Maternal presence and environmental enrichment affect food neophobia of piglets

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Young omnivores show food neophobia in order to avoid the potential harmful effects of ingesting unfamiliar food items. We investigated whether the presence of the mother and an enriched rearing environment would reduce food neophobia in piglets. A mother may provide information on suitable food types to include in the diet, whereas an enriched environment may stimulate behavioural development and reduce reactivity towards novel stimuli (including food). Five barren-reared or enriched-reared piglets per litter were exposed to two novel food items in the presence, and the other five per litter in the absence, of the mother in a 7 min test. Maternal presence reduced food neophobia profoundly as reflected in a reduced latency to touching the food, a higher proportion of piglets sampling the two different food items and a higher intake. Latency to touch the food, however, was affected by maternal presence more strongly for barren-reared piglets than for enriched-reared piglets, and in the absence of the sow, consumption of one novel food type and time spent in the feeding area were higher for enriched-reared piglets.

Environmental enrichment does have the potential to reduce food neophobia, but the presence of the mother during the encounter with novel food seems more efficient in decreasing food neophobia of piglets.

Keywords: food neophobia; piglets; maternal presence; environmental enrichment

1. INTRODUCTION

Omnivores have a broad range of potential food items that can be included in their diet. To avoid potential harmful effects of ingesting unfamiliar food, most young omnivores show food neophobia, i.e. an initial reluctance to eat novel food items [1]. Apart from dietary selection through a trial-and-error process of individual learning, young animals rely on older, experienced conspecifics for information on what to include in their diet [2]. When learning about novel food, young animals may direct more attention

towards their mother, who is more genetically related to her offspring and spends more time with them than most other adult conspecifics [3,4]. Social learning regarding food intake may be more efficient when the animals are provided with stimulus- and substrate-rich environments, in which the mother can show the full range of foraging behaviours [5]. Enrichment of the rearing environment also has the potential to reduce food neophobia independent of social learning. Environmental enrichment results in a higher behavioural flexibility and a lower reactivity towards unfamiliar stimuli [6,7]. As novel food can be seen as an unfamiliar stimulus, it can be hypothesized that enriched-reared animals would be less neophobic towards unfamiliar food than barren-reared animals.

The aim of this experiment was to investigate neophobia of barren- and enriched-reared piglets towards unfamiliar food items presented in the presence or absence of their mother. Piglets in pig husbandry generally show a reluctance to ingest solid food after weaning, resulting in health and welfare problems [8]. This makes piglets interesting subjects for research regarding food neophobia.

We predicted that, in addition to maternal presence, an enriched rearing environment would reduce food neophobia in piglets. This effect might be observed particularly in piglets tested in the absence of the mother.

2. MATERIAL AND METHODS

The experiment was set up in a 2×2 factorial arrangement, with rearing environment (barren or enriched) and maternal presence during testing (sow present or absent) as factors, and was carried out in two successive batches using 16 multiparous sows and their offspring.

From one week before parturition, sows were either housed in barren (B; 9.2 m^2 , $n = 8$) or in enriched farrowing pens (E; 18.4 m^2 , $n = 8$). Enrichment consisted of wood shavings, straw (added to the pen daily), peat and branches (replaced once and twice weekly, respectively; see the electronic supplementary material for further details). Sows were confined in a farrowing crate between days 0 and 4 after parturition. Litter sizes were set at 10 piglets per litter on day 4 (1 : 1 sex ratio, see electronic supplementary material). Sows were fed twice a day, while piglets had food available continuously. Both sows and piglets received standard food for lactating sows.

The behavioural test was conducted on day 25 after parturition in a $7.7 \times 7.7 \text{ m}$ arena, located in a different room, with walls of 1 m height and a concrete floor. A $2 \times 2 \text{ m}$ square, drawn on the floor in the centre of the arena, served as a feeding place. Sows and piglets were habituated to the arena and food types (sows only) before the test; see the electronic supplementary material for procedures.

Five piglets from each litter were tested with the sow present in the arena (SP), and the other five piglets were tested in her absence (SA; see the electronic supplementary material for a video). Five pieces of cheese and five differently coloured pieces of equally sized, chocolate-covered peanuts per piglet and sow were evenly distributed over the feeding place of the arena before the start of the test. Before testing, the sow was brought to another, empty pen. SP piglets were brought to the sow and sow and piglets were guided to the arena together. During SA trials, the sow stayed in the other pen.

