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Pigs with but not without access to pieces of recently harvested wood show reduced pen-mate manipulation after a provision of feed and straw

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Abstract

In barren environments of commercial farms, pig often redirect their rooting and chewing behaviours at other pigs, which can lead to tail biting. When materials such as straw are provided, the quantity is usually too small to have an effect. The aim of this study was to test whether small provisions of straw and species-relevant point-source objects would have an additive effect in reducing pen-mate manipulation. The animals were 167 gilts with undocked tails on a commercial farm in Finland, housed in 12-m2 pens with partly slatted floors, on average 7 pigs/pen. Liquid feed and 20 g/pig of long straw were provided once a day. The pigs had continuous access to suspended objects: in each control pen (N = 12), a 40 cm x 10 cm x 2 cm piece of commercially sourced wooden board and a 60-cm metal chain, and in each experimental pen (N = 12), an 80-cm piece and two 40-cm pieces of birch trees with a diameter of 5 to 7 cm, harvested 1 month earlier. After 2 months of exposure, frequencies of pig- and object-directed manipulation before and after consuming the feed and straw were recorded by continuous observation on video. Pre-consumption pig-directed manipulation did not differ between the treatments (means: 39.3 events/pig/hour (SD = 11.7) in the experimental pens and 42.1 events/pig/hour (SD = 12.1) in the control pens; $t = -0.6$, $df = 21$, $P > 0.1$), but post-consumption manipulation was significantly lower in frequency in the experimental treatment (means: 31.5 events/pig/hour (SD = 10.4) in the experimental pens and 41.0 events/pig/hour (SD = 8.6) in the control pens; $t = 2.4$, $df = 21$, $P < 0.05$). Object-directed manipulation was higher in the experimental treatment both pre- and post-consumption (pre-consumption medians: 9.7 events/pig/hour (min = 2.0, max = 14.9) in the experimental pens and 3.1 events/pig/hour (min = 0.9, max = 13.7) in the control pens ($U = 18.5$, $P < 0.01$); post-consumption means: 9.2 events/hour/pig (SD = 2.7) in the experimental pens and 4.8 events/pig/hour (SD = 2.0) in the control pens ($t = 4.5$, $df = 20$, $P < 0.001$). It was concluded that the experimental objects with improved material, quantity, shape and location had an additive effect with straw in reducing pen-

mate manipulation, whereas objects ordinarily used on the farm had no beneficial effect. Further research is needed on the effects of the odour, taste and consistency of optimal objects.

Keywords

Enrichment; Manipulable materials; Fresh wood; Exploratory behaviour; Oral-nasal manipulation; Pig welfare

Highlights

We tested whether improvements in available objects reduced oral behaviours at pen-mates..

In pens with pieces of recently harvested wood, receiving feed and a small daily provision of straw reduced manipulation of pigs.

In pens with pieces of dry wood and metal chain, receiving feed and a small daily provision of straw increased ear manipulation.

1. Introduction

Rooting and chewing are behavioural needs in pigs (Studnitz et al., 2007), and lack of opportunity to perform innately motivated behaviours reduces welfare (Hughes and Duncan, 1988; Jensen and Toates, 1993; Hemsworth, 2018). When suitable materials are not available, rooting and chewing are redirected at other targets such as pen-mates (Fraser et al., 1991; Beattie et al., 2001), which increases the risk of tail and ear biting (Smulders et al., 2008; Taylor et al., 2010). Straw is one of the best materials to meet pigs' needs for manipulation (Tuyttens, 2005; van de Weerd and Day, 2009; Godyn et al., 2019), but the extent of benefit depends on the quantity of straw. In the

European Union, the Council Directive 2008/120/EC (European Council, 2008) requires provision of material suitable for manipulation for pigs but does not specify the quantity. Interpretation of the directive by relevant authorities varies across countries. For example in Finland, the Finnish Food Safety Authority (Evira) states that pigs should either have permanent access to material such as wood shavings, peat or straw as an amount that makes it possible to form small piles on the floor; or, if permanent access is not possible e.g. because of a risk of obstructing the manure management system, the pigs should have permanent access to "toys" such as balls and chains as well as two provisions of manipulable material such as straw, hay or paper (Evira, 2010). Even though many pig farmers consider straw as effective in reducing tail biting (for example, a survey in Finland found that farmers ranked it as the most effective material), the quantities used on most commercial farms are substantially smaller than the quantity needed to adequately fulfil the need for oral-nasal behaviours. For example, a survey in Sweden found that the average straw use for finishing pigs on partly slatted floor was 50g per pig per day for finishing pigs (Wallgren et al., 2016). In studies to determine a daily amount of straw after which further increases in quantity no longer reduced pen-mate manipulation, the resulting values pigs have ranged from 250 g/pig/day (Jensen et al. (2015) to slightly below 400 g/pig/day (Pedersen et al., 2014). Pigs given 100 g/day have more overall activity and straw-directed activity than pigs given 25 g/day or 50 g/day, but no difference in manipulation of pen-mates (Oxholm et al. 2014). On farms with slatted or partly slatted floors and managing the manure as slurry, few of the above amounts are likely to be adopted, because there is a need to save in labour costs and to prevent obstruction of the manure management system.

When pigs have insufficient access to straw or other substrates, redirected manipulation of pen-mates can be reduced by well-designed point-source objects (van de Weerd et al., 2006). Materials and designs of point-source objects vary greatly in their ability to sustain pigs' interest. Testing the characteristics required, van de Weerd et al. (2003) found that when an object is novel to pigs, it is most attractive if it is solid, chewable, movable, deformable or has a strong odour; and the interest

82 is most likely to be sustained over five days if the object is solid, ingestible, destructible or
83 contained, e.g. in a box. The authors noted that successful object design requires meeting several of
84 these criteria, which is supported by the finding that some combinations of materials have additive
85 behavioural benefits (Guy et al., 2013). In order to become adopted in commercial farming, point-
86 source objects also have to maintain or improve pig health, improve production economics and be
87 easy to use (van de Weerd and Day, 2009).

