Pig personalities:

A search for traits and types

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Abstract

This thesis examines in detail the extent to which individual differences in specific aspects of behaviour in pigs can be characterised as stable personality traits showing consistency across time and context. On the basis of previous work which has identified relationships between various behavioural characteristics, behavioural tests were developed to measure aggressiveness, the active/passive responses to challenging situations and flexibility/persistence of behaviour.

- Aggressiveness: Attack latency in a standardised resident-intruder test situation was found to be consistent across four weeks, and predicted the behaviour when unfamiliar pigs were mixed
- Active/passive responses: The reaction to a tonic immobility test (susceptibility to and duration of immobility) predicted ease of handling, speed of movement and reaction speed in an emergence test across time (tested up to an interval of eight weeks)
- Flexibility/persistence: The persistence to continue an ongoing behaviour or to perform a behaviour once learned to be successful was studied in a distraction task and a reversal task in various maze experiments. Individual differences in the behaviour in the distraction task were consistent across at least 7 weeks and predicted the speed at which pigs mastered a reversal task in a Y-maze.

The behaviour in these tests was shown to be consistent across time as well as across situation, which suggests that the differences between individuals may be a reflection of underlying differences in stable personality characteristics.

Finally, the relationship among these traits was investigated to determine whether traits cluster within individuals to form personality types. Few, weak links were found, which led to the conclusion that while specific personality traits can be found and assessed, these do not cluster together in pigs, as they appear to in some other species, to form distinctive personality types.

Declaration

I hereby declare that this thesis has been composed by me, and that it is a recount of my own work. The results presented here have not previously been submitted for any degree or qualification.

Hans W. Erhard

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Chapter 1

General Introduction

In some ways each pig is like **all** other pigs.

In some ways each pig is like **some** other pigs.

In some ways each pig is like **no** other pig.

These three levels of individuality were described by Henry Murray (Murray's dictum), modernized by Liebert & Spiegler, 1994 (referring to Kluckhohn & Murray, 1953 and Runyan, 1983), and adapted here to pigs.

1.1 Individual differences in behaviour, personality and behavioural strategies

Given the same situation and the same stimulus, individual animals (and humans) may show considerable differences in what they do and in how they do it. This can be very inconvenient for scientists who study the behaviour of animals, because it may confound potential treatment effects (Martin & Bateson, 1992).

Sometimes, however, this variation has an element of consistency, and people then often use it to divide individuals into categories, such as 'curious', 'fearful', 'playful' etc. (Mendl & Harcourt, 1988). These terms take a step back from the observed behaviour, and infer internal states of the animals. What we observe is behaviour, e.g. fear-related behaviour, such as escape attempts. From this we may infer a mental state of the individual in this situation: "The individual experiences fear". If in a series of situations a particular individual displays fear-related behaviour more frequently than other individuals, we conclude that this individual "is more likely to experience fear", or, in other words, "has a fearful disposition". These dispositions (or personality traits) can relate to internal states, in the way 'fearfulness' relates to 'fear' (Boissy, 1995), or to different aspects of behaviour, in the way 'vocal' relates to 'vocalisation'. Zuckerman (1983) discusses this distinction between states and traits in more detail.

It has to be noted that these terms are descriptive. They do not explain WHY an individual is more likely to show that it experiences fear, they merely state that it IS more likely to show it. Personality traits do not answer questions concerning their function.

When one considers the sequence: 'animal performs behaviour which is directed towards a goal', the 'personality trait' approach can be said to focus on the animal, whereas the 'behavioural strategy' approach is more concerned with the function of the behaviour by focusing on the relationship between behaviour and goal (Mendl & Deag, 1995). Two alternative strategies can be regarded as two different ways of attempting to achieve the same goal.

1.1.1 Personality - disposition

The description of the link between 'states' (e.g. fear) and 'traits' (e.g. fearfulness) used above is called the 'dispositional approach' (Liebert & Spiegler, 1993). A disposition is an enduring, stable personality characteristic, which predicts, to a certain extent, an individual's behaviour across time and situation (Liebert & Spiegler, 1993).

Three major assumptions underlie the theory of dispositions:

i) dispositions are relatively consistent within the individual across time (temporal consistency);

ii) and across situations and time (cross-situational consistency), and

iii) individual differences in behaviour are the result of differences in strength, amount and number of dispositions present in a person (Liebert & Spiegler, 1993).

Assumption iii) already points to the existence of a number of dispositions. Each of these dispositions can be seen as a position on a continuum, and described either by this position or by the 'dimension' in which the continuum lies. An example is the shy-bold continuum with 'shyness' and 'boldness' on opposite ends (e.g. Wilson et al., 1994). Other 'dimensions' are sociable/retiring, talkative/quiet, persevering/quitting etc. (McCrae & Costa, 1987).

Categories of personality may be seen as organised in a hierarchical way (Eysenck, 1967). This structure is shown in Figure 1.1 (adopted and modified from Eysenck, 1967, and illustrated using the 'active/passive coping' theory in mice (Benus, 1988)). In this structure, different 'states' cluster to describe a personality 'trait', and different 'traits' cluster to describe a personality 'type'.

1.1.2 Personality traits

Fearfulness (the 'shy-bold continuum'), aggressiveness, persistence/flexibility etc. are dimensions of personality traits. They cannot be observed themselves, but they can be inferred from the behaviour an individual performs in specific situations. Fearfulness, for instance, may be inferred from behaviours ('states') like vocalising, locomotion, freezing, etc. (Gray, 1991).

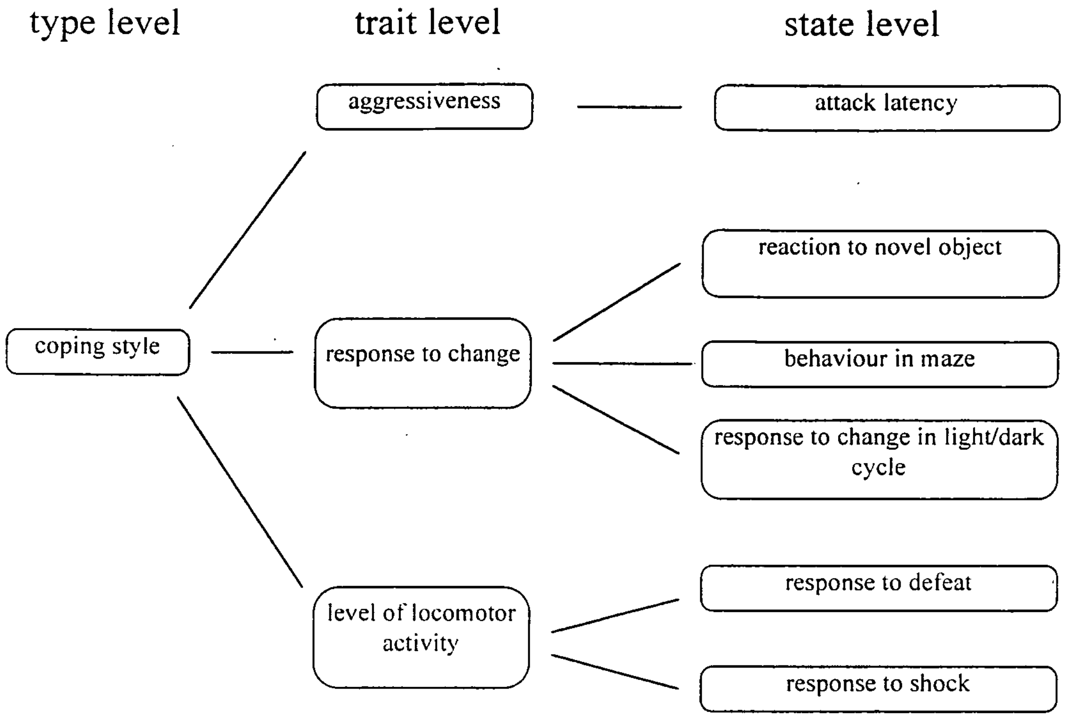

Figure 1.1 A hierarchical structure of personality, using the 'active/passive coping' model as example

The major personality traits which are most intensively studied in animals are emotionality (see Archer, 1973 for a review), fearfulness (Lyons et al., 1988, Boissy & Bouissou, 1995, Boissy, 1995), and aggressiveness (Benus et al., 1991, Mendl et al., 1992, Jensen, 1994, Jensen et al., 1995a, Forkman et al., 1995).

1.1.3 Personality types

When personality traits are found to be linked in a systematic way, they can be grouped into personality types in a hierarchical structure. This means that from an individual's position in one personality trait dimension one can determine the individual's personality 'type', which in turn makes it possible to predict its position in other trait dimensions.

Eysenck (1967) identified three main personality types (or 'supertraits' or 'factors'), extraversion, introversion and neuroticism. Later, 'neuroticism/stability', 'extraversion/introversion', 'openness', 'agreeableness/antagonism', and 'conscientiousness/undirectedness' were suggested as main personality types or dimensions, the so-called 'Big Five' (McCrae & Costa, 1987; see Deary & Matthews, 1993, for a discussion).

The extent to which such links between personality traits (in humans) really exist is still being debated (Buss, 1989, Deary & Matthews, 1993).

1.1.4 Behavioural strategies

Unlike the study of personality traits, the study of behavioural strategies is focused less on differences between individuals, but on differences between behaviours, i.e. focuses on alternative ways of trying to achieve the same goal. Similar to the personality dispositions, behavioural strategies can be arranged in 'dimensions'. In the 'migration' dimension one would find birds who migrate while others stay at home (Krebs & Davies, 1991), in the 'reproductive strategy' dimension, one finds territoriality versus sneaking (e.g. tree lizards, Thompson et al., 1993), or displaying followed by mating attempts versus quick sneak-copulations (e.g. guppies, Godin, 1995), or mate-guarding versus sneak-copulations (e.g. rhesus macaques, Berard et al., 1994, or horned beetle, Emlen, 1997). Some of these 'strategies' are clearly situation dependent. High-ranking rhesus macaques, for instance, form long-term consorts and guard female mates, while low ranking males may perform quick copulations out of sight of the higher ranking males (Berard et al., 1994). Mating 'tactics' of male guppies are affected by perceived predation risk. In the presence of a predator model, sneak copulations occurred more and displays less frequently than in absence of a predator (Godin, 1995). Other strategies are not situation dependent, but a stable characteristic of an individual, in the same way as a personality disposition. One process for achieving such a stability is by genetic determination. One example for a genetically determined strategy is the size-related courtship behaviour of swordtail fish, where the size of adult males is controlled by a single locus on the Y-chromosome (Ryan et al., 1992).

While there appears to be no universally accepted definition of 'strategy', in fact, some of the examples mentioned below were called 'tactics' by the authors, the underlying principles may well provide a useful tool for the understanding of variation in behaviour (Mendl & Deag, 1995).

1.1.5 'Coping strategies' in animals

The term 'behavioural strategy' has been used with reference to a specific context (e.g. migration) or to summarise an animal's behaviour across a variety of situations (e.g. the 'coping strategies' described by Benus 1988). The first is logically equivalent to the personality trait level of description, while the latter is more equivalent to personality type.

Figure 1.2 illustrates the hierarchical structure of the theory. On the type level, there is the 'coping style' dimension, with active and passive coping. Within a 'coping style', individuals can be found at predictable places in the 'trait dimensions', e.g. 'active copers' are expected to score high in aggressiveness and locomotor activity and in persistence in the face of change.

This model is based on studies on lines of wild house mice, divergently selected for short and long attack latencies (van Oortmerssen & Bakker, 1981). In extensive studies on male mice from these two genetic lines, Benus (1988) found fundamental differences between the behaviour of the two strains. In a defeat test, aggressive mice ('SAL' for short attack latency) were more likely to show flight or attack behaviour (the latter when there was no opportunity to escape), whereas non-aggressive mice ('LAL' for long attack latency) were more likely to show immobility. In an active shock avoidance test, SAL mice performed well, in

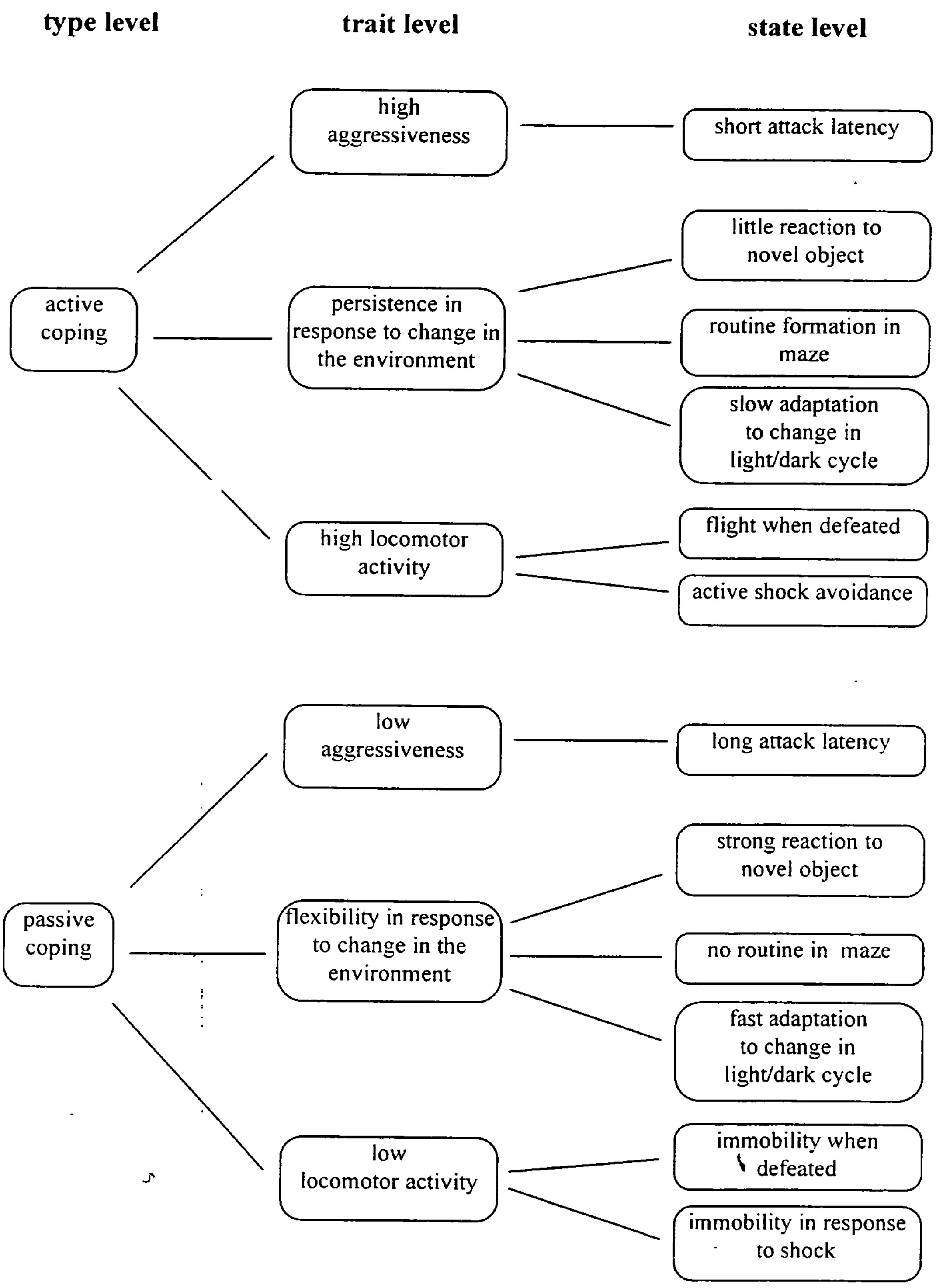

Figure 1.2 A hierarchical structure of personality, with 'state', 'trait' and 'type' level, using active/passive coping as example

that they escaped from the shock, whereas there was a clear dichotomy within the LAL mice into high and low avoidance individuals (Benus et al., 1989). When faced with an inescapable shock, SAL mice did not change their activity level, whereas the activity of LAL mice was suppressed (Benus, 1988). When the mice were trained to run a maze and subsequently, a change was introduced, SAL mice - unlike the LAL mice - did not react to this change, which was interpreted as them forming behavioural routines. When the maze was changed continuously, so that it was not possible to form a routine, SAL mice did worse in the maze than LAL mice (Benus, 1988). Based on these results, Benus hypothesised that the behaviour of LAL mice was more controlled by external influences, whereas the behaviour of SAL mice was more intrinsically controlled. This hypothesis was tested in an experiment, in which the adaptation of mice to changes in the light/dark cycle was investigated. And in agreement with the hypothesis, LAL mice adapted faster to the change than SAL mice (Benus, 1988). The neurochemical background of these differences between the two selection lines was confirmed in an experiment investigating the response to apomorphine (Benus et al., 1991). SAL mice showed a greater increase of stereotypic behaviour than LAL mice, and it was suggested that there was a link between the dopaminergic system and the flexibility of behaviour (Koolhaas et al. (1997) reviewed and discussed the behavioural, neuroendocrinological, and central-nervous differences between aggressive and non-aggressive mice and rats in more detail). Based on the differences in the level of locomotion between the two mouse lines when they were confronted with a challenge, Benus (1988) suggested the terms 'active and passive coping strategies'. This has raised a discussion which has mainly focused on the term, rather than on the content of the research.

Mainly in human psychology, but also sometimes in animal behaviour research, the term "coping" is used to refer to behaviour in situations of high stress, which exceed an individual's competency, for instance restraint (Schouten & Wiepkema, 1991) or caging (Braastad & Bakken, 1993). Problems within its competency can be solved, those outwith its competency have to be coped with. Restraint by a tether or a cage is usually a problem which the animal cannot solve. It therefore has to learn how to cope with it. There appears to be a fundamental difference between situations within and those outwith an individual's competency. Mischel (1984) found cross-situational consistency in behaviour of emotionally disturbed children at a summer camp to be higher when the children were tested in situations which were outwith their capacities, than when tested in situations within their capacities (see also Wright & Mischel, 1987). Coping strategies in people, therefore, appear to be sets of behaviour, which are to a large extent independent of the circumstances.

The same term (coping) is used in different ways by different authors. Particularly in the field of animal welfare, some authors associate 'coping' with some sort of success, i.e. the term 'coping' implies that the problem has been solved or is under control (e.g. Fraser & Broom, 1990, Schouten & Wiepkema, 1991). For other authors, the context in which the behaviour is shown is more important than its success, i.e. coping happens in situations in which the demands exceed a person's resources (Lazarus & Folkman, 1984) or which are outwith a person's competency (Mischel (1984); for a discussion of these different definitions of the term 'coping' see Wechsler, 1995).

The term "strategy" is controversial as well. It has led to the discussion of issues such as the distinctiveness required before the term can be used (Mendl & Deag, 1995), and the shape of the population distribution (Jensen et al., 1995, Jensen et al., 1995). Another important feature of a 'strategy' is its evolutionary significance ("validity of the test", Jensen et al., 1995). There is a theory explaining the adaptiveness of two opposing strategies in mice, one being more successful in a changing, the other in a stable environment (van Oortmerssen et al., 1985), and in spiders (high/low level of predation and high/low availability of food (Riechert, 1993)). A similar theory has not been formulated in pigs. There is some evidence that high levels of aggressiveness are less adaptive for lower ranking sows than low levels of aggressiveness (Mendl et al., 1992). It is also possible that maternal and paternal lines of modern hybrid pigs may favour different 'types' of individuals. But at the moment, this is mere speculation.

The terms ‘active’ and ‘passive’ have also been criticised. Koolhaas et al. (1997) suggested that ‘proactive’ and ‘reactive’ described the differences better than ‘active’ and ‘passive’ do.

Regardless of the discussions of the most appropriate labels, the suggestion that natural populations of certain animals show extremes which differ in a coherent way in several aspects of behaviour has been backed up by research on spiders (Riechert, 1993) and great tits (Verbeek, 1998).

1.1.6 Assessment of personality

1.1.6.1 Data collection

Human personality research uses methods such as self-reports (in which a person indicates whether a given statement in an inventory is true or false), or ratings (in which a person’s behaviour is assessed in a variety of situations, either by the person him/herself or by people who know the person well). The study of personality of animals uses similar methods. Self-reports are replaced by behavioural tests. The behaviour of individual animals can be rated objectively, either qualitatively (how is a behaviour performed?) or quantitatively (how often or how fast is a behaviour performed?), or subjectively by asking people who know the animals, such as their owners (Mendl & Harcourt, 1988, French, 1993) or scientists who observed the animal in question for a long time (primates, Clarke & Boinski, 1995).

1.1.6.2 The search for links between personality traits

Studies of personality usually use one of three major methods, (i) case studies, (ii) correlational studies, or (iii) an experimental approach.

(i) Case studies, in which individuals who are distinct in one specific aspect of personality (e.g. aggressiveness) are studied in great detail are widely used in human psychology, often to investigate into the causes of the particular aspect of personality. Similar approaches have been used in the study of animals, when extremes in a population were selected, either phenotypically (e.g. Hessing et al., 1993), or genotypically in a selection experiment over several generations (e.g. Benus et al., 1991). The individuals belonging to the two extremes were then tested in several behavioural tests to study relationships between the behaviour the animals were selected for and behaviour in other contexts.

(ii) The second major approach are correlational studies, in which a random sample of individuals are assessed in several situations. The assessments in these situations are then tested for correlations between the responses in the different situations (e.g. French, 1993, Verbeek et al., 1994). One of the earlier papers on the interrelationship between individual differences in behaviour in different situations (Billingslea, 1940) used this approach. The study investigated what the author called 'salients of individuality', namely body weight, curiosity, activity, persistence, and emotionality. The individuals were ranked according to their performance in the different tests, and a correlation matrix was calculated. Lawrence et al. (1991) combined these two approaches by first studying a random sample of pigs and correlating the behaviours, and then further studying the extremes found in this sample (see also Verbeek et al., 1994, for a similar approach in a study on great tits).

Multivariate statistics, such as factor analysis (e.g. Armitage, 1986) and principal components analysis (e.g. Forkman et al., 1995; Spoolder et al., 1996) are used to look for connections between the different behaviours.

(iii) The third way of investigating personality traits is the experimental approach, where specific aspects of personality are experimentally manipulated to bring about systematic changes in one trait, while the effect on other personality traits is investigated. This approach was used by e.g. Lyons et al. (1988), who manipulated fear of humans by using dam-reared and hand-reared goats for their experiments to show the effect of early experience on fearfulness of humans, and by deJonge et al. (1996), who compared the effect of barren as opposed to 'enriched' rearing environments on aggressiveness.

