

Measuring a Pig's Preference for Suspended Toys by Using an Automated Recording Technique

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ABSTRACT

Not all suspended materials for finishing pigs are equally suited to meet the natural behavior of the animal, but the required physical properties of the toys have yet to be identified. The present study aimed to develop a labor saving electronic recording device for animal-material interactions. Furthermore, the study tested the attractiveness to pigs of a small number of material characteristics: orientation (horizontal vs vertical), destructibility and flexibility. These characteristics were combined in a factorial design with materials wood, rope, chain and pipe, either suspended horizontally or vertically. To test behavioral responses to the toys offered, video recordings of animal-material interactions were taken three times during the finishing period. No difference between horizontal and vertical suspension of the toys was found. The rope treatment gave the highest level of animal-material interactions, but the separate effects of its properties 'destructible' and 'flexible' could not be identified. Furthermore, because the rope had to be replaced regularly, the result was confounded by a degree of novelty. The electronic recording device, the 'play sensor', functioned well. However, when comparing different toys with unequal probability of accidental animal-material interaction, the calculation of a correction factor with which the device can be calibrated is necessary.

Keywords: Pigs, Toys, Recording technique, Material characteristics, Environmental enrichment

INTRODUCTION

In order to avoid behavioral vices such as tail and ear biting in groups of finishing pigs, materials and toys are developed that will direct the animals' normal exploratory behaviors away from their pen mates. Not all materials are equally suited to do this, but the required physical properties of the toys have yet to be identified. However, some indications on the nature of these properties can be deduced from the behavioral literature. Pigs seem to have a preference for materials that can be manipulated. Fraser et al. (1991) find that materials must be destructible to keep the pig's attention. Grandin and Curtis (1984) suggested that pig's toy preference might relate to toy texture and to the ability to grab a toy. It is likely that other properties such as taste, flexibility, color, sound, orientation and perhaps many others also play a role.

Measuring a pig's preference for toys is mostly done by analyses of video recordings (Guy and Cussins 2000) or by direct behavior sampling of the animals (Beattie et al. 1995). Indirect measurements, such as the scoring of skin or tail lesions, also provide means to assess the effectiveness of a toy. The main disadvantage of these recording techniques is the amount of time required for data collection and analyses. Automated recording techniques may provide more data with less effort. Feddes et al. (1993) used an electronic chew sensor for registration of non-destructive chewing by pigs. With the device, which consisted of a hollow flexible plastic ring connected to a pressure sensor, they could easily monitor the diurnal chewing behavior for several days. However, the device does not allow a range of different materials to be tested. As part of an ongoing project on the development of methods to reduce behavioral vices in conventional, slurry based finishing accommodations, the Research Institute for Animal Husbandry set out to develop an electronic measuring device that would allow the testing of a range of suspended materials. As part of the development process, three properties of potential toys were investigated.

OBJECTIVES

The aim of this research was twofold: (1) to develop, test and calibrate the electronic 'play sensor'; (2) to quantify the effects of destructibility, flexibility and orientation of the play material on the level of material manipulation by the pigs.

MATERIAL AND METHODS

The research was conducted at the Research Center Raalte, part of the Research Institute for Animal Husbandry at Lelystad, The Netherlands.

The recording device

Figure 1 presents a schematic impression of the play sensor. The materials under investigation were suspended from a metal pin into the hatched area. Contact between the small metal ring and the metal pin created an electronic pulse, which was recorded and stored on the computer. The play sensor was located in the back of the pen against the wall above the slats. There was a minimum of 0.5 m between any walls or pen divisions and the suspended materials. A total of 16 play sensors were built and linked to a computer for continuous simultaneous data recording.