88 One of the materials likely to not yet have been tested to its full potential is wood. In an assessment
89 by nine senior experts scoring 64 different materials, horizontal hardwood beams were ranked as
90 approximately equal in behavioural benefits as rope and shredded paper (Bracke et al., 2007).
91 However, the physical and chemical characteristics of wood vary greatly, depending on e.g. the
92 time elapsed since felling of the trees (Brand et al., 2011) and whether the wood has been dried
93 (Möttönen, 2006). Saplings and branches of living trees constitute a part of the natural diet of the
94 wild boar (Kuijper et al., 2009). Wood from recently harvested trees may therefore have
95 motivational relevance to pigs, as the wood will retain some of the odour, taste and consistency of
96 living trees. This hypothesis was supported by the results of our previous study, in which we found
97 that pieces of young birch tree trunks, harvested less than 2 months before the start of the
98 experiment, sustained pigs' interest throughout the 2.5-month experiment and reduced tail and ear
99 biting (Telkänranta et al., 2014).

100 The main aim of this study was to test whether the level of oral-nasal manipulation directed at pen-
101 mates before and after consuming a provision of straw would be influenced by the types of point-
102 source objects continuously available in the pens. The two point-source object arrangements that
103 were compared to each other were (i) pieces of recently harvested wood, suspended on chains, and
104 (ii) pieces of commercially sourced wood, suspended on chains, and suspended feeder chains to
105 represent metal chains with added complexity. Additional aims of the study were to compare total

106 object interaction between the treatments; to test for object preferences within each treatment; and
107 to test for effects on production-relevant parameters such as tail and ear biting.

108

109 ## 2. Materials and methods

110 ### 2.1. Animals and housing

111 The experiment was carried out on 167 breeder gilts (hereafter called pigs) on a commercial piglet-
112 producing farm in Finland. The pigs were crosses of Large White and Norwegian Landrace, from
113 consecutive litters born on this farm. They had been born to crated sows on partly slatted floors with
114 no bedding; cross-fostered if necessary during the first days of life to attain approximately equal
115 numbers of females in each litter to be reared as potential breeders; and weaned at the age of 3 to 4
116 weeks without mixing litters. At the age of 2 months, the pigs were transferred from weaner pens to
117 gilt pens, in which this experiment also was carried out. At the age of 6 months, the pigs to become
118 breeders were selected by the farmer.

119 From the age of 2 to 6 months, which also was the duration of this experiment, the pigs were
120 housed in pens with a concrete floor, 40% of which was slatted and 60 % solid floor, and with solid
121 pen walls. The mean number of pigs per pen was 7 (range: 6 to 8 pigs/pen). The floor area of each
122 pen was 3m x 4m, resulting in a mean floor area of 1.7m2/pig (range: 1.5 to 2.0m2/pig). There was
123 one water nipple per pen. The mean trough length was 43cm/pig (range: 38 to 50cm/pig). The pigs
124 were fed a standard liquid feed for commercial production of breeder gilts, according to the normal
125 practice on the farm. Feed was provided once a day at 8:30h, and immediately after this, long uncut
126 straw was distributed manually on the solid part of the pen floor, approximately 20 g per pig. The
127 lights were on from 7:15h to 20:30h. All of the above housing and husbandry practices were the
128 ordinary practices of this farm.

129 An ethical approval for the study was obtained from the Ethics Board of Viikki Campus of the
130 University of Helsinki.

131

132 2.2. Treatments

133 There were two treatments in the experiment, with different point-source objects for manipulation.
134 In the control treatment, the objects in each pen were the same as normally used on this farm. In one
135 corner of each pen, there was a 60-cm piece of feeder chain made of metal (a long-link chain with a
136 circular piece of metal at the end of each link), suspended at snout height in a vertical position in a
137 pen corner above the slatted floor; and in another corner of the pen, a piece of commercially
138 sourced wooden board made of Norway spruce (Picea abies) and having been dried by the
139 processes normally used in timber industry: heated in a kiln, which results in a substantially harder
140 consistency of the wood and removes most of the odour and taste that is present in recently
141 harvested wood. The wooden piece measured 40 cm x 10 cm x 2 cm and was suspended by a metal
142 chain below snout height in a horizontal position in the other pen corner above the slatted floor. The
143 chain and boards were furnished in the pens at the start of the experiment, i.e. they did not carry
144 smells from earlier use in pig pens. In the experimental treatment, the objects were made of young
145 birch trees (Betula pendula and Betula pubescens) harvested 1 month before the arrival of the pigs
146 in the pens. Tree trunks with a diameter of 5 to 7cm were sawn to pieces with lengths of 40cm and
147 80cm, and these were stored in a barn at a temperature fluctuating between approximately -5°C and
148 +15°C. At the time of suspending the pieces to pens, the odour reminiscing freshly felled trees still
149 was sufficiently intensive to be discerned by a human nose.

150 Each pen in the experimental treatment was furnished with two 40-cm pieces and one 80-cm piece,
151 suspended by metal chains in a horizontal position below snout height but not touching the floor.
152 The 40-cm pieces were suspended in the pen corners above the slatted floor, and the 80-cm pieces

were suspended on pen walls above the solid floor. In both treatments, the 40-cm wooden objects were suspended by attaching a metal chain in the middle, and in the experimental treatment, the 80-cm wooden piece was suspended by two metal chains at each end. This way, the objects could be moved by pigs but did not come into contact with faeces on the floor. In both treatments, all the objects were suspended in the pens during the week before the pigs arrived at the age of 2 months, and the pigs had continuous access to the objects throughout their stay in the pens, i.e. until the age of 6 months. The objects were not cleaned, repaired, replaced or otherwise maintained during this time. For photographs of the objects in each treatment, see Fig. 1. For a floor diagram of a pen in each treatment, see Fig. 2.