1.2 Research in personality in pigs

Studies in pigs aiming at finding a dichotomy similar to the active/passive coping dichotomy in mice have produced inconclusive results. Hessing et al. (1993) reported that pigs which were resistant to physical restraint were more likely to be aggressive towards other pigs than those who showed low resistance. Subsequently, they showed that pigs who were both resistant to restraint and aggressive made more escape attempts, vocalised more, and had higher cortisol levels in an open field, were less inhibited to approach a novel object, and spent less time exploring it than pigs who were of low resistance to restraint and low-aggressive (Hessing et al., 1994). Forkman et al. (1995), using slightly different methods, did not find a link between resistance to restraint and aggressiveness. Jensen et al. (1995b), again using slightly different methods, failed to find a link between aggressiveness and behaviour in an open field test.

1.2.1 Methods used

Most studies investigating aspects of personality used the correlational approach to link behaviour across a range of situations and times in the search for consistent individual differences (Lawrence et al., 1991, Forkman et al., 1995, Jensen, 1994, Jensen et al., 1995a, Spoolder et al., 1996). Lawrence et al. (1991) reported consistent differences of gilts in response to non-social challenges, which suggested underlying personality traits. They found that the behaviour in different challenging non-social situations correlated, and that it predicted certain elements of agonistic behaviour in a social situation.

Spoolder et al. (1996) subjected gilts to a series of non-social test situations which are potentially fear-inducing (open field, novel object etc.), and observed the animals' behaviour in their social group. The authors reported high consistencies within animals across time for the behaviour within the tests and for the behaviour in the social group, but found no relationship (only weak correlations) between the behaviour in the tests and the animals' position in the social hierarchy.

In another study investigating pigs' responses to social and non-social challenges, Hessing et al. (1993) preselected pigs according to their behaviour in the so-called backtest. In this test, a piglet is manually restrained on its back for one minute. Pigs who made more than two escape attempts were classified as resistant, pigs who made less than two were classified as non-resistant. In a social confrontation test involving 4-6 piglets, pigs were categorised as aggressive or non-aggressive. The authors reported a link between the resistance to restraint in the backtest and aggressiveness (Hessing et al., 1993). When they compared pigs who had been both resistant in the backtest and high-aggressive in the social confrontation test (so-called R/A) with pigs who had shown little resistance and low aggressiveness (so-called NR/NA), Hessing et al. (1994) found R/A pigs to react in a generally more 'active' way to challenges than NR/NA pigs. This approach can be regarded to be similar to case studies, in which individuals who are distinct or extreme in a particular aspect of their personality are studied in great detail to explore links between the personality trait in question and potential causes in the individual's background. It was, however, criticised for arbitrarily dividing individuals into two categories and for using an arbitrary cut-off point (Jensen et al., 1995b). The first point is very valid when there is a need to clearly identify individuals, and when the consequences of putting an individual into the wrong category are severe, as is the case, for example, in breeding experiments. If the categorisation is only used to compare extremes within a population, however, an arbitrary cut-off point which is not identical or close to the 'real' cut-off point (if such a point should exist), will only lead to an increase in variability within the category. This in turn, will decrease the chances of finding statistically significant differences between the categories. If these differences are found to be significant, the cut-off point, albeit arbitrary, is probably not too far off the 'real' point. This method, however, only allows for differences between extremes to be detected. Whether these differences warrant the term 'strategies' or not depends on the definition of the term, which has not yet been universally agreed (Mendl & Deag, 1995).

1.2.2 Validity of the tests

In order to investigate personality traits, it is of vital importance that it is clear which trait is assessed by which test, and how exactly these tests ought to be carried out in order to achieve reliable results. Boissy & Bouissou (1995) criticised that "...for a given test situation, the design of the apparatus, the duration of the session and the behavioural patterns recorded vary to a great extent according to the authors, and are almost unique to each experiment." When Hessing et al. (1993) described their backtest, for instance, they used two escape attempts as cut-off point between resistant and non-resistant pigs. Forkman et al. (1995) found a mean escape frequency of approximately 15. This gives reason to assume that Hessing et al. used struggling bouts, while Forkman et al. counted individual struggling movements. The data are therefore not directly comparable.

Test situations also differ greatly between tests. Aggressiveness in pigs was assessed by Hessing et al. (1993) by subjectively rating pigs who were in groups of four to six animals, while Jensen (1994), Jensen et al. (1995a) and Forkman et al. (1995) assessed aggressiveness by attack latency in opponent tests, in which an individual test pig encountered an individual opponent. These studies, however, differed in the habituation of the test pig to the arena (from no habituation to being tested in the home pen), in the size difference between test- and opponent pig (the opponent pig was between less than 50 % of the test pig's body weight and the same size), in the order of appearance in the arena, and in the duration of the test. The effect of these differences on the behaviour of the test pigs has not been investigated.

1.2.3 Assessing validity of tests

There are different ways of determining whether a behavioural test gives reliable information. One approach is to carry out a large number of tests in a variety of situations and to then to use statistical procedures to find out which behaviours in which of the tests are related. If links are found, they are interpreted post-hoc and named (e.g. sociality, activity etc.). Methods often used are principal components analysis and factor analysis (e.g. Forkman et al., 1995, Spoolder et al., 1996). Liebert & Spiegler (1994) criticised this approach by pointing out that the analysis of the data entailed many subjective decisions. They claim that the number and kind of factors found in the analysis differ, depending on the subjective decisions made, and on the mathematical procedure chosen. Factor analysis, in their view, can therefore not be described as a completely objective tool. Another problem is that the researcher may be left with some mathematically significant components which are biologically not meaningful (Spoolder et al., 1996).

Another option is to develop separate tests which assess specific personality traits. Each test has to be shown to be of temporal and cross-situational consistency, for it to be a meaningful indicator of the personality trait. Once this is achieved, the different tests can be applied to a number of individuals to investigate any interrelationship between the personality traits.

1.3 Personality traits to be investigated

Based on the studies by Benus (1988) and Hessing et al. (1993 and 1994), three areas of individual variation will be investigated in the present study. The aim is to find out whether they can be called 'personality traits', and whether they are linked in a systematic way, similar to the 'active/passive coping' theory described by Benus (1988). These areas are the propensity to show aggressive behaviour, the active/passive dimension of behaviour, and the persistence in the face of change. As a working hypothesis, it is suggested that they are 'traits'.

1.3.1 Aggressiveness

Aggression can be categorised in many ways. Archer (1988) uses the classes protective, parental, and competitive aggression. Aggressive behaviour can range from non-damaging threat displays to damaging attacks. If these attacks are retaliated, and the aggression becomes 'bilateral', it is called a fight. The type or level of aggressive behaviour shown depends on the class of aggression concerned, experience, type of opponent, to name just a few (Archer, 1988). As a personality trait, aggressiveness can be defined as the propensity to perform aggressive behaviour. It is often measured by attack latency.

Due to the importance of aggressive behaviour in pig husbandry, aggressiveness is a very important personality trait in pigs. A great number of experiments have been carried out with the aim to reduce aggression after mixing unfamiliar pigs (Friend et al., 1983, McGlone & Curtis, 1985, Rushen, 1987, Gonyou et al., 1988, McGlone & Morrow, 1988, Schaefer et al., 1990, Mount & Seabrook, 1993, Moore et al., 1994; see Petherick & Blackshaw, 1987, for a review of earlier work). These studies revealed considerable differences in the level of aggressive behaviour performed by individuals, which were often larger than the differences between the treatments. One immediate application for a test of aggressiveness is therefore its use to standardise for aggressiveness across treatments, thereby reducing the variation within treatment, which in turn reduces the size of the sample needed to achieve statistically significant results.

As mentioned above, the tests used to assess aggressiveness differ considerably in their methodology. As a personality trait, aggressiveness has to be a property of an individual animal. Since aggression has always an object (e.g. an opponent animal), it is important to assess it in a way that makes it independent of the attributes of its object. Studies in rodents have shown the effect of the type of opponent on the behaviour of the test animal. Hilakivi-Clarke & Lister (1992) carried out a study comparing the behaviour of mice paired with light, matched and heavy opponents. They reported that mice with heavy opponents showed most defensive behaviours, whereas mice with light opponents spent a longer time performing aggressive behaviour. Martinez et al. (1989) compared the behaviour of male mice when tested with antihormone-treated, with non aggressive anosmic and with vehicle-treated opponents. They found that the type of opponent had a strong effect on the behaviour of the test animals, and suggested that some apparently contradictory results reported in the literature can be explained by the use of different types of opponents.

Thus, if attack latency was used to assess aggressiveness, it must be shown that the attack latency of the test pig is not affected by attributes of the opponent. In order to determine whether attack latency is indeed a measure of aggressiveness, it would also have to be shown that it is not only consistent across time, but that it also predicts the level or type of aggressive behaviour shown in other situations.

1.3.2 The active/passive dimension

If faced with a challenging situation, individual animals often differ in their behaviour. One element in which they may differ is the level of 'activity' they show. This difference can be discrete, i.e. the behaviour shown is either active or passive. A common example is 'fight' (active defense) or 'flight' (active avoidance) as opposed to 'freezing' (passive response; Gray, 1991, Boissy, 1995). The difference can also lie on a continuum, in the level of 'activity', e.g. the latency to respond, the frequency or intensity of a behaviour. A common situation in which to observe this type of variation is the 'open field test' (Hall, 1934 and 1941, Kilgour 1975, Walsh & Cummins, 1976). Parameters usually recorded are defecation, urination, and ambulation. While the interpretation of the behaviour in the test is not universally agreed upon (Archer, 1973, Misslin & Cigrang, 1986), the variation in the level of 'activity' has been used to infer psychological states such as fear, and a construct called 'emotionality'. These are often used synonymously (Walsh & Cummins, 1976). Savage & Eysenck (1964) defined 'emotionality' as "an inherited predisposition of the autonomic nervous system to react particularly strongly, quickly and lastingly to certain classes of stimuli". This definition points to the active/passive dimension of the behaviour.

But the 'predisposition' need not necessarily be inherited. Walsh & Cummins (1976) pointed out that the behaviour in any behavioural test "represents the interaction of the subject with the experimental situation". They concluded that the behaviour shown in the test is affected by attributes of the environment, and by the attributes of the subject, which they categorised as genetic, developmental, and experiential. The genetic component of the active/passive dimension has been demonstrated in selection experiments, in which animals were divergently selected for high and low responses in specific situations. Savage and Eysenck (1964) provide a review of studies carried out with mice selected for high and low 'emotional reactivity', and Benus (1988) carried out experiments on mice which were selected for short and long attack latencies. The effect of experience was shown by Henderson (1967), who reported that early stimulation (pre-weaning loud noise) reduced 'emotional reactivity' (see also Walsh & Cummins, 1976).

Benus (1988), working on mouse strains which had been divergently selected for short and long attack latencies, suggested that active and passive behaviour were different behavioural ("coping") strategies. They suggested that these strategies were linked to the control of behaviour (active coping being internally, and passive coping being externally controlled) as opposed to high and low levels of fear. Hessing et al. (1993, 1994) described a test for measuring resistance to restraint in pigs, the so-called 'backtest', and suggested that the behaviour in this test reflects similar strategies.

This personality trait would be of importance in pig husbandry, since more active animals may be more difficult to restrain, hence making certain husbandry procedures very stressful for animals and handlers (see Grandin, T., 1993 and LeNeindre et al., 1996 for examples with cattle). Active animals could as a consequence be more likely to be injured than passive animals.

For this personality trait (if indeed it is one), I suggest the term 'active/passive dimension' (A/P dimension). This does not make assumptions about underlying emotions, in the way 'emotionality' does, nor about the success of the behaviour in the way 'coping' does. By including the term 'dimension', it allows for a continuum between active and passive, unlike the term 'strategy' which implies a certain distinctness.

1.3.3 Persistence

It is often assumed that animals perform behaviour to achieve a goal (Dantzer, 1991). Depending on the context, a specific goal can be achieved by persisting in a specific behaviour (e.g. digging for a root) or by switching to a different behaviour (e.g. breaking clam shells with a beak as opposed to dropping them (Richardson & Verbeek, 1986). This latter phenomenon is called 'mode-switching' (for a review see Helfman, 1990). Persistence can thus be found in the pursuit of a particular goal as well as in the performance of particular behaviour (see Andrew, 1972).

The persistence in pursuing a specific goal or in performing a specific behaviour ought to be positively related to the quality of the goal, the alternatives available, and the motivation of the individual. The interrelationship between the relative value of the resource (the goal) and the persistence of the behaviour is discussed extensively in the optimal foraging literature (see Krebs & Davies, 1991), and forms the basis for consumer-demand theory (see Dawkins, 1983).

Persistence of behaviour was shown to be affected by levels of specific hormones, such as testosterone (Andrew, 1972). The effect of hormones on persistence is supported by the study of Birke et al. (1979), who found that distractibility of rats changed during the oestrous cycle.

Thus, even in situations, where care is taken to ensure that the goal is of a standard quality and quantity (e.g. feed), and that the animals are in a similar motivational state (similar level of food deprivation), individuals still differ in their persistence (Mendl et al., 1997). This points to the possibility of a personality trait contributing to differences in persistence (see also Benus, 1988).

The importance of persistence as a personality trait in pigs lies in its potential effect on the development of stereotypic behaviour. The development of stereotypic behaviour was suggested to be connected to an individual's persistence in performing a specific behaviour which does not lead to the expected reward (Hughes and Duncan, 1988, Dantzer, 1991). In this situation, when the intended goal cannot be achieved with the behaviour performed, which is often the case for domestic animals, flexibility of behaviour may be advantageous over its persistence.

1.4 Aims and objectives of the thesis

The aim of this thesis is to assess whether behavioural characteristics, such as aggressiveness, the A/P dimension, and persistence, in pigs, appear to be stable personality traits, and if so, to study the extent to which they are linked to form personality types.

Particular emphasis will be put on the development and interpretation of behavioural tests. Each behavioural test has to be shown to reflect properties of the individual test animal rather than the test situation. Furthermore, it has to produce behaviour which is stable across time and across situation. The meaning of the behaviour shown (i.e. the personality trait it is connected to) will be interpreted by comparing responses in different situations.

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Chapter 2

A resident-intruder test to measure attack latency*

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2.1 Abstract

Studies concerning aggression after mixing unfamiliar pigs have shown that there is a great variability in the levels of aggression shown by individual pigs. This study examined whether individual aggressiveness can be measured in a resident-intruder situation and whether it is a stable characteristic of individuals, which does not simply reflect the age or sex class of the animal. These latter requirements are of fundamental importance in establishing the existence of individual personality or temperament characteristics in animals. The research was carried out in three datasets, with a total of 218 pigs, females and entire males, at the age of 7 and 11 weeks. For the test, individual pigs were isolated in one half of their home pen, and an intruder pig was introduced. This pig was 2-3 weeks younger than the resident pig. The time from when the resident first made contact to when it attacked the intruder pig was used as a measure of aggressiveness. If the resident did not attack, the test was terminated after 3.5 minutes. The test was repeatable across two consecutive days as well as across four weeks. Aggressiveness was found to be unrelated to characteristics of the test pigs, such as sex, age, body weight and body weight ranked within litter. Attack latency was not affected by the sex of the intruder pig. If the intruder was less than half the body weight of the test pig, it was less likely to be attacked. Considerable variation was found within as well as between litters. The importance of the nature of the test arena, and implications of the duration of the test are discussed. Using attack latency as a measure of aggressiveness and a relatively short time limit, the test provides a useful tool for measuring aggressiveness without compromising the welfare of the animals involved.

KEYWORDS: pig, aggression, test, resident-intruder, measuring

2.2 Introduction

Over the years, aggression in pigs has received a lot of attention, since it poses serious welfare and economic problems in pig farming (e.g. Petherick & Blackshaw, 1987). Applied studies aimed at reducing the levels of aggression in regrouped pigs have revealed considerable variation between individuals (Kelley et al., 1980, McGlone & Morrow, 1988, Mount & Seabrook, 1993), which can conceal possible effects of experimental treatments. Prior assessment of individual aggressiveness would therefore provide a powerful tool in the design of such experiments. Tests of individual aggressiveness are also used in research on behavioural strategies in pigs (Hessing et al., 1993, Jensen et al., 1995, Forkman et al., 1995). In these studies attempts have been made to relate individual aggressiveness to behaviour shown in other social and non-social situations.

Interest in individual variation in behaviour reflects an often implicit underlying assumption that individuals have distinctive and stable behavioural or "personality" characteristics that can not easily be explained in terms of variables such as sex or age. Test situations may indeed measure "personality" characteristics of this sort, but they may also simply measure responses typical of a particular age or sex class, or even behaviour which has no stability within the individual and hence no predictive value. To date, these two possibilities have not received detailed attention in research on individual differences in aggressiveness in pigs. As they form such an important first step in understanding whether individual personality or temperament characteristics exist (Mendl & Harcourt, 1988; Jensen, 1995), we examine them in detail here.

Using a test of aggressiveness in a resident-intruder situation, with intruders which were two to three weeks younger than the residents, we attempt to answer the following questions:

(1) Do individuals show cross-time consistency in their behaviour in this test?

(2) Does aggressiveness as measured in this test appear to be directly related to characteristics of the test pig, such as sex, age, body weight, and body weight ranked within litter, or to characteristics of the opponent?

(3) Is aggression related to litter identity?

The following study aimed to answer these questions to provide important fundamental information about the validity of aggressiveness testing in pigs and what exactly it measures. In doing this work we were aware that a major concern in studies of aggression is the welfare of the animals involved. Using attack latency as measure of aggressiveness allowed us to terminate an experiment at the first occurrence of aggression, thereby preventing the occurrence of damaging fights.

2.3 Material and methods

2.3.1 The datasets

The results presented in this paper are based on data from three datasets (comprising a total of 218 pigs from 23 litters) and refer to behaviour in tests of aggression (Table 2.1).

Table 2.1: Description of the 3 datasets used in this paper. The data for dataset 1 were collected in 1994, for datasets 2 and 3 in 1995. In dataset 3, the animals were tested at 7 weeks of age (3a) and again at 11 weeks of age (3b). The table displays for each dataset the number of animals, the sex ratio (male/female), and the mean ± SEM and range for the body weight of the resident and for the weight ratio intruder/resident

dataset	N	sex	body weight resident (in kg)		body weight intruder / body weight resident	
1	85	38/47	33.3 ± 0.61	19.0 - 48.0	0.60 ± 0.01	0.38 - 0.84
2	80	33/47	35.4 ± 0.65	20.0 - 46.0	0.63 ± 0.01	0.38 - 0.80
3a	53	30/23	15.8 ± 0.35	9.5 - 20.5	0.61 ± 0.02	0.30 - 0.86
3b			34.0 ± 0.64	23.5 - 43.5	0.55 ± 0.03	0.27 - 0.95

All three datasets differ in prior experience of the animals. All pigs were part of a larger experiment investigating individual behavioural characteristics, and were therefore subjected to a number of tests before the final aggression test (at 11 weeks) which is described in this paper. All tests involved varying degrees of handling, but none, apart from the aggression tests, brought them in contact with pigs from other litters. Pigs in datasets 1 and 3 had no other tests for two weeks before the aggression test, and pigs in dataset 2 had the last test done one week before the aggression test. The datasets 1 and 2 differ in year (1994 and 1995), and in that the end of the test in dataset 1 was determined by the incidence of a fight as opposed to an attack (datasets 2 and 3). Dataset 3 investigated the effect of age on attack latency. In order to avoid confounding the effect of age with a potential effect of the intruder pig, residents were paired with the same intruders at 7 and at 11 weeks

2.3.2 Animals and housing

The housing was standardised for all animals used in this study and is similar to general farming practice.

All sows, whose litters were used in this experiment, were group housed prior to farrowing and farrowed in a temperature controlled building in farrowing crates with concrete floors. The pens consisted of a heated creep area (144 x 50 cm) and a pen area (250 x 144 cm). In the pen area, the sow was kept in a farrowing crate in the centre of the pen (47 cm wide). Between pen walls and the lower bars of the crate, there was a space of 27 cm. Some straw was provided to sows' and piglets. The offspring were the subject for this study and were all crossbred (Large White x Landrace) x Large White, females or entire males. For logistic reasons, litters in each dataset were born two at a time, with each set of two litters being born 2-3 weeks apart. The pigs were kept in litter groups from the day of farrowing, without visual contact with pigs from other litters other than during the aggression tests.

Cross fostering was kept to a minimum, and if necessary, happened within two days after farrowing. Litters were weaned at 4 weeks of age and moved into a different building. Pigs weighing less than 5.0 kg were not weaned. In dataset 1 only, a maximum of 10 pigs per litter were weaned. If necessary, pigs of intermediate weight rank within a litter were left behind. In datasets 2 and 3 all pigs heavier than 5.0 kg were weaned. Litter sizes therefore varied between 7 and 12.

From weaning onwards, pigs were kept in an experimental building in pens (2x3m) with kennels. The building was ventilated and temperature controlled. The temperature was set to 18°C. The lights were set to a 12h:12h light regime with lights on at 0730 h. From 4 weeks after weaning, they were housed in pens (4 x 3 m) without kennels. The pigs were fed *ad libitum* on a commercial diet from feed hoppers with 8 feeding spaces per litter. Water was provided by two nipple drinkers per litter. Pens and kennels were cleaned daily and fresh straw was provided.

2.3.3 Aggression tests

2.3.3.1 Procedure

We chose to test the pigs in their home pen (e.g. Forkman et al., 1995), which allows the individual to express its aggressive behaviour in a relatively unconstrained way. All tests of aggression were done in one half of the home pen of a litter and involved encounters between one 'resident' pig and an 'intruder' pig from another litter. The procedure used was identical for all datasets. Intruder pigs came from litters 2-3 weeks younger than the residents. On the day of the test, the pigs from the resident and intruder litters were individually spray-marked and weighed. They were then ranked for body weight within litters, and residents and intruders were matched according to weight rank (heaviest resident with heaviest intruder etc.). The order in which individuals were tested was randomised.

For the purpose of the test, the home pen of the resident litter was divided in half by a solid door. One pig (the 'resident') was placed on its own in the test area (home pen), while the rest of the litter was retained in the lying area. The intruder pig was then introduced into the test area. The time between placing the resident in the test area and introducing the intruder was kept to a minimum (up to 5 minutes). In a pilot study we found that some intruder pigs became agitated, vocalised frequently and tried to escape from the test pen when the test lasted for more than approximately four minutes. To keep the stress imposed on the intruder pigs to a minimum, and because the behaviour of an agitated intruder might influence the resident's response, we decided to limit the test period to 3.5 minutes. In datasets 2 and 3, the experiment was terminated immediately after an attack had occurred, or, if no attack occurred, after 3.5 minutes. The intruder was then returned to its home pen. The resident pig was returned to the lying area, the next resident placed in the test area and the next intruder introduced into the pen. In dataset 1, the intruder was removed as soon as the intruder fought back, or when the attack was vigorous; the time limit was again 3.5 minutes.