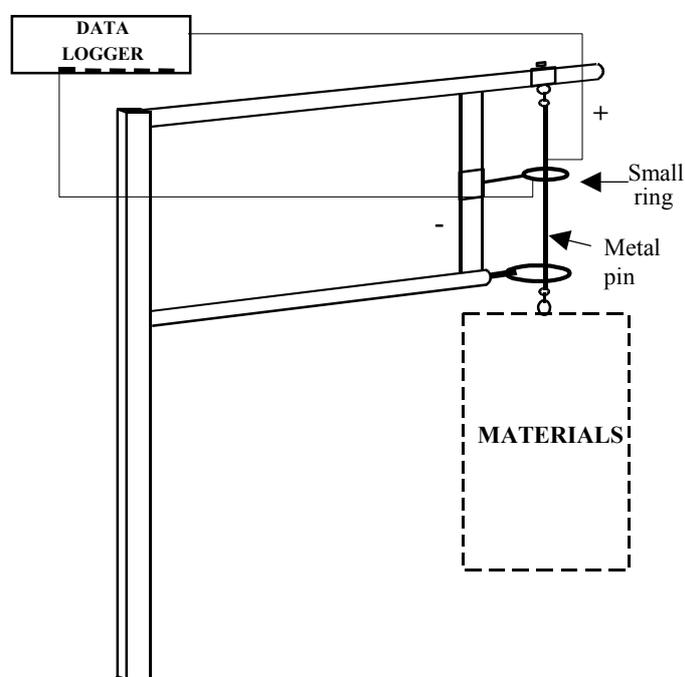


Figure 1: Schematic presentation of the play sensor

Animals and housing

Yorkshire/Dutch Landrace crossbred pigs (n=128) were stratified by bodyweight (24-28 kg) and sex (50% male and 50% female) and assigned to groups of eight. This was done to ensure homogeneity of bodyweight within groups. The pigs had no previous experience with toys other than a metal chain. Animals within each pen had access to one and the same toy during the finishing period. For this research three finishing rooms were used, each room containing six pens, which were 2.0 m wide and 4.0 m deep (see Figure 2). The pens were of a typical Dutch design with partly slatted floor and an arched concrete solid floor. Each pen housed eight pigs with 0.45 m² solid floor per animal and a total area of 1.0 m² per animal. Lights were on from 6.30 to 18.30 hours. The animals had *ad libitum* access to a commercial finishing pig diet from a single space dry feeder, which also had a drinking nipple.

