ELSEVIER

Personalities in female domesticated pigs: behavioural and physiological indications

Marko A.W. Ruis [a,b,*], Jaap H.A. te Brake [a], Harry J. Blokhuis [a], Jaap M. Koolhaas [b]

[a] *Department of Behaviour, Stress Physiology and Management, Institute for Animal Science and Health (ID-Lelystad), P.O. Box 65, 8200 AB Lelystad, Netherlands*
[b] *Department of Animal Physiology, University of Groningen, P.O. Box 14, 9750 AA Haren, Netherlands*

Abstract

The inconclusive evidence so far on the existence of distinct personality types in domesticated pigs, led us to perform the present experiment. A total of 128 gilts from 31 sows were systematically studied from birth to slaughter in two identical trials. Intra-test consistency in individual behavioural and/or physiological reactions was studied in three different tests. We were not able to show consistencies in reactions of gilts over time to a backtest (at 2–4 days and 4 weeks of age) and to a novel environment test (at 10 and 24 weeks of age). Individual aggression, however, as measured in a group-feeding competition test in stable groups (at 10 and 24 weeks of age), proved to be highly consistent. Explanations for these discrepancies in intra-test consistencies are critically discussed. Inter-test consistencies were determined by relating the individual reactions of gilts to the backtest to various characteristics and responses to tests at a later age. The highest correlations were found when resistance in the first backtest was involved. No evidence was found for the existence of specific isolated categories of animals with respect to this resistance. For further analysis, extreme responding gilts in the first backtest (roughly the top and bottom 25% of the distribution) were classified as low resistant (LR; < 3 escape attempts; $n = 31$) or high resistant (HR; > 4 escape attempts; $n = 45$). By comparisons of mean responses of LR and HR gilts within groups, we have established a relationship between the backtest and several other variables. Behaviourally, the HR gilts showed more aggression in the group-feeding competition tests. Also, in the competition for the most productive teats at the anterior, a predominant position of HR piglets at this site was observed during the suckling period. The latter piglets also gained more weight during this period than LR ones. Compared to HR pigs, in the

---

[*] Corresponding author. Tel.: +31-320-238191; fax: +31-320-238208; E-mail: m.a.w.ruis@id.wag-ur.nl

first novel environment test LR pigs hesitated longer to leave their home pens and to contact a human, but no difference in their locomotory behaviour was observed. Contrasts between LR and HR pigs in the second novel environment test were reduced or absent. Physiologically, when compared to HR gilts, LR ones had a higher reactivity of the hypothalamic–pituitary–adrenocortical (HPA) system. This was shown by higher cortisol responses to the first novel environment test, to routine weighing at 25 weeks of age, and to administration of a high dose of ACTH. It is discussed that these findings for LR and HR gilts, may provide support for the existence of behavioural and physiological responses in pigs, resembling those of proactive and reactive rodents. © 2000 Elsevier Science B.V. All rights reserved.

1. Introduction

Various animal studies, predominantly those in rodents, have stated the existence of basically two distinct ''personality types'' within populations (Bohus et al., 1987; Benus et al., 1991). The two types of animals are classified as either having a proactive (active) or a reactive (passive) ''coping style'' (for a discussion of new terms, see Koolhaas et al., 1997; Koolhaas et al., in press). Each type has a closely associated set of behavioural and physiological characteristics. In a given challenging situation, proactive animals show more aggression, a higher general activity and a predominant sympathetic reaction (fight/flight). On the other hand, the reactive type responds more with immobility and avoidance, and a predominant parasympathetic/hypothalamic activation (conservation/withdrawal). These individual responses are highly consistent, both in identical situations (Benus et al., 1991) and in different unrelated, i.e., in social and non-social, situations (Von Holst et al., 1983; Benus et al., 1991). Individual responses of animals may be the result of ontogenetic and learning processes, but they are at least partially determined by genetic factors (Benus et al., 1991).

Studies in domesticated pigs have demonstrated that large individual variation in behaviour and physiology exists, but attempts to categorize these animals in distinct personality types, as done for rodents, were less successful and showed divergent results. Domestication may have (had) an important effect on the distribution of individual characteristics, by selective breeding of pigs that were more adapted to farm conditions. In many studies no correlations were found between responses to a series of different situations, consisting of both social and non-social challenges (Lawrence et al., 1991; Jensen, 1994; Jensen et al., 1995a,b; Forkman et al., 1995; Spoolder et al., 1996). Hessing et al. (1993), however, showed correlations between responses to manual restraint in a backtest and responses to social encounters. In addition, Mendl et al. (1992) observed correlations between social success in sows and various physiological measurements. More recently, Thodberg et al. (1999) have reported the existence of stable reaction patterns across situations, characterised by novelty, including social as well as non-social contexts. Some studies provide support for consistency in the reactions of pigs to similar situations (Lawrence et al., 1991; Spoolder et al., 1996; Erhard and Mendl, 1997), while others found only few indications for this (Jensen et al., 1995b). Forkman et al. (1995) showed a lack of intra-test consistency for the backtest,

whereas Hessing et al. (1993; 1994) reported a high consistency in behavioural resistance in this restraint test over time. Hessing et al. (1993; 1994) also argued that according to the distribution in reaction patterns in the backtest, pigs could be classified in two types, reflecting either proactive or reactive responders. These findings of subpopulations of pigs according to the backtest, with indications for proactive and reactive types of animals, could not be supported by Forkman et al. (1995). Finally, Erhard et al. (1999b) argue that tonic immobility exists in pigs and that this phenomenon may predict the behaviour of pigs in different unrelated situations.