For datasets 1 and 2, the procedure was carried out at 11 weeks of age and repeated on the following day, the residents being paired with different intruders. To test the effect of age on attack latency (unconfounded by identity of the intruder pig), the residents in dataset 3 were confronted with the same intruders once at 7 weeks and once more four weeks later. If in dataset 3 the intruder had the same or a higher body weight than the resident at the time of the second test, then this resident was excluded from the sample (four pigs). The remaining 53 pigs were used for the analysis. In all three datasets, a total of three pigs were not tested due to poor health.

2.3.3.2 Behaviour recorded

The time from introduction of the intruder to the resident's first snout contact with the intruder was recorded, as was the time when the resident attacked the intruder. An attack was defined as at least one quick bite; mere chewing of the intruder was not counted as attack. A fight (dataset 1) was recorded when both pigs bit each other simultaneously.

Attack latency was defined as the time between first contact and attack. This definition is unusual. Traditionally, latency is defined as time from start of test, i.e.

from when the animal (in this case the intruder) enters the test pen to when the behaviour occurs. I found that immediately prior to the test, resident pigs sometimes nosed parts of the test pen (walls or litter), and, as a consequence, may have missed the introduction of the intruder. The traditional method would assign a long attack latency to resident pigs who spent considerable time nosing parts of the test pen before they contacted and attacked the intruder. The method I used assigns a long attack latency to a resident who attacks a long time after contact, but a short one to a resident who attacks immediately after contact. This made a difference only for a small number of pigs, who did not contact the intruder shortly after it entered the test pen.

There were several reasons for choosing attack latency as measure. Scott & Fredericson (1951) defined aggressiveness as the tendency to attack, of which attack latency is a measure. It is also less dependent on the behaviour of the opponent, than e.g. bite-frequency. By allowing us to terminate the test at the first incidence of aggressive behaviour, the recording of attack latency has only a minimal impact on the welfare of the animals involved, and prevents animals gaining experience of fights

2.3.3.4 Data handling and analysis

Attack latency was recorded unless the resident did not attack within the 3.5 minutes of the test, in which case 210 seconds was used as the latency to indicate the low level of aggressiveness. If an intruder attacked the resident, the reaction of the resident was used to assess its aggressiveness. If the resident did not fight back, it was scored as not having attacked (210 seconds latency), if it did fight back, the start of the fight was used as attack time. Whether or not the resident mounted the intruder (3 out of 218 times in test 1 and 13 out of 218 times in test 2) was ignored and attack latency recorded as described earlier, since half of these cases were later followed by an attack and the other half were not.

Attack latency could be represented as both ordinal (latency in seconds for attackers; Figure 2.1) and categorical (attack versus no attack) data. The analysis was therefore done in three stages. First the data were analysed on an ordinal level using all pigs. Then this analysis was repeated using data from attackers only. And finally, the data were treated as categorical, comparing attackers with non-attackers.

Due to the non-normality of the distribution of the data, most analyses were done using non-parametric tests. Correlations used are Spearman rank order correlations. Attackers were compared with non-attackers using the Mann-Whitney test or the t-test in case of the body-weight data, which were normally distributed. For t-tests, equality of the variances in the two samples is not assumed (hence the varying degrees of freedom).

Changes from test 1 to test 2 in attack latency were analysed using the Wilcoxon test and changes of category by using the McNemar change test. The McNemar change test is a method to test the significance of changes in related samples, particularly in 'before and after' designs (Siegel & Castellan, 1988).

Proportional body weight was calculated by dividing the intruder's body weight by the weight of the resident pig with whom it was paired.

Since the comparison of tests 1 and 2 of the datasets 1 and 2 revealed a significant priming effect, we used only the results from the first test day for the analysis (see also Brain & Poole, 1974).

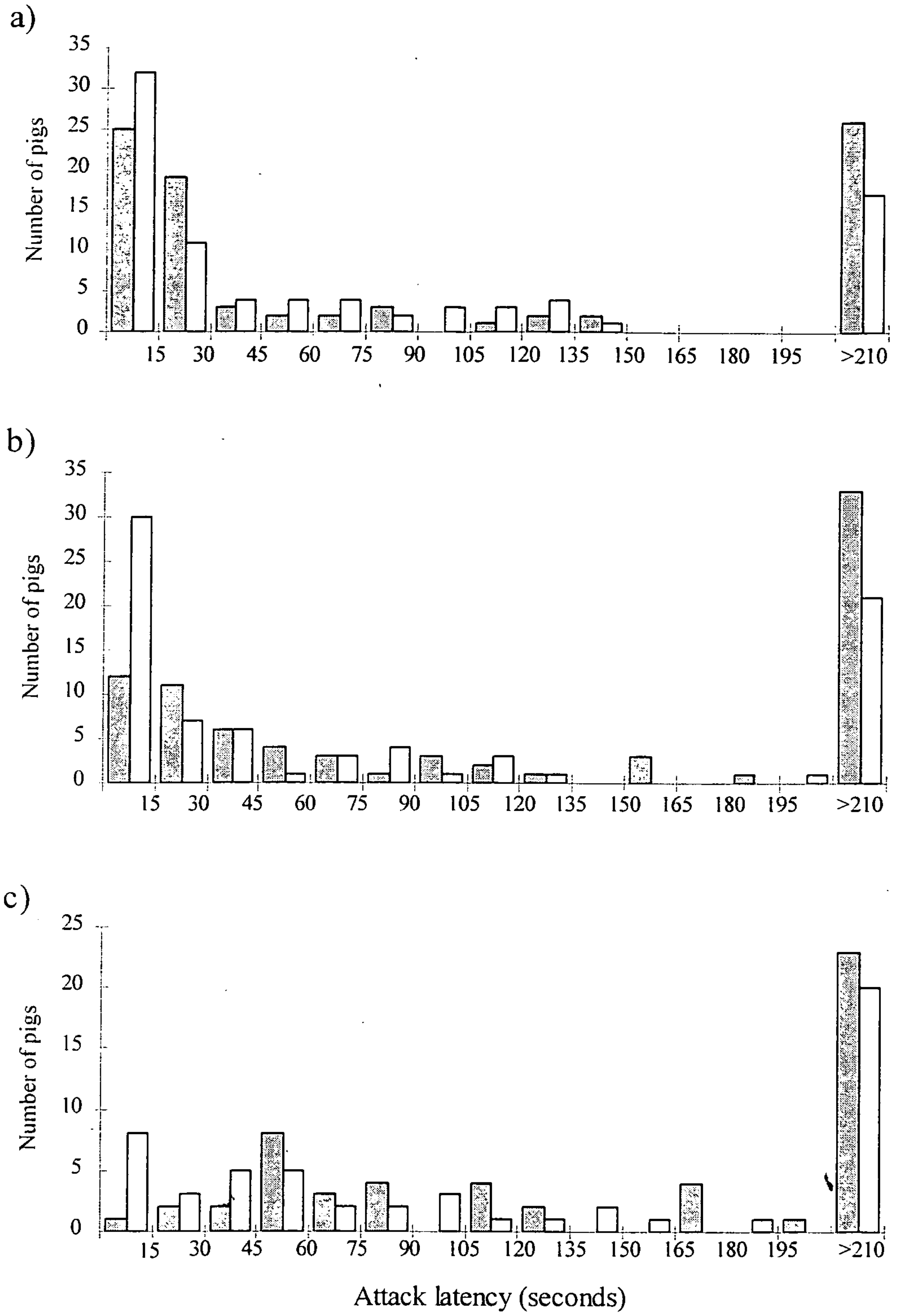

Figure 2.1 Frequency distribution of attack latency for a) dataset 1, b) dataset 2, c) dataset 3 (time from first contact to first attack by the resident pig). >210 indicates that the resident did not attack within the 3.5 minutes of the test (dark bars: test 1, white bars: test 2).

2.4 Results

2.4.1 Test arena

Only four of 218 residents tried to escape from the intruders (one in dataset 1, two in dataset 2 and one in dataset 3a). Intruder pigs attacked the resident pig in 13 of the 436 tests which were carried out (6 in test 1, 7 in test 2).

2.4.2 Cross-time consistency in individual aggressiveness

When all pigs were included in the analysis, the rank order correlations of attack latencies between the two tests ranged between 0.55 and 0.73 and were statistically highly significant. When only the data of pigs who attacked in the first test were used, the correlations were considerably smaller (Table 2.2).

Table 2.2: Consistency of attack latency between first and second intruder test (Spearman rank order correlation; + = p<0.10)

correlations of attack latencies between	dataset	all pigs			attackers on day 1		
		N	r_S	p	N	r_S	p
day 1 - 2	1	85	0.56	***	59	0.34	**
day 1 - 2	2	78	0.73	***	45	0.50	***
week 7 - 11	3	53	0.57	***	31	0.28	n.s.

Individual pigs were significantly quicker to attack in the second test than in the first in datasets 2 and 3, and tended to attack faster in dataset 1 (Table 2.3a). When only pigs who attacked in test 1 were analysed, only pigs in Dataset 2 showed a significant decrease in attack latency (Table 2.3a).

Table 2.3a: Change in attack latency (test 1 - test 2) in seconds for ordinal data (significance levels refer to Wicoxon signed ranks tests for changes > 0 (one-tailed), i.e. for decrease of attack latency from test 1 to test 2; the Wilcoxon test uses only pairs whose difference is ≠ 0; + = $p<0.10$)

	dataset	N	N used for test	estimated median difference	Wilcoxon statistic	p
all pigs	1	85	70	6.50	1538.5	+
	2	78	58	29.50	1499.5	***
	3	53	40	19.50	574.0	*
attackers only	1	59	56	- 2.75	719.5	n.s.
	2	45	44	21.50	796.5	***
	3	31	31	19.50	319.0	+

Using the data in their categorical form, there were some changes in how attackers and non-attackers in test 1 responded in test 2. In dataset 3, the categories remained unchanged between the tests, whereas in datasets 1 (tendency only) and 2, some individuals changed from non-attacking to attacking (Table 2.3b).There was also a priming effect when tests were performed on consecutive days, with attack latencies decreasing and non-attackers becoming more likely to attack on the second day.

Table 2.3b: Change in occurrence of attacks (test 1 to test 2) for categorical data (+ = $p<0.10$)

	test 1					
	attackers test 2 attack		non-attackers test 2 attack		McNemar Change test	
dataset	yes	no	yes	no	χ^2	p
1	54	5	14	12	3.37	+
2	43	2	14	19	7.56	**
3	25	6	9	13	0.27	n.s.

2.4.3 Effects of the characteristics of the resident on its propensity to attack

2.4.3.1 Sex of resident

Sex of resident had no influence on attack latency. The sexes did not differ in their likelihood to attack either. Between 54.5 and 68.4% of males and between 47.8 and 70.2% of females attacked in the four datasets (chi-square tests on frequency data, $p>0.10$).

2.4.3.2 Body weight of resident

Body-weight was not related to attack latency in datasets 1 and 2. In dataset 3 we found a very small, but statistically significant correlation indicating that smaller pigs were less aggressive (Spearman rank order correlation between body weight of resident and attack latency for residents aged 7 and 11 weeks: $r_S(7wks)= -0.27$ and $r_S(11wks)= -0.25$; $p<0.05$). Attackers tended to be heavier than non-attackers at seven weeks of age (Body weight of residents at 7 weeks of age; attackers: 16.3±0.45 kg, non-attackers: 15.1±0.53kg, t-test, T=-1.77, df=45, $p<0.10$), but this relationship had disappeared at the age of 11 weeks.

Body-weight, ranked within litter was not correlated with attack latency in any of the datasets when all pigs were included. When only attackers were considered, there was a significant if very small negative correlation in dataset 3a ($r_S= -0.28$, $p<0.05$), indicating that the smaller pigs in a litter attacked faster. There was no significant difference between attackers and non-attackers in any of the datasets.

2.4.3.3 Age of resident

Tests performed on pigs at seven and at eleven weeks of age (datasets 3a and 3b) showed that attack latency decreased with age if all pigs were included in the analysis, but not for attackers only. There was no significant change between categories (attack vs. no attack) across age (dataset 3, Tables 2.3a and 2.3b).

2.4.4 Effects of the opponent's characteristics on the resident's propensity to attack

2.4.4.1 Sex of opponent

The sex of the opponent had no impact on the attack latency of the resident pigs, nor on the likelihood of attacks occurring. There was, however, an effect of sex on the behaviour of the intruder. In dataset 1, of the intruders who were attacked by the resident, male intruders were significantly more likely to fight back than females (87% of the males and 62% of the females fought back, chisquare-test, $\chi^2=4.69$, df=1, $p<0.05$).

2.4.4.2 Weight difference between resident and opponent

Due to the pairing procedure, the weight range between residents and intruders was limited. Significant correlations between relative body-weight (this is calculated as intruder body weight divided by resident body weight) and attack latency were negative (Table 2.4). Negative correlations indicate that the larger the weight difference between resident and intruder, the longer it takes for the resident to attack. These correlations were, however, small and could only be found in half of the cases analysed.

In dataset 3, there was an effect of relative body weight on the aggressiveness of residents at 11 weeks of age. Residents who attacked were paired with relatively larger intruders than those who did not attack.

Table 2.4: The interrelationship between the body-weight intruder / body-weight resident ratio and the attack latency by the resident (Spearman rank order correlation; t-test, equal variances not assumed)

	ordinal data		categorical data		
	all pigs	attackers only	attackers	non-attackers	
dataset	r_S	r_S	mean ± SE	mean ± SE	p
1	0.03	-0.23*	0.59 ± 0.01	0.62 ± 0.02	n.s. [a]
2	-0.24*	-0.32*	0.64 ± 0.01	0.62 ± 0.02	n.s. [b]
3a	0.05	0.17	0.61 ± 0.02	0.61 ± 0.03	n.s. [c]
3b	-0.25*	0.07	0.60 ± 0.03	0.47 ± 0.05	* [d]

[a] ttest, T = -1.52, df = 43

[b] ttest, T = -1.23, df = 57

[c] ttest, T = -0.01, df = 40

[d] ttest, T = -2.33, df = 34

2.4.5. *Litter effect*

When data from all pigs (attackers and non-attackers) were included in the analysis, we found significant differences between litters in datasets 1 and 2 (Median attack latencies per litter 9.5-210.0 and 32.0-210.0 seconds for datasets 1 and 2, respectively; Kruskal-Wallis, $p<0.05$), a tendency in dataset 3b (11 weeks of age; median attack latencies per litter 20.5-210.0 seconds; Kruskal-Wallis, $p=0.06$), and no significant differences in dataset 3a (7 weeks of age; median attack latencies per litter 93.0-210.0 seconds; Kruskal-Wallis, $p>0.10$). When looking at attackers only, litter differences were significant in datasets 1 and 3b only (median attack latencies per litter 6.3-53.0 and 4.0-95.0 seconds, respectively; Kruskal-Wallis, $p<0.05$). This result, however, has to be treated with caution, since the samples used in this analysis were reduced to only three pigs for some litters, due to the omission of non-attackers. The percentage of attackers within a litter ranged from 22% to 90%. Even though the differences between litters are significant, both attackers and non-attackers occurred in all of the 23 litters tested.

2.4.6. Distribution of the data

Looking at the percentage of attackers who attacked in the first 2.5 minutes of the test, we found that on the two test days in datasets 1 (100% and 100%), 2 (91% and 98%), 3a (84%) and 3b (94%, see figure 2.1), there were suggestions of a gap (period of time in which no attacks were observed) between attackers and non-attackers.

2.5 Discussion

The first question we set out to answer was whether attack latency is stable across time. In our experiments, we found repeatability as well as a priming effect (i.e. a decrease in attack latency, see Scott, 1949). Even though pigs attacked faster in the second test, the attack latencies in the two tests were highly correlated in all three datasets, which points to the consistency of individual aggressiveness over time. It is unlikely that the pigs can remember their opponents for four weeks after having met them for a few minutes or even seconds only. Consequently, the difference in likelihood to attack between datasets 1 and 2 (pigs are more likely to attack in test 2) and dataset 3 (no change) can be interpreted as demonstrating the short term 'priming' effect of repeating a test on consecutive days in comparison with the long term consistency of aggressiveness across a four week interval. The change can therefore be considered to be a mere scaling effect, affecting the level of aggressiveness of individuals, but not affecting the differences between individuals.

The second question concerned the extent to which specific characteristics of a pig can predict its attack latency. Hessing et al. (1993) found no difference between females and castrated males in their aggressiveness when tested in groups of four to six animals. Our data provide more precise information on this issue having individually tested females and entire males and support the results of Hessing et al. (1993). We should emphasise that in this experiment, the pigs had not reached sexual maturity and that we only assessed an individual's propensity to attack. We cannot make any assumptions about the intensity of fighting or the perseverance of an individual once a fight has started. Jensen et al. (1995), however, found that male pigs were more likely to attack than females. Comparing the methodology used in our study with the one used by Jensen et al. (1995), a possible explanation is that Jensen's test pigs were in a situation which resembled that of our intruder pigs rather than our resident pigs. Jensen's pigs were handled and moved into an unfamiliar test pen, where an opponent was already present and had been so for up to five minutes. In our study the intruder was moved into the test pen - unfamiliar to it - where it faced a resident pig. Following Jensen's observations, one would expect to find the sex differences in our study in the intruders rather than in the resident pigs. And indeed, the male intruder pigs were more likely to fight back when they were attacked by the residents than were the female intruders. It is conceivable, that being handled, moved, put into an unfamiliar environment and facing an unfamiliar pig already present, affected males and females in different ways. Since the experiments compared here differed in more than the nature of the test arena (e.g. size-difference between opponents), we cannot come to a conclusive answer. The results do, however, support the notion that the nature of the test arena is an important factor when measuring aggressiveness. They emphasize that great care has to be taken when comparing results of different experiments, the methods used can clearly affect the results obtained.

In agreement with the data presented by Jensen (1994), the probability that a pig will attack did not change significantly with age in our experiments. Eleven week old pigs attacked faster than seven week old ones, but the relative aggressiveness as represented by correlations did not change, i.e. pigs who were relatively fast attackers in the first test also were relatively fast attackers in the second test. Aggressiveness seems to be an individual characteristic which remains stable across at least four weeks in growing pigs.

One possible reason for variation within litter is the dominance hierarchy. We did not measure dominance rank directly, but body-weight, ranked within litter, is an indirect indicator of social rank. It also reflects potential for relative (within litter) growth rate. The absence of a significant interrelationship between weight-rank within litter and aggressiveness is in agreement with Meese & Ewbank (1973) and Scheel et al. (1977), who found no relationship between dominance and aggressiveness. Since neither absolute body weight nor weight ranked within litter are highly correlated with aggressiveness, selection for low-aggressiveness is unlikely to lead to a reduced weight gain.

Rushen (1988) reported that the likelihood of fights occurring between pigs at the age of five to six weeks did not differ with the relative size of the opponents. He compared pigs who were paired with opponents of the same size with pigs who were paired with opponents who weighed 40% less. Accordingly, we found the body weight of the intruder in relation to that of the resident to have little impact on the aggressiveness of the resident. If at all significant, the correlations point to a small effect, with large weight differences between the opponents leading to longer attack latencies. When we compared attackers with non-attackers, however, we found that in dataset 3b (which had a larger variation in relative body weight than the other datasets) relative body weight was a source of variation. Non-attackers were those paired with intruders less than half their body weight and attackers were those paired with intruders who were almost two thirds of the residents' body weight. It is possible, that an intruder has to be of a certain size relative to the resident in order to provoke aggressive behaviour. Alternatively, it could mean that the assessment of an opponent's fighting ability becomes easier with increasing difference in body-weight, which may make fighting unnecessary (cf Rushen & Pajor 1987).

To summarise, we found attack latency to be largely independent of sex, age and body weight. As long as the opponent pig is of about two thirds of the body weight of the test pig, we suggest that the intruder test described here does indeed measure a characteristic of an individual pig, which is relatively stable across at least four weeks.

Differences in aggressiveness between litters were sufficiently large to point to possible maternal or genetic effects. Since all sows in this experiment had been housed in similar conditions prior to farrowing and farrowed in crates, their direct influence on their litters was limited. A genetic effect may have been more likely. This result is in agreement with McBride et al. (1964) and Fraser (1974), who found different genotypes to differ in their aggressiveness.

There was, however, still a sufficiently large variation within each litter to suggest that within litter experience (cf. Mendl & Paul, 1991) or genotype differences between siblings may affect individual aggressiveness. This finding suggests that balancing for aggressiveness by randomly selecting individuals from different litters may be a questionable procedure. If the treatments within an experiment are to be balanced for aggressiveness, it is safer to test the animals individually beforehand.

The proportion of responders in latency data depends to a certain extent on the duration of the test. Choosing a short duration, like the 3.5 minutes we used, means running the risk that some otherwise late attackers are recorded as non-attackers. A longer duration may avoid this risk, but compromises the welfare of the animals involved in the test. The choice of test duration can therefore be seen as a trade-off between gaining additional information and reducing the welfare of the animals. In Jensen (1994; cut-off point 15 minutes) 72% of the attackers attacked within 3.5 minutes. In Forkman et al. (1995; cut-off point 10 minutes) 84% of the pigs who attacked did so within 3.5 minutes. This leads us to believe that we did not lose too much information by reducing the time limit to 3.5 minutes, and we insured that most intruder pigs were behaving in a similar, non-agitated, way.

Which cut-off point is chosen will depend on how essential it is to distinguish late attackers from non-attackers. There is also the danger, that the test situation changes over time. The motivation to attack after having spent 30 minutes in the same pen may well differ from the motivation to attack immediately. The fact that an individual did not attack immediately may provide more valuable information than the time when it eventually did attack. Scott & Fredericson (1951) argued in favour of such a yes/no approach, suggesting that the presence or absence of a behaviour can provide very valuable information. We cannot give a conclusive answer to the question whether the early-attackers differ from the late-(or non-) attackers not just quantitatively (in latency) but qualitatively. The 'gap' between the early responders and the 'non-responders' which has been found in other studies as well (with longer test durations) seems to suggest a significant difference in attack latency which, given the possibility that the test situation itself changes over time, may lead to the conclusion that the two groups do differ qualitatively. A possible way of testing this hypothesis would be to compare late-attackers with non-attackers in other situations which are socially challenging. A test duration of 3.5 minutes may not be sufficient for such a study.