2.3. Experimental design

The experimental unit was a pen. There were 12 pens in the experimental treatment and 12 pens in the control treatment. All the pens were in the same room, and all the pigs were in the pens at the same time. The pens formed two rows along the central corridor of the room. The treatments were balanced across the ages of the litters and across the pen locations in the room as follows: at birth, the litters were assigned alternatingly to each of the two treatments, creating 12 pairs of litters matched by age; and at the age of 2 months, when the pigs were transferred to the pens observed in the experiment, the pens in each row in the room were furnished alternatingly as either an experimental or a control pen, housing each matched pair in adjacent pens.

2.4. Data collection

2.4.1. Oral-nasal manipulation

A 24-hour video was recorded in each pen, simultaneously in all pens, using wireless Intellicam IPC04 video cameras operated with Blue IrisTM software (Perceptive Software, USA). The recordings were carried out on one day when the pigs were 4 months old, i.e. after 2 months of exposure to the treatments. Behavioural data were collected from the videos by continuous observation of two periods, before and after the daily provision of feed and straw: a 30-min period that ended 5 min before the feed and straw were delivered, and a 90-min period that started one hour after the feed and straw were delivered. The timing and duration of these two periods had been selected by a pilot test on these same videos, in order to determine which periods best represent long-term ordinary behaviour. The period before the provision was selected to start at a time point when there was no more behaviourally observable arousal after the lights were turned on in the morning, and to end before there was any behaviourally observable arousal by sound cues indicating the arrival of the feed and straw. The period after the provision was selected to start when there was no more behaviourally observable arousal from consuming the straw and all or nearly all of the straw had disappeared, and to end when all or nearly all of the pigs were still awake. Based on these criteria, the periods selected for video observation and used for all pens were from 7:55 h to 8:25 h and from 9:30 h to 11:00 h. (In one of the pens, camera failure resulted in obtaining no video for the first period; thus the N's given in the behavioural results represent alternatingly 23 or 24 pens.)

Data were collected on the frequencies of (i) oral-nasal manipulation of other pigs, recording whether the manipulation was targeted at a tail, an ear, a head excluding ears, a leg or the torso i.e. rest of the body; (ii) oral-nasal manipulation of each of the point-source objects separately; and (iii) oral-nasal manipulation of straw if there was any straw left on the pen floor at the time of the observation. Oral-nasal manipulation was defined as touching the target (i.e. an object or a pig) with the snout or mouth intensively enough to cause visible movement in the target. Individual pigs were not marked; instead, the observer followed one pig at a time on the video, from the beginning to the

end of the denoted period of time, after which the observer rewinded to the beginning and followed a different pig, reiterating the process until each pig in the first frame of video had been followed. The frequencies of manipulations at each target were recorded in each pen for each pig and averaged per each pen for statistical analysis. All of the data points represent the average number of manipulation events/pig/hour at each target.

2.4.2. Tail and ear lesions

Data on tail and ear lesions were collected by visually examining the pigs on the day after the video recording. The tails and ears were scored using the following three categories: no lesions = intact skin in the entire tail/ears; mild lesions = scratches, wounds or scars; or severe lesions = part of tail/ear missing. Scratches were defined as superficial lesions with no bleeding, wounds were described as involving bleeding, and scars were defined as wounds no longer bleeding but with the skin not yet healed. Missing parts of tails and ears were defined by comparing the length of the tail or the shape of the ear to those of an undamaged pig. For statistical analysis, the data collected at individual level were combined into pen-level percentages of each lesion category present.

2.4.3. Human approach test

A human approach test was carried out on the same day on which the tail and ear lesions were scored. The experimenter, who was unfamiliar to the pigs, stepped into the pen at the midpoint of the pen wall facing the corridor and remained standing immobile. The recorded parameter was the number of seconds before three different individual pigs had touched the experimenter with the snout or mouth.

223 2.4.4. Soiling of the solid floor

224 Data on the state of cleanliness of the solid floor were collected during the afternoon on the same
225 day when the tails and ears were scored; any cleaning of pens on this farm was carried out in
226 mornings only. These data were collected on the pen level, using a dichotomous variable to
227 represent whether or not there were wet faeces (either freshly defecated or soaked with urine) on the
228 solid part of each floor.

229

230 2.4.5. Percentages of gilts approved as breeders 235

231

232 In order to assess the economic impact of the treatments, data were obtained from the farmer on the
233 percentage of gilts in each pen that passed his selection criteria at the age of 6 months to become
234 breeder sows. The data were collected as the number of rejected pigs in each pen, from which the
235 percentage of approved pigs in each pen was calculated for statistical analysis.

236

237 2.5. Data analysis

238 The data were analysed with SPSS Statistics 23 (IBM, USA). Treatment effects on the frequencies
239 of manipulation at each of the targets before and after consuming the daily provision of feed and
240 straw were tested with an independent samples t test for the parameters that were normally
241 distributed (total pig-directed manipulation both pre- and post-consumption and total object-
242 directed manipulation post-consumption) and with a Mann-Whitney U test for the parameters that
243 were not normally distributed (object-directed manipulation pre-consumption and straw
244 manipulation both pre- and post-consumption). Within-treatment differences in pre- vs. post-
245 consumption frequencies of manipulating each body part were tested with a repeated measures t test

246 for the parameters that were normally distributed both pre- and post-eating (manipulation of tails,
247 ears, heads and legs in the experimental treatment and manipulation of ears in the control
248 treatment); and with a related-samples Wilcoxon Signed Rank test for the other parameters
249 (manipulation of the rest of the bodies in the experimental treatment and manipulation of tails,
250 heads, legs and the rest of the bodies in the control treatment). Object preferences within treatments
251 were tested with a repeated measures t test for the parameters in which both parameters to be
252 compared were normally distributed (manipulation of the 80-cm piece of fresh wood vs.
253 manipulation of the pair of 40-cm pieces of fresh wood, both pre- and post-consumption), and with
254 a related-samples Wilcoxon Signed Rank test for the other parameters (manipulation of the piece of
255 commercially sourced wooden board and the chain, both pre- and post-consumption). Treatment
256 effects on the percentages of each of the tail and ear lesion categories in the pens and the
257 percentages of pigs approved as breeders were analysed with a Mann-Whitney U test. The
258 dichotomous-variable data on soiling of the solid floor were analysed with a Chi-square test.