With respect to behavioural and physiological reactions of growing pigs to management-associated stress factors, individual animals may respond differently. This may indicate differences in appraisal of situations or points to a more fundamental difference in coping with the challenge. As described above, the data on this subject are conflicting and inconclusive. To advance knowledge on this subject, the present experiment aimed at portraying some important aspects of individual variation in young gilts. Since this study is part of a larger study to investigate reactions of young gilts to various challenges, only female pigs were studied. Intra-test consistencies were tested by subjecting gilts twice to three different tests. Repeatability of reactions of gilts to novel stimuli was tested by opening of the door of the home pen (to enter a novel corridor), and by a sudden human approach. Consistency in aggressive features of gilts was tested in a repeated group-feeding competition test, in which aggressive encounters were triggered by providing only small amounts of food after food deprivation. Finally, we tried to replicate results of Hessing et al. (1993), concerning classification of pigs into proactive and reactive responders according to the backtest. Besides a repetition of the test over time, we tested whether relationships exist between behavioural resistance in the backtest and other variables at a later age (inter-test consistency). However, our approach differed from that of Hessing et al. (1993), since we carried out a first backtest at a very young age (2–4 days after birth), with rather naive piglets.

2. Materials and methods

All procedures involving animal handling and testing were approved by the Institutional Care and Use Committee of the Institute for Animal Science and Health (ID-Lelystad) in Lelystad, The Netherlands. Fig. 1 shows the timing of experimental and routine procedures.

2.1. Experimental housing and animals

The experiment was conducted at Institute for Animal Science and Health (ID-Lelystad) experimental farm ''Bantham'' in Maartensdijk, The Netherlands. A total of 128 gilts (Great Yorkshire × (Great Yorkshire × Dutch Landrace)) was used in two identical trials (batches). Gilts were selected from 14 and 17 litters for batch one and two, respectively. They were born in farrowing pens (2.40 × 1.60 m) with partly slatted concrete floors. Within one day after birth, piglets were weighed and received an ear tattoo for identification. Furthermore, between 2 and 4 days of age, eye-teeth and tails

Experimental procedures: Routine procedures:

b backtest   w weighing

t determination of teat order   c eye-teeth and tail clipping

n novel environment test   we weaning

g group feeding competition test   r relocation

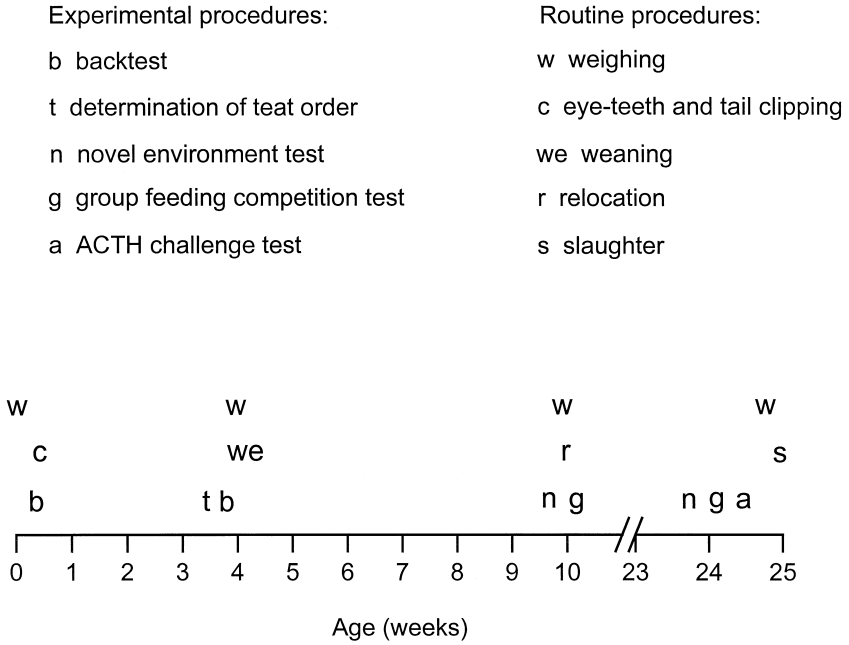a ACTH challenge test   s slaughter

Fig. 1. Timing of experimental and routine procedures.

were clipped, and iron was injected. Piglets were weaned at 4 weeks of age by removing the sow. At 10 weeks of age, in each trial gilts were selected and randomly assigned to 8 groups consisting of 8 gilts each. On average, the number of litters making up a group was 7–8, and each gilt was housed with a maximum of one litter-mate. They were relocated in fattening pens (3.20×2.25 m) with partly slatted concrete floors in another room, where they were housed until 25 weeks of age (age of slaughter). This room was ventilated and temperature controlled, with temperatures kept between 19 and 21°C. Artificial lights were on from 0600 until 1800 h. Food (commercial pelleted dry diets) and water (from nipple drinkers) were available ad libitum. Besides within one day after birth, pigs were routinely weighed at 4, 10 and 25 weeks of age.

2.2. Backtest

Each piglet was subjected to this test twice, i.e., at the start (2–4 days of age, before eye-teeth and tail clipping) and at the end (4 weeks of age) of the suckling period. The test was performed with individual piglets in a corridor close to the home pen. A piglet was gently removed from its pen with the right arm and put on its back on a foam rubber mat. The piglet was manually restrained in this supine position for 1 min by placing the hand of the left arm loosely over the thorax of the animal (adapted from Hessing et al., 1993). The left foreleg of the piglet was held between the index and middle finger of the hand, wile the piglet was allowed to move freely with the hind legs. Resistance was then determined by counting the number of escape attempts. One escape

attempt was characterized by one continuous series of wriggles. The duration of escape behaviour during the test (in percentage of time) was also determined, together with registration of the number of vocalizations.

2.3. Group-feeding competition test

Animals were not allowed to eat from 12 h before until the start of this test, carried out twice in the fattening pen, i.e., at 10 and 24 weeks of age. The test, adapted from Lawrence et al. (1991), lasted 1 h and was performed in 6 sessions of 10 min each. At the start of each session, aggressive interactions were triggered by providing a small amount of food in the front middle of the pen. It was not possible for all 8 pigs to gain access to the food at the same time. Behaviour was recorded on video and scored afterwards by using the software programme The Observer 3.0$^®$ (Noldus Information Technology, Wageningen, The Netherlands). Aggressive acts included biting (bites directed to all parts of the body), knocking (rapid thrusting the head or snout upwards or sidewards to any part of the body) and non-damaging threats (aggressive interactions, not involving physical contact). For each animal in a group, aggression was determined and expressed in an index (X) (Lee et al., 1982): $X = 0.5 \times (D - R + N + 1)$, where D is the number of other animals to which more aggressive acts were directed than received from, R is the number of other animals from which more aggressive acts were received than given to, and $N =$ group size. The higher the index, the higher the aggression score.