2.6 Conclusions

To conclude, we suggest that the test described in this paper can be used to measure individual attack latency in growing pigs. It is repeatable and does not seem to be affected by the characteristics of the test pig (e.g. its sex, body weight at any one age, age). Pigs which are 2-3 weeks younger than the test pigs can be used as standardised opponents, irrespective of their sex. They should weigh approximately 60% of the test pig's body weight. If they weigh less than half of the body weight of the test pigs, the latter show lower levels of aggressiveness. Since the test is repeatable and to a large extent independent of the physical characteristics of the test pig and the opponent, the test can be said to measure something that could be attributed to an individual's aggressive 'personality'. To find out whether the attack latency measured in this test does indeed reflect some sort of 'personality', it has to predict the behaviour in a different situation. This has been shown by Erhard et al. (1997).

The differences in attack latency between litters point to possible genetic factors affecting aggressiveness. Should an experiment require balancing for aggressiveness, the individuals' aggressiveness should be assessed. Randomly choosing individuals from different litters may not give satisfactory results.

Performing the aggression tests in the home pen of the test pig and using attack latency as measure of aggressiveness and intruder pigs which are two to three weeks younger than the test pigs provide reliable information about individual attack latencies and have minimal impact on the welfare of the animals involved.

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Chapter 3

Attack latency as a measure of aggressiveness: predictive of aggressive behaviour in another situation[*]

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[*] A paper based on this chapter has been published as 'Individual aggressiveness of pigs can be measured and used to reduce aggression after mixing' by Erhard, H.W., Mendl, M. and Ashley, D.D. in Applied Animal Behaviour Science 54 (1997) 137-151

3.1 Abstract

Many studies have been carried out with the aim of reducing aggression after mixing unfamiliar pigs. A major problem in these studies has been the individual variation in aggressiveness between pigs. This study examined whether aggressiveness, as measured in tests on individual animals in a resident-intruder situation, is predictive of the level of aggression shown after mixing unfamiliar pigs, and whether information on this individual aggressiveness can be used to reduce aggression after mixing. 189 pigs were tested for individual aggressiveness in their home pens and categorised as high- or low-aggressive (H or L), according to their attack latency. 88 of these pigs were then mixed in groups of eight, with four pigs from each of two litters. The combinations used were H/H (4H+4H), H/L (4H+4L), and L/L (4L+4L). In a follow-up study, a further 32 pigs were mixed into the combinations HL/HL (HHLL+HHLL). The pigs were observed for three hours on the day of mixing, and for two hours on days 1, 2, 6, and 7 after mixing. During observations, aggressive interactions, and whether the pigs avoided lying down next to a pig from the unfamiliar litter were recorded. Fresh skin lesions were counted on each pig 2 h following mixing, and again 2 days later. In the majority of the groups, there was a clear distinction between a winner and a loser litter within the first two hours after mixing. The number of pairs fighting in the two hours immediately following mixing was lowest in the H/L groups. The number of skin lesions on the pigs from the winner litter both immediately after mixing and 2 days later was highest in H/H groups. Thus, the relative level of aggressiveness seemed to determine the number of pairs that fought and the absolute level determined the intensity of fighting, with L pigs fighting less vigorously than H pigs. Speed of group integration was again affected by the absolute level of aggressiveness. The presence of H pigs in a group slowed down group integration. These data, particularly those relating to group integration, suggest that if mixing is unavoidable, it is preferable for pigs to be mixed into groups containing low-aggressive pigs only.

KEYWORDS: aggression, pigs, mixing, welfare

3.2 Introduction

The aggression resulting from mixing unfamiliar pigs is a serious problem in pig farming. It has received a great deal of attention over the years, with most researchers coming to the conclusion that mixing should be avoided. Stolba and Wood-Gush (1984) designed a housing system that aimed to achieve this (see also Ekkel et al., 1995). Unfortunately, regrouping is still a standard procedure in pig husbandry. Young pigs are mixed after birth to equalise litter size, after weaning, when starting the fattening period, during transport and at the slaughter house. Sows are mixed when returning from farrowing to the herd. Associated problems include reduced weight gain (e.g. Tan et al., 1991, Stookey and Gonyou, 1994, but see also Moore et al., 1994), reduced meat quality (Warris and Brown, 1985) and other documented changes (Glover et al., 1984). These result in economic consequences, and are also a serious welfare issue. Since all the advice about avoiding the mixing of unfamiliar pigs has in general not been heeded, research about reducing its impact on the animals is still important.

Why are pigs so aggressive after regrouping? The main factor responsible for the aggression is believed to be unfamiliarity or 'social strangeness' (Zayan, 1990). The result of this aggression is the establishment of a social hierarchy (e.g. Meese and Ewbank, 1973), which helps to decrease further aggression.

Research done on reducing mixing aggression has approached the problem from different angles (see Petherick and Blackshaw, 1987, for a review). Some studies aimed at reducing the symptoms of aggression (aggressive behaviour), using boars (or boar smell), toys or hiding places (McGlone and Curtis, 1985, McGlone and Morrow, 1988, Schaefer et al., 1990). Other studies addressed the underlying causes as opposed to the symptoms through attempts at reducing unfamiliarity by applying artificial masking odours (Friend et al., 1983), by increasing the time that pigs are together before fighting starts (e.g. by use of tranquillisers (e.g. Tan and Shackelton, 1990)), or by 'pre-exposure' techniques (Kennedy and Broom, 1994). Increasing differences in animals' competitive abilities was thought to be another way of reducing aggression by speeding up the establishment of the new hierarchy (see

Rushen, 1987). Manipulations of the relative weights of unfamiliar pigs were used by for example Tindsley and Lean (1984) and Moore et al. (1994), in order to facilitate the formation of a new social hierarchy.

In many of these studies individuals showed considerable variation in the level of aggressive behaviour (e.g. Kelley et al., 1980, McGlone and Morrow, 1988, Mount and Seabrook, 1993). Hessing et al. (1994) proposed to use this individual variation by suggesting that mixing groups of pigs who show a large variation in their aggressiveness could help to create a more stable social hierarchy. A similar point was made by Tindsley and Lean (1984). They suggested that differences in body weight lead to a 'pre-formed weight hierarchy', which does not necessarily reflect a 'true' dominance hierarchy, and that if the hierarchy initially formed after regrouping is not in accordance with the individual's fighting abilities, individuals will continue to challenge heavier, initially higher ranking pigs, leading to high levels of aggression in the group. The closer the initial hierarchy is to one which reflects the 'true' competitive abilities of individuals, the faster the group will settle down. One of the factors determining this 'true' hierarchy is, according to Tindsley and Lean (1984) the number of offensive encounters that each individual initiates.

Following this line of argument, we designed a test of aggressiveness of individuals, which measures an individual's propensity to start an offensive encounter (Erhard & Mendl, 1997). These attack latency tests were terminated after the first occurrence of aggression to protect the welfare of the animals involved. We set out to answer three questions:

(1) Can behaviour in this attack latency test be used to predict aggressive behaviour after mixing?

(2) When pigs are mixed, is it the absolute level of aggressiveness of individuals which determines the level of aggression shown or their aggressiveness relative to their opponents?

(3) Can a knowledge of individual aggressiveness be used to reduce aggression after mixing?

To answer these questions, we carried out tests of aggressiveness on individual pigs and categorised these pigs as high- or low-aggressive. We then simulated standard husbandry procedures by mixing pigs together. We mixed them in several combinations of high- and low-aggressive individuals and observed their behaviour at mixing, and for the following week.

3.3 Material and methods

3.3.1 Animals and housing

The animals were 11 week old crossbred ((Landrace x LargeWhite) x LargeWhite) female and entire male pigs.

For logistic reasons, litters were born two at a time, with each set of two litters being born 2-3 weeks apart. The pigs were kept in litter groups from the day of farrowing, without visual contact with pigs from other litters other than during the aggression tests.

Cross fostering was kept to a minimum, and if necessary, happened within two days after farrowing. Litters were weaned at 4 weeks of age and moved into a different building. Pigs weighing less than 5.0 kg were not weaned. From weaning onwards, pigs were kept in an experimental building in pens (3x4 m^2) with kennels. The building was ventilated and temperature controlled. The temperature was set to 18°C. The lights were set to a 12h:12h light regime with lights on at 0730 h. From 4 weeks after weaning until the end of the experiment, they were housed in pens (3x4 m^2) without kennels. The pigs were fed ad libitum on a commercial diet from feed hoppers with 8 feeding spaces per pen. Water was provided by two nipple drinkers per pen. Pens and kennels were cleaned daily and fresh straw was provided.

In the main experiment, 115 pigs (34.4±0.54 kg) were tested for aggressiveness, and 88 of them were selected for regrouping. In a follow-up study, 74 pigs (33.7±0.59 kg) were tested for aggressiveness, and 32 of them selected for regrouping.

Two additional groups of H/H pigs (not mentioned in the methods section) showed such high levels of aggression after mixing that the pigs had to be separated and the data collection stopped before the initial two hour period had ended. Therefore these groups are not included in the results. In one of the H/L groups described in this paper, the winner group (H-pigs) was so aggressive, that one pig from the loser group had to be removed from the group on day 5, and another two in the afternoon of day 6. The two litters were separated and the trial terminated. Day 7 for this group was treated as a missing value.

3.3.2 Aggression test to assess individual propensity to attack

All tests of aggression were done in the home pen of a litter and involved encounters between one 'resident' pig and an 'intruder' pig from another litter. Intruder pigs came from litters 2-3 weeks younger than the residents. The test methodology is identical to that described in Erhard and Mendl (1997), and is briefly summarised here.

On the day of the test, the pigs from the resident and intruder litters were individually spray marked and weighed. They were then ranked for body weight within litters, and residents and intruders were matched according to weight rank (heaviest resident with heaviest intruder etc.). The order in which individuals were tested was randomised.

For the purpose of the test, the home pen of the resident litter was divided in half by a solid door. One pig (the 'resident') was placed on its own in the dunging half of the pen (test area), while the rest of the litter were retained in the lying area of the pen. The intruder pig was then introduced into the test area. The time between isolating the resident and introducing the intruder was kept to a minimum and was always less than 5 minutes. The experiment was terminated immediately after an attack had occurred (in about half of the tests after the intruder fought back or when the attack was vigorous), or, if no attack occurred, after 3.5 minutes. This was done for ethical reasons, to prevent injury, and also to prevent animals from experiencing fights. An attack was defined as at least one quick bite; mere chewing of the intruder was not counted as attack. The intruder was then returned to its home pen. The resident pig was returned to the lying area, the next resident placed in the test area and the next intruder introduced into the pen.

The procedure was repeated on the following day, the residents being paired with intruders from a different litter.

3.3.3 Categorisation of individuals as high- and low-aggressive

The time from first snout contact to first attack by the resident pig was defined as its attack latency. The mean of the two tests (day 1 and day 2) was calculated and used to categorise pigs into high- and low-aggressive individuals (H and L).

For logistic reasons (restrictions on time and number of animals available) we had to categorise eight pigs per litter. We were therefore not able to set absolute criteria (in seconds) for categories of aggressiveness. While in each group containing H and L pigs, the H pigs always had shorter attack latencies than the L pigs, in the whole of the experiment there were five pigs categorised as H who had longer attack latencies than pigs in other groups categorised as L (Figure 3.1; attack latencies: main experiment: H: 20.6±2.9 s, L: 156.5±8.5 s; follow-up study (not shown in figure): H: 22.8±5.5 s, L: 189.2±10.5 s). Since this overlap increases the variation within category, and decreases the variation between categories, it creates a bias against finding differences between categories, and therefore does not invalidate our results.

3.3.4 Combinations of high- and low-aggressive animals used for regrouping

We always mixed four pigs from one litter with four pigs from another litter. Since a litter effect on the behaviour of the animals was to be expected, we chose to form litter groups of similar aggressiveness. In the main experiment, the four pigs chosen from one litter were therefore either all H or all L. The group mean (of each litter group of four) was used as a mean for the specific type of pig (H or L).

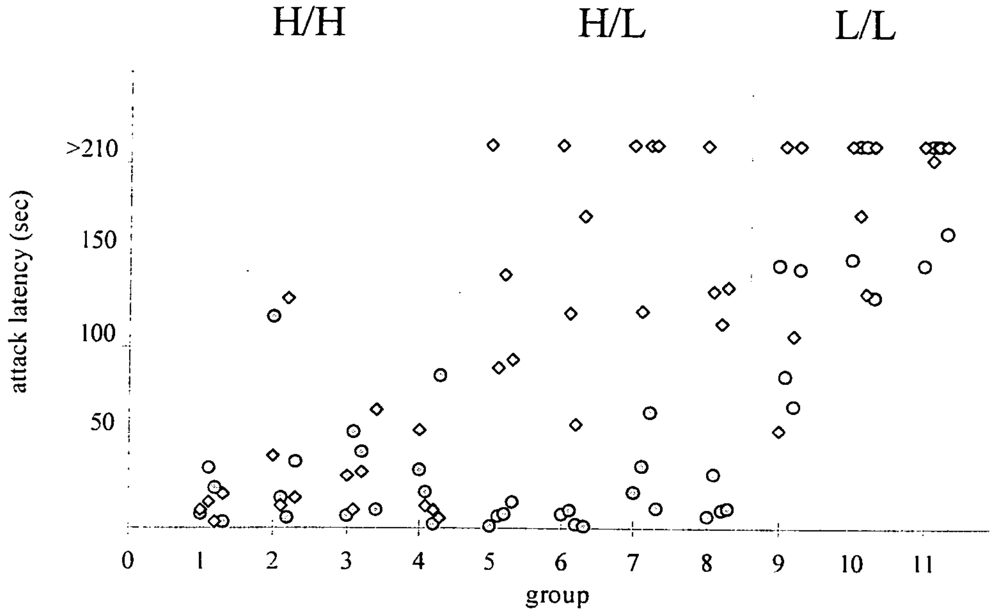

Fig. 3.1: Attack latencies in the intruder test of individual pigs which were then categorised as high-aggressive (H; dark symbols) and low-aggressive (L; white symbols). For each of the eleven groups, the attack latencies of eight individual pigs are displayed, circles are used for the pigs who later became the winner litter, diamonds for the individuals who later became the loser litter.

In order to investigate whether and how the behaviour of high-aggressive animals differed from that of low-aggressive animals, we regrouped the pigs in three combinations: four high-aggressive pigs from one litter with four high-aggressive pigs from another litter to form H/H groups (HHHH + HHHH, n=4), four high-aggressive pigs from one litter with four low-aggressive pigs from another litter to form H/L groups (HHHH + LLLL, n=4), four low-aggressive pigs from one litter with four low-aggressive pigs from another litter to form L/L groups (LLLL + LLLL, n=3)).

Since pigs from the original litters formed winner or loser groups (see results), we did a follow-up study mixing two high- and two low-aggressive pigs from each of two litters (HL/HL (HHLL + HHLL, n=4)), to examine how litter effects and individual differences interacted. Since the strongest effects were seen in the two hours post mixing, these groups were recorded on video tapes for the two hours after mixing only. This follow-up study is not included as a fourth treatment, because the behaviour was recorded from video tapes as opposed to directly.

Within the constraints presented by the number of animals available, we attempted to balance experimental groups for body weight and sex. The weight differences between litters in the three experimental groups did not differ significantly (mean difference in body weight between the two litters of four which were mixed in each group: H/H: 3.4±0.41 kg, H/L: 6.1±1.16 kg and L/L: 2.83±1.67 kg; ANOVA, F2,8=2.54, p>0.1). The male/female ratio was 17/15 in H/H, 10/22 in H/L, and 11/13 in L/L groups (Difference in sex-ratio between the treatments: Chi-square test, $\chi^2=3.22$, df=2, n.s.).

3.3.5 *Mixing*

Two days after the second intruder test the pigs were mixed into the experimental groups. On the morning of mixing (ca. 0930 h), four pigs from each of two litters were simultaneously moved from their home pens into a new pen of the same size and design. Fresh straw was provided in one half of the new pen, the other half was soaked in water to encourage its use as dunging area.

3.3.5.1 Observations

The pigs were weighed on the day of the first aggression test (day -4), and also on day 8 after mixing. On the day of mixing (day 0), the pigs were marked with numbers on their flanks and backs for individual identification before being moved into their new pens. Continuous observation of their behaviour started at the time when they entered the new pen and was performed for two hours. In the follow-up study, behaviour was recorded from video tape. After this observation period, all fresh skin lesions on the pigs were counted. In the afternoon, continuous observations were carried out for another hour . On days 1, 2, 6, and 7, the groups were continuously observed for one hour in the morning and one hour in the afternoon. At 1200 h on day 2, all fresh skin lesions were counted again.

3.3.5.2 Parameters recorded

To assess the effects of mixing, we recorded aggressive behaviour, such as fights, bites etc. and their direct consequences, i.e. skin lesions. Overt aggression at mixing, however, is only one result of regrouping pigs. Stookey and Gonyou (1994) pointed out that a certain level of stress may be associated with merely being in the presence of unfamiliar pigs. They claimed that it is not only the level of overt aggression that persists beyond 24 hours after regrouping, but also social "unease" which causes the reduced weight gain they found. Since some of the aggression and therefore 'stress' resulting from mixing is said to be associated with the presence of unfamiliar pigs (e.g. Zayan, 1990, Stookey and Gonyou, 1994), we used the degree to which pigs accept unfamiliar pigs as group members as an indicator of the level of social 'unease'. A similar method was described by Ewbank and Meese (1971). One of the parameters they used to define the time of acceptance of individuals into a group was the time when the individual concerned first lay with the group. To measure this aspect of group integration we recorded whether pigs avoided lying next to non-litter mates. While other studies (e.g. Moore et al., 1994 and Spoolder et al., 1996) recorded the nearest neighbour whilst lying (at specific time intervals), which is a combination of the behaviour of the two pigs involved, we recorded the behaviour of the individual when it lay down.

The measures recorded are defined below:

- threat (frequency): The pig performs behaviour not involving physical contact that results in an avoidance response by another pig (Kelley et al., 1980).
- head-knock (frequency): The pig uses a vigorous side to side movement of its head to hit any part of the head or body of another pig. The mouth is kept closed (Mendl et al., 1992, see also Jensen, 1980).
- bite (frequency): The pig opens its mouth and closes it on another pig (Kelley et al., 1980).
- chase (frequency): One pig follows another in quick pursuit, usually biting or trying to bite.
- fight (frequency and duration): A fight lasts longer than a single aggressive contact and begins when open-mouthed contact occurs and concludes when the pigs lose contact with each other prior to a separation of at least 5 sec. Pushing and brief intervals of non-contact are considered as fighting, provided they occur between the beginning and the end of a fight (Gonyou et al., 1988).
- skin lesions (number): fresh skin lesions were counted for ear, shoulder, flank and hind legs, left and right side of body separately.
- lying preference: whenever a pig lay down and at least one pig from the other litter was lying already, the choice it made was recorded. It could either AVOID the unfamiliar pig by lying down on its own or next to a litter mate or NOT AVOID it by lying down next to the stranger.

3.3.6 Data handling

The total amount of agonistic behaviour occurring within litters was negligible. Agonistic behaviour was therefore only analysed when it occurred between pigs of different litters. Only aggressive interactions which were followed by a clear submissive behaviour, such as shifting the body away from the aggressor or moving away (94% of all aggressive interactions on the day of mixing) were used for the analysis.

Fighting time: Some fights involved more than two pigs at a time. To take the difference between fighting against one and fighting against two opponents into account, we decided to calculate fighting time in the following way: When two pigs fought for 10 seconds, it was treated as 10 seconds per pig, and a total fighting time of 20 seconds. When one pig fought against two other pigs for 10 seconds, then it was treated as if this pig had been involved in two fights lasting 10 seconds each, resulting in a total fighting time for all three pigs of 40 seconds. This method assumes that fighting against two opponents is twice as costly as fighting against one opponent. As a result of this method the time spent fighting by one litter in a group was equal to the time spent fighting by the other litter. For the analysis, we divided this number by the number of pigs in a group to get the average 'fighting time per pig'.

The total number of skin lesions was used for comparison between the treatments.

A lying preference score (LPS) was also calculated. The number of times a pig avoided lying next to a stranger and the number of times, it did not avoid lying next to it were used.

LPS = (AVOID - NOT AVOID) / NUMBER OF CHOICES MADE

If a pig always avoided the stranger, it had an LPS of '+1', if it never avoided a stranger, it had an LPS of '-1', and if it made both choices equally often its LPS was '0'.

3.3.7 Analysis

In general, ANOVA was used to analyse the data as long as there was no reason to assume strong non-normality of the data (as checked by distribution of the residuals and fitted values). Whenever normality could not be safely assumed, non-parametric statistics were used for the analysis. The Kruskal-Wallis test was then used to compare treatments. The table used to test for significance was table O in Siegel and Castellan (1988), which is used when comparing three treatments with ≤5 replica per treatment. Where appropriate, we display the litter data points rather than means or medians to provide the reader with full information.

To compare the frequency of fights in the follow-up study (HLHL treatment), we performed an ANOVA based on ranks, as suggested by Kramer and Schmidhammer (1992).

To test whether a distribution-score was significantly different from zero (lying preference score and distribution of skin lesions), we used the t-test. Since the lying preference data were repeated measures, we initially summarised the data across time (using the means per individual across five observation days to calculate group means) and performed t-tests on these means. t-tests were used since the non-parametric Wilcoxon signed-rank test does not reveal statistical significance below a sample size of seven. With small sample sizes, the results have to be regarded with caution. The distribution of the group means are displayed in the figures. The results given in the text are: means ± standard errors of the mean.

3.4 Results

3.4.1 Winners/Losers

In 14 of the 15 groups there was a clear distinction between a winner- and a loser-litter after the initial fighting was over. Pigs from the winner litter could move freely in the pen and showed a lot of exploratory behaviour (sniffing and nosing straw and penning). The losers tended to cluster in a corner of the pen, trying to avoid aggressive behaviour by the winners. In all 4 H/L groups, the H-pigs became the winner litters. Whenever winner and loser litter differed in their behaviour, they were treated separately in the subsequent analyses.

Winners performed 94% of all aggressive behaviours (excluding fights) in the first two hours after mixing. During the first two hours following mixing, the losers received a higher number of skin lesions than winners (Figure 3.2a). After two days, the number of lesions had clearly decreased (Figure 3.2b).

There was no difference in lying preference between winner and loser litters (overall LPS; winner litter: 0.36±0.08; loser litter: 0.31±0.09; paired t-test, n=11, T=0.81, p>0.10).

