Novel object test can detect marginal differences in environmental enrichment in pigs

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Abstract

In search for a test measuring positive emotions in pigs for application in on-farm welfare auditing, three small experiments were conducted to examine the sensitivity of a novel object test designed to measure the pigs’ (residual) need/motivation for enrichment. In the experiments the interactions with a novel piece of rope were measured at pen level using a so-called AMI sensor (AMI: animal–material interactions). Measurements were taken at several points in time over a 1–2 h period in order to test the effects of marginal enrichments, namely the provision of a jerrycan canister (Experiments 1a and 1b) and the provision of some sawdust and/or removal of the metal chain (Experiment 2).

The first experiment was replicated in, respectively, 8 and 15 matched pairs of pens with groups of about 11 growing pigs per pen. A jerrycan was provided in one pen of each pair as of the day before the novel object test. In the first replicate (Experiment 1a) only a main effect of time was found in that AMI decreased over time. In the second replicate (Experiment 1b) the provision of the jerrycan significantly reduced AMI. A sign test also confirmed this effect for the data in the first replicate. The recent provision of a jerrycan, therefore, marginally, but statistically significantly, reduced AMI in the novel object test.

Experiment 2 was a $2 \times 2$ factorially designed study conducted in 40 pens containing groups of 24 weaned piglets. Factors were sawdust provision and chain removal. The four treatment combinations were applied as of 45 min before the test. In addition to a main effect of time, it was found that AMI significantly increased when the chain had been removed ($P = 0.006$), and that the provision of sawdust tended to depress AMI at 10 min, while tending to enhance AMI at 30 min (interaction between time and sawdust provision: $P = 0.097$).

The results indicate that the novel object test may be used to detect relatively minor differences in environmental enrichment.

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1. Introduction

At present research is being conducted to develop animal-based monitoring schemes for on-farm welfare assessment at the European level (Blokhuis et al., 2003; Butterworth, 2005; Velarde and Geers, 2007). As part of this work a semi-automated novel object test was developed to measure the level of environmental enrichment and/or the level of positive welfare (positive emotions) in the pigs. When play would indicate ‘having fun’ (Spinka et al., 2001) the exploration of a novel object, i.e. object play, could, perhaps, be used to measure the pigs’ residual need (i.e. their remaining motivation) to explore/play. If so, we would expect an inverse relationship between the interaction with the novel object and the level of enrichment in the pen.

The level of enrichment is known to have an effect on both play behaviour and on redirected activities (e.g. Wood-Gush and Vestergaard, 1991; Fraser et al., 1991; for a review see Bracke et al., 2006). For example, barren housed pigs were less active, showed less explorative and play behaviour and spent more time on oral activities directed at pen mates than pigs from enriched housing (Bolhuis, 2004; Bolhuis et al., 2005).

When pigs in barren housing tend to redirect their exploratory behaviour, for example to the tails of other pigs (Van Putten, 1969; Fraser, 1987; Schroder-Petersen and Simonsen, 2001), this tendency could perhaps also be detected with a novel object test. In fact, this test has been shown to be able to differentiate widely different levels of enrichment. Comparing pigs in a semi-natural environment, furnished (family) pen, open-fronted straw pen and Danish partly slatted pen, Stolba and Woodgush (1981) have shown that over an 80 min observation period the pigs’ interaction with a novel object (car tire) decreased with increasing environmental complexity. They found that pigs in more intensive systems were more interested in the car tyre immediately after introduction and that their interest was maintained for a longer period of time.

One aspect of the (further) development of the test concerned showing that it would be sensitive to much smaller differences in enrichment compared to those studied by Stolba and Woodgush (1981). A second aspect of the test concerned the ‘hope’ that a good measure of enrichment should be animal-based and preferably even be able to detect levels of enrichment that would not be directly observable (e.g. because the enrichment had been provided early in the morning, before the auditor has arrived on the farm; see also Bracke, in press-a). A final aspect of the test concerned feasibility: for on-farm application the novel object test should be feasible within a limited time frame and within a limited budget. To this end automated recording could be beneficial.

This paper reports on two experiments where a semi-automated novel object (rope) test was applied in barren pig pens treated with marginal changes in environmental enrichment, namely the provision of a jerrycan (canister), the provision of some sawdust and the removal of the metal chain standardly provided to the pigs, in order to examine whether the test could detect different levels of exposure to enrichment and/or different levels of the pigs’ motivation to interact with enrichment materials. A further objective, especially of the second 2 × 2 factorial study, was to examine interactions between the provision of sawdust and the removal of the metal chain, as part of (on-going) validation work of an assumption underlying previous modelling work (namely that interactions between enrichment materials are ignored until they have been confirmed in scientific studies; see Bracke, in press-b).