The test started when all the animals were present in the arena. Several behaviours were scored (see the electronic supplementary material), and the number and weight of pieces of both food types still present in the arena at the end of the test were determined. Test time was 7 min.

Data were averaged per half litter. One SP group from a barren pen was excluded from the analysis because the sow was in oestrus. Data (see the electronic supplementary material) were analysed with generalized linear mixed models (SAS 9.0, SAS Institute Inc.), with sow presence, enrichment, their interaction and batch as fixed effects and pen as random effect, using the appropriate distributions and link functions.

Electronic supplementary material is available at <http://dx.doi.org/10.1098/rsbl.2010.0430> or via <http://rsbl.royalsocietypublishing.org>.

Figure 1. (a) Latency to touch the food (average per half litter), (b) proportion of piglets sampling both food types, (c) number of cheese pieces eaten per piglet, (d) number of chocolate peanuts eaten per piglet, (e) grams of cheese eaten per test and (f) grams of chocolate peanuts eaten per test for barren-reared and enriched-reared piglets, tested with the sow present (white bars) or absent (grey bars). * $p < 0.05$; *** $p < 0.001$; # $p < 0.1$; n.s., not significant.

3. RESULTS

Sow presence reduced latency to touch the food ($F_{1,13} = 714$, $p < 0.0001$; figure 1a) and the number of vocalizations ($F_{1,13} = 1665$, $p < 0.0001$; table 1), and increased the percentage of piglets sampling cheese ($F_{1,13} = 8.3$, $p = 0.01$; table 1) and both food types ($F_{1,13} = 8.2$, $p = 0.01$; figure 1b), though not chocolate peanuts ($F_{1,13} = 2.4$, $p = 0.14$; table 1). SP piglets also ate more chocolate peanuts ($F_{1,13} = 5.0$ pieces, $p = 0.04$; figure 1d) and more pieces of both food types ($F_{1,13} = 5.6$, $p = 0.03$; table 1), though not cheese ($F_{1,13} = 2.7$, $p = 0.12$; figure 1c), and tended to spend more time in the feeding area than SA piglets ($F_{1,13} = 4.6$, $p = 0.05$), though not when corrected for latency to enter the feeding area ($F_{1,13} = 0.42$, $p = 0.55$; table 1). Food consumption by the sow was high (barren sows 12.7 and 16.0

enriched sows 12.8 and 14.0 pieces of cheese and chocolate peanuts on average, respectively), and there was a negative correlation between total pieces of food eaten by sow and by the piglets ($r = -0.84$, $p < 0.001$). Sows were not observed pushing the piglets towards the food, nor were special vocalizations observed.

There were, however, differences between barren and enriched piglets in the potential of maternal presence to reduce food neophobia: maternal presence reduced latency to touch the food (sow × enrichment interaction, $F_{1,13} = 32.0$, $p < 0.0001$; figure 1a) and the number of vocalizations (sow × enrichment interaction, $F_{1,13} = 4.3$, $p = 0.06$; table 1) more strongly in barren-reared than in enriched-reared piglets. Environmental enrichment also affected some of the neophobia indicators measured directly: enriched-reared piglets

Table 1. Food ingestion and exploration of piglets reared in a barren or enriched environment, tested in the presence (SP) or absence (SA) of their mother. (Data are depicted as averages $\pm$ s.e.m. Bold values are values with $p < 0.1$.)