2.4. Novel environment test

This test was performed twice, i.e., at the ages of 10 and 24 weeks. The first test was performed in the farrowing and the second one in the fattening room. By opening the door, pigs were allowed to leave their home pens to enter a corridor (7×1 m), divided in 5 equal sections and serving as an unfamiliar enclosure. The opening of the door was wide enough to allow several pigs to leave the pen simultaneously. The pigs were allowed to move freely for 10 min. At the end of this period, one experimenter suddenly entered the corridor (sudden human approach) and remained in a stationary posture at one end of the corridor for 1 min. Behaviour was recorded on videotape and studied afterwards with The Observer$^®$ 3.0 software programme. Parameters that were determined were (1) latency time for each pig to leave the home pen; (2) locomotion in the corridor, by scoring the number of sections crossed; and (3) latency time to initiate contact with the experimenter (sniffing, chewing or biting overalls or boots). The cortisol response to the overall test was determined by sampling saliva 5 min prior to and 5 min after the test.

2.5. Teat order

The teat order of piglets was determined a few days before weaning. For each sow, functional teats were determined and teat pairs were numbered from anterior (1) to posterior (usually 7). During the first attended suckling period, piglets were given a

number on the back for recognition. From the observations during 5 suckling periods, the most frequently occupied teat for each animal was determined. Only this ''primary teat'' (Fraser and Jones, 1975) was used for analysis.

2.6. Routine weighing

At 25 weeks of age, routine weighing was accompanied by collecting saliva for assaying cortisol. Weighing consisted of moving individual gilts from their home pen into a mobile weighing box placed in the corridor close to the home pen. Saliva was collected 5 min prior to and 5 min after weighing.

2.7. ACTH challenge test

This test of pituitary adrenal function was performed at 24 weeks of age in the home pen of the animals. A large dose of adrenocorticotrophic hormone (ACTH1-24, Synacthen®, Ciba-Geigy, Basle, Switserland; 200 IU per pig dissolved in 5 ml saline) was injected intramuscularly to test the capacity of the adrenal cortex under maximal stimulation. At the timepoints 5 min before and 5, 15, 30, 45, 60, 75, 90 and 120 min after ACTH administration, saliva was sampled for cortisol determinations.

2.8. Saliva collection and cortisol analysis

Both procedures were described by Ruis et al. (1997). In short, saliva samples were collected by allowing animals to chew on two cotton buds simultaneously until the buds were thoroughly moistened. The buds were placed in special centrifuge tubes and kept on ice until centrifuged for 5 min at $400 \times g$ to remove the saliva. Saliva was then stored at $-20°C$ until analysis. Cortisol concentrations were measured by using a commercial radioimmunoassay (RIA) kit (Coat-A-Count Cortisol TKCO, Diagnostic Products, Apeldoorn, The Netherlands). The detection limit of the assay was 0.13 ng cortisol per ml, and the intra-assay and inter-assay variances were, respectively, 5.5 and 8.3%.

2.9. Statistical analysis

Spearman rank correlation coefficients (R_s) were employed to test whether individual responses to the backtest, the novel environment test and the group-feeding competition test were consistent between repeated exposures (intra-test consistency; $n = 128$). Initially, this correlation analysis was also performed to describe the relationship between backtest behaviour and variables from other test situations (inter-test consistency). Subsequently, as described under Section 3, according to backtest behaviour low resistant (LR; $n = 31$) and high resistant (HR; $n = 45$) gilts were compared for most variables.

Scores of aggression in the group-feeding competition tests were obtained per group of 8 animals (index from 1 to 8). Responses of animals to the novel environment tests were also obtained per group and were therefore dependent on the specific group. Therefore, in each group, mean scores of LR and HR animals in both tests were

calculated first. Then, within-group differences between means were analyzed with Wilcoxon's signed rank test.

For associations between backtest behaviour and teat order, Chi-square analysis was used to study whether the frequencies of LR and HR pigs, suckling at the first two teat pairs (anterior; pairs 1 and 2) of the sow, differ from frequencies expected on a random basis. Similarly, frequencies of HR and LR piglets at the last two teat pairs (posterior; pairs 6 and 7) were studied and compared.

Analysis of variance was performed to analyze data with respect to cortisol responses to routine weighing, body weights (within time points), and characteristics of responses to the ACTH challenge test. Fixed effects were main effects for the factors backtest resistance and trial. Litter and group effects were introduced as random effects. Components of variance were estimated by restricted maximum likelihood (REML; Engel, 1990). Tests for main effects were based on the Wald test (Buist and Engel, 1994). Pairwise comparisons were based on a two-sample Student's *t*-test. Where variances of groups were unequal, an approximate *t*-test was used, employing an approximation of the distribution of the variance of the difference between the means (in the denominator of the test statistic), see e.g., Scheffé (1959).

For analyzing cortisol observations after ACTH administration, a separate curve was fitted to the data of each individual gilt. A family of curves based on the incomplete gamma function (sometimes referred to as Wood's curve in the context of lactation data) was employed: $Y_t = D + A * t^B * \exp(-C * t) + e_t$. Here, for the individual under study, Y_t is the measured cortisol concentration at time t after ACTH administration and e_t is an associated error term. This is a unimodal curve, which starts at the baseline concentration D, increases to a maximum at $t = t_{max} = B/C$, and then decreases again to level D. B determines the rate of increase before the peak position t_{max} is reached, C determines the rate of decrease after t_{max}, and A determines the hight of the peak $Y_{max} = D + A * t_{max}^B * \exp(-C * t_{max})$ at $t = t_{max}$. For each individual, its constants A, B, C and D are estimated by the method of least squares. From these individual estimates, for each animal, the area S under the curve and the slopes s_5 and s_{75} at $t = 5$ and $t = 75$ min respectively, were estimated. Each of the summary statistics t_{max}, Y_{max}, S, s_5 and s_{75} was analysed separately as a (new) response variable. Additionally, for the sake of completeness, the simple but less efficient Student's *t*-test was applied to observations at each individual time-point.