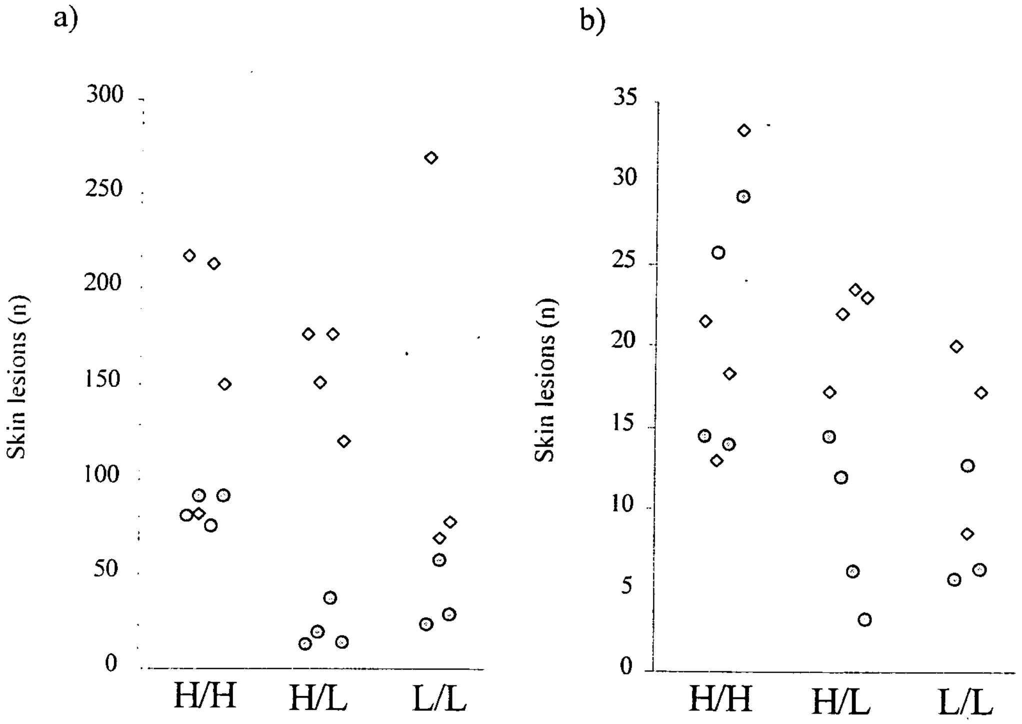

Fig. 3.2: Number of skin lesions per pig (each symbol represents the mean of a group of four pigs; winners: •; losers: ◊), a) 2 hours after mixing and b) 2 days after mixing.

3.4.2 Aggressive behaviour

In this study we divided aggressive behaviour into fighting (frequency, duration and intensity), and other types of aggressive interactions, which we only recorded as frequencies. These consisted of the non-damaging threats and head-knocks and the damaging bites and chases.

3.4.2.1 Fighting

Number of pairs which fought

We found that more pairs fought in H/H than in H/L groups and L/L groups tended to have more fighting pairs than H/L groups (Number of fighting pairs per group; H/H: 7.25±0.75; H/L: 3.0±0.58; L/L: 7.0±1.73; ANOVA, $F_{2,8}=6.09$, $p=0.03$).

In the follow-up study, where each litter group consisted of two H- and two L-pigs, comparing the number of pairs fighting for the three combinations H-H, H-L, and L-L, we found that 'combination' is a significant cause of variation (ANOVA based on ranks, $F_{2,6}=22.16$, $p<0.01$), with H-H and H-L combinations being more likely to fight than L-L combinations. H-H combinations fought in 56% of all possible pairs, H-L in 31%, and L-L in 6% (see Table 3.1). There was no significant difference between fighting and non-fighting pairs in the weight-differences between pair-members.

Table 3.1: Fighting behaviour of pairwise combinations in the follow-up study (HL/HL-combination; number of pairs fighting or not-fighting during the first two hours after mixing)

	fight			
combination	yes	no	total	% pairs fighting
H - H	9	7	16	56
H - L	10	22	32	31
L - L	1	15	16	6
total	20	44	64	31

Time spent fighting

The total time spent fighting in a group in the first two hours after mixing tended to differ between treatments, with pigs in H/H groups spending the longest time fighting (Time spent fighting per pig per 2 hrs: H/H: 443.6±168.0, H/L: 82.8±54.5, L/L: 144.0±7.75, $F_{2,8}=3.12$, $p<0.10$).

Intensity of fighting

During the first two hours after mixing, winners in H/H groups received more skin lesions than winners in H/L or L/L groups (Figure 2a, Mean number of skin lesions on winners (per pig): H/H: 84.5±3.95, H/L: 20.5±5.67, L/L: 36.1±10.57; ANOVA, $F_{2,8}=28.27$, $p<0.001$). This shows that L-pigs (in both H/L and L/L groups) fought less vigorously than H-pigs (in H/H groups), and that this effect did not depend on the aggressiveness of the opponent. The same effect was found on day 2 after mixing (Figure 2b, Number of skin lesions on winners (per pig): H/H: 20.9±3.88, H/L: 9.0±2.59, L/L: 8.2±2.25; ANOVA, $F_{2,8}=5.21$, $p=0.04$).

3.4.2.2 Non-fighting aggressive events

Since losers displayed virtually no aggressive behaviour except for their involvement in initial fights, we analysed these data for winners only.

Differences between the treatments were only apparent in the two hours after mixing, and did not show more than a statistical tendency (Number of aggressive interactions per group per 2 hrs: H/H: 53.5±24.5, H/L: 111.5±16.8, L/L: 68.0±13.0, ANOVA, $F_{2,8}=2.48$, $p=0.15$). In the 2 hours after mixing, more chases tended to occur in H/L groups than in H/H groups (Number of chases per pig per 2 hrs: H/H: 3.0±1.73, H/L: 9.2±1.04, L/L: 5.3±2.67, ANOVA, $F_{2,8}=3.39$, $p<0.10$). Aggressive interactions seemed to be influenced by the preceding fighting (i.e. pigs who spent a long time fighting seemed to be too exhausted to show a high level of subsequent aggressive behaviour). This view is supported by the fact that there were apparently more aggressive interactions in the H/L treatment, which had the lowest number of pigs fighting. This may explain the fact that losers in this group experienced similar levels of skin lesions despite the fact that there were few fights (Figures 3.2a and 3.2b).

There were no differences between the treatments on the other observation days.

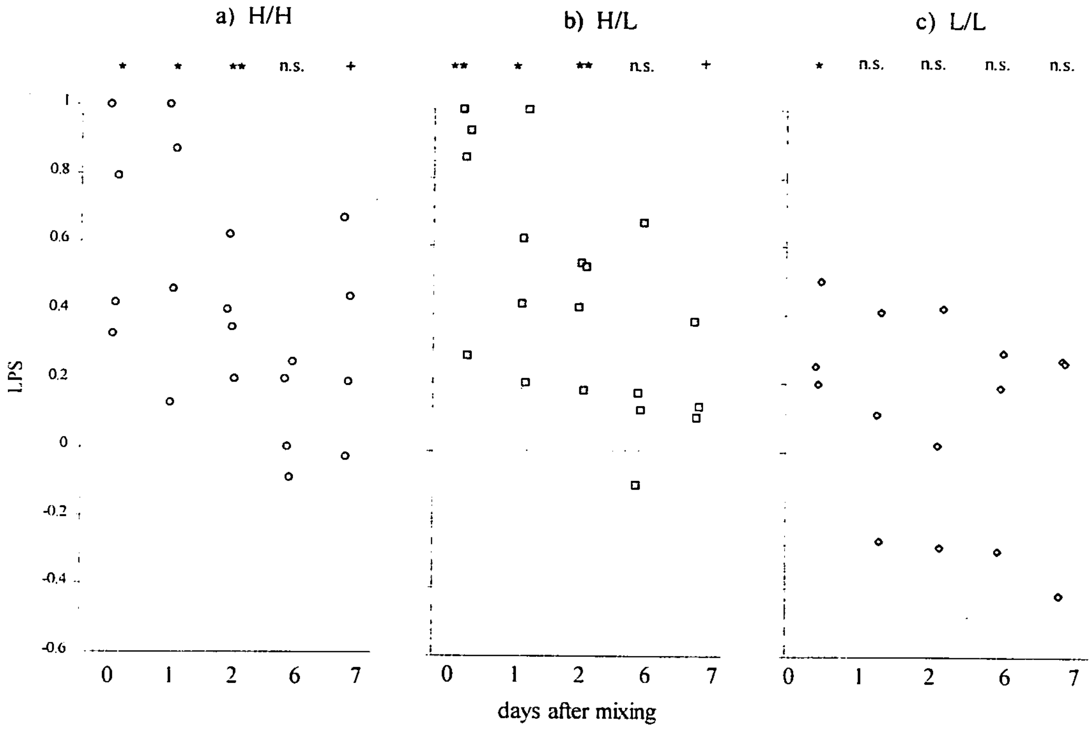

Fig. 3.3: Lying preference scores (LPS) for a) H/H, b) H/L, and c) L/L groups. Each symbol represents the mean of a group of 8 individuals on one observation day. An LPS of '1' indicates that pigs from the unfamiliar litter were always avoided, '-1' that they were never avoided, and '0' that both choices were made equally often. The t-test was used to test whether the LPS was significantly greater than 0 ('+' = $p<0.10$).

3.4.3 Lying preference as measure of group integration

To get an overall measure of preference, we calculated the mean lying preference score (LPS) per individual over the five observation days, and then tested whether group-means (each based on the scores of eight individuals) differed from zero. Over all 5 days, only pigs in the H/H and H/L treatment showed a significant avoidance of pigs from the other litter, while L/L pigs did not (LPS: H/H: 0.41±0.12, t=3.44, n=4, p=0.03; H/L: 0.45±0.12, t=3.70, n=4, p=0.02; L/L: 0.09±0.16, t=0.53, n=3, p=0.32). Having found an overall effect, we then analysed each day separately (Figure 3): L/L pigs only avoided the pigs from the other litter on the day of mixing, while H/H and H/L pigs avoided members from the other litter on days 0, 1, and 2. On day 6, pigs in H/H and H/L groups appeared not to avoid members from the other litter, but on day 7, they again show a tendency to avoid them.

3.5 Discussion and Conclusions

The first question we set out to answer was whether the attack latency measured in the intruder test was predictive of aggressive behaviour after mixing. After mixing, we found the probability of a fight happening, the duration and intensity of the fighting, and the speed of group integration to be influenced by the level of aggressiveness of the individual pigs. This shows that the intruder test (see also Erhard and Mendl, 1997) does indeed provide a measure of aggressiveness with predictive value in a different context.

The second question we wanted to answer was whether, when pigs are mixed, it is the absolute level of aggressiveness of individuals which determines the level of aggression shown or their relative aggressiveness as compared to their opponents. For most of the behaviours recorded, we found the absolute level of aggressiveness to be predictive. Pigs with long attack latencies in the intruder test fought for a shorter amount of time and less vigorously and accepted their position in the newly formed hierarchy more easily than pigs with short attack latencies. The presence of the latter in a group slowed down group integration. In the (mixed) groups containing high- and low-aggressive pigs from the same litter, the probability of fights occurring was also influenced by individual aggressiveness in an apparently additive way, H-H combinations being twice as likely to fight as H-L combinations. This was not so in groups containing only either H or L pigs from the same litter. Here, the relative aggressiveness seemed to be more important, with more pairs fighting in H/H and L/L groups than in H/L groups. One possible explanation for this difference between the behaviour in uniform (L/L) groups and that in mixed groups (HL/HL) is that the experience of seeing fights between the other (high-aggressive) pigs and of being involved in fights with high-aggressive pigs reduced the motivation to fight amongst low-aggressive pigs in mixed groups. An alternative explanation is that there is indeed some kind of assessment occurring. The pigs' relative aggressiveness is similar in H/H and in L/L groups, but different in H/L groups, where fewer fights happen. This seems to suggest that pigs at 11 weeks of age are able to assess each other's behavioural characteristics in some way, an ability they do not seem to have at a younger age (Rushen and Pajor, 1987, discussed by Mendl & Erhard, 1997). A possible confounding factor was body weight. Due to the restricted number of pigs available for each mixing test, we were only able to exercise limited control over relative body weight of the litters that were mixed together. However, the weight differences between litters in the three experimental groups did not differ significantly (mean difference in body weight between the two litters of four which were mixed in each group: H/H: 3.4±0.41 kg, H/L: 6.1±1.16 kg and L/L: 2.83±1.67 kg; ANOVA, $F_{2,8}=2.54$, $p>0.1$). In addition, within the H/L treatment, weight difference between litters did not seem to influence the number of pairs fighting. Also in one group, the lighter litter won, suggesting that weight differences are not a straightforward reliable predictor of success (see also Meese and Ewbank, 1973).

One possible explanation for the differences in group integration follows Lorenz (1966), who suggested that high levels of aggression directed towards individuals outside a group reflect a strong bond within a group (see also Le Neindre, 1989). Thus, low-aggressive pigs show more rapid group integration because they never had a strong group cohesion in the first place. If this is true, the rapid group integration can be seen as lack of group cohesion rather than a response to the level of aggression after mixing. If this was the case, then the H pigs in the H/L groups (i.e. the winners) should show a higher level of avoidance of strangers than the L pigs (i.e. the losers) in this group. However, this was not the case, giving more strength to the argument that the lying preference reflects the reaction of pigs to the aversiveness and social stress induced by their group mates.

The third question concerned a more applied issue: Can a knowledge of individual aggressiveness be used to reduce aggression after mixing? By mixing high-aggressive pigs with low- as opposed to high-aggressive pigs, we reduced the intensity of fighting. Mixing low- with other low-aggressive pigs maintained this effect, but in addition speeded up group integration. This last measure can be looked upon as reflecting how the mixing situation, a combination of all different types of aggressive behaviours, is perceived by the pigs.

Independent records of the number of agonistic interactions, the number and duration of fights, skin lesions, etc., tell us little about the combined effect of these measures on individual pigs. Is being chased for 10 seconds as bad as or worse than fighting for 10 seconds? Are 10 bites received in a fight the same as 10 bites received while being chased? By looking at how individuals react to pigs from the other litter, we can examine how aversive their presence is to them (cf. Wemelsfelder, 1997). Our measure of lying preference was designed to reflect how the social situation in the group is 'perceived' by the pigs by measuring how willing they are to lie next to an unfamiliar pig (see also Ewbank and Meese, 1971, Spoolder et al., 1996 and Moore et al., 1994). The lying preference could therefore be the strongest indicator that the welfare of pigs in groups containing only low-aggressive animals was better than that of pigs in the other treatments. This is supported by the fact that all three groups which had to be separated before the end of the 7-day period due to excessive levels of aggression contained high-aggressive pigs.

From a welfare perspective, it would appear preferable for pigs to be mixed in groups which consist of low-aggressive pigs only. Research by Beattie et al. (1995 and 1996) and de Jonge et al. (1996) has shown that the rearing environment has an impact on aggressiveness in pigs. Beattie et al. (1996) reported that the environment the sows were kept in could influence aggressiveness of the piglets. There is also evidence, that aggressiveness in pigs has a genetic component (McBride et al., 1964, Fraser, 1974). To improve the welfare of pigs when mixed, we therefore suggest that consideration be given to the impact of the genetic background and the rearing environment on the aggressiveness of individuals.

To summarise, the aggression test which was used to categorise pigs in this study does predict aggressiveness after regrouping. It can be used in experiments concerning aggression in pigs to reduce the variation between pigs and thereby helping to detect treatment effects. From a welfare perspective, it would appear preferable for pigs to be mixed in groups which consist of low-aggressive pigs only.

Acknowledgements

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Chapter 4

The active/passive dimension of personality: coping strategies and tonic immobility [*]

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[*] A paper based on this chapter has been submitted as 'Individual differences in tonic immobility may reflect behavioural strategies' by Erhard, H.W., Mendl, M., and Christiansen, S.B. to Applied Animal Behaviour Science

4.1 Abstract

Many species of animals have been reported to show tonic immobility (TI) in response to physical restraint. In this paper, we investigate the interrelationship between tonic immobility in pigs, responsiveness in challenging situations and active/passive behavioural strategies. Individual piglets were tested for TI at 2.5 weeks of age (susceptibility to and duration of immobility), for their response to being physically restrained while receiving an anti-parasite injection at 4 weeks of age (relaxed (R), tense (T), and struggle (S); screaming yes/no), and for their speed and ease of movement through an unfamiliar environment at 10 weeks of age.

We found TI to be predictive of behaviour across the two month test period. Pigs who screamed in response to the handling /injection were either tense or struggled. Relaxed pigs did not scream. This we interpret as indicating that both T and S were responses indicating that the pigs found the situation challenging, while the absence of screaming in conjunction with the relaxed muscles of the R pigs may indicate that the situation presented little or no challenge to the pigs. T/S pigs did not differ to R pigs in their behaviour in the TI test at 2.5 weeks. However, T pigs did show longer TI durations than S pigs. In the movement test, pigs who had previously shown a low susceptibility to TI moved faster than those who had become immobile.

We propose that TI is one possible way of assessing whether individual pigs are more likely to adopt a more active (low susceptibility/short duration of TI, struggle, move fast) or a more passive behavioural strategy (high susceptibility to/long duration of TI, tense, move more slowly) in a challenging situation.

KEYWORDS: Personality, individual differences, responsiveness

4.2 Introduction

Motor inhibition in response to restraint is a phenomenon which is well-documented across the animal kingdom (Erhard, 1922; Crawford, 1977; Maser & Gallup, 1977). Maser & Gallup (1977) found approximately 30 labels for this behaviour and expressed concern over the ongoing creation of new terms. Some of the older terms used are 'animal hypnosis', 'immobility reflex', 'Totstellreflex', and 'fright paralysis', and often refer to a cause or function of the behaviour. 'Tonic immobility' (TI) is more descriptive and therefore a more neutral term for a very complex phenomenon (Gallup 1974a). What most of the behaviours described as TI have in common is some sort of physical restraint, and a reversible physical immobility, which is ended abruptly "with the animal making an almost immediate transition from the immobile to a mobile state" (Gallup 1974a). Individuals vary in their susceptibility to as well as in the duration of tonic immobility (Gallup, 1974a). Particularly in birds, this variation has been said to reflect different levels of fear or timidity, high susceptibility to TI and long durations of immobility being a sign of high levels of fear (Gallup, 1977; Jones, 1986a and 1986b). The level or type of reaction is seen as a reflection of the level of the underlying emotion, fear.

In contrast to this, Klemm (1977) suggested that at least in rabbits, fear was "neither the sole nor necessary cause" of the immobility. As an alternative interpretation of tonic immobility, a link between TI and 'emotionality' was proposed by McGraw & Klemm (1973) who reported an interrelationship between the ability of rats to learn a maze, exploration of new environments and TI and by Gallup et al. (1976) who suggested that differences in emotionality were the basis for the differences in immobility in chickens. 'Emotionality' in this context is used to describe a predisposition to react more or less strongly, quickly and lastingly to certain classes of stimuli (Savage & Eysenck, 1964). This definition of 'emotionality' is close to what Benus et al. (1991) called 'coping strategies'. The theory of behavioural strategies (e.g. 'active/passive coping' strategies, Benus et al., 1991, Hessing et al. 1993) suggests that a given challenging situation will evoke specific responses, depending on the temperament or 'personality' of the individual involved.

Benus et al. (1991) identified 'active' and 'passive' types of mice. They found that individuals genetically selected over several generations for short attack latencies reacted in an active way (e.g. fight/flight in response to an opponent), while those selected for long attack latencies reacted in a passive way (e.g. immobility in response to an opponent). These strategies therefore had a genetic background and predicted the behaviour of individuals in response to various social and non-social challenges. They did not make any assumptions about underlying emotions. Hessing et al. (1993) reported a similar result in pigs. They recorded the reaction of piglets to manual restraint in the so-called 'back test', and found that more resistant pigs differed from less resistant pigs in their reaction to several challenging situations, which is in agreement with the concept of 'coping strategies', as individual characteristics with cross-situational stability.

A 'behavioural strategy' is one of at least two distinct types of behaviour shown in a challenging situation. Strategies can be regarded as categorically distributed (e.g. active - passive) and are a reflection of different categories within a personality trait. We use the term 'behavioural strategy', because 'behavioural' does not imply the success of these strategies in the way the word 'coping' does. 'Coping', furthermore, is used in the psychology literature when the challenge exceeds an individual's competence (Liebert & Spiegler, 1994). For individual differences in behavioural responses to be called 'personality traits', they have to show consistency across time and in different situations (Jensen, 1995).

Is the susceptibility to or the duration of tonic immobility in pigs a reflection of the level of fear experienced or of the strategy used when challenged? 'Fear' (a feeling of distress (an emotion) caused by impending danger, pain etc. (sensu Collins English Dictonary) is usually inferred from an animal's behaviour, from its response to a specific stimulus or situation. The personality trait linked to fear is fearfulness (or 'timidity'), a predisposition to experience fear, or, as Boissy (1995) put it "...the general susceptibility of an individual to react to a variety of potentially threatening situations." A reaction to a potentially threatening situation can be triggered by an underlying emotion such as 'fear', it can also be a result of a more general 'aversiveness' of the stimulus, in the same way as sheltering from rain may be caused by fear of water or by 'a dislike of getting wet'. It is difficult to distinguish between these two. In this paper we will therefore use the more descriptive general definition of Boissy and refer to the behaviour as 'response' and the underlying personality trait as 'responsiveness', since it is not clear whether in the situations investigated in this paper the subjects actually experienced fear or merely a feeling of aversion, or some other emotion or state.

We set out to investigate whether TI was shown by pigs, and if so, whether any potential variation in the pigs' susceptibility to and duration of TI reflected different levels of responsiveness (similar to fearfulness/timidity, as suggested for chickens by Jones (1986b)) or different behavioural strategies (as suggested by Hessing et al. (1993) for the 'back test' in pigs).

By performing three tests which presented individual pigs with challenging, and potentially fear-inducing situations at three different ages, we tried to investigate the consistency of the pigs' behaviour across time and situation, but within the same context. The tests we chose were i) tonic immobility at 2.5 weeks of age, ii) handling in combination with an injection (as part of a normal husbandry routine) at four weeks of age, and iii) speed of moving pigs individually through a raceway consisting of parts which differed in their aversiveness and which were comparable to situations pigs encounter on farms or during transport (10 weeks of age). If TI is an indicator of individual personality characteristics, the three tests should reveal consistency in the individual pigs' behaviour.

If the reaction to the TI test predicts the behaviour in the other two situations, in other words the ease of handling, it could be used to assess individual pigs and potentially help farmers or pig breeders to select animals with a more desirable personality trait. Indeed, some time ago pig farmers in Denmark used the reaction of young boars to a specific handling situation similar to the 'back test' described by Hessing et al. (1993) as one selection criterion for deciding whether boars should be kept for breeding or not (personal communication Mrs. P.B. Gade, Danish Meat Research Institute).