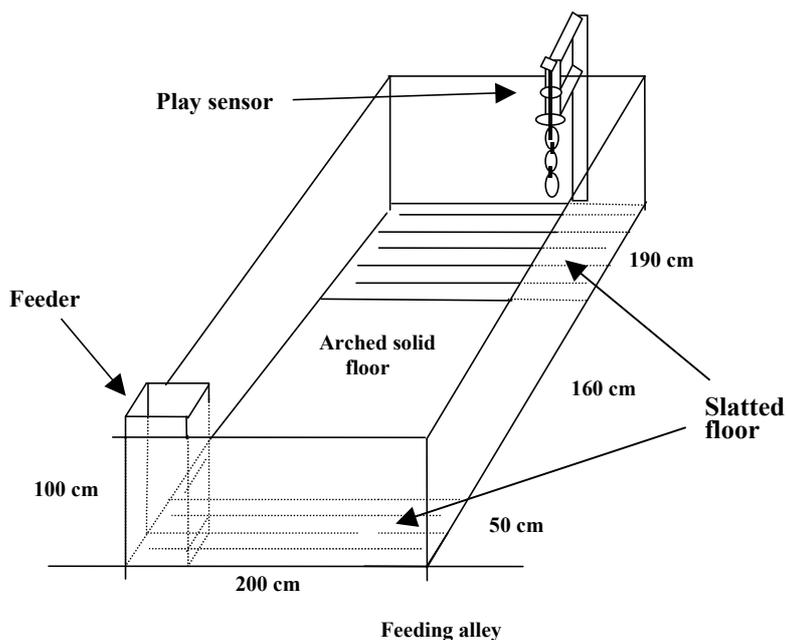


Figure 2: Schematic lay out of the pen for eight animals

Treatments

The study was set up as a factorial design with three factors (material properties and orientation of material), each with two levels. There were therefore eight different treatments. The properties tested were destructibility, flexibility and orientation. Four treatment materials were used: rope (R; destructible, flexible), wood (W; destructible, inflexible), chain (C; non-destructible, flexible) and metal pipe (P; non-destructible, inflexible), all of which were either suspended in a horizontal or vertical position. Contrasts between the treatment materials were used to assess effects of destructibility and flexibility. Table 1 summarizes the relationships between properties and materials used. The three rooms contained six pens each, resulting in 18 pens. Two groups of nine pens each were formed. The first group consisted all six pens of room 1 and the first tree pens of room 2. The second group consisted the remaining pens. In each group one pen contained animals, but was no part of the experiment. The eight different treatments were randomly allocated over the pens within each group.

Table 1: Treatments used in the experiment

Material	Material characteristics		Orientation
Rope	Destructible	Flexible	Vertical or Horizontal
Wood	Destructible	Inflexible	Vertical or Horizontal
Chain	Non-destructible	Flexible	Vertical or Horizontal
Pipe	Non-destructible	Inflexible	Vertical or Horizontal

The rope was made of cotton and had a diameter of 18 mm. Throughout the experiment the length of available rope was maintained at approximately 0.4 m, by feeding it through the metal tube when necessary (see Figure 3). In the horizontal version, two ropes were used, sticking approximately 0.2 m out of a metal holder.