All calculations were performed with the statistical programming language Genstat 5 committee (1993). Effects were considered significant if $P < 0.05$ (ns = not significant). Unless stated otherwise, data are presented as mean ($\pm$SEM). Data of both trials were comparable and no significant trial effects were observed. Consequently, data of both trials were combined for further analyses.

3. Results

3.1. Intra-test consistency

There was no agreement between responses in the first and the second backtest. Rank correlations (R_s) were 0.17 (ns), 0.21 (ns) and 0.23 (ns), respectively, for the number of

escape attempts, duration of escape behaviour and number of vocalizations. Moreover, no consistency was found for responses to the first and the second novel environment test: for latency to leave the home pen, locomotion in the corridor, latency to human contact, and cortisol response, correlations were -0.06 (ns), 0.21 (ns), 0.01 (ns) and -0.07 (ns), respectively. In contrast, aggression measured in both group-feeding competition tests, was found to be highly consistent ($R_s = 0.61$; $P = 0.003$).

3.2. Inter-test consistency: backtest resistance vs. other variables

Since backtest behaviour was not found to be consistent upon repeated testing, relationships between escape behaviour in the backtest and responses to other tests or challenges were first studied separately for each backtest. The piglet's reactions to the first backtest were higher correlated to various other variables than reactions in the second backtest did. For instance, mean correlations with aggression were 0.33 ($P = 0.02$) and 0.10 (ns), for resistance in the first and the second backtest, respectively. These findings led us to consider data with respect to behaviour in the first backtest, carried out at a very young age with rather naive piglets, for further analysis.

3.2.1. Backtest behaviour

Fig. 2A shows the histogram for resistance (number of escape attempts) of individual gilts in the first backtest. The figure suggests an unimodal distribution, with no indication for a limited number of isolated classes. However, this distribution may reflect an underlying continuum in individual variation and does not exclude that animals towards the ends of the scale have a prevalence for one or another strategy. To test this, we selected gilts with extreme numbers of escape attempts (roughly the top and bottom 25% of the distribution). By this selection, we also reduced the influence of ''measurement error'' in number of escape attempts (lower or higher values just by chance). On the basis of the histogram, we removed gilts in the middle two highest bars from the analysis, which seems to be a reasonable compromise with respect to the number of animals left for analysis. The two groups thus selected were entered as a two level factor in a statistical model (see statistical analysis). Piglets were classified as low resistant (LR) when less than three escape attempts were made, and as high resistant (HR) when more than four escape attempts were observed (Fig. 2B). A total of 31 gilts (originating from 20 litters) was classified as LR and 45 gilts (originating from 23 litters) as HR. Table 1 shows a summary of the distribution of LR and HR gilts in the 16 groups of 8 pigs (in the fattening pens). When resistance was expressed as percentage of escape behaviour per min, a high and significant ($P < 0.001$) contrast was also seen: 9.6 (± 1.1) and 41.5 (± 2.6)%, for LR and HR gilts, respectively. Numbers of vocalizations were also found to differ significantly ($P < 0.01$): LR gilts vocalized 12(± 3) and HR animals 32(± 2) times.

3.2.2. Associations with aggression in the group-feeding competition tests

The LR gilts in each pen in the first group-feeding competition test, showed significantly ($P < 0.05$) lower aggression towards other pigs than the HR animals in each pen: mean indexes of aggression were 3.9 (± 0.33) vs. 5.5 (± 0.26), respectively.
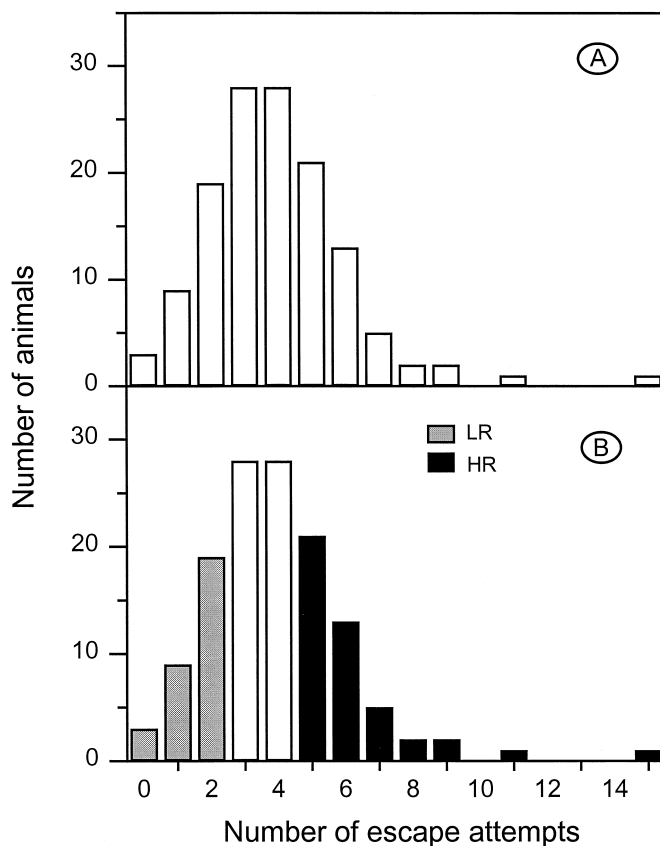
Fig. 2. (A) The histogram of escape behaviour (number of escape attempts) of gilts in a 60-s backtest performed at 2–4 days of age ($n = 128$); (B) The same distribution as above, but after classification of extreme responding gilts as either low resistant (LR; less than 3 escape attempts; $n = 31$) or high resistant (HR; more than 4 escape attempts; $n = 45$).