The objectives of the experiments, therefore, were to examine whether (semi-)automated recording can work in a feasible way on commercial farms, to test the sensitivity of the novel object test in relation to selected marginal changes in environmental enrichment, and to (re-)examine the enrichment value of ‘jerrycan’, ‘sawdust’ and ‘metal chain’.
2. Materials and methods

2.1. Modelling background

What constituted marginal enrichment was determined on the basis of previous modelling work, where a model, called RICHPIG, had been constructed to specifically assess the value of enrichment materials for pigs (expressed on a scale from 0 to 10) based on available scientific information collected in a database (Bracke et al., 2006, in press-a,b). First, a jerrycan (empty plastic canister, size: 20 cm × 30 cm × 40 cm) was selected, as, especially when a jerrycan has been in the barn (unit) for longer, its attractiveness was expected to be low (e.g. Stubbe, 2000), and because jerrycans lack properties that stimulate the pigs’ interest such as novelty, chewability, ingestibility and destructibility (see Zonderland et al., 2001; Van de Weerd et al., 2003; Bracke et al., in press-b). Second, the commonly provided metal chain in pig pens was considered to be marginal enrichment (Bracke, 2006; Bracke et al., 2006, in press-a), e.g. because it is not destructible, not rootable, not chewable (with molar teeth, to be differentiated from biteable with the front teeth) and not ingestible. Finally, a very small amount of sawdust was considered to be hardly enriching, as it would not be rootable, not destructible and hardly chewable. Therefore, the prediction was made that a jerrycan, a metal chain and a bit of sawdust were very modest, perhaps negligible enrichment materials, at least when compared to other enrichments such as providing ample straw (Zonderland et al., 2003) and mushroom compost (Beattie et al., 2001). If the novel object test would detect these marginal materials, then the test could be considered to be sensitive to small changes in enrichment.

2.2. Experiments 1a and 1b: jerrycan

Experiments 1a and 1b were performed as two replicate studies in one building of a commercial farm. In each replicate matched pairs of pens were selected across the age groups present in different units (rooms) in the building. As a general rule, the pens contained uniform groups of 11 crossbred growing pigs per pen. All pens were 3.05 m deep and 2.65 m wide. They had a partly solid, concavely curved floor (1.2 m deep), extending from 0.4 m from the front wall to 1.45 m from the back wall, with concrete slatted floors in the front and the back of the pen. All pens had a dry feeder containing a drinking nipple, and a chain hanging on the pen wall dividing neighbouring pens. There was no additional environmental enrichment in the pen before the experiments started.

The two pens within each pair of pens were located in the same unit (room). Pens of a pair were as much as possible similar with respect to the number of pigs in the pen and location in the unit (front, middle, back). One pen of the pair was (randomly) provided with a jerrycan on the day before the novel object test. The jerrycans had been in the barn for longer, and all jerrycans had been used as enrichment material in previous batches of pigs raised in the same building. In the first replicate (Experiment 1a) eight pairs of pens were used. Each pen contained between 7 and 11 pigs. The pigs had been on the premise for between 21 and 126 days on the day of testing.

The second replicate (Experiment 1b) used 15 different pairs of pens, as preliminary analysis of Experiment 1a suggested that repetition of the test with a larger number of pens and slight modification of the test might reveal previously unexpected differences between pens with and without a jerrycan. In Experiment 1b each pen contained 10 or 11 pigs (except for 1 pair with 5 pigs per pen, 1 pair with 8 pigs per pen, and 1 with 9 pigs). The pigs had been in the building for between 26 and 138 days.

In Experiment 1a a longer orange nylon cord (diameter: 4 mm; suspended 20 cm above the floor) with untwined strands was introduced in each pen as novel object, while in Experiment 1b a somewhat shorter white nylon cord (diameter: 3 mm) with twined strands was used, hanging at nose height (approx. 30–40 cm). The interactions with the rope were counted ‘on-line’, using so-called AMI sensors (modified after Zonderland et al., 2001; AMI: animal–material interactions) that were randomly allocated to pens across treatments. Recordings were made after 7 and 8 intervals of 15 min each (in Experiments 1a and 1b, respectively). The sensors (Volkraft®) were mounted in the ropes and out of reach of the pigs, counting the number of times the pigs interacted with the rope.
A Split plot ANOVA (on observations within pens within units) was done on log transformed data using Genstat 8 (Anonymous, 1993). Since this analysis assumes a constant covariance between observations, the dataset was condensed to three data points per pen, each consisting of the average AMI per minute for the first, second and third half hour, respectively. The measures taken after 90 min were ignored in the Split plot analysis, also because a feasible test should preferably take a limited period of time to record.