4.3 Material and methods

Care was taken to ensure that, even though the tests involved a certain degree of fear, the welfare of the animals was not seriously compromised. The tests were short (on average less than two minutes per pig, TI up to 5 minutes) and the injections were given against internal/external parasites as part of normal husbandry routine and were not part of the experiment as such. The injection 'test' consisted merely in recording the behaviour whilst this routine was performed. Immediately after each test, the animals were returned to their litter mates, which ensured that social isolation was kept to a minimum.

4.3.1 Animals and housing

In this study, we used 219 (Large White x Landrace) x Large White pigs from 22 litters, 106 females and 113 entire males for the initial TI tests (test 1; 2.5 weeks of age). The only handling of the piglets prior to this test consisted of teeth clipping, ear notching and iron injections on the first day after birth. At the age of 4 weeks (weaning), 11 of these litters (110 pigs) were randomly chosen for the handling test (test 2). At the age of 10 weeks, 7 of these 11 litters (70 pigs) were chosen at random for the speed of movement test (test 3). All pigs were kept unmixed in litter groups throughout the experiment.

4.3.2 Test 1: Tonic immobility

Immediately after a suckling bout had finished, an entire litter was put into a transport box and taken into a separate test room. When the piglets had settled down (which took up to about 10 minutes), the first piglet was lifted out of the box by its hind legs and placed on its back onto a V-shaped cradle (ca. 50 cm long, angle approximately 80°). The handler then put a sand-filled bag (15 x 20 cm, ca. 500g) onto the piglet's chin, gently stretched its hind legs and then let go of both the hind legs and the sand bag (figure 4.1). If the pig became immobile, the duration of immobility was recorded from this point onwards. As soon as the piglet struggled, the bag was removed and the response latency recorded. If the piglet did not respond within 5 minutes, the test was terminated, and a latency of 300 seconds was allocated to this pig.

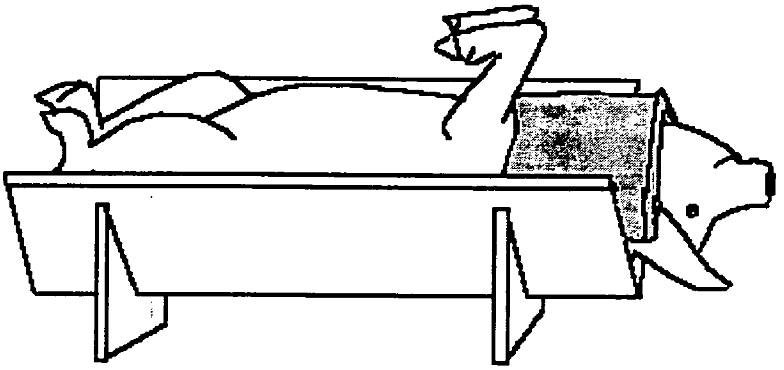

Figure 4.1: Pig in tonic immobility

Some piglets did not show the immobility response described above ('non-TI pigs'). They usually struggled before they were placed onto the cradle, or as soon as they touched the cradle. It was not possible to get them through the process described above. In this experiment, they were recorded as having a struggling latency of 0 seconds. With these pigs, TI was induced up to a total of three times. Preliminary analysis revealed that the susceptibility of pigs to TI at first induction was more predictive of future behaviour than the duration of the immobility finally induced. Investigating the first induction only also removes differences between individual pigs which are the result of experience from one induction to the next. Unless stated otherwise, all data relating to TI are those obtained at first induction.

The immobility reaction can be seen as categorical (becoming immobile or not) and/or as continuous (duration of immobility, absence of immobility represented by a duration of 0 seconds). Terms used to describe this are susceptibility and duration. Low susceptibility (non-TI) means that the pig did not show an immobility response at first induction, high susceptibility (TI-) means that it did. When durations are analysed, pigs with low susceptibility were given the duration of 0 seconds. 'Long TI' and 'short TI' refer to the duration of immobility. They are not discrete categories with a clear cut-off point, but descriptive labels, pointing to the lower or upper end of the distribution.

Some piglets vocalised when being picked up, but vocalisations during immobility were generally no more than one or two within the first two seconds of immobility, and within the last two seconds, just before the pigs started to struggle. Most pigs did not vocalise at all during the test. Excessive handling prior to the test leads to the pigs' vocalising and screaming during immobility (Erhard et al., 1998). The results described in this paper were obtained from pigs having received minimal handling prior to the TI test (see above), and should not be extended to pigs which have been handled before, until more is known about the effect of handling on the TI response.

4.3.3 Test 2: Handling/injection

At weaning, the pigs were moved as litters into an experimental building and given IVOMEC® injections (s.c.) against parasites. One person held a piglet using a standard procedure (one hand around the head, the other around the hips of the pig), while another person gave the injection into the pig's neck. The pig's reaction to being held and to being injected was qualitatively assessed by the two handlers and divided into three categories:

- relaxed (R): the pig did not react to being held, its muscles were relaxed
- tense (T): the pig's muscles were contracted, but it did not make attempts to escape; similar to a 'freezing' response
- struggle (S): the pig tried to escape by struggling; similar to a 'fight/flight' response.

It was also recorded whether the pigs screamed or not during the handling procedure.

At the time of this test, the two handlers were unaware of the behaviour of the pigs in test 1.

4.3.4 Test 3: Speed of movement in a raceway

The pigs were moved individually from a start pen (SP; 1.5 x 4 m) along a passage in the room they were housed in (familiar passage, FP; 1.5 x 9 m), through an unfamiliar corridor (UC; 1.5 x 8 m), towards a well-lit hide, behind which the observer (O) was located, into an unfamiliar room (UR; 2 x 3 m), up a ramp (RP; 1.2 x 1.4 m, slope 17°) and into a box (B; 1.4 x 1.8 x 1.6 m, closed on three sides and top). The ramp and box were meant to resemble a loading procedure. The handler followed the pig with a ply-wood board at a ca. 30 cm distance. Only when the pig stopped, did the handler tap the pig with the board. If the pig still did not move, it was tapped again, up to three times (every single 'tap' was recorded). After three 'taps' the pig was pushed for approximately 20 cm. This set of three 'taps' and one push could be repeated if necessary. Only at that time was the speed of the pig actively controlled by the handler. Once on the ramp, the board was kept in constant contact with the pig. The handler tried to push the pig up the ramp in as standardised a manner as possible. The pig was recorded as being in the box, when all four feet were in the box. The behaviour of the animals was recorded using the Keybehaviour and Keytime programs (Deag, 1993). The time it took to move an individual pig was recorded from the moment it left the start pen to when it was in the box, and analysed for the entire raceway.

The behaviour of the pigs in the unfamiliar corridor was qualitatively assessed and categorised based on the following definitions:

H: walk **h**esitantly (pig does not nose surroundings, but looks at 'goal' ahead, sometimes tries to turn back, needs pushes or 'taps')

F: walk freely at a constant pace (i.e. does not stop and nose, sniff, or stare at the surroundings)

E: explore (pig sniffs thoroughly while slowing down and/or stops to nose or lick floor/walls of UC)

Furthermore, the number of times a pig turned around to get back to the familiar room was recorded.

2 of the 70 pigs could not be categorised because they showed a combination of these behaviours. They were excluded from the analysis.

At the time of this test, both the handler and the observer were unaware of the behaviour of the pigs in test 1 and test 2.

4.3.5 Data handling

Whenever the data were not normally distributed, we used non-parametric tests for the analysis. The relationships between categorical data were analysed using the χ^2-test. Since TI durations had a floor and a ceiling (0 seconds for non-TI pigs and 300 seconds for durations longer than the test duration), the median test was used to compare groups in respect to their TI durations (Siegel & Castellan, 1988). The results presented in this paper use the behaviour of the pigs at the first induction of TI.

The data for individual animals were treated as independent, since the tests described in this paper were carried out on individuals. The behaviour of one pig in a test did not directly affect the behaviour of another pig tested later.

The distribution of the data in the speed of movement test allowed a detailed analysis of the relationship between litter differences and individual personality. To determine with less ambiguity the extent to which the data supported the hypothesis that piglets response to the tonic immobility test is related to the time taken to complete the raceway, the total time was re-analysed using REML (Residual maximum likelihood; Patterson and Thompson 1971). The REML analysis allows differential specification of the response to the tonic immobility test, which is treated as a fixed effect, compared to the litter effect which is treated as random. The REML analysis was fitted using Genstat 5.3.2 (Genstat 5 Committee, 1993)

4.4 Results

4.4.1 TI test

At the first induction, 44 of the 219 pigs tested (20 %) showed a low susceptibility to TI (no immobility; 'non-TI'). 13 (6 %) stayed immobile for the duration of the test (300 seconds). The median duration of pigs who became immobile was 50 seconds (figure 4.2). There was no difference in the duration of TI between non-TI (duration of TI after up to 3 inductions) and TI-pigs (duration of TI after first induction; median test, χ^2=0.051, df=1, n.s.).

4.4.1.1 Litter differences

15 of the 22 litters tested had both non-TI and TI pigs. Between 0 and 70% of the piglets within a litter had a low susceptibility to TI. Litter medians of duration of immobility ranged from 0 to 80 seconds. It was not possible to perform a median test (frequencies per cell sometimes 0). The Kruskal-Wallis test showed a significant difference between litters (H=55.97, df=21, p<0.001).

4.4.1.2 Sex differences

Males and females did not differ in their susceptibility to TI (percentage of non-TI animals; males: 20.4%, females: 19.8 %, χ^2=0.01, df=1, n.s.), nor in the duration of immobility (median duration of immobility; males: 26 sec, females: 27 sec, median test, χ^2=0.003, df=1, n.s.).

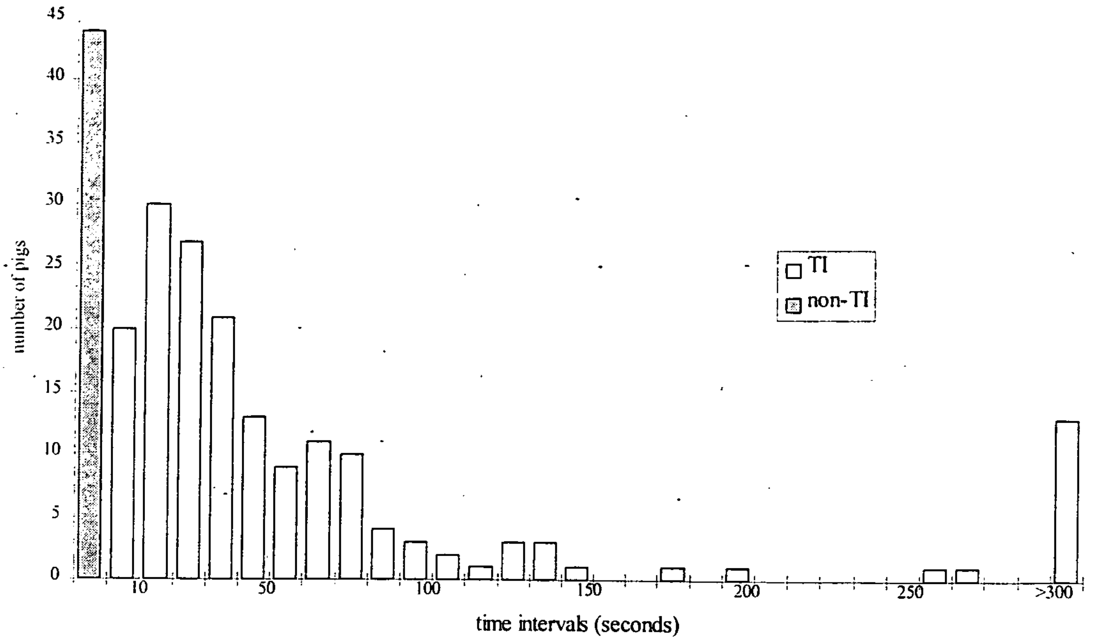

Figure 4.2: Frequency distribution of durations of tonic immobility (in 10-second-intervals) of 219 piglets. The dark bar represents the number of piglets who did not become immobile at first induction (non-TI).

4.4.1.3 The effect of order of testing

The first piglet of a litter was usually tested about 10 minutes after a suckling bout had finished. The last piglet was tested approximately one hour later, depending on the duration of immobility in the previous pigs. The order of testing therefore is correlated with the time passed since the last suckling bout. Individual pigs were categorised according to their order of testing within a litter (1st, 2nd, 3rd, etc.).

Within each order, the proportion of non-TI animals ranged from 13.6 to 33.3 %. Some of the frequencies (i.e. number of TI- or non-TI- animals within one order) were too small to allow a χ^2 test. There was no order effect on duration of immobility (Kruskal-Wallis, H=7.24, df=11, n.s.).

4.4.1.4 The effect of body weight

There was no linear relationship between body weight and duration of TI, but non-TI pigs were smaller than TI-pigs (body weight, mean ± SEM: non-TI pigs 5.1 ± 0.18 kg and TI pigs 5.7 ± 0.1kg, Mann-Whitney test, W=3911.5, n_1=44, n_2=175, p<0.02). This effect was mainly due to the difference between extremely heavy and extremely small pigs. Piglets weighing less than 3.9 kg did not stay immobile for the duration of the test (five minutes), while only 5% of piglets heavier than 6.7 kg had a low susceptibility to TI.

4.4.2 Handling (injections)

43 of the 110 pigs tested (39.1%) screamed during handling. Males were equally likely to scream as females (42% and 37%, respectively; χ^2 test, χ^2= 0.33, df=1. n.s.). Males and females were equally likely to be relaxed (R), tense (T), or to struggle (S) in response to handling (χ^2 test , χ^2=2.33, df=1, n.s.).

Pigs who screamed were significantly heavier than silent ones (body weight, mean ± SEM: screaming pigs 7.9 ± 0.25 kg, silent pigs 7.2 ± 0.19 kg; Mann-Whitney test, W=3467.5, p<0.05). Screaming pigs were also heavier within a litter (body weight ranked within litter (heaviest pig rank 1), mean ± SEM: screaming pigs rank 4.6 ± 0.42, silent pigs rank 6.1 ± 0.34; Mann-Whitney test, W=4359.0, p<0.01).

Pigs who screamed during handling were more likely to react as T or S than those who did not scream (χ^2 test, χ^2= 65.42, df=2, p<0.001; table 4.1). Based on this result, pigs reacting as T or S were grouped together as 'responders' (T/S) for some further analysis.

Table 4.1: Relationship between screaming and muscular responses during the injection test (test 2; frequencies)

	relaxed	tense	struggle	all
silent	63	1	3	67
scream	8	17	18	43
	71	18	21	110

$\chi^2=65.42$, df=2, $p<0.001$

Relaxed (R) pigs tended to be the smaller pigs of a litter, T and S pigs tended to be the heavier ones (body weight ranked within litter, mean ± SEM for R, T, and S pigs: 6.0 ± 0.32, 4.5 ± 0.70, and 4.8 ± 0.75, respectively; Kruskal-Wallis test, H=5.86, df=2, p=0.06). T pigs did not differ in body weight from S pigs (Mann-Whitney test, W=352.0, p=0.83).

The susceptibility to TI of R pigs did not differ from T/S pigs (χ^2 test, R vs. T/S: $\chi^2=0.04$, df=1, $p>0.1$; figure 4.3), but T pigs were more susceptible to TI than S pigs (Fisher's exact test, T vs. S: $p<0.02$; figure 4.4).

R pigs did not differ from T/S pigs in their duration of immobility (median duration in seconds; R: 28, T/S: 37; median test R vs. T/S: $\chi^2=0.78$, df=1, n.s.; figure 3), but T pigs had longer TI than S pigs (median duration in seconds; T: 64, S: 25; median test, T vs. S: $\chi^2=4.31$, df=1, $p<0.05$; figure 4). The differences between these two types of pigs were most distinct in the extreme responses to TI. While all T pigs were susceptible to TI, none of the S pigs stayed immobile for the duration of the test (5 minutes). As both T and S pigs tended to be heavy pigs (screamers), weight does not explain their differences in susceptibility to TI.

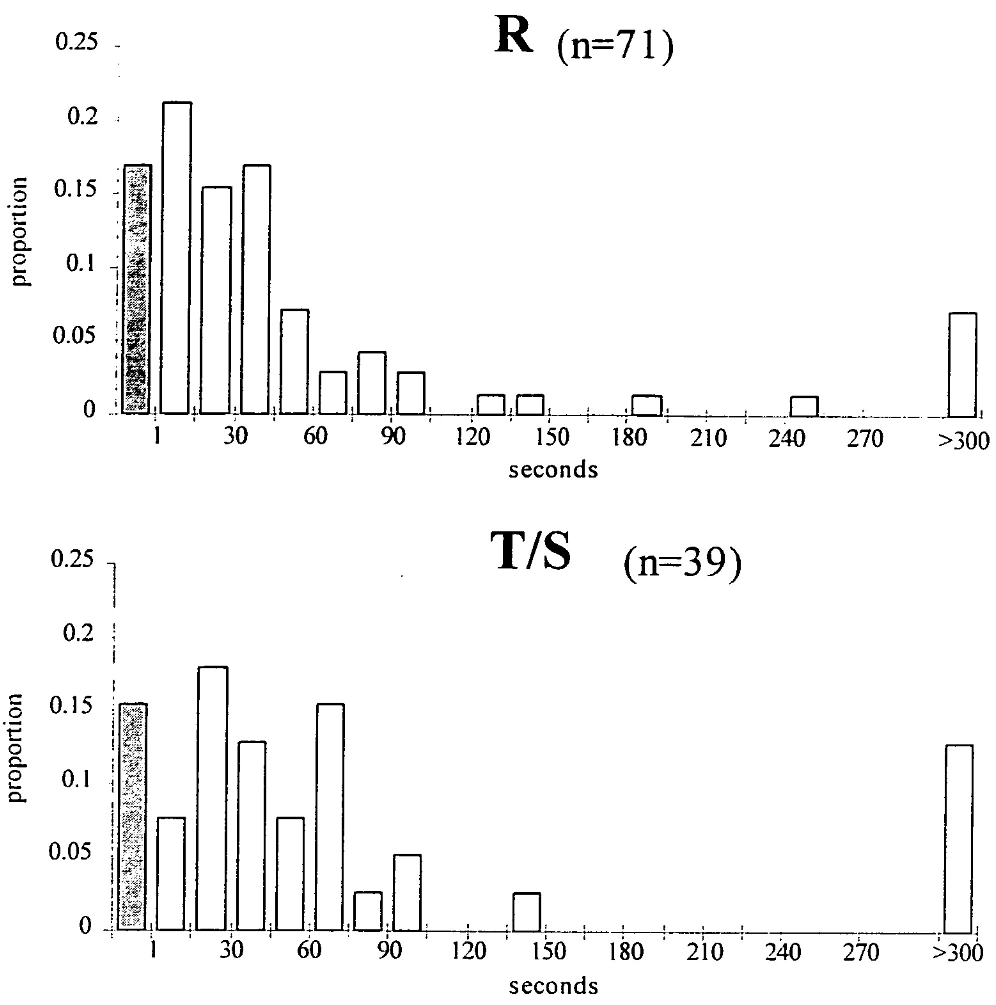

Figure 4.3: Frequency distribution of durations of tonic immobility (in 15-second intervals) of pigs who did not react (relaxed, R) and of those who reacted (tense or struggle, T/S) in the handling/injection test. The first bar represents the number of piglets who did not become immobile in the tonic immobility test (non-TI)

4.4.3 Speed of movement

Overall, the pigs were easy to move. Only 14% of the pigs turned in an attempt to get back to the familiar room. 33% received no 'tap', 67% received at least one 'tap', 17% received 10 or more. 37% of the pigs were 'hesitant' (H), 14% 'explored' (E), and 49% 'walked freely' (F). The three categories differed in their speed throughout the raceway, H and E pigs being slow, receiving more 'taps', and F pigs being fast, receiving few 'taps'.

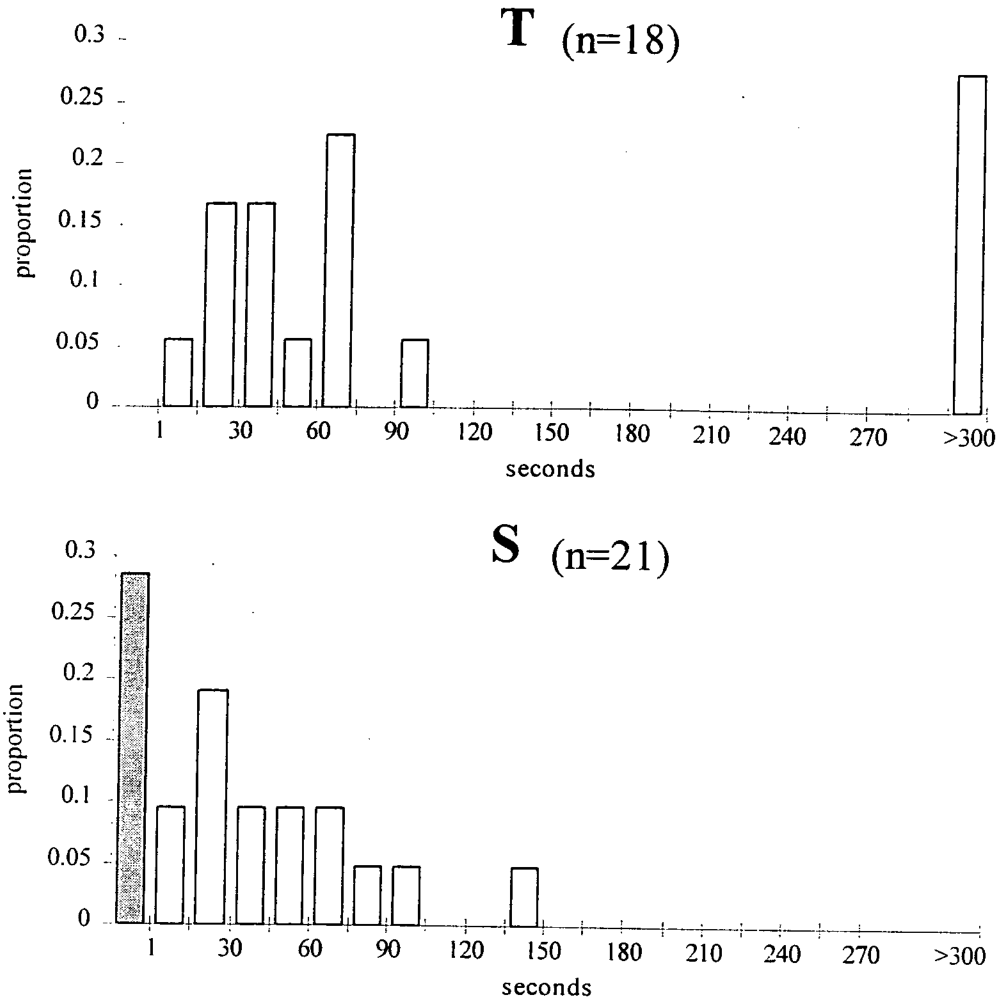

Figure 4.4: Frequency distribution of durations of tonic immobility (in 15-second intervals) of pigs who were tense (T) or struggled (S) in the handling/injection test. The first bar represents the number of piglets who did not become immobile in the tonic immobility test (non-TI)

None of the 12 non-TI pigs turned in the raceway, while 10 of the 58 TI- pigs turned at least once (Fisher's exact test, p=0.13). 50% of non-TI pigs never stopped (i.e. received no 'tap'), compared with 30% of TI- pigs. All pigs who received more than 10 'taps' were TI-susceptible (χ^2 test , χ^2=2.96, df=2, n.s.).