	barren		enriched		<i>p</i> -value		
	SP	SA	SP	SA	sow	enrich	enrich $\times$ sow
vocalizations (number)	28 $\pm$ 6	276 $\pm$ 45	24 $\pm$ 11	193 $\pm$ 61	<0.001	0.33	0.06
food items eaten (number per piglet)	6.5 $\pm$ 1.4	3.9 $\pm$ 0.9	6.1 $\pm$ 1.2	5.4 $\pm$ 1.2	0.03	0.44	0.18
piglets sampling chocolate peanuts (proportion)	0.94 $\pm$ 0.06	0.77 $\pm$ 0.12	0.94 $\pm$ 0.04	0.89 $\pm$ 0.06	0.14	0.34	0.41
piglets sampling cheese (proportion)	0.91 $\pm$ 0.04	0.80 $\pm$ 0.04	0.94 $\pm$ 0.04	0.83 $\pm$ 0.08	0.01	0.61	0.95
time spent in feeding area (percentage)	33.8 $\pm$ 4.0	22.9 $\pm$ 2.3	41.3 $\pm$ 4.9	35.2 $\pm$ 5.4	0.05	0.07	0.55
time spent in feeding area corrected for latency (percentage)	18.1 $\pm$ 5.5	21.2 $\pm$ 2.5	31.0 $\pm$ 3.2	32.8 $\pm$ 4.8	0.53	0.02	0.87

consumed (in grams) more chocolate peanuts than barren-reared piglets (SA only: $F_{1,12} = 68.4$, $p < 0.0001$; figure 1f), though not cheese ($F_{1,12} = 3.6$, $p = 0.08$; figure 1e) and spent more time in the feeding area than barren pigs ($F_{1,13} = 4.0$, $p = 0.07$), also when corrected for the latency time to enter the feeding area ($F_{1,13} = 6.8$, $p = 0.02$; table 1). The number of pieces of both food types eaten, vocalizations, latency to touch the food and the proportion of piglets sampling both food types, however, were not affected by environmental enrichment (all p -values > 0.1 ; figure 1 and table 1).

4. DISCUSSION

This study demonstrates that the presence of the mother during exposure to novel food items reduces neophobia in piglets. Moreover, enriched-reared piglets appeared less neophobic in this experiment, irrespective of maternal presence. Enriched-reared piglets consumed more chocolate in the absence of the sow and spent more time in the feeding area of the arena than barren-reared piglets. The presence of the sow seemed, furthermore, to reduce neophobia more in barren piglets. This is, to our knowledge, the first demonstration of an effect of environmental enrichment on food neophobia. The effect could have been caused by differences in activity and thus energy requirements of barren and enriched piglets, however, piglets still regularly suckle their mother's milk and no differences in suckling frequency or duration were observed (data not shown). It is therefore more likely that the enrichment instead may have resulted in a lower responsiveness to the test situation, which is supported by the shorter time spent attending the food by barren piglets and by the finding that maternal presence tended to reduce the number of vocalizations more strongly in barren piglets. Enrichment may also have reduced food neophobia owing to enhanced experience with sampling unfamiliar items in the environment [9,10], possibly leading to improved foraging skills and a higher eagerness to explore [5,11].

The presence of the mother during exposure to novel food items, however, seemed to result in a

stronger reduction in food neophobia of piglets than environmental enrichment, though the effect may be modulated by environmental enrichment, as the effect of maternal presence appeared more profound in barren-reared than in enriched-reared animals. Although all animals were thoroughly habituated to the test arena, we cannot rule out the possibility that the presence of the sow reduced stress of the piglets during the test. This is supported by the lower number of vocalizations given by piglets in presence of their mother, which could be indicative of lower stress levels [12]. Increased stress levels in barren piglets may, in turn, lead to increased food neophobia, as has been shown in humans [13] and sheep [14]. However, the time spent in the area close to the food did not differ between piglets tested with or without the sow. This suggests that piglets of both treatments spent the same time attending to the food but differed in consumption, pointing to a specific effect on food neophobia. The mother was previously familiarized with the food, and testing piglets with an unfamiliarized mother or with a mother who has experienced negative consequences of ingesting the food may give information on the learning processes involved. Social facilitation and local enhancement seem likely candidates as no active behaviours were made by the sow towards the piglets [2]. In conclusion, environmental enrichment does have the potential to reduce food neophobia, but the presence of the mother during the encounter with the novel food seems to overrule the possible effects of enrichment. The reduction in food neophobia by maternal presence and by environmental enrichment may be important to stimulate food intake of piglets in pig husbandry. Piglets often have their first experience with solid food without the sow present, whereas the current study suggests that the presence of the mother during contact with novel food items could stimulate food intake before weaning. Providing piglets with an enriched rearing environment may further decrease neophobia and increase adaptability of piglets to novel stimuli. Combining increased foraging opportunities together with the sow in an

enriched environment may therefore reduce food neophobia, thereby improving health and welfare of newly weaned piglets.