The contrast in aggression between LR and HR gilts was also significant ($P < 0.01$) in the second group-feeding competition test: indexes of 3.5 (± 0.44) vs. 5.7 (± 0.36), respectively.

Table 1
Distribution of LR and HR gilts in the fattening pens

	Trial 1								Trial 2							
Pen	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
#LR	2	2	2	3	2	2	2	1	2	2	2	2	1	2	2	2
#HR	3	3	2	3	4	3	2	3	2	3	2	3	4	2	3	3

3.2.3. Associations with reactions to the novel environment tests

The relationships between backtest resistance and responses to the repeated novel environment test are shown in Table 2. When compared to HR gilts, LR animals showed a significantly ($P < 0.05$) longer latency time to leave their home pen in the first novel environment test and a tendency ($P = 0.05$) for a longer latency time in the second one. For latencies to contact a human and for cortisol responses, significantly ($P < 0.05$ and $P < 0.01$, respectively) higher values were seen for LR gilts in the first novel environment test. No differences for these parameters were found in the second test. Locomotions in the corridor did not differ between LR and HR gilts in either test.

3.2.4. Associations with teat order

The two anterior teat pairs were significantly ($P < 0.05$) more frequently occupied by HR gilts than expected on a random basis. The frequency data at the anterior teats for LR gilts were not found to differ from expected (random) values. The ratio LR:HR at the anterior teats was 1:3. At the two posterior teat pairs, frequency data for LR and HR did not differ from those expected on a random basis, and the ratio LR:HR gilts was 1:1.

3.2.5. Associations with cortisol responses to routine weighing

The cortisol response (increase) to weighing at 25 weeks of age was significantly ($P < 0.05$) higher in LR gilts (1.07 ± 0.11 ng/ml) than in HR animals (0.51 ± 0.14 ng/ml). Baseline cortisol concentrations did not differ between LR and HR gilts.

3.2.6. Associations with cortisol responses to ACTH

When analyzing the characteristics of individual cortisol plots, backtest resistance was significantly ($P < 0.01$) related to the height of the cortisol peak after ACTH injection, being higher for LR (6.5 ± 0.45 ng/ml) than for HR gilts (5.1 ± 0.35 ng/ml). Areas under the curves (AUC) were also significantly ($P < 0.05$) higher for LR (513 ± 37) than for HR gilts (414 ± 26). No differences were found for other curve variables. Fig. 3 illustrates the within time differences between LR and HR gilts. Cortisol concentrations in LR gilts were significantly higher at 15 ($P < 0.01$), 30 ($P < 0.05$), 45 ($P < 0.01$) and 60 ($P < 0.01$) min after ACTH injection.

Table 2

Characteristics of responses (mean $\pm$ SEM) to the repeated novel environment test for low resistant (LR) and high resistant (HR) gilts

	Novel environment test 1		Novel environment test 2	
	LR	HR	LR	HR
Latency time to leave home pen (s)	213 (22.5)	131** (18.1)	159 (35.3)	97* (10.6)
Locomotion in corridor (# of sections entered)	64 (13.2)	77 (4.5)	54 (8.0)	55 (4.9)
Latency time to contact human (s)	52 (3.5)	37** (3.4)	38 (6.1)	29 (3.0)
Cortisol response (ng/ml)	0.92 (0.18)	0.26*** (0.1)	0.73 (0.25)	0.47 (0.12)

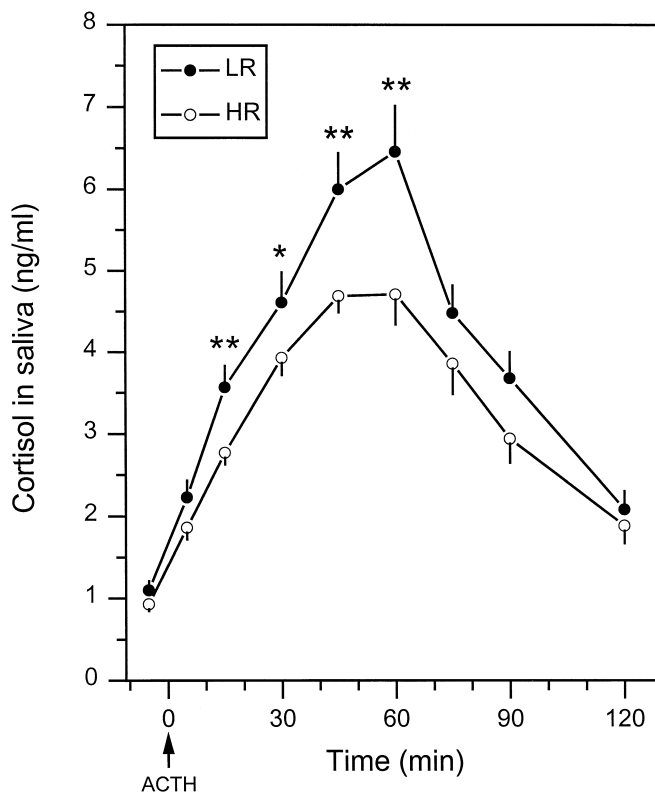Differences within separate tests are indicated: ***$P < 0.01$, **$P < 0.05$, *$P < 0.1$.

Fig. 3. Mean (±SEM) salivary cortisol concentrations (ng/ml) of 45 HR and 31 LR gilts before and after administration of $ACTH_{1-24}$ (200 IU per pig; i.m. injection). Differences between LR and HR gilts within timepoints: **$P < 0.01$, *$P < 0.05$.