259

260 # 3. Results

261

262 ## 3.1. Pig-directed manipulation

263 Before receiving the provision of food and straw, the frequency of pig-directed manipulation did
264 not differ between the treatment groups, but after the consumption of the provision, the frequency
265 of pig-directed manipulation was significantly lower in the experimental treatment; see Fig. 3.
266 Within-treatment comparisons of pre- vs. post-consumption manipulation showed that in the
267 experimental pens, there was a post-consumption reduction in manipulation directed at the torso,
268 i.e. main part of the body. In the control treatment, there was a post-consumption increase in
269 manipulation directed at ears; a tendency for a post-consumption increase in manipulation directed

at other parts of the head; and a tendency for a post-consumption decrease in manipulation directed at the torso. For details on all the within-pen comparisons of manipulating the different body parts, see Table 1.

3.2. Object-directed manipulation

The frequency of object-directed manipulation was higher in the experimental pens than in the control pens, and the difference was significant both pre- and post-consumption; see Fig 4.

Within-treatment comparisons between the different types of objects provided showed significant differences in object preference before but not after the daily provision of straw; see Table 2. After the daily provision of straw, there were no significant within-pen differences in object interaction ($P>0.1$); see Table 3.

3.3. Straw-directed manipulation, tail and ear lesions, human approach test, soiling of the solid floor and approvals as breeders

None of these other variables differed between the experimental and control groups ($P > 0.1$). For overall descriptive data on these parameters, see Table 3.

4. Discussion

The main finding of this study was that the type of continuously available point-source objects affected whether a provision of feed and straw reduced oral-nasal manipulation of other pigs. Before receiving the provision, the frequency of pig-directed oral-nasal behaviours was equally high in both treatments. After consuming the provision, the frequency of pig-directed oral-nasal

behaviours was significantly lower in the experimental treatment than in the control treatment. Because the objects differed in material, shape, quantity and locations in pen, it is now known to which extent each of these differences contributed to the result. Other findings of this study were as follows: Objects made of recently harvested wood elicited more object interaction than objects made of commercially sourced wood and metal feeder chain. There also were within-pen differences in object interaction before but not after the provision of food and straw: a 80-cm long piece of recently harvested wood, suspended above solid floor, elicited a higher level of object interaction than the same amount of wood provided as two 40-cm long pieces, suspended above slatted floor; and the commercially sourced wood elicited more object interaction than metal feeder chain. The reduction in pen-mate manipulation in the experimental but not control pens suggests that there can be an additive effect between (i) receiving feed and/or a small provision of straw and (ii) the altering of other components of the environment.

The reduction in pig-directed manipulation in the experimental group was specifically in manipulation of the torso, i.e. the main part of the body excluding the head, legs and tail. The positioning of the 80-cm piece of recently harvested wood (above the solid floor, below snout level) was designed to encourage rooting in addition to chewing; therefore, it is speculatively possible that the reduction in torso manipulation was related to the ability of these objects to meet the need for rooting to some extent. In the control group, there was the unexpected finding that the frequency of ear-directed manipulation was increased after consuming the provision of feed and straw. This further suggests that the material, shape, location and/or quantity of objects in the control pens, representing objects used on many farms, were not effective in reducing pig-directed manipulation.

Object-directed manipulation was more frequent in the experimental pens than in the control pens, with a more than twofold difference in the number of observed events. Since the difference in the level of object manipulation was substantially higher than the difference in the number of objects in the treatments (three vs. two), and the difference in total length of the objects (160cm vs. 100cm),

317 the result is likely to reflect a difference in perceived attraction of the materials, although the shapes
318 and locations may also have had an effect. In the control pen, the chain was in a vertical position,
319 making it more difficult for the pigs to manipulate than the wooden objects. Although wooden
320 objects were in a horizontal position in both treatments, they differed in shape: one of the
321 improvements in the experimental objects was that they did not have the flat cross-section of 2 cm x
322 10 cm as in ordinary commercial board, but instead were round with a cross-section of 5 to 7 cm to
323 make it easy for pigs to take the pieces in their mouth. In the control pens, both objects were in
324 corners above the slatted floor, while in the experimental pen, the third object was above the solid
325 floor. It is also important to note that behavioural data were collected on one day only and so may
326 potentially have be affected by random factors. The higher frequency of interaction with recently
327 harvested wood was similar to the results of our earlier study, in which wood from recently
328 harvested birch trees elicited more object interaction and reduced tail and ear biting as compared to
329 objects made of polythene plastic or metal chain (Telkänranta et al., 2014). In an experimental study
330 by Cornale et al. (2015), it was also found that access to suspended pieces of black locust tree
331 (Robinia pseudoacacia) reduced tail biting and aggression; and an epidemiological study by van
332 Staaveren et al. (2019) found a lower prevalence of damaging behaviour on farms that provided
333 objects made of wood or plastic, as compared to farms that provided metal chains.

334 In several studies testing wooden objects for manipulation, the observed welfare benefits or lack
335 thereof have varied substantially (Bracke et al., 2006). Part of the variation is likely to have been
336 caused by different object designs, quantities and locations in the pens. However, an additional
337 factor is likely to be the substantial variation in the wood itself. In studies involving wood for
338 manipulation, authors usually report the dimensions of the pieces and the species of the tree, or
339 whether the species is classified as hardwood or softwood. However, important characteristics that
340 seldom are reported include the time since the trees were felled and the methods with which the
341 wood was stored and treated after felling. Recently felled trees have an intensive odour and taste.

During the months after felling, substantial changes occur in the moisture content, hardness and chemical composition. The nature and magnitude of such changes partly depend on the temperature and humidity of the storage facilities (Brand et al., 2011). Commercially sourced wood has also undergone a drying process in a kiln or other drying facility, which further alters it physical and chemical composition (Möttönen 2006). The frequency with which pigs interacted with recently harvested wood in the present study may partly be explained by the finding that an intensive odour, defined as discernible by human nose, is one of the characteristics promoting pigs' long-term interest in objects (van de Weerd et al., 2003). The presence of bark on the recently harvested wood may have contributed to the effect, but the bark was eaten during the first days, and therefore the effect over the months is likely to have been caused by the characteristics of the wood itself. However, there has been little research on the relative relevance of different intensive odours for pigs. The role of olfactory experiences on animal welfare in in general has been studied to a limited extent so far, and e.g. Nielsen et al. (2015) have called for further study in this field.

