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Preference for and behavioural response to environmental enrichment in a small population of sexually mature, commercial boars

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Abstract

*An increasing public concern over the welfare of livestock species is motivating more producers to consider changes to production practices. Providing environmental enrichment for intensively housed animals is one such potentially welfare-enhancing change. The goal of environmental enrichment is to provide biologically relevant environmental stimuli that allows an animal to perform highly motivated, species-specific behaviours. To date, there is no research specific to the applicability of environmental enrichment for commercial boars (*Sus scrofa domesticus*), nor on commercial boar welfare in general. In this study, eight individually housed, mature boars were observed to prefer interacting with hanging cotton rope enrichment over hanging rubber chew sticks when given the option. There was a significantly negative correlation between the amount of time boars spent interacting with rope and the amount of time they spent performing stereotypic pen manipulation, suggesting that the rope was more effective at reducing stereotypic behaviour than the rubber. Such reductions in amount of time spent performing abnormal stereotypic behaviours could indicate that some of the animals' behavioural needs are being met by the enrichment object. Thus, the results of this study could help provide producers with more objective, research-based suggestions concerning the efficacy of practical enrichment choices for individually housed boars.*

Keywords: *animal welfare, boar, commercial swine, environmental enrichment, single housing, stereotypic behaviour*

Introduction

Commercial boars (*Sus scrofa domesticus*) have been largely overlooked by recent studies into production animal welfare. This could be due to their relatively small presence in commercial facilities as compared to breeding sows and market pigs. However, this does not preclude the importance of accounting for the impact of commercial housing conditions and management styles on the welfare of this particular population of animals.

In most commercial swine facilities, commercial boars are housed individually, starting at approximately 20 to 30 weeks of age, to prevent any potential injuries from mounting or aggressive behaviour between sexually mature boars. This social isolation mirrors that of wild and feral boars. Intact males will leave their natal sounder around 26 to 43 weeks of age; spending 8 to 10 h a day foraging for fibrous feed sources (eg grasses, roots, nuts, berries, some invertebrates and small animals) (Mauget 1981; Graves 1984). The size and complexity of boar housing will vary among commercial and breed stock facilities and are often contingent on the role of the boar (eg heat-check boar, AI boar, or mating boar). In many commercial swine facilities, the environment is made of durable surfaces, such as metal gating and smooth or slatted concrete floors, to prevent clogging of manure flush systems (Westin *et al* 2013). Given the genetic tendency to gain weight rapidly, commercial boars are fed restrictive diets consisting of high concentrate (corn-soy) feed (Young *et al* 1994). Thus, boars are often limited in the expression of complex foraging behaviour in commercial facilities.

Unfortunately, there is little information on the impact of this limited environment on the welfare of commercial boars. Previous literature on production sows and weaned, grower, and finishing swine indicates that these animals often develop orally fixated behaviours, such as sham chewing and bar-biting, to compensate for a lack of opportunity to forage or utilise their highly developed oral senses (Lawrence & Terlouw 1993; Spoolder *et al* 1995; Van de Weerd & Day 2009). These behaviours are examples of stereotypic behaviours, or abnormal repetitive behaviours that serve no obvious function, aside from being maladaptive attempts to relieve frustration built up from the inability to perform other highly motivated behaviours (Van de Weerd & Day 2009). Thus, performance of stereotypic behaviours, such as sham chewing, bar-biting and other pen-directed oral manipulations, is often indicative of negative mental states (eg boredom or frustration) in swine (Lawrence & Terlouw 1993; Spoolder *et al* 1995; Mason *et al* 2007; Van de Weerd & Day 2009).

Providing species-specific environmental enrichment to encourage highly motivated behaviours can relieve frustra-

Figure 1

Individually housed commercial boar with option to interact with cotton rope (left) or rubber chew sticks (right).

tion and, thus, reduce the performance of stereotypic behaviours (Mason *et al* 2007; Meehan & Mench 2007; Beattie *et al* 2016). Previous studies on swine-specific environmental enrichment in sows and juvenile pigs have found that swine show preference for items with characteristics which target their highly developed oral senses (Feddes & Fraser 1994; Van de Weerd *et al* 2003; Van de Weerd & Day 2009; Horback *et al* 2016; Nordquist *et al* 2017). Some characteristics include being chewable, deformable, destructible, odorous and ingestible (Van de Weerd *et al* 2003). However, whether or not boars show the same preference for these characteristics has not been investigated.