3.2.7. Associations with body weight

At 4 weeks of age, but not at birth, the difference between body weights of LR (7.21 ± 0.29 kg) and HR gilts (8.27 ± 0.23 kg) was significant ($P < 0.05$). At 10 weeks of age, a tendency ($P = 0.09$) for a higher body weight of HR gilts was observed: 33.2 (±0.9) vs. 31.3 (±0.8) kg. No differences between LR and HR gilts were observed at the other ages. Differences in body weight between batches were significant at 4 ($P < 0.01$), 10 ($P < 0.01$) and 25 ($P < 0.05$) weeks of age.

4. Discussion

4.1. Intra-test consistencies

Our results with respect to intra-test consistencies showed divergent results. While our data on individual aggression in a group-feeding competition test indicated a high consistency, we failed to show this for reactions to a backtest and a novel environment

test. We propose a few explanations for these discrepancies. For example, they may be attributed to differences in stability of underlying emotions (motivations) of behavioural and physiological reactions to a certain test. Individual aggression, as the underlying emotion of behaviour in the group-feeding competition test, was highly consistent between two occasions. This high consistency may be due to the similarity in the purpose of performing that behaviour, i.e., the biological motivation to feed, associated with aggression to fulfil that need (see also Section 4.2). Erhard and Mendl (1997) showed that aggression, displayed towards intruders, is a relatively stable personality trait of individual pigs, being independent of age. Reactions in the novel environment test were not consistent on two occasions, and it was seen that responses to the second test were much reduced. This may indicate that animals may be affected by the first test, resulting in an altered motivation of responses over time to a comparable test situation. An altered underlying motivation of responses over time to comparable test situations was also observed by Erhard and Mendl (1999a) and Erhard et al. (1998) for behaviour in a tonic immobility test. They showed that susceptibility to tonic immobility changed across different test days. Our results may reflect that when tested for the first time, latency times to leave the home pen may be a measure of fear or timidity to leave the familiar environment (Archer, 1973; see also Erhard and Mendl, 1999a). However, when the test is repeated, the threatening impact of leaving the home pen may be much reduced and reactions may be a reflection of reduced fear or another (balance of) emotion(s). An increased willingness of pigs to move from their home pens voluntarily upon repeated opening of the door was also found by Geverink et al. (1998). A similar reasoning for a reduced fearfulness upon reexposure, may be followed for the shortened latency period to contact an experimenter in the human approach test. The perception of the novel environment test may also be changed by aging, i.e., with an increase in age, animals become more experienced and (unescapable) difficulties may arise in standardization of a test situation (methodological problems) when repeated. An example of the latter is the size of an animal, possibly differing much between two occasions (especially in adolescent animals), may influence the perception of a test situation, such as a novel corridor and a human being. This may be substantiated by results of Jensen et al. (1995b) who found that some behavioural patterns of pigs correlated well between three subsequent novel environment (open field) tests. In their study (with piglets at the age of 7 weeks), tests were only two days apart, whereas this was 14 weeks in our study. The previous arguments may also explain why the reactions of piglets differed so much between two backtests. Specific (adverse) experiences that may affect the perception of the threat, such as the backtest are those which were applied shortly after the first backtest: tail and eye-teeth clipping, and injection of iron. The non-repeatability of reactions to the backtest agrees with results of Forkman et al. (1995), but contrasts findings of Hessing et al. (1993; 1994). To some extent these differences may be attributed to the time span between subsequent tests, being shorter in the studies of Hessing et al. (1993; 1994).

   We also address the limitations of the correlational technique as an explanation for the discrepancies in results on intra-test consistencies. The analysis used all individuals, irrespective of group-specifics. Although it may be emphasized that group dynamics should be excluded when testing individuality of animals, it is a fact in pig husbandry

that animals are part of (often) non-homogenous groups. The design of our study is thus a reflection of everyday life. Nevertheless, it may be possible that differences between (dynamics of) groups may affect correlations, thereby limiting the interpretation of the data. This may especially be considered for individual responses in the novel environment test, in which group-specific processes may determine the magnitude of individual responses, and animals were part of different groups on two occasions. Individual scores of aggression (indices) in the group-feeding competition test, on the other hand, were rated (1–8) within each group, and individuals were part of the same groups on both occasions.

4.2. Inter-test consistencies

We provide some support for the validity of the backtest to gather information about differences between animals at a very early stage. The quality of a backtest at a very young age may be attributed to testing of rather naive animals, unaffected by previous experiences. The population distribution of escape behaviour in the first backtest was found to be continuous (unimodality; Fig. 2). In our study, we have selected the extreme responders in the first backtest, the LR and HR gilts, to study relationships between resistance in the backtest and responses in other challenge tests. With the statistical procedure to test differences between LR and HR gilts, problems arising from relationships between animals in the same group are circumvented. The pooled within-group contrasts between low and high responders for the backtest do not affect the validity of conclusions about the presence and nature of relationships. Although it may be argued that the differences between mean responses of LR and HR gilts do not necessarily reflect differences within a homogenous population of individuals, our design reflects routine procedures in modern pig husbandry.

The extremes, according to resistance in the first backtest, may adopt responses that resemble those observed in studies of rodent coping styles. Behaviourally, within each group, gilts classed as HR showed a higher mean score of aggression than those classed as LR. Behavioural studies in rodents have indicated that the more aggressive animals cope more actively with environmental challenges (Benus et al., 1991; Koolhaas et al., 1997). Measures of aggression in these rodent studies were based upon measures of attack latencies in resident-intruder paradigms, mimicking aggression in a setting that conforms to what happens in the field. The common function of aggression, however, is clearly related to the establishment and defense of property, like territory and food. In our study, we have investigated two situations, in which aggression occurred to establish defense of food, i.e., in the group-feeding competition tests and in competition for teats during the suckling period. We have observed a relationship between higher resistance in the first backtest and a higher number of attacks towards others in the group-feeding competition tests. This agrees with results of Hessing et al. (1993), who also showed that the piglets they classified as resistant ones in the backtest, were mostly the aggressive animals. The piglets they classified as aggressive ones in social confrontation tests shortly after birth, were also the ones that mainly showed aggressive behaviour after mixing at 10 and again at 15 weeks of age. Contrasting results were found by Mendl et al. (1998), who were not able to predict aggression (expressed by attack latencies) from

behaviour in the tonic immobility test, a test much resembling the backtest. With regard to competition for teats, we have observed the teat order. LR gilts less frequently occupied the anterior teats. Although controversial (Fraser and Jones, 1975), it is often suggested that the glands of the anterior teats produce more milk, and that piglets actively compete for these teats. Once a teat is preferred the occupying piglet usually defends it against the others. Hoy et al. (1995) showed that piglets in anterior position had the highest daily weight gain during the suckling period. Our results are in line with this, since a difference in body weight developed from birth to 4 weeks of age. Regarding their mean scores within groups, pigs classed as HR gained more weight than the LR classed ones. It seems that the HR animals took advantage of their predominant suckling position at the anterior teats. The difference in body weight was less prevalent present at 10 weeks of age, and was disappeared at the age of slaughter.