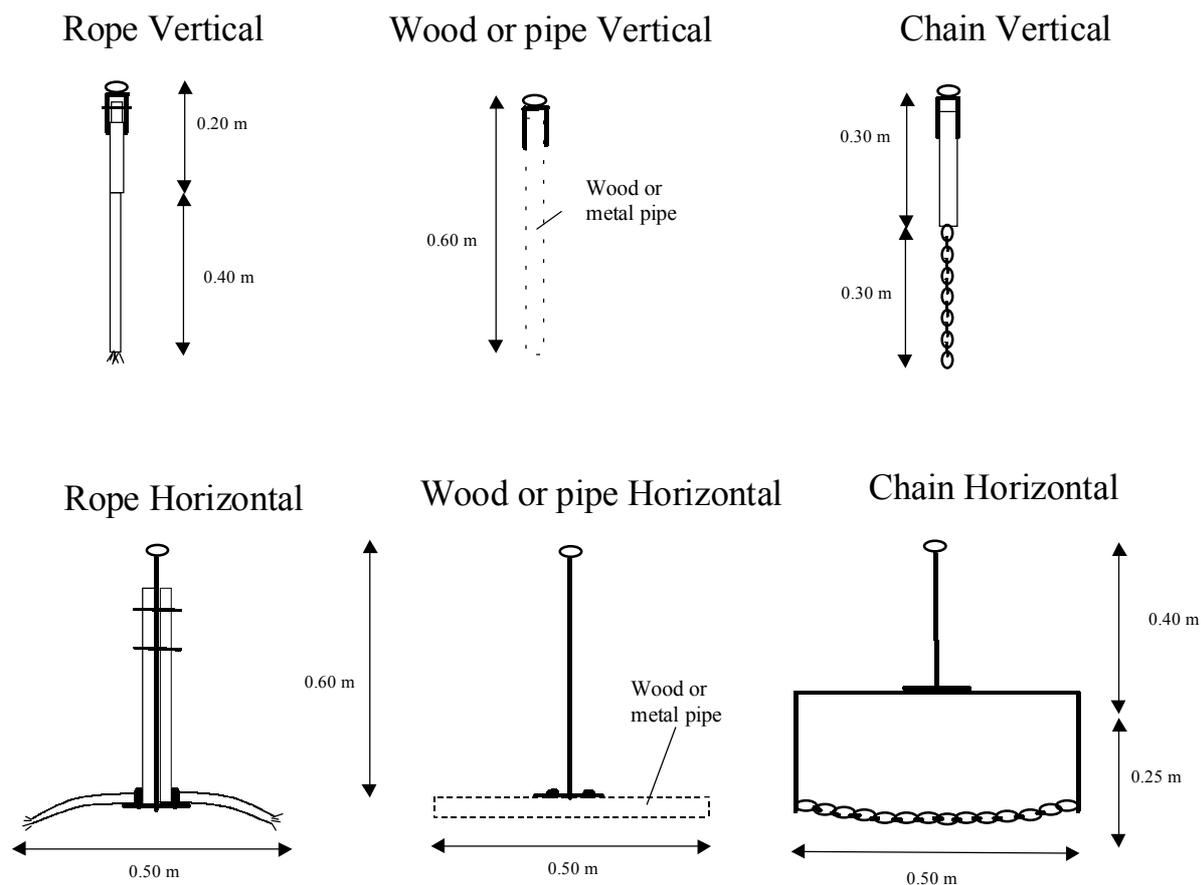


Figure 3: Schematic representation of the different toys used

Deal wood measuring approximately 50 x 30 x 500 mm was used for the wood treatment. The chains used for the chain treatment had links with a 30 mm diameter. In the horizontal version, the chain was suspended using a metal “bridge”. The metal pipes had a diameter of approximately 20 mm, and were approximately 500 mm long.

The play sensor was mounted in the back of the pen and the toy hung freely above the slats. The animals had good access to the toys and there was enough space for several pigs to play simultaneously which may increase play behavior. The toys were suspended at shoulder height, which according to Blackshaw et al. (1997) stimulates play behavior. As the pigs grew bigger, the toy height was adjusted three times during the finishing period.

Recordings and their calibration

The presence or absence of one or more movements of the toys was recorded electronically at each 30-second interval (‘active’ or ‘passive’ interval). From this, the average percentage of active intervals was calculated on a daily and weekly basis. These active intervals could represent both ‘deliberate’ and ‘accidental’ animal-material contact. It was expected that different materials (and in particular the different material orientations) would result in different ratios between deliberate and accidental contacts. Therefore electronic recordings were calibrated, using video tape recordings. Video recordings were made of each play sensor area over 12 hour recording periods during weeks 3, 6 and 9 of the experiment (Period 1, 2 and 3, respectively). All play sensors in a room were video taped at the same time. The

recordings started at 6.30 hour and ended at 18.30 hour. Videotapes were analyzed in random order by assessing animal-material contacts and qualifying them as deliberate (all oral behaviors directed to the toy) or accidental. For each 12-hour period, the average percentage of 30 s intervals with deliberate contacts were calculated per play sensor. This frequency of 'active intervals' was subsequently compared to the electronic assessment of the same sensor. The ratio between the two was used as a correction factor for the given treatment.

Statistics

Effects of material, orientation and observation period on the video frequency data as well as the correction factors, were investigated using a split-plot model for the repeated measurements in time. In the model effects of room, material, orientation and period and the two and three factor-interactions between material, orientation and period were taken as fixed explanatory variables. In the model an additional random effect for differences between pens within a room was taken to model dependencies between repeated measurements in time of the same pen. The model reads

$$Y_{ijklm} = \text{constant} + \text{room}_i + \text{material}_j + \text{orientation}_k + \text{material} * \text{orientation}_{jk} + \text{pen}_{il} + \text{period}_m + \text{interactions between material and orientation with period} + e_{ilm}, \quad [1]$$

Y denotes the response for the correction factor per pen per period or the log-transformed frequency of active intervals from video registration. Pen_{il} is the random effect of pen l in room i, e_{ilm} is the residual effect and the remaining terms denote corresponding effects.