In order to show the ‘full’ dataset (not transformed) mean values and their standard errors were graphically represented, and a time series regression analysis (ANOVA) was done on the intercepts (with the y-axis) and slopes of the log-transformed curves (as described in Oude Voshaar, 1995). Finally, one-sided Sign tests were done comparing treatment effects under the hypothesis that (matched) control pens had higher AMI values than pens enriched with a jerrycan.

2.3. Experiment 2: chain and sawdust

Experiment 2 was conducted on another commercial farm. Six units of weaned pigs, housed in one building, were available for the experiment. The pigs had been in the building for between 18 and 46 days. Each unit contained 10 pens with approximately 24 pigs per pen. In total 40 pens were used in the experiment. Each pen contained a metal chain hanging at a distance of 30 cm from the side and back walls. All pens were 2.30 m wide, 3.70 m deep with two meal feeders, left and right, with 2 nipples at the sides of the feeder. A solid, concavely curved concrete floor (1.7 m deep) separated the front 60 cm of plastic slatted floor from the back 140 cm with iron slats. Other than the chain, there was no additional environmental enrichment in the pen permanently available to the pigs before the experimental work commenced. In the experiment, two factors were studied in a two by two factorial design, resulting in four treatment combinations that were applied randomly in 10 sets of 4 pens. The factor ‘chain removal’ involved the withdrawal of the chain 45 min before the start of the novel object test. The factor ‘sawdust provision’ involved the provision of a small amount (500 ml) of dustfree sawdust (with reasonably uniform particles of about 1 mm) on the solid floor, at the same time (i.e. at 45 min before the novel object test). Pens with treatment combinations involving ‘no chain removal’ and/or ‘no sawdust provision’ received sham treatments in order to eliminate handling effects.

The novel object test involved the introduction of a novel piece of white nylon rope (3 mm diameter) reaching 20 cm above the floor and hanging in the middle of the front wall in each pen. AMI sensors were the same as the ones used in Experiment 1. They were randomly allocated to pens and read out in Experiment 2 at three points in time, namely at 10, 30 and 60 min after the start of the novel object test.

A Split plot ANOVA (on observations within pens within units) was done on log-transformed data using Genstat 8 (Anonymous, 1993). The mean values per treatment factor are also presented graphically.

3. Results

3.1. Jerry can experiment

In Experiment 1a a significant effect of time was found in that the predicted mean values for the first half hour were higher compared to the second and third half hour (12.82\(^a\), 7.36\(^b\) and 5.75\(^b\), respectively, where different superscripts differed significantly, \(F = 20.50, P < 0.001\)). There were no further noteworthy effects found in the Split plot analysis or on intercepts and slopes of the time-series regression lines.

Fig. 1, however, shows that on each of the seven recorded time points the mean value of control pens was higher than the mean value of the jerrycan-treated pens. This ‘finding’ drew our attention because it would be significant in a Sign test. When subsequently (more appropriate) Sign tests were done on the 15 min average AMI values and the cumulative AMI values per time period, trends were found for the time points 15 and 45 min (\(P < 0.1\)).
In Experiment 1b the provision of the jerrycan significantly reduced AMI (predicted means were 2.53 and 4.08 for jerrycan pens and controls respectively, $F = 5.59$, $P = 0.036$). No significant effects were found for time, for the covariates ‘age’ and ‘number of pigs per pen’ and for any interaction with treatment. The predicted means of both controls and jerrycan-treated pens decreased progressively, but not significantly over the three half-hour time periods in the Split plot ANOVA. In the analysis of the intercepts a trend ($P = 0.099$) was found for a treatment effect, while no effect (of any factor or interaction) was found for the analysis of the slopes of the time-series regression lines.

Fig. 2 shows that, again, all mean values for the controls in each of the eight time periods were higher than the means for the jerrycan-treated pens (eight observations out of eight time periods). When the 15 min average AMI values per time period were compared only a trend was found for the 30 min time period ($P < 0.1$). The cumulative averages per time period, however, were significant at times 75 and 90 min, while a trend was observed for the times 30, 105 and 120 min.