Furthermore, when tested for the first time in the novel environment test (with respect to mean scores within each group), those gilts classed as LR hesitated for a longer time to leave the home pen and were more inhibited to approach a human being, than those animals classed as HR. This may reflect a more reactive feature of the former animals. Studies of reactive rodents showed that their behaviour is more directed by environmental stimuli (extrinsic behavioural control), whereas the behaviour of proactive rodents is more routine-like and intrinsically determined (Benus et al., 1991). This means that upon a change in the environment, reactive animals more gradually and intensively respond to changes, whereas the reactions of proactive animals are less inhibited. To substantiate this, Hessing et al. (1994) showed that their so-called reactive pigs, were more inhibited to approach a novel object, but that they spent more time in exploring it, than proactive animals did. A more intense exploration of the corridor by more reactive animals may explain why in our study the (mean score of the) number of sections entered in the corridor did not differ between LR and HR classed gilts, although LR pigs took longer to enter the corridor. The more reactive feature of LR pigs was less evident in the second test, suggesting that for this parameter backtest resistance only reflects the behaviour evoked upon a first challenge (i.e., fear-evoked: see Section 4.1). In line with these findings, Erhard and Mendl (1999a) showed that tonic immobility revealed something about the behaviour of pigs that were put in a potentially fearful (novel) environment for the first time, but not upon reexposure. In our study, regarding mean scores within their groups, those gilts classed as LR also took more time to initiate contact with the experimenter upon a sudden approach, but again this was only seen in the first test.

Physiologically, when compared within groups to animals classed as HR, gilts characterized as LR had higher mean scores of reactivity of the (hypothalamic)–pituitary–adrenocortical (HPA) system. This higher responsiveness of the pituitary adreno-cortical system of LR gilts may resemble reaction patterns of the same axis observed in rodents having reactive coping strategies (Koolhaas and van Oortmerssen, 1988; Koolhaas et al., 1997). The LR gilts in our study displayed higher salivary cortisol responses to the first novel environment test, to routine weighing and to administration of a high dose of ACTH. We did not observe differences in baseline cortisol concentrations between LR and HR gilts, which contrasts findings of Hessing et al. (1994) who reported higher resting (plasma total) cortisol concentrations in less resistant pigs.

Moreover, they found in the latter animals that the cortisol response to novelty was generally lower than in more resistant pigs, being opposite to our results. However, as they also argued in their discussion, samples were taken just before and 90 min after testing, so that it may be questioned whether the actual cortisol responses were measured in both groups, since both timepoints were so far apart. Also, they did not find a difference between backtest extremes in (plasma total) cortisol concentrations after intra-muscular administration of a high dose of ACTH. Again, this may be explained by the previous reasoning that time intervals between (few) samplings were too long and did not allow to discriminate between animals. This is supported by our data, showing that after 60 min following injection of a high dose of ACTH, differences between backtest extremes in their cortisol concentrations disappeared (Fig. 3). Another factor responsible for these diverging results between the mentioned studies may be attributed to the fraction of cortisol measured, i.e., the predominantly unbound fraction in saliva or the total (i.e., unbound and bound) fraction in plasma. The salivary cortisol concentration reflects the biologically active plasma unbound cortisol level and is unaffected by elevations in cortisol binding globulins (CBG), which confuse the interpretation of plasma cortisol levels (Vining et al., 1983).

5. Conclusions

Although selective breeding took place among domesticated pigs, we still observe large individual differences in behaviour and physiology. Our results indicate that individual aggression is a stable personality feature of gilts over time, shown in the group-feeding competition test. In contrast, we failed to show consistency in reactions to a backtest and a novel environment test. We found no indications for the existence of different categories of pigs. However, we argue that for gilts with extreme high or low resistance in a firstly performed backtest, at a very young age, relationships may exist between responses in this test and several other variables at later age. To conclude, our findings may provide support for the existence of behavioural and physiological responses in pigs, resembling those of proactive and reactive rodents.

References

Archer, J., 1973. Tests for emotionality in rats and mice: a review. Anim. Behav. 21, 205–235.
Benus, R.F., Bohus, B., Koolhaas, J.M., van Oortmerssen, G.A., 1991. Heritable variation for aggression as a reflection of individual coping strategies. Experientia 47, 1008–1019.

Bohus, B., Benus, R.F., Fokkema, D.S., Koolhaas, J.M., Nyakas, C., van Oortmerssen, G.A., Prins, A.J.A., de Ruiter, A.J.H., Scheurink, A.J.W., Steffens, A.B., 1987. Neuroendocrine states and behavioral and physiological stress responses. In: De Kloet, E.R., Wiegant, V.M., de Wied, D. (Eds.), Progress in Brain Research, Vol. 72. Elsevier, Amsterdam, pp. 57–70.

Buist, W., Engel, B., 1994. Procedure VWALD. In: Goedhart, P.W., Thissen, J.T.N.M. (Eds.), Genstat 5 GLW-DLO procedure library manual release 3[1], Report LWA-94-17. DLO-Agricultural Mathematics Group, Wageningen.

Engel, B., 1990. The analysis of unbalanced linear models with variance components. Statistica Neerlandica 44, 195–219.