Enrichment items for production swine must also be practical enough for producers to invest the time and effort required to implement them. For example, in their review of environmental enrichment for intensively housed swine, Van de Weerd and Day (2009) reported that straw was the single most successful enrichment item. However, they also stressed how undesirable straw is in many modern production systems where producers favour the use of manure-flush systems and sterile, inorganic fixtures. Straw and other fibrous substrates can block and compromise such systems. While straw has the potential to harbour bacteria, like any organic material, there is limited and conflicting research on the link between straw provision and biosecurity risks in commercial swine (Stege *et al* 2001; Tuyttens 2005). Additionally, producers may find nutritive, ingestible enrichment items challenging to incorporate without promoting weight gain in feed-restricted boars. In order to take a first step towards improving swine welfare, producers need new enrichment items that offer swine the desirable characteristics of heavily preferred substrates like straw, but that are also easily applicable.

Given this prerequisite, two non-particulate, easy to clean, and non-ingestible items, cotton rope strands and rubber chew sticks, were chosen for this study. Each object offers swine-favoured characteristics: the rubber chew sticks are somewhat malleable, and the cotton rope is very malleable and somewhat destructible. We hypothesised that the boars would spend more time interacting with the rope than with the rubber due to its higher degree of malleability and destructibility and that the boars would spend a shorter proportion of observed time performing oral manipulative stereotypic behaviours when provided enrichment as compared to when not provided enrichment.

Materials and methods

This study was conducted at the Swine Teaching and Research Center at the University of California, Davis, and approved by an institutional animal care and use committee (protocol #20013). This was a specific pathogen-free facility with a herd of 60 sows and gilts, and 13 sexually mature boars. Eight of the facility's 13 boars were observed for this study, as the remaining five boars were involved in a separate reproductive study. These eight boars ranged in age from 12 to 17 months over the course of the study. All boars were individually housed in pens measuring 4.90 × 4.90 m (length × width). The pens had smooth concrete floors with an alley at the back measuring 0.91 × 2.43 m (length × width) into which the boars' urine and faeces were flushed by an automatic water flush system. All boars were fed a standard corn and soybean oil meal ration once a day at 0800h. For the duration of the study, all boars continued to be housed and cared for by the Swine Teaching and Research Center staff as outlined by the facility's standard operating procedures. The only change in the boars' maintenance was the provisioning of two different enrichment items during the treatment phase of the study.

Each boar was observed for a phase of time with no enrichment (control) followed by a phase with enrichment (treatment). Each phase took place over four consecutive days, during which each boar was observed for 1 h between 0900 and 1100h, and for 1 h between 1400 and 1600h each day. Observations started at 0900h to ensure that each boar had finished consuming the daily ration before observation. For each phase, each boar was observed for 2 h (one in the morning and one in the afternoon) every day for four days.

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Thus, each boar was observed for a total of 8 h per phase (128 h of observation across all boars over both phases).

During the no enrichment phase, no changes were made to the boars' environment or management procedures. The day after the no enrichment phase, each boar was presented with both enrichment objects, in the same manner as the objects would be presented in the following enrichment phase, for at least 10 min. If a boar did not approach the enrichment items during the initial 10 min of habituation, the observer drew the boar's attention to the items and left the items in the pen for an additional 10 min. The goal of the habituation phase was to reduce initial fear or hesitation to interact with objects during the enrichment phase. Two days after the habituation phase, the treatment phase began. During the enrichment phase, the hanging rubber chew sticks (BiteRite™, Ikadan Systems USA, Wilmington, NC, USA) and the strand of twisted cotton rope (Koch Industries Cotton, Shakopee, MN, USA) were hung from opposing corners of the front of the boar pen from 0800 to 1600h each observation day. Both the rubber chew sticks and the cotton rope (3.80- and 1.90-cm wide, respectively) were of equal length to provide 30.50 cm of access to the boar. A new strand of rope was provided at the start of each enrichment phase for each boar, and repeatedly used for that boar throughout its enrichment phase. The rubber chew sticks were cleaned following use by each boar and prior to being used as enrichment for another boar. Each item was suspended from the plastic funnel of a BiteRite™ apparatus, which was hung via metal chains from a horizontal beam clamped onto the side walls of the boars' pens (Figure 1). Both enrichment items were suspended from the same height, which was adjusted for each boar so that the enrichment was accessible to each boar's snout when in sitting or standing positions, but not when in a lying down position. Each enrichment item was suspended directly across from the other on opposite sides of the pen, 0.50 m from the front bars of the pen. This set-up allowed the boar equal free access to both enrichment items, and thus comprised a preference test. The side of the pen that each enrichment item was on was alternated every day to avoid any side bias effects.