In case effects of material were found, the data were analyzed under a split plot model with 'material effects' subdivided into main effects of its physical properties 'flexibility' and 'destructibility' as well as interaction between these properties resulting in the model

$$Y_{ijklmq} = \text{constant} + \text{room}_i + \text{flexibility}_j + \text{destructibility}_q + \text{orientation}_k + \text{pen}_{il} + \text{period}_m + \text{interactions between treatment factors} + e_{ilm}, \quad [2]$$

The models assume random effects of pen and the residual to be independently normally distributed with mean zero and variance equal to σ^2_{pen} and σ^2 respectively.

Estimates of the variance components σ^2_{pen} and σ^2 and of fixed effects were obtained with the REML method (Residual Maximum Likelihood) in Genstat (Genstat 5 Committee, 1993). Fixed terms in the model were screened using Wald statistics. Usually chi-square tests are used for Wald statistics, ignoring the variability due to estimation of the variance components. Chi-square tests, however, are found to be too generous for small data sets. In stead of chi-square tests, F-tests were used for the ratio of the Wald statistic and the degrees of freedom of the corresponding effect. The ratios were compared with an F-distribution with df_{effect} and d (= minimum of degrees of freedom used to estimate the variance components) for numerator and denominator respectively. Pair-wise differences between predicted means were tested using a two-sided Student t-test ($\alpha = 0.05$).

RESULTS AND DISCUSSION

Video registration

Model [1] was fitted to the log-transformed(natural base) percentages of active intervals to stabilize the variance. Referring to F distributions interaction effects seem to be unimportant ($p>.05$) and were excluded from the subsequently fitted models. Fitting the model with only main effects for material, orientation and period showed significant effects of material and period ($p<.05$). No effect of orientation was found. The following predicted means on log-scale were found for period: 1.37, 1.10, 0.90, for period 1, 2 and 3 respectively with SED(standard error of difference)=0.18. Period 1 had higher percentage active intervals compared to Period 2 and 3 (4.74, 3.67 and 3.68% of intervals active, for Periods 1, 2 and 3 respectively). Rope (both flexible and destructible) showed a significantly higher percentage active intervals compared to the other three materials (Table 2). Further subdivision of materials into material characteristics (model [2]) resulted in significant interaction between flexibility and destructibility ($p<0.01$). From this we concluded that both flexibility and destructibility are important.

Table 2: Means of observed percentage (n = 6) of active intervals (Act.int) and predicted means of the log transformed percentage of active intervals recorded by video per material characteristic.

	Flexible		Non flexible		SED	Level of significance ²		
	Destruct (Rope)	Non destr (Chain)	Destruct (Wood)	Non destr (Pipe)		Flex	Destr	FxD
Act.int(%)	7.9	2.2	2.9	3.1				
Act. int. ¹	1.90 ^a	0.71 ^b	0.94 ^b	0.95 ^b	0.31	-	-	<.01

¹ Different letters between columns indicate a significant difference ($p<0.05$)

² The level of significance of the main effects depended on the order in which they were included in the model: both are around $p=0.05$ and are significant if they are entered first, but not significant if they are entered secondly in the model.

Play sensor

During the trial period data were collected for each play sensor over 84 consecutive days. The non-destructible materials remained intact during this period. Wood was damaged, but did not need replacement during trial periods. The cotton rope had to be fed through the device regularly. In the beginning this had to be done at a rate of approximately 100-150 mm per week, towards the end of the study the replacement rate had to be doubled.

During the study the wiring connecting the data logger to the play sensor broke on a few occasions. Replacing the wires was relatively easy, but the data during the period of disconnection had to be treated as missing. Furthermore, although the play sensor was designed to withstand forces of over 100 kg, pigs managed to bend the metal pins carrying the toy occasionally. This happened mainly in pens with treatment rope and chain. The pin used had a diameter of approximately 10 mm. A thicker metal pin should be used.. A bent metal pin in contact with the ring sent a continuous flow of data recordings to the computer and these data were also removed from the database.