Animal care and experimental procedures performed were approved by the Animal Care and Use Committee (DEC) of Wageningen University.

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- 1 Rozin, P. & Vollmecke, T. A. 1986 Food likes and dislikes. *Annu. Rev. Nutr.* **6**, 433–456. (doi:10.1146/annurev.nu.06.070186.002245)
- 2 Nicol, C. J. 2006 How animals learn from each other. *Appl. Anim. Behav. Sci.* **100**, 58–63. (doi:10.1016/j.applanim.2006.04.004)
- 3 Thorhallsdottir, A. G., Provenza, F. D. & Balph, D. F. 1990 Ability of lambs to learn about novel foods while observing or participating with social models. *Appl. Anim. Behav. Sci.* **25**, 25–33. (doi:10.1016/0168-1591(90)90066-M)
- 4 Galef Jr, B. G. & Giraldeau, L. A. 2001 Social influences on foraging in vertebrates: causal mechanisms and adaptive functions. *Anim. Behav.* **61**, 3–15. (doi:10.1006/anbe.2000.1557)
- 5 Jensen, P. 1988 Maternal behaviour and mother–young interactions during lactation in free-ranging domestic pigs. *Appl. Anim. Behav. Sci.* **20**, 297–308. (doi:10.1016/0168-1591(88)90054-8)
- 6 Würbel, H. 2001 Ideal homes? Housing effects on rodent brain and behaviour. *Trends Neurosci.* **24**, 207–211. (doi:10.1016/S0166-2236(00)01718-5)
- 7 Leggio, M. G., Mandolesi, L., Federico, F., Spirito, F., Ricci, B., Gelfo, F. & Petrosini, L. 2005 Environmental enrichment promotes improved spatial abilities and enhanced dendritic growth in the rat. *Behav. Brain Res.* **163**, 78–90. (doi:10.1016/j.bbr.2005.04.009)
- 8 Bolhuis, J. E., Oostindjer, M., Van den Brand, H., Gerrits, W. J. J. & Kemp, B. 2009 Voluntary feed intake in piglets: potential impact of early experience with flavours derived from the maternal diet. In *Voluntary feed intake in pigs* (eds D. Torrallardona & E. Roura), pp. 37–61. Wageningen, The Netherlands: Wageningen Press.
- 9 Launchbaugh, K. L., Provenza, F. D. & Werkmeister, M. J. 1997 Overcoming food neophobia in domestic ruminants through addition of a familiar flavor and repeated exposure to novel foods. *Appl. Anim. Behav. Sci.* **54**, 327–334. (doi:10.1016/S0168-1591(96)01194-X)
- 10 Schrijver, N. C. A., Bahr, N. I., Weiss, I. C. & Würbel, H. 2002 Dissociable effects of isolation rearing and environmental enrichment on exploration, spatial learning and HPA activity in adult rats. *Pharmacol. Biochem. Behav.* **73**, 209–224. (doi:10.1016/S0091-3057(02)00790-6)
- 11 Rosenzweig, M. R. & Bennett, E. L. 1996 Psychobiology of plasticity: effects of training and experience on brain and behavior. *Behav. Brain Res.* **78**, 57–65. (doi:10.1016/0166-4328(95)00216-2)
- 12 Weary, D. M., Ross, S. & Fraser, D. 1997 Vocalizations by isolated piglets: a reliable indicator of piglet need directed towards the sow. *Appl. Anim. Behav. Sci.* **53**, 249–257. (doi:10.1016/S0168-1591(96)01173-2)
- 13 Pliner, P., Eng, A. & Krishnan, K. 1995 The effects of fear and hunger on food neophobia in humans. *Appetite* **25**, 77–87. (doi:10.1006/appe.1995.0042)
- 14 Burritt, E. A. & Provenza, F. D. 1997 Effect of an unfamiliar location on the consumption of novel and familiar foods by sheep. *Appl. Anim. Behav. Sci.* **54**, 317–325. (doi:10.1016/S0168-1591(97)00005-1)