Video recordings (Sony Handycam DCR SX85, Sony Corporation of America, New York, NY, USA) were taken for observations during each phase. The video data were coded using continuous sampling (The Observer XT v 11, Noldus Information Technology, Wageningen, The Netherlands). Prior to the start of data collection, inter-observer reliability was established across two observers for the no enrichment phase (single measures intra-class correlation coefficient = 0.99) and across five observers for the enrichment phase (single measures intra-class correlation coefficient = 0.96). Behaviour and posture were recorded for each boar in each phase, as described in Table 1. However, the behavioural events 'Interaction with rope' and 'Interaction with rubber' were not recorded during the no enrichment phase.

Table 1 Operational definitions of body postures and behaviours recorded. All postures and behavioural events were classified as continuous and mutually exclusive (except for pen manipulation and sham chewing, which could occur simultaneously).

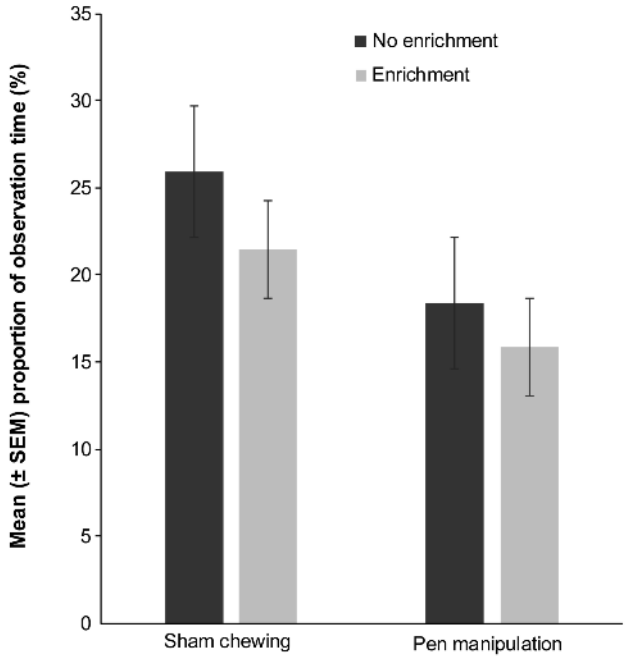
Posture		Operational definition
Lying down		Boar is in a recumbent position and is thus not using any of his feet to support his weight
Sitting		Boar has his two front feet placed on the ground, and his rear legs folded underneath him so that his hindquarters are in contact with the ground, but he is not fully recumbent
Standing		Boar is upright and supporting his weight with at least three feet. Includes walking
Behavioural events		**Operational definition**
Interaction with rope		Any part of boar's head, ears, nose, or tongue is actively or passively in contact with the rope (ie chewing, licking, smelling, or just physical contact with the rope)
Interaction with rubber		Any part of boar's head, ears, nose, or tongue is actively or passively in contact with the rubber (ie chewing, licking, smelling, or just physical contact with the rubber)
Sham chewing		Boar is making a masticating motion with his mouth. He may be opening and closing his mouth frequently and making a 'slapping' noise. Saliva is often produced. Boar is making a chewing motion, but not actually chewing on any external object
Pen manipulation (includes any of the following behaviours)	Bar-biting	Boar is actively using his nose, mouth, and/or tongue to manipulate or chew the metal bars of the gates in his pen. Or boar is moving his head in front of, or along, the bars and/or sticking his nose in and out of gaps in the bars
	Floor/wall manipulation	Boar has his tongue on the ground or wall and is moving it back and forth in a licking motion. Or boar has his snout/nose directly against the floor or wall and is moving it back and forth. This is separate from eating behaviour and does not involve the consumption of any substrates
	Windsucking	Boar has front of mouth pressed up against the solid wall of his pen and is repetitively drawing/sucking in air through his partially open mouth

Table 2 Mean (± SEM) proportion (%) of time boars were observed in each body posture and performed stereotypic behaviours during a no enrichment phase and an enrichment phase.