Correction factor

Table 3 presents the average percentage ($n = 6$) of active intervals for video and computer registrations, for each treatment by video recording period. The ratios are the mean ratios of video / computer registration per pen per period, averaged over treatment.

Table 3: Average percentage ($n = 6$) of active intervals for video and computer registration and their ratio by video recording period, for each treatment.

Treatment ¹	Period 1			Period 2			Period 3			Mean		
	Vid	Com	Ratio	Vid	Com	Ratio	Vid	Com	Ratio	Vid	Com	Ratio
WH	4.48	12.60	0.34	3.30	10.45	0.33	2.92	10.14	0.29	3.57	11.07	0.32
WV	2.15	8.47	0.25	3.13	9.93	0.35	1.49	8.92	0.16	2.26	9.11	0.25
CH	2.99	5.67	0.57	1.35	3.19	0.41	1.46	3.47	0.42	1.93	4.18	0.47
CV	2.08	3.30	0.85	3.09	4.58	0.75	1.98	3.47	0.64	2.38	3.79	0.75
PH	3.79	13.75	0.28	1.53	7.05	0.21	2.85	10.94	0.23	2.72	10.58	0.24
PV	4.03	7.36	0.56	4.03	7.81	0.51	2.36	6.15	0.33	3.47	7.11	0.47
RH	9.76	12.47	0.78	8.09	9.13	0.89	10.00	10.93	0.92	9.28	10.85	0.86
RV	8.61	9.41	0.96	4.83	6.91	1.01	6.39	8.51	0.76	6.61	8.28	0.91
Mean	4.74	9.15	0.57	3.67	7.38	0.55	3.68	7.81	0.47	4.03	8.12	0.53

¹ WH=Wood horizontal, WV=Wood vertical, CH=Chain Horizontal, CV=Chain vertical, PH=Pipe horizontal, PV=Pipe vertical, RH=Rope horizontal and RV=Rope vertical.

The percentage of active intervals from the computer registration exceeded the video registration of deliberate contacts for almost all treatments in all periods, except for RV in Period 2. Therefore, with one exception, the calculated ratios of Video / Computer were always below 1. Model [1] was fitted to the ratio data. Referring to F distributions, interactive effects seem to be unimportant ($p > 0.05$) and were excluded from subsequently fitted models. Fitting the model with main effects for material, orientation and period showed a material effect ($p < 0.001$). Analysis following subdivision of the material effects into the properties flexibility and destructibility using model [2], showed an interaction between both properties ($p < 0.05$). However, the main effect of flexibility on the ratio was also significant ($p < 0.001$), unlike the factor destructibility (Table 4).

The proportion of accidental animal-material interactions differs between different suspended toys, depending on their shape and other characteristics. The flexibility of the toy played an important role. Accidental contacts are recorded more often with inflexible toys than with flexible ones. Furthermore, animals can chew on flexible toys without moving the toy and therefore without registering any animal-material-contact. Theoretically this could result in ratios of deliberate / electronically recorded interactions which were above 1, indicating that the electronic device underestimated the level of contact. Although it was expected that horizontally orientated toys were more likely to generate accidental contacts, this was not confirmed by the data.

As the properties investigated resulted in different levels of accidental contact, the electronic data obtained from different toys were not comparable without correction. For toy properties which are less likely to affect the ratio of accidental / deliberate contacts (e.g. taste or color), correction factors could perhaps be omitted.

Table 4: Predicted means (n = 12) of the ratios Video/Computer registration per material characteristic.