All pigs who 'explored' had a high susceptibility to TI (χ^2 test , χ^2=3.68, df=3, n.s.), but there was no statistically significant relationship between these categories (H, E, F) and the pigs' behaviour in TI (χ^2 test , χ^2=3.18, df=2, n.s.), nor to their behaviour in test 2. There was no statistically significant difference between R, T, and S pigs in their speed of movement (Kruskal-Wallis test, H=3.77, df=2, n.s.).

The speed of movement was not correlated with the duration of tonic immobility (Spearman rank order correlation, r_S=0.03). Pigs with low susceptibility to TI moved significantly faster than those with high susceptibility (time taken to complete the raceway, mean ± SEM: non-TI pigs 33.7 ± 2.0 seconds and TI pigs 41.1 ± 1.7 seconds). This result was checked for potential confounding effect of litter (see 2.5. Data Handling).

In the REML analysis, the stratum variance for litters has 6 degrees of freedom, which is the maximum possible, whilst the stratum variance for within-litter variation has 61 degrees of freedom, the minimum possible. This suggests the effect of the tonic immobility test is estimated almost entirely within litters rather than between litters. Thus the Wald statistic of 3.9 for tonic immobility can be referenced to an F distribution on 1 and 61 degrees of freedom, for which p=0.05. This p-value was confirmed by a simulation study in which times were randomly permuted between piglets within litters. Of the 1000 randomisations performed, the observed Wald statistic was exceeded on exactly 5% of occasions. The estimated mean times are 34.1 and 41.1 seconds (sed=3.5 seconds).

4.5 Discussion

Tonic immobility was shown by the majority of the pigs we tested (80%). We found it not to be related to sex, nor to the order of testing. Since order of testing was correlated with time since the last suckling, we can exclude a direct effect of the meal on the subsequent immobility. The differences between litters are in agreement with studies on other species which established a strong genetic influence on TI (chickens: Gallup, 1974b, rats: McGraw & Klemm, 1973). The large within-litter variation, however, indicates that TI is not a property of the litter, but of individual piglets in a litter. Most of the litters included in this study had at least one non-TI pig.

If an experimenter assigns different treatments to different animals, and is interested in the effect the treatment has on them, then it is important that the differences between litters do not mask or enhance this treatment effect. In this paper, however, we did not assign treatments to animals. We were interested in "naturally occurring" individual behavioural characteristics. Differences between litters point to an influence of genetic and environmental factors on the behaviour. In the case of personality tests, this influence is to be expected. Genetic and environmental factors do not MASK differences in personality, they CAUSE them. We therefore do not consider differences between litters as confounding, but as an integral part of personality research.

To address the question as to whether TI is an indicator of the level of responsiveness (predisposition to respond, in the same way as 'fearfulness' is the predisposition to experience fear) or of behavioural strategies, i.e. the type of response shown when responding, we compared the behaviour in the TI test with the behaviour in response to test 2 (handling/injection). First, we have to interpret the three types of behaviour shown in response to the injection as concerns their relationship to responsiveness. We suggest that 'tense' (T) and 'struggle' (S) represent two ways of responding to the situation while 'relaxed' (R) constitutes no change in behaviour, i.e. no response. The distribution of vocalisations supports this view of dividing the categories into two groups, with T and S on one side (screaming) and R on the other side (non-vocalising). Since calling by piglets, and screaming in particular have been shown to be signals of need (e.g. Weary & Fraser, 1995), we conclude that T and S may be reactions of pigs who perceived handling as aversive, whereas R pigs were less distressed by the situation. Following this hypothesis, we suggest that T and S may indicate that the situation was experienced as a challenge, while R indicates 'no challenge'. Since T and S pigs (responding) did not differ in TI from R pigs (not responding), we conclude that, if our assumptions are correct, TI does not reflect levels of responsiveness in a challenging situation.

On the second level of analysis, we compared the TI response of those pigs who showed different ways of responding to the handling test. Within the group of pigs who responded to the injection, T may be regarded as the more passive response, similar to freezing, whereas S may represent a more active response, similar to fight/flight. Since T pigs were more susceptible to TI and stayed immobile for longer than S pigs, we conclude that TI is more related to how an individual reacts in an aversive situation (i.e. to behavioural strategies) than to whether it finds a situation aversive or not (i.e. responsiveness). This line of argument is summarised in figure 4.5.

But how consistent are animals across a longer time period and in a different, but still challenging situation? Both TI and the injection test involved restraint of the pigs. In the 'speed of movement' test, the challenging stimulus is not physical restraint, but aspects of the environment, like unfamiliarity, differences in lighting levels, and being enclosed in a small space (Lambooij & van Putten, 1993). If TI reflects stable behavioural strategies, then one would expect pigs who differ in their reaction to TI to also differ in their behaviour in the raceway. And if these strategies concern the way an individual behaves in a challenging situation, the largest differences ought to be expected in the most aversive situations. As far as the speed of movement is concerned, the results followed this pattern, revealing the largest differences between TI- and non-TI pigs in the unfamiliar corridor and on the ramp. Pigs who had moved faster and sooner in the TI test (non-TI), also moved faster along the raceway. Detailed analysis has shown that even though there were considerable differences between litters in the reaction to TI as well as in the speed of movement, the predictive effect of TI was not due to these litter differences.

It should be noted that the speed of movement was only different between TI- and non-TI animals, the susceptibility to TI being more predictive than the duration of immobility. The link between TI and other aspects of the behaviour in the raceway was less clear. We found that none of the 12 non-TI pigs tried to turn back, and none of them explored the corridor. Since the TI- pigs were also less likely to

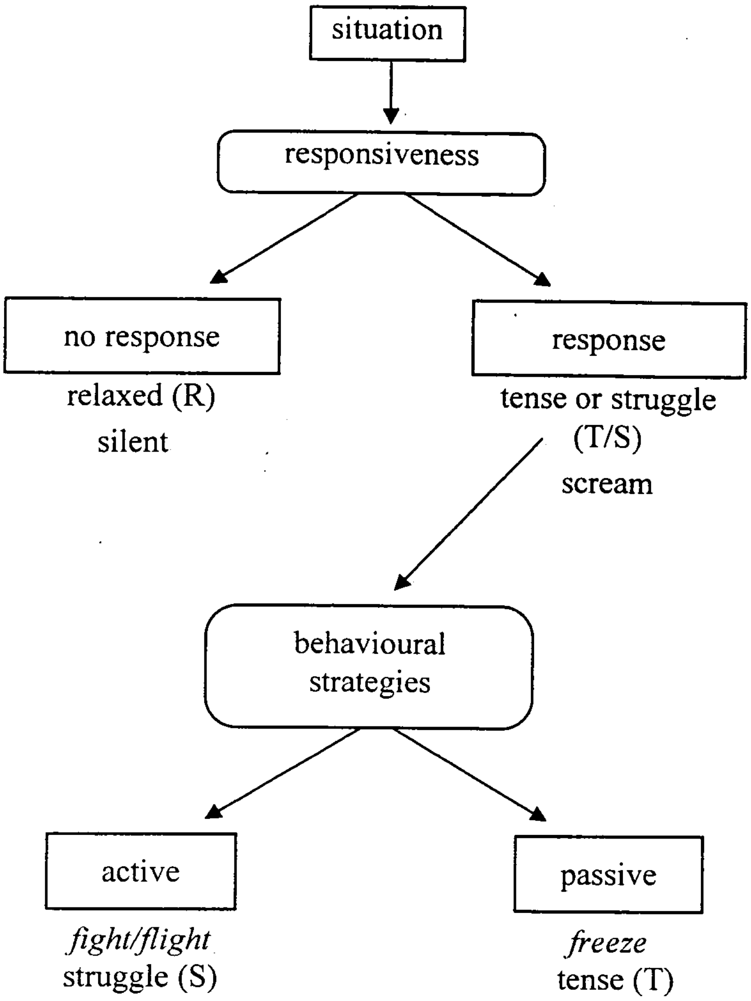

Figure 4.5: Model of responsiveness and behavioural strategies

turn back than not to turn, and less likely to explore than not, the differences between the two categories were not found to be statistically significant. But is the fact that no non-TI pig showed turning or exploration meaningful? We feel that the sample size of twelve non-TI pigs is not sufficiently large to answer this question, and therefore refrain from drawing any conclusions about exploratory behaviour etc.

From an animal husbandry point of view, the relative desirability of the different strategies is context dependent. While TI- pigs were easier to hold (test 2), non-TI pigs were easier to move (test 3).

4.6 Conclusion

Individual differences in tonic immobility predicted the behaviour of juvenile pigs across a two month interval. Non-TI pigs, those who struggled immediately when turned on their backs, appeared more 'active' in the handling test (were more likely to struggle), and moved faster in the raceway, than those pigs who became immobile in the TI test.

These differences are better explained by differences in behavioural strategies than by differences in responsiveness. In this respect we propose that TI is one possible way of assessing whether individual piglets are more likely to adopt a more active or a more passive behavioural strategy in a challenging situation.

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Chapter 5

Tonic immobility and emergence time in pigs: Behavioural strategies in the active/passive dimension[*]

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[*] A paper based on this chapter will be published as 'Tonic immobility and emergence time in pigs: more evidence for behavioural strategies' by Erhard, H.W. and Mendl, M. in Applied Animal Behaviour Science 61 (3) 227-237

5.1 Abstract

The aim of this study was to further investigate the link between tonic immobility (TI) in pigs and active/passive behavioural strategies. Twenty-nine female and entire male pigs were subjected to a series of tests at the age of three weeks. Individual pigs were tested for their latency to emerge from a box and this was followed by a tonic immobility test. This procedure was carried out on four consecutive days. The behaviour of the pigs on day 1 differed from the behaviour on the other test days in that the emergence time was shorter ($p<0.01$), and in that pigs looked out of the box less frequently before leaving it ($p<0.01$). Emergence times on days 2-4 were correlated, but not with the emergence time on day 1. Pigs tended to be less resistant to TI on days 3 and 4 than on days 1 and 2. Pigs who did not become immobile in the TI test on day 1 had significantly shorter emergence times on that day than pigs who did become immobile ($p<0.01$). There were no other significant relationships between TI and emergence test behaviour.

These results are discussed in the context of fear and active/passive behavioural strategies. It is suggested that the link between TI and emergence time on the first test day is more easily explained by differences in active/passive behavioural strategies than by differences in fear.

KEYWORDS: Personality, individual differences, responsiveness

5.2 Introduction

Immobility as well as fight or flight are both responses to threatening situations (Gray 1987). In the context of active/passive behavioural strategies (sensu Benus et al., 1991), immobility can be said to represent a passive, and fight/flight an active response. Benus et al. (1991) showed that individual behavioural strategies in mice are consistent across different contexts. They found that mice from a line selected for short attack latency are fast attackers, quick to form a routine (i.e. perform poorly when maze configurations are changed), and show a low responsiveness to changes in their environment, whereas mice from a line selected for long attack latency are slow attackers, less likely or slower to form routines (i.e. make fewer errors when maze configuration is changed), and highly responsive to changes in their environment. They called the short attack latency lines "active copers" and the long attack latency lines "passive copers" according to their locomotor response to social (aggression) and non-social challenges (electric shock).

McGraw & Klemm (1973) have shown a similar interrelationship between tonic immobility (TI) in rats and their speed of learning to run a maze (i.e. ability to solve new maze configurations). Rats bred for high performance in a maze task ('maze-bright') were more susceptible to TI, and showed generally a more 'passive' behaviour than those bred for low performance in the maze ('maze-dull'), who were generally more 'active'. Tonic immobility, particularly in birds, is generally seen as indicating the level of fear (Jones, 1986, Gallup, 1977). If, however, susceptibility to TI can be regarded as reflecting the level of 'activity' on an active-passive continuum, or as indication of an active or passive behavioural strategy in an aversive situation (low susceptibility = quick escape response = active; high susceptibility = slow escape response = passive), then the rats tested by McGraw & Klemm (1973) showed the same link between a more active behaviour and poor performance in a maze on one hand and a more passive behaviour and high performance in a maze on the other hand.

Erhard & Mendl (1997) reported the phenomenon of tonic immobility in pigs and suggested that the susceptibility to/duration of the immobility response in pigs may be seen as an indicator of the type of fear response (freezing vs. fight/flight) shown in a challenging situation rather than of fear itself (sensu Boissy 1995). The authors suggested the possibility that the behaviour in TI reflects a predisposition to react more or less strongly, quickly and lastingly to challenging stimuli, meeting the definition used by Savage & Eysenck (1964) for 'emotionality'. Similar definitions are used for the terms 'temperament' (e.g. Fordyce et al., 1988, Grandin, 1993) or active/passive behavioural strategies (Benus et al., 1991, Hessing et al., 1993).

In this experiment, we set out to further investigate the relationship between TI, fearfulness, and active/passive behavioural strategies. According to Gray (1979), fear-evoking stimuli can be categorised (among others) as those which are part of a species' evolutionary history, those which are results of learning, and novelty. One test which confronts animals with a variety of these stimuli is the emergence test. This test belongs to the group of 'timidity tests' (Archer 1973), and measures the reluctance to enter an arena from a start box. One interpretation of the test is that the more 'timid' an individual is, the more reluctant it will be to enter the arena. This measure, the animal's reluctance to enter the arena/leave the box can be seen in both the emergence time and the number of times the animal looks into the arena before it finally enters it. The 'looking' bears similarities to the behaviour of rats in a maze, who "...at a point of choice often hesitate and alternately face the alleys ahead of them" ('vicarious trial and error'; Muenzinger, 1938). Muenzinger (1938) suggested that the behaviour reflects a 'testing out of the choice possibilities" (see also Grandin et al., 1986 for similar behaviour in sheep). In the same way 'looking' into the arena can be regarded as anticipating the consequence of entering it, and the frequency of this behaviour as an indicator of the reluctance to do so. Another interpretation of the behaviour in an emergence test is that it presents the animal with a conflict between the motivation to explore the novel environment and the fear of novelty (Montgomery, 1955). The reluctance to leave the emergence box may be regarded as a reflection of the severity of the conflict.

The aim of this experiment was to compare the behaviour of pigs in an emergence test with their susceptibility to and duration of TI, in order to gain more information about the relationship between TI, fear, and active/passive behavioural strategies. To investigate the extent to which the behaviour in the two tests (TI and emergence test) is repeatable, we performed both on four consecutive days. This repetition provided information about the changes across days within the tests (intra-test consistency). Cross-time and cross-situation consistency are required before differences in behavioural responses can be regarded as a personality trait (Liebert & Spiegler, 1993).

5.3 Material and methods

5.3.1 Animals and housing

Experimental subjects were 29 female and entire male pigs from three litters. They were 3 week old commercial (Large White x Landrace) x Large White crosses and housed with their dams in farrowing crates. The only handling of the piglets prior to the experiment consisted of teeth clipping, ear notching and iron injections on the first day after birth.

5.3.2 Behavioural tests

Immediately after the completion of a suckling bout, an entire litter of pigs was put into a transport box and moved into a separate room, where the piglets were individually marked with a marker pen on their backs.

The tests were performed on individual piglets, the emergence test being carried out first, immediately followed by the TI test. Individual pigs were tested in a randomised order. This procedure was carried out on four consecutive days.

Behaviour was recorded using KEYTIME® and KEYBEHAVIOUR® (Deag, 1993).

5.3.2.1 Emergence test

The start box measured 55 x 53 cm and was 60 cm high, closed by a lid, with a sliding door (37 x 48 cm) to the arena. The arena was 1.5 x 1.5 m wide, the sides were metal sheets approximately 1.20 m high. The experimenter stood behind the start box, outside the visual field of the piglet (Figure 5.1).

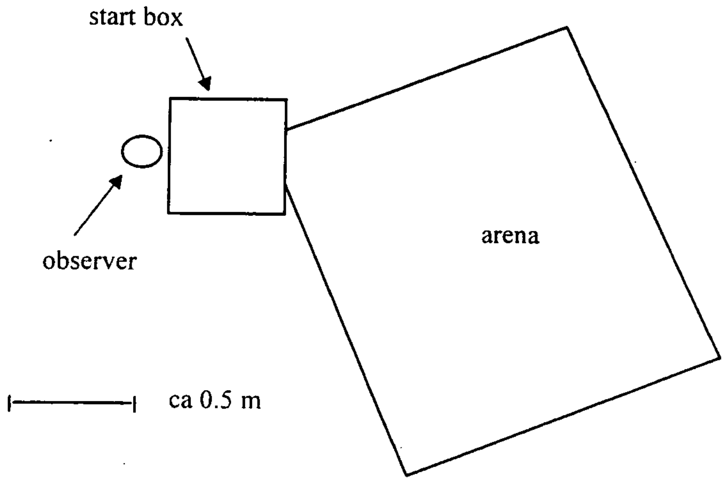


Figure 5.1: The setup for the emergence test

The experimenter picked up a piglet from the transport box, placed it into the start box, closed the lid of the box and immediately opened a sliding door to the arena. Parameters recorded were the latency to leave the box (emergence time, 'ET'; all four legs outside the box) and the number of times the piglet put its nose outside the box before it emerged ('look'). As soon as the piglet had entered the arena, the experimenter picked it up and performed a TI test (see below). If a piglet did not leave the start box within 10 minutes, the experimenter picked it up from the start box to perform the TI test. The pig was allocated an emergence time of 600 sec. One pig did not leave the start box on day 2, and three pigs on days 3 and 4, only one piglet stayed in the box on two test days.

5.3.2.2 Tonic immobility test

Having picked up the piglet from the arena, the experimenter placed it on its back onto a V-shaped wooden cradle (55 cm long, angle approximately 80°). He then put a sand-filled cloth bag (15 x 20 cm2, ca. 500g) on the piglet's chin and gently stretched its back legs. The time from when the experimenter released the piglet to when it struggled was recorded as duration of tonic immobility (we call these pigs 'TI pigs'). If a piglet struggled immediately when put on its back ('non-TI pigs'), the procedure was repeated up to three times. If the piglet did not respond within 5 min, the test was terminated and a latency of 300 seconds was allocated.

The piglet was then returned to the transport box, and the next piglet picked up for the emergence test. For a detailed discussion of the TI test see chapter 4.

5.3.3 Data handling

Having tested 22 litters of pigs, Erhard et al. (chapter 4) reported that litters as well as individuals within a litter can differ significantly in their susceptibility to and duration of TI. Non-TI pigs (those who did not show an immediate immobility response) were found in each litter (1, 2, and 3 non-TI pigs in each of the three litters). The differences found between non-TI and TI pigs were therefore not due to differences between litters, but resulted from differences between individual pigs within litters.

On each day, the response to the TI test consisted of two separate parts, the number of inductions needed to induce immobility (susceptibility to TI) and the duration of the immobility once induced. The analysis showed that it was more predictive of future behaviour how a pig responded to the first induction than for how long it eventually stayed immobile after several inductions (see also chapter 4). In the analysis we therefore used a TI duration of 0 seconds for pigs who struggled immediately at their first induction (non-TI pigs).

Since all tests were performed on individual pigs, the data were considered independent and individual piglets were treated as units, resulting in a sample size of 29. Due to non-normality of the data, nonparametric statistics were used for the analysis. We used the Friedman test to investigate day effects. If a significant effect of day was found, we carried out paired Wilcoxon tests to determine when the changes had occurred. We calculated Spearman Rank Order Correlations for the comparison of the behaviour in the two tests, and for comparing the repeatability of each test across days. To compare the emergence times of pigs who showed an immobility response with those who struggled immediately we used the Mann-Whitney test (Siegel & Castellan, 1988).

5.4 Results

5.4.1 Day effect

There was a highly significant day effect on emergence time, piglets leaving the box faster on day 1 than on the other three days (Friedman test, S=13.96, df=3, p<0.01; figure 5.2). The emergence times on days 2, 3 and 4 are correlated with each other, but not with the one on day 1 (Table 5.1).

Table 5.1: Consistency of the emergence latency to enter the arena between the four test days (Spearman rank Order Correlation)

	day 1	day 2	day 3
day 2	0.15		
day 3	-0.07	0.66***	
day 4	0.07	0.52**	0.64***

The frequency of piglets looking out of the box before finally emerging was smaller on day 1 than on days 2, 3 and 4 (Friedman test, S=12.97, df=3, p<0.01; figure 5.3).

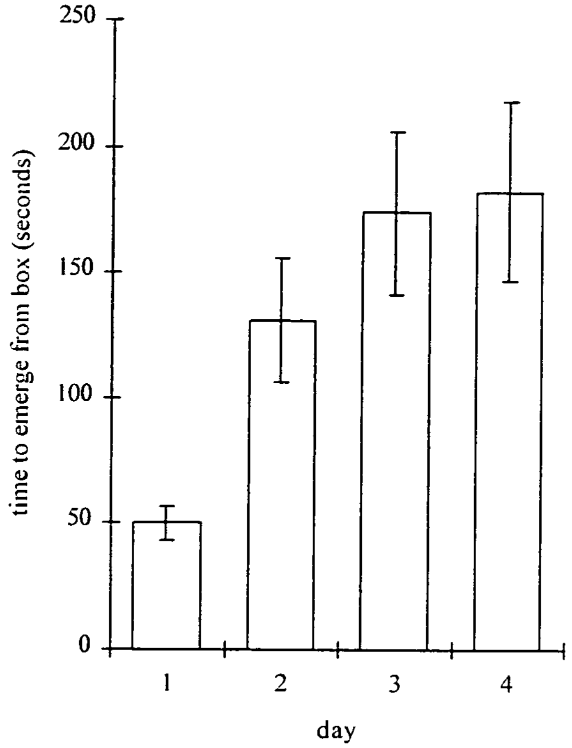


Figure 5.2: Emergence time on 4 consecutive test days (MEAN ± SEM)

The number of immediate strugglers in the TI test decreased from day 2 to day 3, with 6, 7, 2 and 1 on days 1, 2, 3 and 4. We found a tendency for piglets to stay immobile for longer on day 3 than on day 2. The other days did not differ significantly (Friedman test, S=7.54, df=3, $p<0.06$; figure 5.4). Immobility durations on the four days were correlated (Table 5.2).