Behaviour/ posture	No enrichment phase	Enrichment phase	*P*-value
Sham chewing	25.93 (± 9.17)	21.45 (± 7.58)	0.09
Pen manipulation	18.35 (± 6.49)	15.85 (± 5.60)	0.48
Lying down	62.52 (± 22.11)	41.57 (± 14.70)	0.02*
Sitting	1.05 (± 0.37)	6.2 (± 2.19)	0.02*
Standing	36.32 (± 12.84)	51.68 (± 18.27)	0.12

* Significant difference ($P < 0.05$) in time spent lying down and sitting between the phases.

Figure 2



Mean (± SEM) proportion of observation time (%) that boars spent sham chewing and performing pen manipulation during the no enrichment and enrichment phases.

Statistical analysis

All statistical analyses were conducted in SPSS version 25.0 (IBM Corp, Armonk, NY, USA) with a significance level set at $P < 0.05$. In order to avoid pseudoreplication, the proportion of time a boar was observed in each behaviour or posture was averaged per boar across all days and times. Wilcoxon signed-rank tests were performed to examine the difference in the performance of stereotypic behaviours, the difference in the proportion of time spent in each body posture between enrichment and no enrichment phases, and the difference in the proportion of time the boars interacted with each item. Spearman's rank-order correlations were performed to evaluate the relationship between time spent interacting with enrichment and the performance of stereotypic behaviours. Data are presented as the mean (± SEM) proportion of observation time boars were recorded in contact with an enrichment item.

Results

During the no enrichment phase, boars spent an average of 25.93 (± 9.17)% of their time sham chewing, and an average of 18.35 (± 6.49)% of their time performing pen manipulation behaviour. In comparison, when given enrichment, boars spent an average of 21.45 (± 7.58)% of their time sham chewing, and an average of 15.85 (± 5.60)% of their time performing pen manipulation behaviour. There was not a significant difference in the performance of sham chewing ($P = 0.09$) or pen manipulation behaviour between enrichment and no enrichment phases ($P = 0.48$) (Table 2, Figure 2). Boars spent significantly more time in a sitting posture ($Z = –2.20$; $P = 0.02$) during the enrichment phase (6.20 [± 2.19]%) than during the no enrichment phase (1.05 [± 0.37]%), and were observed to spend significantly more time lying down ($Z = –2.20$; $P = 0.02$) during the no enrichment phase (62.52 [± 22.11]%) than during the enrichment phase (41.57 [± 14.70]%). There was no significant difference in the proportion of time boars were observed to stand between enrichment and no enrichment phases (Table 2).

Boars spent significantly ($Z = –2.40$; $P = 0.02$) more time interacting with the rope (13.73 [± 7.04]%) than interacting with the rubber stick (7.54 [± 7.04]%; Figure 3). There was a significant negative correlation between pen manipulation and rope use ($r_s = –0.83$; $P = 0.01$), but there was no statistically significant relationship between the proportion of time spent interacting with rubber and the proportion of time performing pen manipulation behaviour ($r_s = –0.43$; $P = 0.30$) (Figure 4). There were no significant correlations ($P > 0.05$) between sham chewing and rope or rubber use.

Discussion

Preference for enrichment item

When given equal access to either a rope or a rubber enrichment item, the boars in this study spent a greater proportion of their time interacting with the rope. This preference for rope over rubber has also been found in previous studies with gestating sows (Horback *et al* 2016) and juvenile pigs (Feddes & Fraser 1994). Thus, the boars in this study also appeared to have a strong motivation to use their highly developed oral senses (through oral manipulation behaviours) in production settings. These results suggest that boars may favour similar enrichment item characteristics to those previously seen to be favoured by other populations of production swine. The malleability of the rope (ie chewable, deformable and destructible) most likely allowed the boars to express more oral manipulative behaviour than the rigid rubber did.