	Flexible		Non flexible		SED	Level of significance		
	Destruct (Rope)	Non destr (Chain)	Destruct (Wood)	Non destr (Pipe)		Flex	Destr	FxD
Ratio ¹	0.88 ^a	0.59 ^b	0.30b ^c	0.37 ^{bc}	0.12	<.001	NS	<.01

¹ Different letters between columns indicate a significant difference ($p < 0.05$)

Corrected computer registration

Using the correction factors found in this study, the percentages of active intervals from the computer recordings were corrected for accidental animal-material interactions. For each material, the effects of time since the start of the study on the corrected percentage of active intervals are presented in Figure 4.

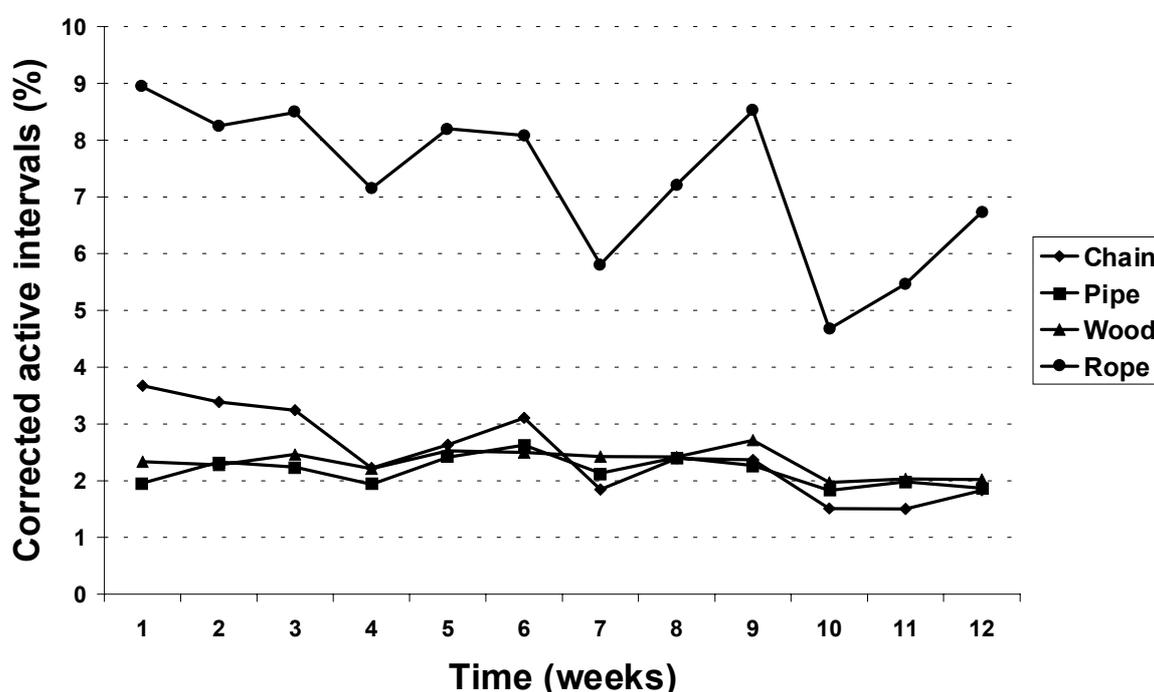


Figure 4: Effect of time since start of the finishing period on the percentage of active intervals by material recorded electronically and corrected for accidental contacts.

The material rope was manipulated more actively than the other materials throughout the finishing period. For the materials chain and rope a small decrease in level of manipulation can be recognized, the materials pipe and wood remained at a relatively constant level.

Both the data recorded through video analysis as well as the (corrected) electronic data indicate that the level of toy manipulation reduces over time. This is not surprising: as the novelty factor wears off, pigs will play less with the toys (e.g. Jungbluth and Stubbe, 1999). The aspect of novelty may in fact have confounded the observations on the rope treatments. Unlike the other ‘destructible’ material (wood), rope had to be fed through the tube that held it

at regular intervals, so that clean unchewed parts became available to the pigs throughout the study. This may have kept the pigs' attention to the material on a higher level compared to other materials.

