., 2010). Conversely in this case, it appears there may be evidence of an opposite effect, whereby the increase in agonistic behaviours follows a period of provision and subsequent loss. Therefore, rather than a justification for not altering the environment these results should be seen as a rationale for either providing permanent complex spatial enrichment or for rolling replacement of enrichment objects with alternative forms of similar value.

Relatedness, familiarity and neuter status have been shown to contribute to a lower rate of agonistic interactions and overt aggression in cats (Crowell-Davis et al., 1997, 2004), and as such the amount of agonistic behaviour was higher than expected, considering the cats were all neutered and lived with either related or familiar cats in relatively small groups. It is possible that the motivation for the agonistic behaviour was not to be aggressive, but a result of ritualised signals or dominance hierarchy within the group, as previously reported by Natoli and De Vito, (1991), Crowell-Davis et al., (1997), Crowell-Davis et al., (2004), Bonanni et al., (2007).

The amount of affiliative behaviours observed was as expected considering the colonies were well established. An increase in fold change for affiliative events was observed between the afternoon pre and post feeding time points in the baseline and removal phases, suggesting that cats engaged in more affiliative behaviour following the afternoon feed when the screen was not present. A possible reason for this could be that the screen provided the cats with more choice for private resting and post-feeding ritual behaviours (such as personal grooming). Yet overall the mean number of affiliative events was principally unchanged between phases suggesting that affiliation still occurred, but at different time points when the screen was present. This finding is important, as the screen provided additional opportunity for retreat, isolation and to increase proximity between cats, and consequently could have had a negative impact by reducing positive social interactions, which are considered to be a sign of social bonding and good welfare (Crowell-Davis et al., 2004; Ellis, 2009).

It is possible that not all behaviours recorded were equally represented during the observation period. For example, affiliative behaviour such as 'rest with cat', is likely to occur overnight when the unit is quiet and inactive, and micro-behaviours (such as blink, ear position, licking lips) were unable to be recorded due to the distance from camera to subject. Collection of video footage over a 24 h period or computational behavioural analysis (such as wearable computing) could offer a more objective way of quantifying cat activity and may provide a more comprehensive

Table 4
The estimated proportion of cats utilising the area given the resource (with 95% confidence intervals).

Resource	Estimated proportion of cats utilising the area given the resource	CI (95%)	Probability of area utilisation given the resource availability	*p*-value (utilisation compared to chance)
Water	0.26	(0.24,0.28)	0.25	0.2740
Bed	0.72	(0.64,0.78)	0.5	<0.0001
Corridor door	0.07	(0.05,0.11)	0.125	0.0118
Internal door	0.05	(0.04,0.05)	0.125	<0.0001
Shelf	0.69	(0.65,0.73)	0.625	0.0005
Litter	0.16	(0.12,0.2)	0.25	0.0002

Table 5
The planned contrasts of the mean number of events (per room/7 cats) for the total affiliative or agonistic with fold changes and 95% confidence intervals.

Measure	Variable	Contrast	Fold change	CI (95%)	p-value
Affiliative	Baseline	PM pre feed – post feed	0.36	(0.18,0.73)	0.0003
Affiliative	Removal	PM pre feed – post feed	0.27	(0.12,0.65)	0.0001
Affiliative	PMpre feed – post feed	Removal – Test	0.3	(0.1,0.92)	0.0244
Agonistic	PM pre feed	Baseline – Removal	0.32	(0.17,0.61)	<0.0001
Agonistic	AM post feed	Baseline – Test	2.72	(1.03,7.17)	0.036
Agonistic	AM post feed	Test – Removal	0.28	(0.11,0.71)	0.0009
Agonistic	PM pre feed	Test – Removal	0.3	(0.16,0.58)	<0.0001
Agonistic	Baseline	AM pre feed – post feed	7.8	(5.04,12.06)	<0.0001
Agonistic	Test	AM pre feed – post feed	16.26	(7.93,33.35)	<0.0001
Agonistic	Removal	AM pre feed – post feed	6.2	(4.26,9.01)	<0.0001
Agonistic	Test	PM pre feed – post feed	1.9	(1.04,3.48)	0.0282
Agonistic	Removal	PM pre feed – post feed	4.18	(2.79,6.28)	<0.0001
Agonistic	AMpre feed – post feed	Removal – Test	0.38	(0.17,0.86)	0.0074
Agonistic	PMpre feed – post feed	Removal – Test	2.2	(1.06,4.57)	0.0221
Agonistic	Baseline	AMpre feed – PM pre feed	4.7	(3.57,6.22)	0.0001
Agonistic	Test	AMpre feed – PM pre feed	3.8	(2.84,5.15)	<0.0001
Agonistic	Removal	AMpre feed k PM pre feed	1.6	(1.32,1.88)	<0.0001