When the Sign tests were done over the dataset combining both Experiments 1a and 1b, the 15 min average AMI values for each time point were significant at time 15 min, a trend was found at times 30 and 45 min, while a near trend ($P = 0.13$) was observed at time 75 min. The cumulative average AMI values for the seven time points tested in the combined dataset all either were significant (times 15, 45, 75, 90 min) or showed a trend (times 30, 60, 105 min).

### 3.2. Chain-and-sawdust experiment

The Split plot analysis showed a significant effect of time and chain removal. AMI at 10, 30 and 60 min were 0.78$^a$, 2.00$^b$ and 2.03$^b$, respectively (different superscripts indicating a significant difference, $P < 0.001$). More interestingly, pens where the chain had been removed showed higher AMI levels compared to pens where the chain had not been removed (1.92$^b$ versus 1.20$^a$, $P = 0.006$). There was no effect of ‘sawdust provision’ and there was no interaction between the treatment factors when all time points were included in the analysis. However, when
the analysis was run on only the first two data points (10 and 30 min) there was a trend for an interaction between time and ‘sawdust provision’ (and the main effects of time and ‘chain removal’ were retained). The trend ($P = 0.097$) indicated that whereas AMI values at 10 min were (somewhat) depressed for the pens provided with sawdust (compared to the pens without sawdust), the AMI values at 30 min where elevated (for pens provided with sawdust compared to the pens without sawdust; see Fig. 3). This analysis on the reduced dataset was justified because it increased ‘focus’ on early time effects and because at the later time testing equipment was lost (almost 40% of the ropes had been lost at time 60 min due to improper fixation of the ropes to the AMI sensors).

4. Discussion and conclusions

The objectives of the work were to examine the effects of marginal changes in environmental enrichment on the novel object test, which involved the introduction of a novel piece of rope into a pen with pigs, and recording the number interactions with the rope (AMI) at several time points after introduction of the rope.

As to the methodology of the experiments several points must be noted. First, the novel object test was used to examine relatively short-term effects of changes in enrichment. This implies that the results cannot directly be extrapolated to on-farm conditions where materials such as a jerrycan and sawdust tend to be provided on a more routine basis. Second, as most clearly indicated by modifications made in Experiments 1a and 1b, the present report concerns findings of a novel object test that is still in development (Feddes et al., 1993; Zonderland et al., 2001). We believe this report will contribute to the ongoing endeavours in this direction (e.g. work in progress on the tail-chew-test by Statham et al., 2006). Finally, in the course of Experiment 2 ropes were progressively lost due to improper fixation. This may have affected the results in several ways, including a reduced probability of finding (significant) differences between treatments. For this reason, the analysis was repeated on only the first two time points (10 and
30 min), and this confirmed the effect of removal of the chain and showed a trend effect for the interaction between the provision of sawdust and time.

The treatment factors in Experiment 2 (provision of some sawdust and removal of the chain) were applied in a $2^2$ factorially designed study. This allows the examination of interactions between factors. This is important because to date relatively little is known about such interactions and, as a consequence, the modelling had proceeded without taking interactions into account. Preliminary support for this assumption had been found earlier in a study comparing the effects of destructibility, hygiene and sound (Bracke, in press-b). In the present study, again, no statistically significant interaction was found between treatment factors. Assuming that the test is sensitive to detecting small changes in environmental enrichment, the absence of an interaction in this study provided some additional support for the modelling principle to ignore (complicating) interactions (until more detailed scientific knowledge has become available).