Although destructibility and flexibility are widely accepted as material characteristics which are relevant to pig toys (e.g. Fraser et al., 1991; Feddes and Fraser, 1994), this could not unambiguously be confirmed by the present study. The data showed that the interactive effect both properties had on the level of material manipulations was not solely caused by the relatively large degree of interaction with rope (which combined destructibility, flexibility and to some degree novelty). There was also a distinct lack of difference between the level of interactions with the pipe (non-destructible, non-flexible) and the two intermediates wood and chain. This would suggest either that just adding one of the two characteristics to any material will not suffice, or that even a limited degree of novelty overshadows the effects of the other two.

Grandin and Curtis (1984) argue that in order for toys to be effective, animals should be able to bite them easily. For pigs this means that the horizontally suspended materials should have been favorite. However, in the present study, orientation of the material did not have an effect on the level of manipulation. Other studies (e.g. Kiezebrink and Vermeer, 1995) found different animal-material interactions with different types of material. Although the present study did not differentiate between types of interactions, it is possible that 'biting' constituted the main behavior for horizontal materials, with nosing, pushing and licking being more common with the vertical toys.

CONCLUSIONS

- It could not be confirmed without doubt that the material characteristics 'flexibility' and 'destructibility' are independently contributing to the success of a pig toy. They may be relevant only when combined (e.g. rope), or in combination with a degree of replacement of the material (i.e. novelty).
- The orientation of the suspended materials (horizontal or vertical) did not affect the level of interactions.
- Pigs prefer playing with a suspended rope above the other materials wood, chain or pipe.
- The play sensor developed and used in this study is a promising device for the fast collection of large amounts of data on animal – material interactions. However, the device requires calibration if the physical characteristics of different toys tested affect the ratio between accidental and deliberate contacts differently.

REFERENCES

- Beattie, V.E., N. Walker and I.A. Sneddon, 1995. Effects of environmental enrichment on behaviour and productivity of growing pigs. *Animal Welfare*, 4:207-220
- Blackshaw, J.K., F.J. Thomas and J. Lee, 1997. The effect of a fixed or free toy on the growth rate and aggressive behaviour of weaned pigs and the influence of hierarchy on initial investigation of the toys. *Applied Animal Behaviour Science*, 53:203-212
- Feddes, J.J.R. and D. Fraser, 1994. Non-nutritive chewing by pigs: implications for tail-biting and behavioural enrichment. In: *Livestock Environment IV. Fourth International Symposium. Am. Soc. Agric. Eng.:*521-527
- Feddes, J.J.R., D. Fraser, D.J. Buckley and P. Poirier, 1993. Electronic sensing of non-destructive chewing by growing pigs. *American Society of Agricultural Engineers*, 36:955-958
- Fraser, D., P.A. Phillips, B.K. Thompson and T. Tennessen, 1991. Effect of straw on the behaviour of growing pigs. *Applied Animal Behaviour Science*, 30:307-318
- Genstat 5 Committee, 1993. *Genstat 5 Release 3 Reference Manual*. Clarendon Press, Oxford.
- Grandin, T. and S.E. Curtis, 1984. Toy preferences in young pigs. *Journal of Animal Science*, 59, suppl. 1: 85
- Guy, J.H. and R.A. Cussins, 2000. The influence of a simple environmental enrichment device on the behaviour and growth of intensively-reared pigs. In: *51st Annual Meeting of the European Association for Animal Production, The Hague, The Netherlands*
- Jungbluth, T and A. Stubbe, 1999. A new technique for the ethological improvement of intensive housing systems for pigs. In: *ASAE Annual International Meeting, Toronto, Canada*
- Kiezebrink, M. en H.M. Vermeer, 1995. Afleidingsmateriaal voor vleesvarkens en gespeende biggen. Rosmalen, *Praktijkonderzoek Varkenshouderij*, P3.127