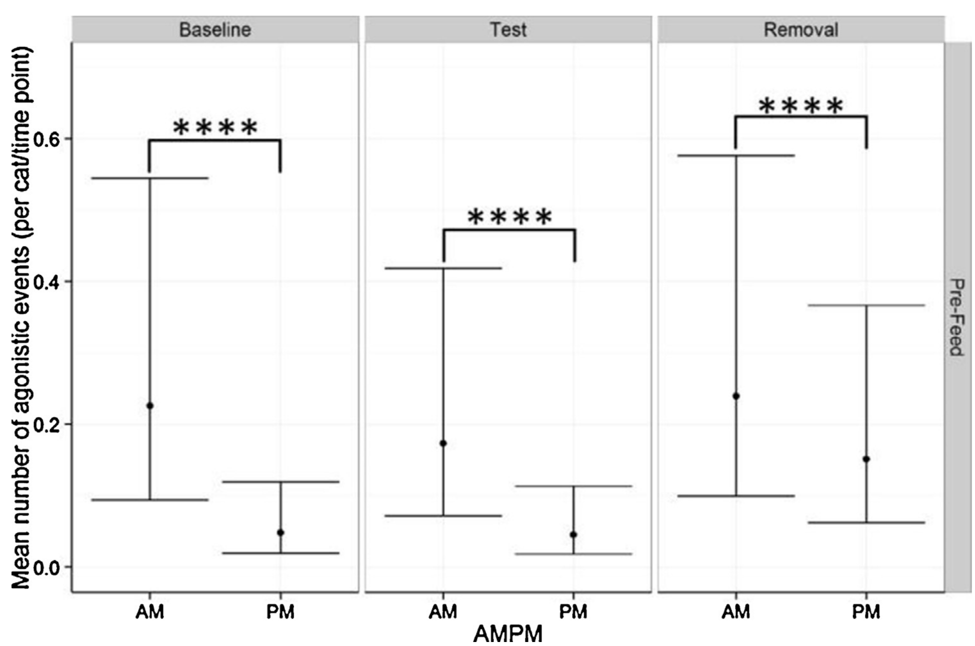

Fig. 3. Comparison between the mean number of agonistic events per cat within a 30 min time point before feeding in the morning and afternoon, before (baseline), during (test) and following (removal) provision of a shelf furnished screen, with 95% confidence intervals. *P*—value; ****≤0.0001.

representation of total agonistic and especially affiliative behaviours within the colony.

When the screen was introduced into a room, cats were approximately three times more likely to be off the ground than when no screen is present (i.e. during baseline and removal phases), suggesting it was a utilisable resource of some value to the cats. In addition, given the ratio of the screen to existing shelving (0.58:0.42), a significantly larger proportion of cats were found to be on the screen when off the ground in the test phase of the study than would be expected by chance, indicating the screen is of some use to the cats. Preferences for provisions such as litter box size (Guy et al., 2014), bedding type (Crouse et al., 1995) and even music (Snowdon et al., 2015) have been previously demonstrated. Interestingly, during all phases the cats continued to have access to pre-existing wall mounted shelves within the room, yet demonstrated a preference for the screen over these shelves. Possible reasons for this prefer-

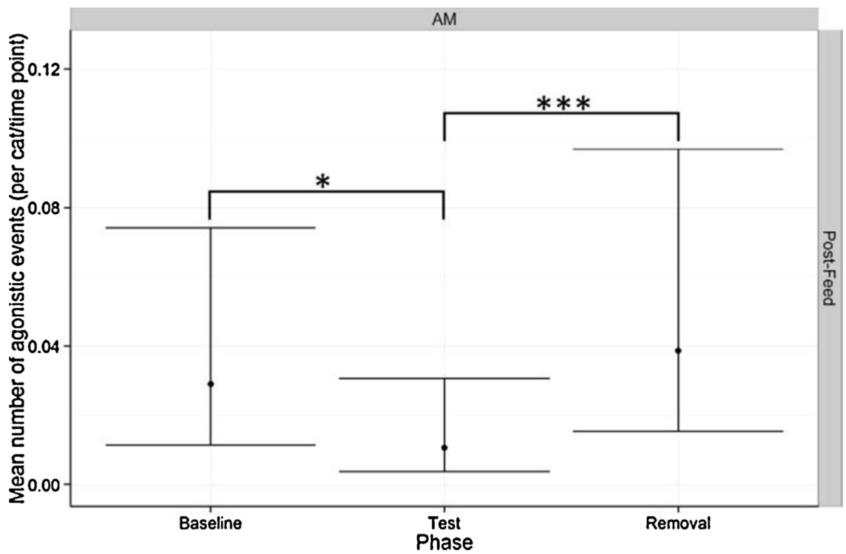

Fig. 4. Comparison between the mean number of agonistic events per cat within a 30 min time point after the morning feed, before (baseline), during (test) and following (removal) provision of a shelf furnished screen, with 95% confidence intervals. *P*—value; *≤0.05; ***≤0.001.