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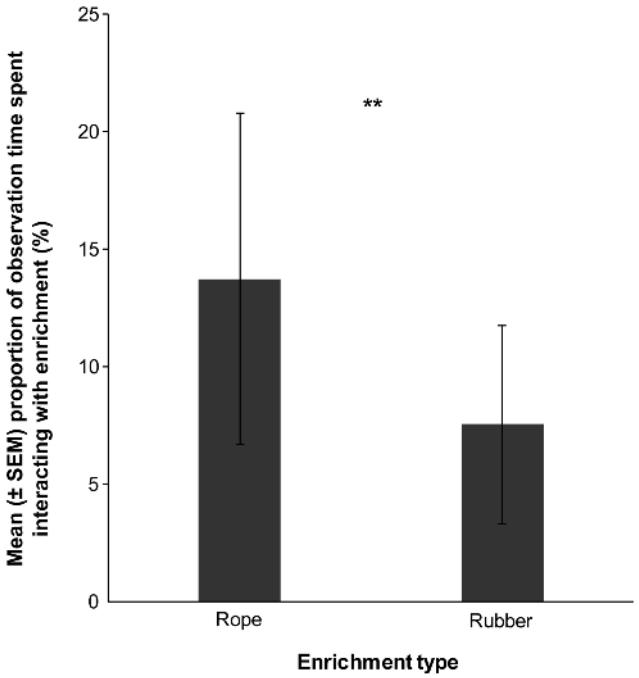
This better understanding of boar-specific preference for two different enrichment items has important implications for producers. Both the rope and the rubber used in this study are relatively easy to sterilise if required, making them ideal for producers needing to ensure biosecurity of their herds. Additionally, despite being destructible enough to be preferable by the boars in this study, the cotton rope strands used were never damaged enough to warrant replacing during the entire four-day enrichment phase and could have continued to be used if this study had been extended. Thus, cotton rope could potentially strike a good balance between being destructible enough to be appealing to boars and durable enough to not require a lot of extra work for producers (eg having to constantly replace and remove particulate enrichment objects like straw). In comparison, Van de Weerd and Day (2009) found chains and car tyres to be common, non-particulate items provided to production swine, if enrichment is provided at all. However, chains and car tyres lack malleability and destructibility, which could be why they have been shown by previous research studies to provide inadequate enrichment (Van de Weerd & Day 2009). Their rigid and abrasive qualities could also pose a danger to the sensitive tissues of swine mouths. Bar-biting is considered a harmful, abnormal, and stereotypic behaviour for the same reasons (Spoolder *et al* 1995). Consequently, the boars' use of both rope and rubber in our study, and their preference for rope, provides producers with more objective, research-based suggestions concerning more effective and boar-specific enrichment choices.

Effect of provided enrichment on posture and performance of stereotypic behaviours

Finding an enrichment item that is both practical for producers and preferred by boars is important. However, it is also important to assess if and how a proposed enrichment item affects the behaviour of the boars. For example, previous research has found that straw provision can reduce chain and bar manipulation in feed-restricted, gestating sows (Spoolder *et al* 1995) and reduce harmful tail-biting in juvenile pigs (Beattie *et al* 1995). An objective of this study was to evaluate whether suspended, non-particulate enrichment items could reduce the performance of stereotypic behaviours by providing a more biologically appropriate outlet for boars to perform highly motivated oral manipulative behaviours.

Time spent performing pen manipulation was negatively correlated with time spent interacting with the rope. This result suggests that the rope could provide an appropriate outlet for highly motivated foraging behaviour in commercial boars. The smaller, non-significant, negative correlation between time spent interacting with the rubber and time spent performing pen manipulation was still biologically relevant, and therefore still suggestive of rubber's potential as a form of enrichment. However, our results suggest that rope, in addition to being preferred, could be a more effective form of enrichment for boars than rubber.