Erhard, H.W., Mendl, M., 1997. Measuring aggressiveness in growing pigs in a resident-intruder situation. Appl. Anim. Behav. Sci. 54, 123–136.

Erhard, H.W., Mendl, M., 1999a. Tonic immobility and emergence time in pigs — More evidence for behavioural strategies. Appl. Anim. Behav. Sci. 61, 227–237.

Erhard, H.W., Mendl, M., Christiansen, S.B., 1999b. Individual differences in tonic immobility may reflect behavioural strategies. Appl. Anim. Behav. Sci. 64, 31–46.

Erhard, H.W., Mendl, M., van Schotthorst, L., 1998. Qualitative and quantitative effects of handling on tonic immobility in pigs. Proceedings 32nd Congress of the International Society for Applied Ethology, Clermont-Ferrand, France, abstr., pp. 110.

Forkman, B., Furuhaug, I.L., Jensen, P., 1995. Personality, coping patterns, and aggression in piglets. Appl. Anim. Behav. Sci. 45, 31–42.

Fraser, D., Jones, R.M., 1975. The 'teat order' of suckling pigs: I. Relation to birth weight and subsequent growth. J. Agric. Sci. 84, 387–391.

Genstat 5 committee (1993). Reference Manual, Release 3. Clarendon Press, Oxford.

Geverink, N.A., Kappers, A., van de Burgwal, J.A., Lambooij, E., Blokhuis, H.J., Wiegant, V.M., 1998. Effects of regular moving and handling on the behavioral and physiological consequences of pigs to preslaughter treatment and consequences for subsequent meat quality. J. Anim. Sci. 76, 2080–2085.

Hessing, M.J.C., Hagelsø, A.M., van Beek, J.A.M., Wiepkema, P.R., Schouten, W.P.G., Krukow, R., 1993. Individual behavioural characteristics in pigs. Appl. Anim. Behav. Sci. 37, 285–295.

Hessing, M.J.C., Hagelsø, A.M., Schouten, W.P.G., Wiepkema, P.R., van Beek, J.A.M., 1994. Individual behavioral and physiological strategies in pigs. Physiol. Behav. 55, 39–46.

Hoy, S., Lutter, C., Puppe, B., Wähner, M., 1995. Correlations between vitality of newborn piglets, teat order, mortality, and live weight development up to weaning. Berl. Münch. Tierärztl. Wschr. 108, 224–228.

Jensen, P., 1994. Fighting between unacquainted pigs — effects of age and of individual reaction pattern. Appl. Anim. Behav. Sci. 41, 37–52.

Jensen, P., Rushen, J., Forkman, B., 1995a. Behavioural strategies or just individual variation in behaviour? A lack of evidence for active and passive piglets. Appl. Anim. Behav. Sci. 43, 135–139.

Jensen, P., Forkman, B., Thodberg, K., Köster, E., 1995b. Individual variation and consistency in piglet behaviour. Appl. Anim. Behav. Sci. 45, 43–52.

Koolhaas, J.M., van Oortmerssen, G.A., 1988. Individual differences in disease susceptibility as a possible factor in the population dynamics of rats and mice. Neth. J. Zool. 38, 111–122.

Koolhaas, J.M., De Boer, S.F., Bohus, B., 1997. Motivational systems or motivational states: Behavioural and physiological evidence. Appl. Anim. Behav. Sci. 53, 131–143.

Koolhaas, J.M., Korte, S.M., De Boer, S.F., Van der Vegt, B.J., Van Reenen, C.G., Hopster, H., De Jong, I.C., Ruis, M.A.W, Blokhuis, H.J., Coping styles in animals: current status in behavior and stress-physiology. Neurosci. Biobehav. Rev., in press.

Lawrence, A.B., Terlouw, E.M.C., Illius, A.W., 1991. Individual differences in behavioural responses of pigs exposed to non-social and social challenges. Appl. Anim. Behav. Sci. 30, 73–86.

Lee, Y.P., Graig, J.V., Dayton, A.D., 1982. The social rank index as a measure of social status and its association with egg production in White Leghorn pullets. Appl. Anim. Ethol. 6, 377–390.

Mendl, M., Erhard, H.W., Christiansen, S.B., 1998. No evidence for strong links between personality traits in pigs. Proceedings 32nd Congress of the International Society for Applied Ethology, Clermont-Ferrand, France, abstr., pp. 65.

Mendl, M., Zanella, A.J., Broom, D.M., 1992. Physiological and reproductive correlates of behavioural strategies in female domestic pigs. Anim. Behav. 44, 1107–1121.

Ruis, M.A.W., Te Brake, J.H.A., Engel, B., Ekkel, E.D., Buist, W.G., Blokhuis, H.J., Koolhaas, J.M., 1997. The circadian rhythm of salivary cortisol in growing pigs: effects of age, gender and stress. Physiol. Behav. 62, 623–630.

Scheffé, H., 1959. The analysis of variance. John Wiley, New York, pp. 247.

Spoolder, H.A.M., Burbidge, J.A., Lawrence, A.B., Simmins, P.H., Edwards, S.A., 1996. Individual behavioural differences in pigs: intra- and inter-test consistency. Appl. Anim. Behav. Sci. 49, 185–198.

Thodberg, K., Jensen, K.H., Herskin, M.S., 1999. A general reaction pattern across situations in prepubertal gilts. Appl. Anim. Behav. Sci. 63, 103–119.

Vining, R.F., McGinley, R.A., Maksvytis, J.J., Ho, K.Y., 1983. Salivary cortisol: a better measure of adrenal cortical function than serum cortisol. Ann. Clin. Biochem. 20, 329–335.

Von Holst, D., Fuchs, E., Stöhr, W., 1983. Physiological changes in male Tupaia belangeri under different types of social stress. In: Dembroski, T.M., Schmidt, T.H., Blümchen, G. (Eds.), Biobehavioral Base of Coronary Heart Disease. Karger, Basel.