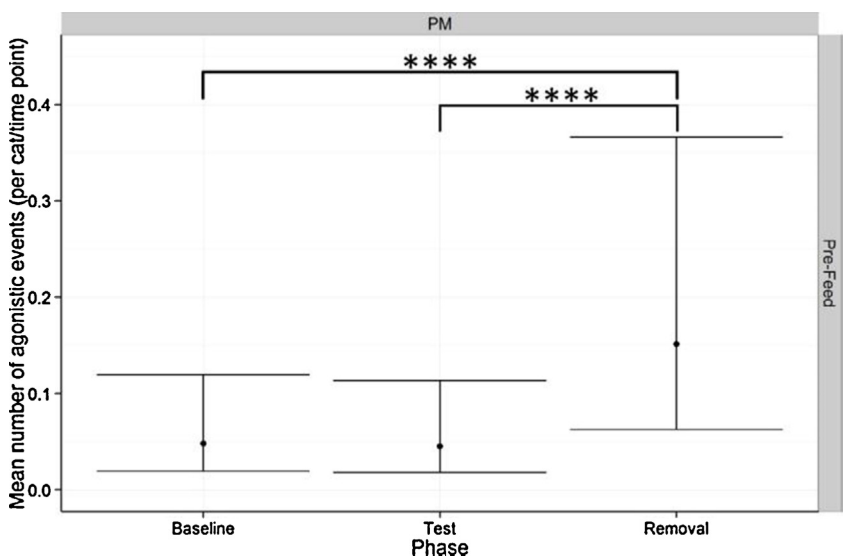

Fig. 5. Comparison between the mean number of agonistic events per cat within a 30 min time point before the afternoon feed, before (baseline), during (test) and following (removal) provision of a shelf furnished screen, with 95% confidence intervals. *P* – value; ****≤0.0001.

ence could be that the provision of the screen was relatively novel and as such increased the performance of exploratory behaviour. It could be that the screen allowed more opportunities for hiding or a better vantage point (being that the screen was almost twice the height of the wall mounted shelves), both of which are considered important provisions for cats (Rochlitz, 2000; Ellis et al., 2013).

Space utilisation was significantly higher in areas containing bed and shelf resources and significantly lower in areas containing the doors and litter resources, than would be expected by chance, indicating that 25% of the floor space is being underutilised. This was to be expected due to the differing values placed on resources within the room by the cats, as previously demonstrated for vantage points (Rochlitz, 2000) and hiding areas (Bernstein and Strack, 1996). The distribution of resources across a range of heights and habitats is recommended to allow the cat to access the resources with a degree of privacy, without competition and out of direct visual contact with other cats (Overall and Dyer, 2005; Health and Wilson, 2014). Possible reasons for the lack of use of areas containing the doors could be that the area was too exposed or less appealing due to lack of provisions. In addition, the higher distribution of cats in areas containing resources may have contributed to the increase in agonistic interactions due to competition for resources. These results provide evidence for ensuring provisions are well distributed across all areas of floor space to avoid conflict and ensure effective utilisation of the available space.

The cats were housed in an area with floor space of 8.41 m^2 which equates to 1.20 m^2 or 1.05 m^2 per cat in the rooms housing 7 cats and 8 cats respectively. This amount of floor space is exceeds the recommendation in the current UK Home Office Code of Practice for Housing and Care of Animals Bred, Supplied or Used for Scientific Purposes (2013), which specifies the minimum floor area when keeping more than one cat in a group as 0.5 m^2 per cat >3 kg. Although floor area allowance is an indicator of room size, it is not an accurate representation of available and useable space, as room height and shelving dimensions need to be considered. Allowing sufficient space to enable the performance of species-typical behaviours is essential for good welfare. The addition of the screen provided a further 2.25 m^2 of useable space (or 0.32 m^2 per cat in a room housing 7 cats) without having to increase room size and resulted in an increase of space use and a reduction in agonistic interactions.

The results of this study agree with previously published studies which have identified that three-dimensional space, shelving and hiding areas are important resources for cats in captive environments (Hart, 1980; Carlstead et al., 1993; McCune, 1995). The increased utilisation of the screen and shelving areas may indicate that the screen has been used for hiding or retreat in response to a threatening situation, which may have contributed to the reduction of agonistic behaviours during the test phase, as suggested by Kry and Casey (2007). The cats did appear to exhibit an effect of an increase in agonistic behaviours when the screen was removed which could be a potential negative consequence of providing semi-permanent enrichment for the cats. In summary, exploiting the unused vertical space by the addition of stand-alone shelving should be considered a valuable resource for the cat by increasing useable space and reducing agonistic interactions, with the caveat that the shelving remains a permanent fixture or for rolling replacement of enrichment objects with alternative forms of similar value.

5. Conclusion

There is a large body of evidence that suggests that the provision of appropriate enrichment to animals (including the cat) promotes good welfare. However, there is a shortage of information which demonstrates the effect of enrichment and other tools on reducing negative interactions or promoting positive behaviours in cats housed in stable colony environments. This trial has enabled research to expand upon the existing knowledge concerning the benefits of feline enrichment aids and demonstrates how exploiting the unused vertical space by the addition of stand-alone shelving should be considered a valuable resource for the cat by increasing useable space and reducing agonistic interactions. Furthermore, a negative effect was observed when the screen was removed; therefore changes intended to provide enrichment should be measured for positive and negative implications on the animal.

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