Within-pen comparisons of object manipulation showed pre-consumption preferences that were no longer significant post-consumption. This may reflect differences in motivation for manipulation before and after receiving the feed and straw. In the experimental pens, the two ways of presenting 80 cm of wood – either as one piece suspended above the solid floor or as two 40-cm pieces suspended above the slatted floor – yielded a significant pre-consumption preference for the longer piece, as compared to the combined frequency of interacting with the two shorter pieces. However, this result may have been affected by the location of the longer piece: it was closer to the feed trough than the short pieces, and the pigs may have spent more time in the vicinity of the trough when anticipating food and straw. In the control pens, pieces of commercially sourced wood elicited more pre-consumption object manipulation than pieces of metal chain. As the wood and chain in control pens were in corresponding locations, this may suggest that even the commercially sourced wooden board was to some extent perceived as edible, but not highly valued as a target for oral-

nasal manipulation after the pigs had eaten and were unlikely to be motivated by hunger. Another explanation may be that the metal chain was suspended in a vertical position while the wooden objects in both treatments were suspended in a horizontal position, making the metal chain more difficult to manipulate.

Tail and ear biting lesions did not differ between the treatment groups in the present study. Lesions in other parts of the body were not recorded for the reason that they were mild and infrequent during the planning phase as well as during the study. The absence of difference in tail and ear biting may be because of the overall low prevalence of tail and ear biting on this farm, and/or because of the small quantity of wooden objects per pen (20cm/pig). In an earlier study on a different farm, we provided a higher amount of wood per pig (30cm/pig) and found significant differences between treatment groups in tail and ear biting (Telkänranta et al., 2014). In the present study, despite the post-consumption increase in ear manipulation in the control group, ear lesion scores did not differ between the treatment groups, suggesting only a small difference in intensity of ear manipulation. Another potential reason for the lack of treatment effects in tail and ear biting is that even if tail and ear biting were reduced in the experimental group, that effect may have been cancelled out by a simultaneous increase in tail and ear biting caused by competition over the limited number of objects. Pigs are motivated to explore and forage synchronously (Docking et al., 2008) and if the quantity of material is insufficient for simultaneous use, the pigs without access can redirect their motivation for manipulation at other pigs (Zwicker et al. 2015). Too small a quantity of highly desirable objects can also cause biting due to competition (Van de Perre et al., 2011). In the present study, we cannot exclude the possibility that the three objects in the experimental pens (two small objects and one large one), accommodating a maximum of approximately four pigs at a time, may have been too small an amount for the seven pigs per pen.

In the parameter most relevant for the farmer in terms of the economics of production, namely the percentage of pigs approved as breeders, there was no significant difference between the treatment

groups. Neither was there any significant difference in soiling of the solid floor. The reason for testing the latter in the study was some farmers' reluctance to place point-source objects above the solid part of the pen floor, as there is a belief this will increase soiling of the solid floor. However, in this study the floor cleanliness was assessed on one day only, and therefore it may not accurately reflect the average situation over time.

It is also important to note that despite a significant reduction in pig-directed manipulation in the experimental treatment, the pigs still did re-direct oral-nasal manipulation at each other. Further improvements in the pen environment are needed in order to satisfy the motivation of pigs to root and chew to the extent that these behaviours no longer are re-directed at other pigs.

These findings show that while the results of the present study do contribute to the knowledge needed to further develop improved solutions in using wood as a material in point-source objects for pigs to manipulate, the experimental treatment used in the study does not yet represent point-source objects effective enough to prevent re-direction of oral-nasal manipulation at other pigs. There is a need for a systematic study on the behavioural and emotional relevance for pigs of different odours, tastes, shapes and levels of hardness of different point-source objects, as well as on the effect of the height and orientation at which the objects are placed, numbers of objects per the number of pigs in the pen, their locations relative to corners and slatted/solid flooring, as well as locations of the objects in pen relative to the corners, feeding and resting areas.

5. Conclusions

Pigs with continuous access to three pieces of recently harvested birch wood, one of which was located above the solid floor, showed a reduced level of redirecting oral-nasal manipulation at pen-mates after consuming a provision of liquid feed and long straw, while pigs with continuous access to two pieces of commercially sourced wooden board, made of dried spruce, and a vertical metal

chain, all located above slatted floor, showed no post-consumption reduction in pig-directed manipulation. Object-directed manipulation was more frequent in pens with pieces recently harvested wood than in pieces with commercially sourced wood and metal chain. Further research is needed on the quantity of wood required to satisfy the preference for synchronous exploration; on which physical and chemical characteristics of wood that are perceived as most relevant by pigs; and on how these characteristics are altered by drying and storage of wood.

Conflict of interest statement

The Authors declare that there is no conflict of interest.

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Figure captions

Fig. 1. The objects provided for manipulation in the two treatments. In the experimental treatment, there were pieces of birch wood harvested 1 month earlier. Each pen contained one 80-cm piece (a) and two 40-cm pieces (b). In the control treatment, the objects were the same as normally used on this commercial farm: each pen contained one 60-cm piece of feeder chain made of metal (c) and one 40-cm piece of commercially sourced wooden board (d).

Fig. 2. Floor diagram of an experimental pen and a control pen. The following features were present in the experimental treatment: long piece of recently harvested wood (a); short pieces of recently harvested wood (b). The following features were present in the control treatment, representing the

point-source objects ordinarily used on this farm: metal chain (c), piece of wooden board (d). The following features were present in both treatments: solid floor, onto which long straw was distributed after feeding (e); slatted floor (f); feed trough (g); water nipple (h).

Fig. 3. The mean frequencies and standard deviations of total observed pig-directed oral-nasal manipulation in the experimental treatment (E) and in the control treatment (C) before and after consuming a daily provision of feed and straw. The asterisk indicates significance of difference between treatments: * $P < 0.5$.