Figure 3



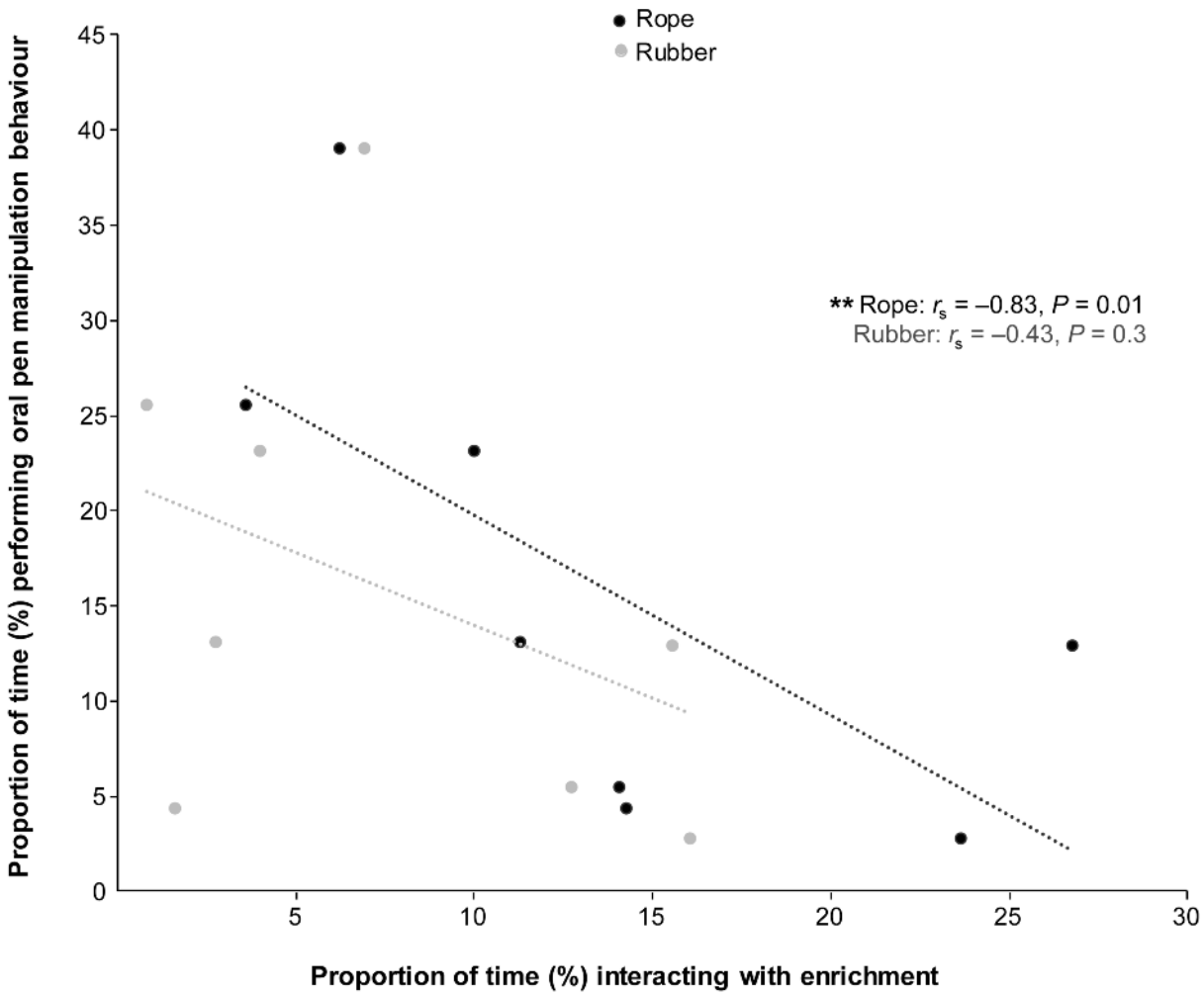
Mean (± SEM) proportion of time the boars were observed interacting with rope and rubber enrichment objects. ** $P < 0.05$ following Wilcoxon signed-rank test.

The increase in time spent lying down during the no enrichment phase could be due to a lack of appropriate stimulation. A similar increase in time spent lying down was seen in weaned piglets raised in bare, unenriched environments compared to weaned piglets raised in enriched environments and was also hypothesised to be a response by the piglets in the unenriched environment to a lack of stimulation (Wood-Gush & Beilharz 1983). In the present study, the enrichment was suspended at a height that was inaccessible to the boars while they were lying down. This may explain why the boars spent more time sitting when given enrichment as compared to the control condition with no enrichment provided. However, time spent sitting did not correlate with time spent interacting with either enrichment item. Thus, the presence and position of enrichment may have affected posture but not the performance of interacting with the enrichment; suggesting that a motivation to interact directly with the enrichment items was not behind the increase in time the boars in this study spent sitting when given enrichment.