The provision of a jerrycan and the removal of the metal chain were shown to significantly affect AMI as measured in the novel object test. The jerrycan decreased AMI and chain removal increased AMI. In addition, there was some indication that the previous provision of some sawdust tended to slightly depress AMI at first (at 10 min) and enhance AMI later (at 30 min). These findings imply that the test may be responsive to relatively small changes in environmental enrichment. Increasing previous enrichment (e.g. providing a jerrycan and to some extent the provision of sawdust) seems to decrease the interest in the new enrichment (test rope), whereas reducing previous enrichment (e.g. removing the chain) seems to increase interest in the test rope. The limited effect of sawdust may be have been due to several factors, including the fact that the amount of sawdust provided was very low (about 21 ml/pig, i.e. about 4 gr/pig), that sawdust was less similar to the test rope than the chain, and the fact that the sawdust had completely disappeared from the pen by the time the test started (i.e. it had moved through the slats and/or was eaten by the pigs). Finding a trend for an interaction of sawdust provision with time is interesting, because it indicates that the novel object test may perhaps be used to detect even previous marginal enrichment, no longer present at the time of recording. This could have practical implications, as one of the ultimate objectives of animal-based monitoring (e.g. for the purpose of certifying farms and/or labelling of products for animal welfare) is to let the animals ‘say’/indicate what their actual level of enrichment is/has been, without having to rely on environment-based criteria and without having to rely on stockmen reports (as there may be problems with their presumed validity and reliability; however see also Bracke, in press-a ).
The responses in the novel object test as reported in this paper in relation to marginal changes in environmental enrichment are probably best explained as redirected exploratory behaviour, i.e. as a redistribution of the level of attention over the different objects in the pen (including enrichment materials, pen walls and fittings, conspecifics and novel objects). This would imply that the provision of a jerrycan (slightly) decreased AMI of the test rope, because to a very small extent the jerrycan has met some of the pigs’ need to perform object-directed play (even though the observer, MB, noted hardly any interaction with the jerrycans when conducting the test). Another possible explanation for this response could be that the animals had become tired as a result of playing with the jerrycan. In both cases the novel object test would indicate some (marginally) enhanced welfare from the provision of a jerrycan. Similar explanation(s) could apply to the trend effect reported for the provision of sawdust. The elevated response after removal of the chain, however, would indicate that the pigs’ motivation to interact with the chain was (at least to some measurable extent) redirected to the rope. To our knowledge, this study was the first to experimentally report redirected behaviour in response to (the removal of) a metal chain provided commonly in pig pens as a means of environmental enrichment, possibly indicating there may be some enrichment value associated with it (and as opposed to its value to reduce frustration as shown by e.g. Dantzer and Mormede, 1981).

It may be debated to what extent the enrichment treatments were actually marginal, as anticipated based on the previous modelling work. Compared to the whole range of enrichment materials that can be provided (including e.g. ample mushroom compost and deep straw bedding) the treatments were certainly marginal. However, against the background of the barren pens in which the pigs were housed it could be argued that these relatively ‘marginal’ improvements were considerable. The present study does not allow drawing definite conclusions in this respect, but the following considerations are relevant to the issue.

Novelty may have contributed to the impact of the treatments on the novel object test. The jerrycan was provided 1 day before the test, while both sawdust provision and chain removal were conducted 45 min before the test. Novelty is known to be important for pigs (e.g. Van de Weerd et al., 2003, also Bracke, in press-b). This has implications for inferring the (more long term) enrichment value of the tested materials, as is common in farming practice and as has been modelled in RICHPIG. For example, the redirected attention to the rope in response to the removal of the chain may have been enhanced by the ‘novelty’ of chain removal. This could make the general expert view that a metal chain has little enrichment value (Bracke, 2006; Bracke et al., in press-a) consistent with the finding in Experiment 2 as the redirected behaviour in response to removal of the chain may have been triggered by an arousal effect of contrast (rather than by the ‘missing’ of the chain per se).

Despite this possible effect of novelty, the experiments reported in this paper have shown that the novel object test appears to be unexpectedly sensitive to marginal changes in environmental enrichment. The measurements were made possible through the use of (semi-)automated recording using AMI sensors. These sensors have previously been shown to be effective in detecting differences in the material properties ‘hygiene’, ‘destructibility’ and ‘sound’, where the parameter was reported as a measure called ‘Ifreq’, i.e. the frequency of a given behavioural (AMI) intensity (Bracke, in press-b). In addition to its relevance as being a measure of behaviour-related intensity (see Bracke, in press-b), an advantage of such automated recording using sensors is that it may improve the ‘objectivity’ of the measurement. A main disadvantage, however, is that at each recording time point, the observer had to enter the unit. This involved some disturbance of the pigs. While conducting the experiments it was noted that younger (weaned) pigs in Experiment 2 appeared to be disturbed more due to human presence than the
older (growing) pigs in Experiments 1a and 1b. Even though this was not problematic from a scientific point of view (because treatments were applied randomly to pens within units), it could have contributed to overall levels of responding of the pigs in relation to both the enrichment materials and the novel object (as disturbance of pigs implies that they were activated and this may have enhanced the pigs’ level of responding in the novel object test).

In conclusion, this paper reported on initially surprising results of a novel object (rope) test in detecting relatively marginal changes in environmental enrichment for pigs, such as the provision of a jerrycan canister, the provision of some sawdust and the removal of a metal chain. The test may be suitable to detect positive welfare through detecting changes in the pigs’ motivation to redirect exploratory behaviour (as indicated earlier by Stolba and Woodgush, 1981).

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