Fig. 4. Frequencies of total observed object-directed oral-nasal manipulation in each treatment group: a) the median frequencies with minimum and maximum values before consuming a daily provision of feed and straw, and b) the mean frequencies with standard deviations after consuming a daily provision of feed and straw, The objects in the experimental treatment (E) were made of wood from recently harvested trees, and the pigs in the control treatment (C) were made of commercially sourced wooden board and metal chain. The asterisks indicate significance of difference between treatments: ** $P < 0.01$, ** $P < 0.001$.

Table 1. Within-treatment comparisons on the frequency of oral-nasal manipulation directed at other pigs before vs. after the daily provision of approx. 20g of long straw per pig. The frequencies are given as pen-level means or medians of the number of oral-nasal contacts per pig per hour.

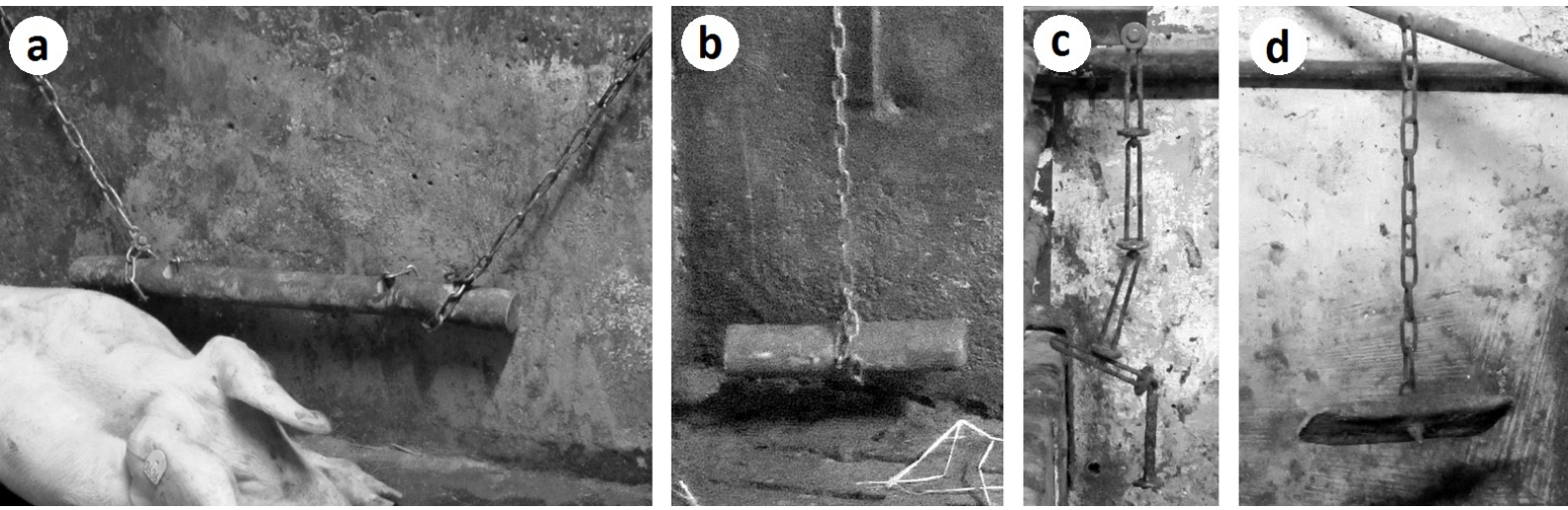
Targeted body part	Treatment	Before straw, mean or median	Before straw, SD or min-max	After straw, mean or median	After straw, SD or min-max	Statistic	*P*
Tail	Experimental	mean 2.1	SD 1.2	mean 1.6	SD 0.8	t=1.5	>0.1
	Control	median 1.3	min 0.6 max 3.9	median 2.2	min 0.9 max 3.3	W=51	>0.1
Ear	Experimental	mean 3.7	SD 1.9	mean 3.7	SD 0.8	t=0.07	>0.1
	Control	mean 3.8	SD 1.8	mean 4.4	SD 1.6	t=–3.0	<0.05
Head, excluding ears	Experimental	mean 9.5	SD 2.5	mean 10.4	SD 2.3	t=–1.1	>0.1
	Control	median 10.5	min 6.6 max 18.6	median 14.3	min 5.6 max 17.1	W=62	<0.1
Leg	Experimental	mean 3.0	SD 0.9	mean 2.4	SD 1.0	t=1.6	>0.1
	Control	median 2.3	min 0.9 max 10.0	median 3.6	min 1.0 max 6.9	W=46	>0.1
Torso, i.e. rest of the body	Experimental	median 18.3	min 6.6 max 50.3	median 9.5	min 6.6 max 47.7	W=4	<0.05
	Control	median 20.0	min 10.0 max 39.4	median 17.0	min 7.5 max 25.6	W=18	<0.1