Limitations

While statistical significance was found for the negative correlation between rope use and pen manipulation, a larger sample size may have resulted in more significant results, such as a significant decrease in sham chewing with enrichment. With a larger sample size, the extreme individual differences observed in oral stereotypic behaviour (which can be affected by factors like age and time spent developing stereotypic behaviour under previous environmental

Figure 4



The relationship between the proportion of observation time the boars interacted with each enrichment object and the proportion of observation time the board performed oral pen manipulation behaviour. ** $P < 0.05$ following Wilcoxon signed-rank test.

conditions) would be minimal due to random sampling. However, small sample sizes, like the one in this study, are vulnerable to influence by extreme individual differences, such as older boars with years of experience using stereotypic behaviour to cope with frustration. Although most commercial facilities maintain few boars (ie one boar per 15 to 20 sows) to assist in identifying gilts and sows in oestrus, it is important for future studies to use larger sample sizes to examine the effects of environmental enrichment on boar behaviour with fewer statistical limitations.

An additional complication may be that stereotypic behaviour can be caused by perseverative dysfunction, which involves the impairment of proper behavioural regulation leading to inappropriate responses to external cues (Mason *et al* 2007). Thus, once entrenched in behavioural coping repertoires (eg from previous states of sustained stress in behaviourally limiting environments), stereotypic behaviours can be very hard to change, even with improved environments to allow for expression of highly motivated behaviours (Mason *et al* 2007). In the present study, two boars were observed to spend over 50% of their time performing stereotypic behaviour regardless of environment. This suggests that their performance of stereotypic behaviour could be mediated by other factors besides current environmental cues (eg perseverative dysfunction). Therefore, future studies should incorporate additional measures of stress, such as physiological parameters, including cortisol levels and heart rate variability, in order to judge welfare effects of enrichment provision more holistically.

The four days of enrichment given to each boar during this study is less than 0.10% of the life of the youngest boar studied (at one years old). Over 99.9% of each of the boars' lives had been spent in a limiting environment without any enrichment. The period of four days was chosen due to logistical constraints of data collection, such as a limited number of cameras, enrichment items, and researchers to collect data, in addition to schedule constraints by other research projects being conducted at the facility. This discrepancy in time spent in a barren environment and time spent with enrichment is another limitation of the current study. Future studies may examine the impact of long-term provision of enrichment as

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a potential protective measure against perseveration of abnormal behaviours (Mason *et al* 2007).

One final limitation to the continued effectiveness of objects used for environmental enrichment is habituation of animals to the objects once the initial attractiveness of novelty wears off. For example, Van de Weerd *et al* (2003) found that declines in pigs' use of enrichment, hypothesised as a result of habituation, can occur in as few as three days. Thus, they suggested that novelty of enrichment items is important to sustain pigs' interests in and continued interaction with the enrichment. However, Van de Weerd *et al* (2003) also found that objects that are destructible and ingestible (ie objects that can be controlled or altered by the pigs) may provide a continuing level of attractiveness for pigs after initial novelty effects for invariable and unalterable objects should have worn off. The boars' preference for rope in the present study could be due to the fact that the cotton rope was more destructible, and therefore alterable, than the rubber chew sticks.

Animal welfare implications and conclusion

Ultimately, results from this novel study suggest that single-housed, commercial boars may prefer to interact with cotton rope strands over rubber chew sticks. This is important for producers who are looking for boar-preferred practical enrichment items that will not compromise their production facilities. This is the first scientific study to report that commercial boars perform oral-manipulative stereotypic behaviours. As with other populations of production swine, these behaviours are hypothesised to stem from frustration resulting from an inability to perform highly motivated foraging behaviours. Despite a limited sample size and a short enrichment phase, we found a significant negative correlation between rope interaction and the performance of stereotypic pen manipulation. Therefore, we conclude that providing boars with environmental enrichment is an important and promising strategy for making future improvements in boar welfare. More specifically, rope was both preferred by boars and more effective in reducing stereotypic behaviour than rubber, suggesting it is a more effective enrichment item. Additionally, on a long-term level, by looking at enrichment strategies for improving commercial boar welfare we hope to promote further research into the understudied area of boar welfare.

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