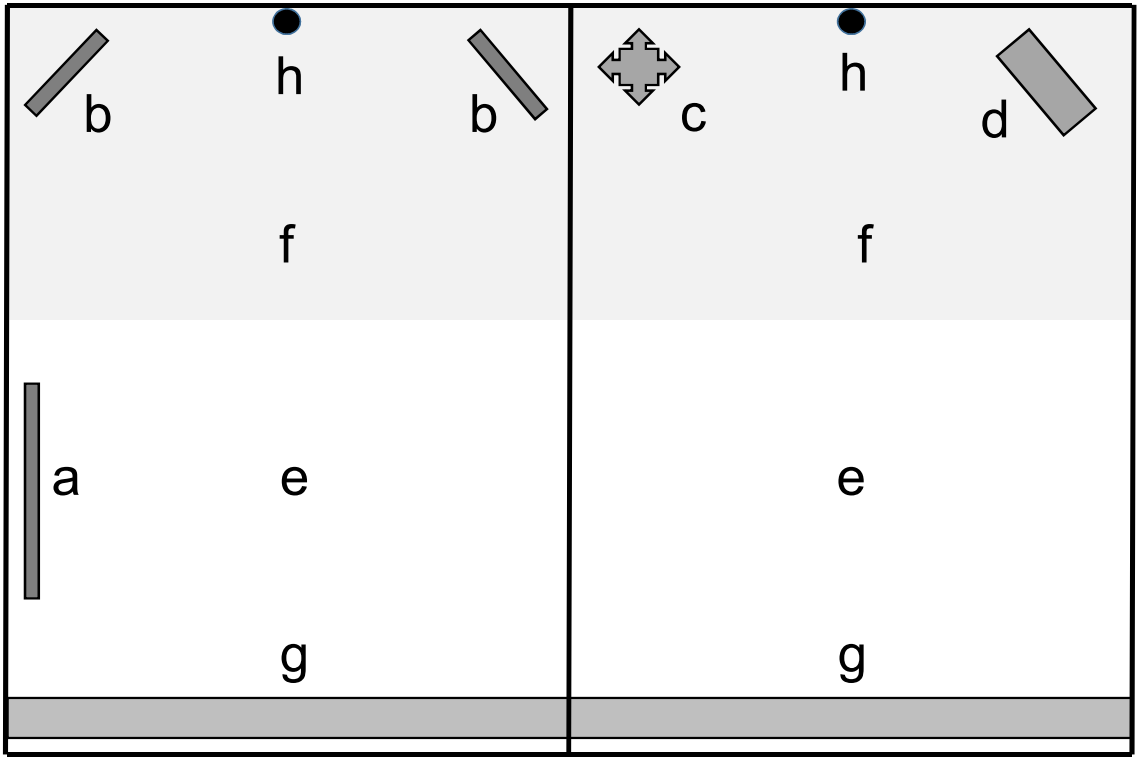
Table 2. Within-treatment comparisons on the frequency of interacting with the different types of objects provided in the pen, observed before the daily provision of straw. The frequencies are given as pen-level means or medians of the number of oral-nasal contacts per pig per hour.

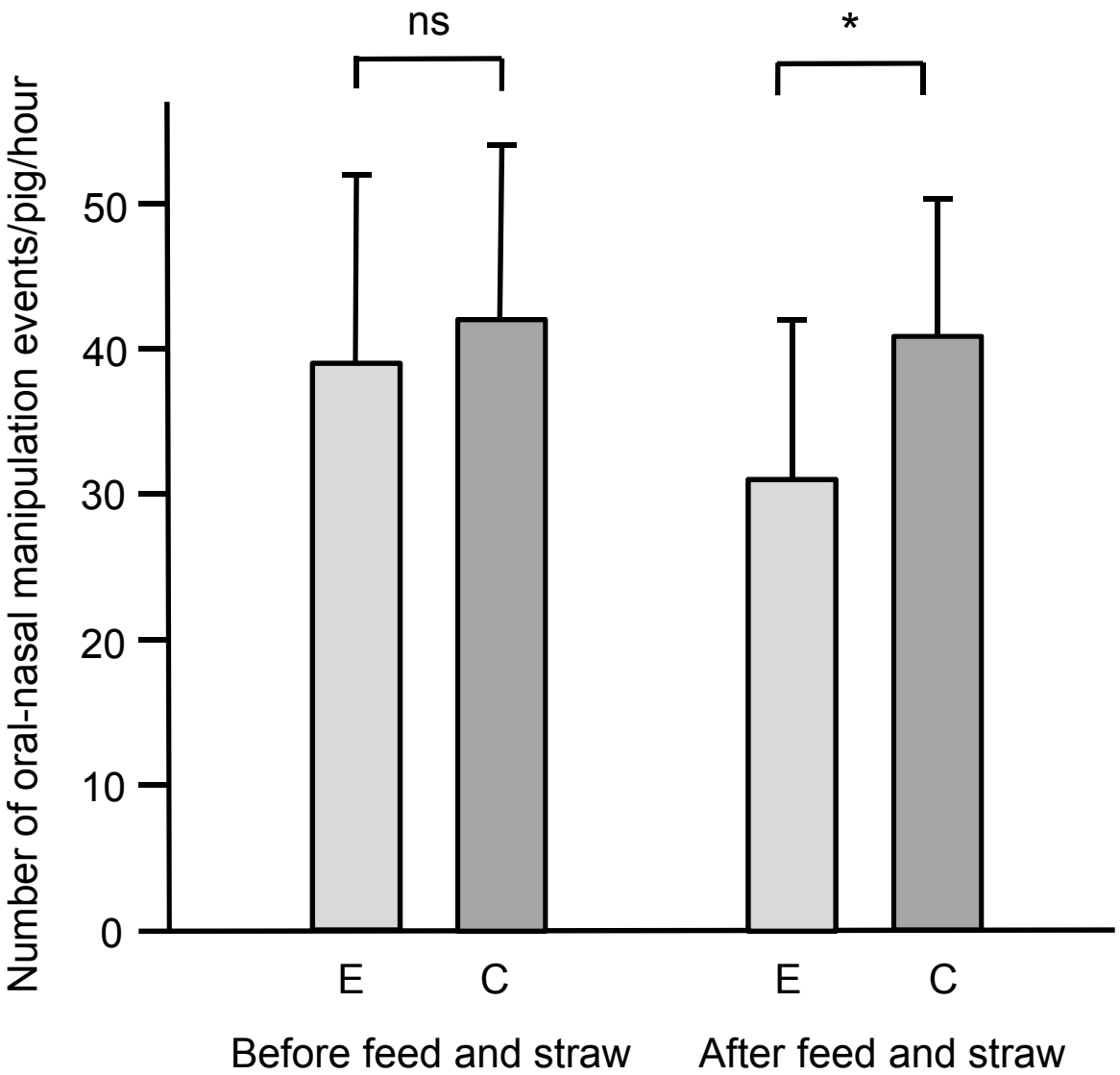
Treatment	Object	Frequency, mean or median	SD or min-max	Statistic	*P*
Experimental	80cm of recently harvested wood	mean 6.3	SD 3.3	t=2.6	<0.05
	2 x 40cm of recently harvested wood	mean 3.6	SD 2.0		
Control	40cm of dried wooden board	median 2.0	min 0.3 max 13.1	W=9.0	<0.05
	60cm of metal feeder chain	median 1.0	min 0.0 max 2.6		

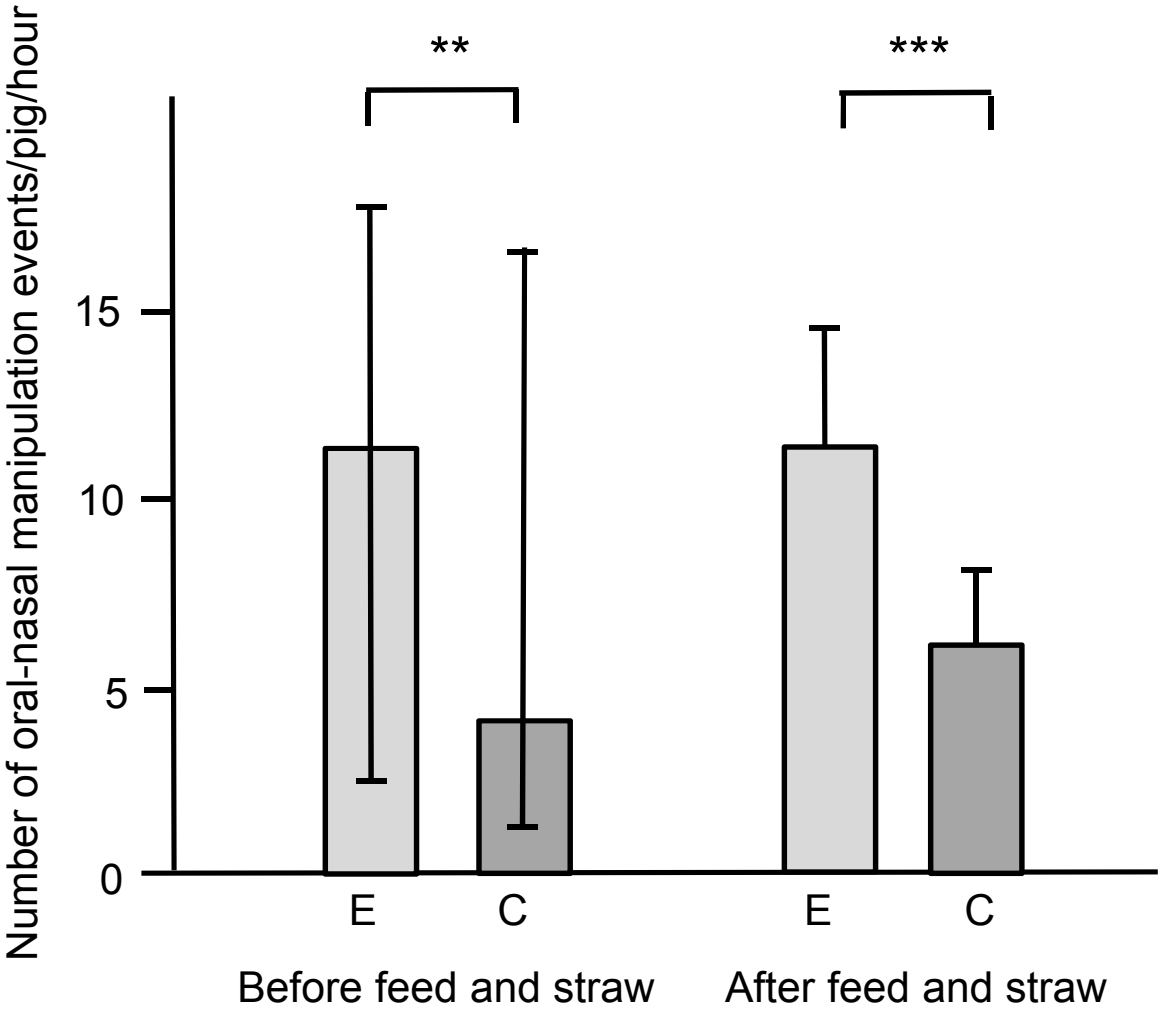
Table 3. Overall descriptive data across treatment groups on the parameters that did not show significant differences across treatments. The figures are pen-level means or medians, except for the pens with soiled floors, in which the figure is the percentage of all pens.

Parameter	Overall mean or median	SD or min-max
Oral-nasal manipulation of either one long vs. two short pieces of recently harvested wood, after the daily provision of 20g straw/pig	median 1.3 events/pig/hour	min 0.0 max 4.1
Oral-nasal manipulation of either a piece of dry wooden board or a metal feeder chain, after the daily provision of 20g straw/pig	median 0.5 events/pig/hour	min 0.0 max 7.8
Oral-nasal manipulation of residual pieces of straw, before the daily provision of 20g straw/pig	median 0.0 events/pig/hour	min 0.0 max 0.9
Oral-nasal manipulation of residual pieces of straw, after the daily provision of 20g straw/pig	median 7.0 events/pig/hour	min 0.7 max 26.5
Pigs with undamaged tails	median 86%	min 57 max 100
Pigs with mildly damaged tails	median 14%	min 0 max 43
Pigs with part of tail missing	median 0%	min 0 max 29
Pigs with undamaged ears	median 29%	min 0 max 86
Pigs with mildly damaged ears	median 71%	min 14 max 100
Pigs with part of ear missing	median 0%	min 0 max 0
Latency for first three pigs to touch an unfamiliar human	mean 11.1s	SD 5.5
Percentage of pens with faeces on the solid part of the pe floor	13%	
Not selected as breeders	median 39%	min 25% max 43%


a
b
c
d


b
h
b
c
h
d
f
f
a
e
e
g
g


ns
*
Number of oral-nasal manipulation events/pig/hour
50
40
30
20
10
0
E
C
E
C
Before feed and straw
After feed and straw


Number of oral-nasal manipulation events/pig/hour
0
5
10
15
**
***
E
C
E
C
Before feed and straw
After feed and straw