Table 5.2: Consistency of durations of immobility (in seconds) between the four test days (Spearman rank Order Correlation; *** = $p<0.001$)

	day 1	day 2	day 3
day 2	0.56**		
day 3	0.52**	0.48**	
day 4	0.28	0.55**	0.68***

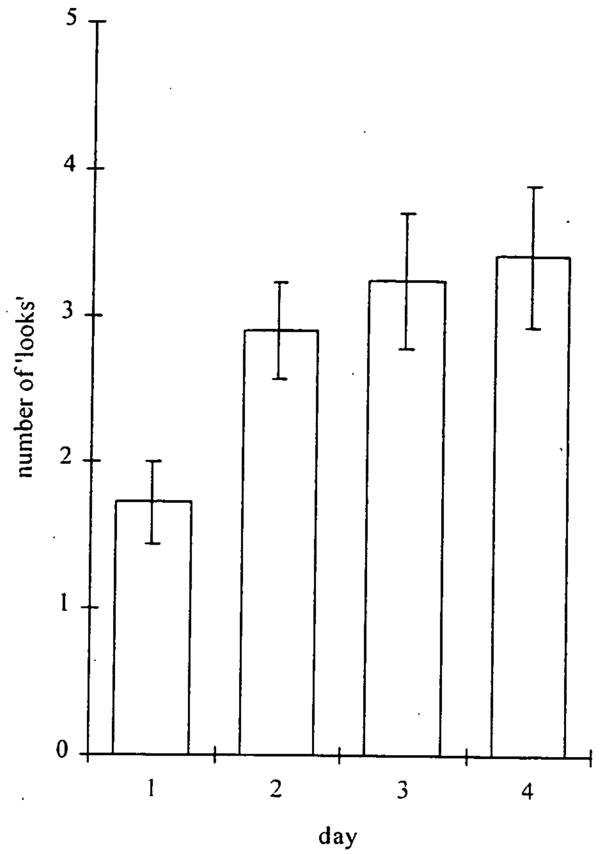


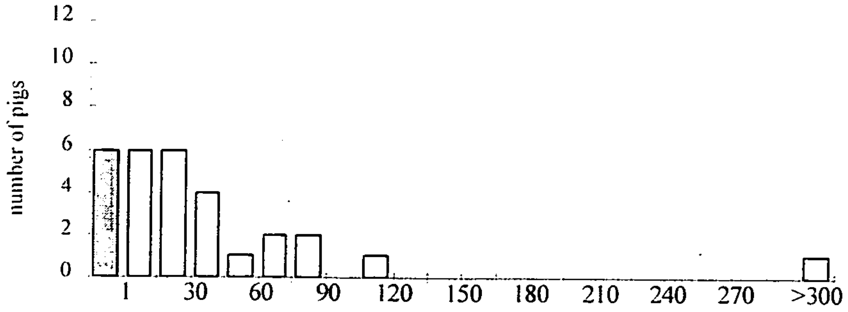
Figure 5.3: Frequency of 'looking' out of the start box before entering the arena on four consecutive test days (MEAN ± SEM)

5.4.2 Interrelationship of TI and emergence test

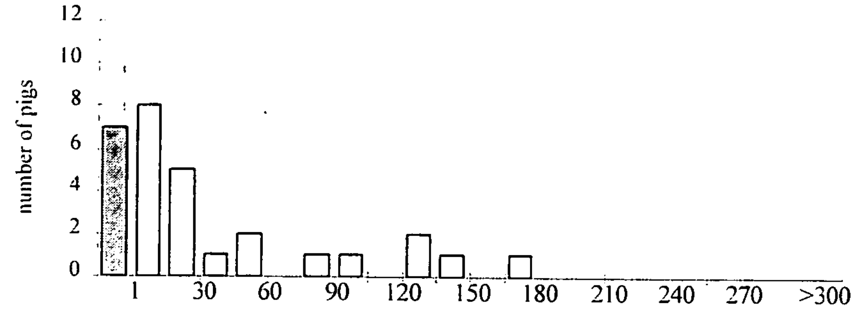
Pigs who struggled immediately in test 1 had significantly shorter emergence latencies than those who showed an immobility response (medians and 25% and 75% interquartile for emergence times (in seconds) of non-TI and TI-pigs in test 1: 17 (12-32.25) and 51.5 (26.5-71); Mann-Whitney, n1=6, n2=23, W=40.0, $p<0.01$; figure 5.5). Our data revealed a statistically significant, but small correlation between emergence latency and duration of immobility on day 1 (Spearman Rank Order Correlation, r=0.37, $p<0.05$).

The two tests showed no other relationship on any of the other test days.

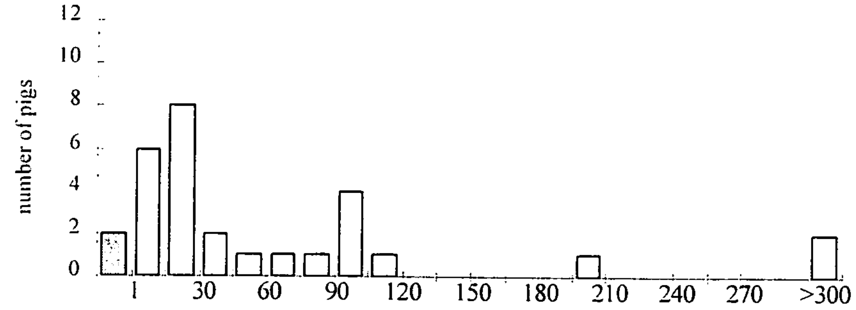
a) day 1



b) day 2



c) day 3



d) day 4

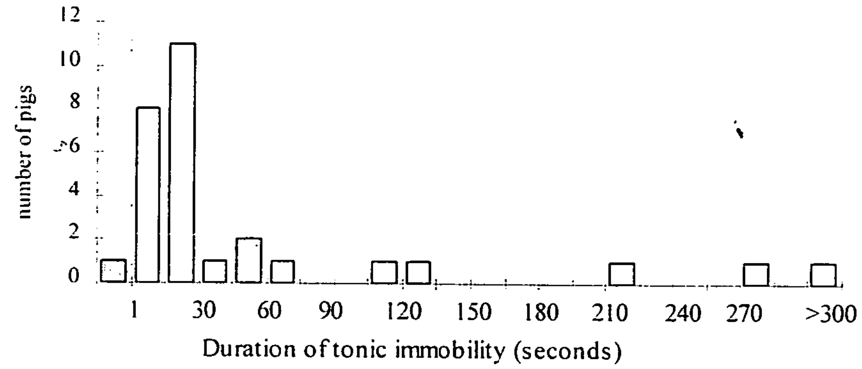


Figure 5.4: Duration of tonic immobility on four consecutive test days

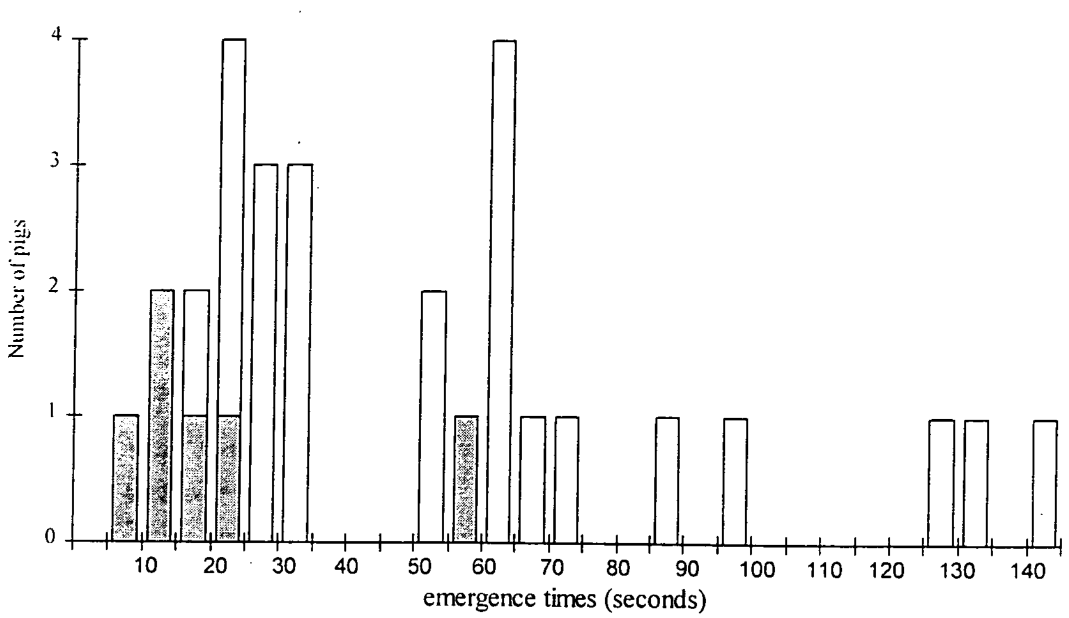


Figure 5.5: Frequency distribution of emergence times in test 1. Pigs with low susceptibility to TI (non-TI) are displayed in grey, pigs with high susceptibility (TI) in white.

5.5 Discussion

In this discussion, we will first try to interpret our results in support of the fear hypothesis (TI reflects fear), and then compare this interpretation with one linking TI and active/passive behavioural strategies.

The fear hypothesis

The time an animal takes to emerge from a box into an arena or open field is a reflection of its timidity (see Archer, 1973). The more fearful an animal is, the longer its emergence time. Piglets with high susceptibility to TI left the box more slowly than piglets with low susceptibility (on day 1). TI thus reflected the levels of fearfulness in pigs on this day. Fearful pigs were either fearful in both tests, or the fear induced by the emergence test (the longer they stayed in the start box, the more afraid they were) was still present in the piglets when tested for TI immediately after the emergence test. That emergence time can be seen as a reflection of the fear of entering the arena, or of the aversiveness of the arena, was indicated by the increase in emergence latency from day 1 to days 2-4, when piglets had probably made the connection between entering the arena and being picked up and handled. The increase in dithering (vicarious trial and error, sensu Muenzinger, 1938) from day 1 to days 2-4 was parallel to the increase in emergence latency and can therefore be regarded as another indication of the increase in fear experienced in the course of the experiment, and underlines the interpretation of emergence time measuring fear.

Inconsistencies between the results and the fear hypothesis

The test environment

Classic emergence tests measure the time an animal takes to enter an unfamiliar test arena from the home pen (see Archer, 1973). The interpretation of the emergence test depends to a large extent on the nature of the start box and of the arena. If the start box is the animal's home pen, the difference between this and the arena is the difference between familiarity (i.e. relative safety) and unfamiliarity (i.e. potential danger). If, however, the start box is novel to the animal, and if the animal belongs to a social species, it may represent danger (unfamiliarity and social isolation) and is therefore an aversive stimulus (the animal is already in this situation). The arena, even though novel and therefore potentially dangerous, represents the only way out of the box, and therefore out of the already dangerous situation. The animal faces the choice not between a safe start point (e.g. home pen), and a potentially threatening novel environment (e.g. arena), but between two fear-evoking situations, one already present and known (the box), the other unknown.

This argument is supported by the findings of Misslin & Cigrang (1986), who investigated the differences in fear experienced by rats when given the opportunity to move around freely between a familiar and a novel environment (voluntary 'exploration'), and when forced to stay in an unfamiliar environment (forced

’exploration’), by either preventing them from leaving the unfamiliar environment once entered, or by placing them physically into this environment. Misslin & Cigrang (1986) found that forced ‘exploration’ resulted in increased levels of blood-corticosterone, and in increased proportion of animals who urinated and defecated during the test, and concluded that fear was imposed by the forced nature of the exposure to novelty, not the novelty as such. Emergence time in itself may therefore be a poor indicator of fear in a test situation, where animals are placed in novel and potentially frightening situations. This view is supported by the changes in dithering from day 1 to days 2-4.

Dithering as an indicator of fear

Dithering or ‘vicarious-trial-and-error’ occurs at a point of choice, when an animal is either unsure or trying to discriminate (Muenzinger, 1938). It is often observed when animals are faced with a choice between two unpleasant alternatives (Brown, 1942; Goss & Wischner, 1956). If the repeated ‘looking’ into the arena of the piglets is related to ‘vicarious trial and error’, then the doubling of ‘looking’ from day 1 to days 2-4 could be regarded as indication that the choice between staying in the box and entering the arena was more difficult on days 2-4. A consequence of this difference is the possibility that the emergence behaviour on days 2-4 was more ’deliberated’, a combination of aspects of the environment and past experiences, whereas the behaviour on day 1 may provide information on how a piglet behaves, when it has no experiences to base its decisions on.

Lack of correlation between test days

If TI was directly related to emergence times (a long time spent in the start box enhances fear and thereby affects the TI response), as suggested in the fear hypothesis, the significant change in emergence times from day 1 to days 2-4 would be reflected in a similar change in TI. This was, however, not the case.

Also, the correlations of emergence times between test days show that there is a meaningful difference between the first and the other test days. This difference is best explained by the effect of experience on the animals' behaviour. If the animal is picked up and handled, as soon as it enters the arena, it may learn to associate entering the arena with this experience. An unpleasant experience would be expected to increase the aversiveness of the arena, while a pleasant one would decrease it.

On day 1, the pigs found themselves in a situation they had never experienced before. Neither the social isolation, nor the relatively small box (as compared to the familiar creep), nor the open, empty space in the arena were familiar to them. They did not know that they would be picked up and handled as soon as they entered the arena. The increased reluctance to leave the box on days 2-4 was most likely a result of the aversiveness of being handled immediately after having entered the arena on the previous day, and of the animals' learning to anticipate this. Nash & Gallup (1975) found that the induction of TI was aversive to chickens. Since the piglets were picked up and handled as soon as they entered the arena, this was most likely perceived as a negative reinforcement, resulting in longer emergence latencies on days 2-4.

If TI in pigs reflected fear, then one should expect a significant between-day-difference in TI, similar to the difference in emergence time. This was, however, not found.

Alternative hypothesis: TI and active/passive behavioural strategies

When in a novel challenging situation, individual pigs can behave in a more active or a more passive way, e.g. fight/flight versus freezing (Erhard et al., 1997; see also Hessing et al., 1994).

Being placed alone into an unfamiliar box can be regarded as being a challenging situation for a piglet (compare Misslin & Cigrang, 1986, for mice), as can being placed up-side-down on a wooden cradle. An active response to bring about change would be to quickly leave the box, and to quickly struggle when turned up-side-down. Piglets who struggled immediately when put on their backs left the emergence box more quickly than those who became immobile. Susceptibility to TI may therefore be regarded as showing whether an individual pig is more likely to adopt an active or a passive behavioural strategy.

Since the relationship between TI and the behaviour in the emergence test was only apparent on day 1, it is possible that TI provides information how pigs are likely to behave in novel situations. This hypothesis takes the differences between day 1 and days 2-4 in emergence time as well as the consistency in TI into account, as well as the specific test environment in the emergence test.

5.6 Conclusion

Even though there was a relationship between TI and the behaviour in the emergence test, the two differed remarkably in their change over time. The link between TI and emergence time existed on day 1 only, which indicates that rather than reflecting a learned aversiveness or fear which may be perceived at a given moment in time, TI reveals something about the behaviour of pigs who are faced with a challenging situation for the first time. The response to TI can be regarded as reflecting an element of activity (e.g. speed of movement/locomotion) comparable to the emergence from the box, in that pigs with low susceptibility to TI respond more quickly (i.e. struggle immediately, leave the box quickly) while those with high susceptibility respond more slowly (i.e. struggle later, leave the box later). In this respect it could be used as an indicator of active/passive behavioural strategies.

We think that the measure of emergence latency is not a good indicator of fear in the test as we used it on all days, but might provide a good measure of active/passive response style on the 1st day, when both environments (startbox and arena) are novel and potentially fear-inducing. If so, then the link between TI and emergence latency on day 1 is most likely to occur because both TI and emergence latency are telling us something about active/passive response styles to a challenging situation.

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Chapter 6

Measuring persistence of behaviour in pigs

6.1 Abstract

There is increased interest in the study of personality of domestic animals. Timidity and aggressiveness, as well as the reaction to challenges, often referred to as 'temperament', 'emotional reactivity', 'active/passive coping', or 'the active/passive dimension', have been extensively studied. The aim of this project was to establish to what extent flexibility in the response to changes in the environment can be seen as another personality trait. The experiments studied the medium term (4 and 7 weeks) consistency of responses to a novel stimulus ('distraction'), and the interrelationship between different aspects of flexibility in two maze-reversal tasks.

We found persistence to be shown in three aspects of behaviour:

- the responsiveness to changes in the environment (whether or not the pigs reacted to a distraction bar) was consistent across time, with 69% (across 7 weeks) and 71% (across 4 weeks) of the pigs showing the same response in both tests ($p<0.01$)).
- the type of response to novel stimuli (the distraction bar) was related to routine formation, in that pigs who were highly distracted by the bars (i.e. nosed them) were likely to learn to run the maze error-free, whereas those who showed low levels of distraction (looked at the bars without nosing them) were likely to form routines ($p<0.01$).
- the resistance to extinction of a conditioned response, which revealed significant sex differences, females being more persistent than males ($p<0.05$).

These three areas were apparently not interrelated. Thus, although each of these aspects of persistence fulfill specific requirements for being regarded as personality traits, they have to be considered independently rather than as a set of aspects of one trait, persistence.

KEYWORDS: Personality, strategy, distraction, novelty, routine

6.2 Introduction

The variability between individuals in expressing behaviour, qualitatively as well as quantitatively, can be due to differences in underlying motivational states (e.g. exploration and feeding motivation, Hughes, 1965), emotional states (e.g. fear, Boissy, 1995), or behavioural strategies (e.g. active/passive coping, Benus et al. 1991). The term 'temperament' ("a person's distinct nature and character, esp. as determined by physical constitution and permanently affecting behaviour", Oxford Concise Dictionary) can be said to describe characteristics which are influenced by the factors mentioned above. Regarding the temperament ('personality') of pigs, Erhard et al (1997a) have shown that aggressiveness can be measured in pigs and that it is relatively stable across time. Behavioural strategies in response to physical restraint (e.g. fight/flight or immobility) were another aspect of temperament which was shown to be measurable and consistent across time (Erhard & Mendl, in press, Erhard et al.1997b).

In this study we attempted to investigate whether persistence is another attribute of temperament which can be measured in pigs. There are two main reasons for studying persistence. Firstly, it was found to be related to aggressiveness in the studies of behavioural strategies by Benus et al. (1991), who reported that mice selected for high levels of aggressiveness also showed high levels of persistence and low levels of distractibility. Therefore, there is some evidence that high persistence is part of a cluster of characteristics typical for a certain behavioural strategy, or personality type. The second reason has a more applied background. Under modern farming conditions, the natural behaviour of pigs often does not help the individual to reach the intended goal (e.g. rooting, chewing, nest-building). If the individual is persistent in performing this unrewarded behaviour, it may lead to the development of stereotypies, such as bar biting or weaving/pacing (Hughes & Duncan, 1988). In an environment which is changing, or, in the case of farm animals, different from the one they have evolved in, flexibility (or lack of persistence) of behaviour may thus be advantageous.

Persistence can be described as the propensity to continue with a behavioural action in the absence of a reward (or despite achieving a reward/goal). Further, more specific definitions have been proposed. For example, in a study on the effects of testosterone on persistence, Andrew (1972) categorized what he called 'processes of attention' into three classes, (i) persistence of response to a particular type of stimulus, (ii) persistence of response to stimuli in a particular place, and (iii) resistance to distraction by irrelevant stimuli.

The study of persistence in pigs in a maze set up allowed us to examine various forms of persistence:

(i) persistence in performing a particular type of behaviour (e.g. behaviour directed towards the exit doors, which the pigs learned to open to leave the maze arms; this we will refer to as 'behavioural tenacity')

(ii) persistence in performing a behaviour in a particular location (i.e. repeatedly returning to a location which has been connected with a reward; this we will call 'place-tenacity')

(iii) lack of distraction from a particular behaviour by an irrelevant stimulus - the distraction can manifest itself by any response as opposed to no response (we will refer to this as 'responsiveness'), or as type of response shown (i.e. the interruption of the ongoing behaviour to investigate the novel stimulus closely as opposed to the continuation of the ongoing behaviour while momentarily orientating towards the novel stimulus), which we will refer to as 'distractibility'.

Studying persistence in performing a newly learned behaviour has the advantage that the test animals have similar experiences with the behaviour investigated. To study persistence, the individual tested has to connect a specific behaviour or location with a reward, and there have to be alternatives to this behaviour or location, once it proves to be no longer successful. A maze task fulfills these requirements. Once individuals have learned to perform a specific goal-oriented behaviour, e.g. running through a runway or maze to obtain a reward, a novel stimulus can be introduced to test distractibility. If the arms of the maze are reversed, the learned behaviour/location is no longer rewarded, which allows the study of the persistence in performing this behaviour or returning to this location.

There are two ways in which an individual can be persistent in location. Place-tenacity refers to the persistent return to one arm of the maze within one run, even though it was found not to lead to the expected reward (exit of maze and food). After the reversal of the arms, a persistent animal will repeatedly choose the arm of the maze it initially connected with the reward, whereas a less persistent animal will soon try out the other arm of the maze. Place-tenacity is reflected in the number of times an animal returns to the locked door after reversal, within one run.

The second manifestation of this type of persistence is routine formation. An individual who has formed a routine will first choose the incorrect arm when entering the maze, but then use the correct arm to leave the maze. It is therefore reflected in the first choice an animal makes when entering the maze. The routine the animal has learned requires it to chose the arm initially learned to be correct. A non-routine forming animal, on the other hand, will incorporate the experience (the other door is open) and alter its first choice of arms. Routine formation thus differs from place-tenacity, in that it refers to the first choice an animal makes when entering the maze. Place-tenacity, on the other hand, refers to the second and subsequent choices within a run.

Another type of persistence relates to the behaviour rather than a specific location. With behavioural tenacity we mean the animal's propensity to maintain a behaviour previously found to be successful (pushing a door to exit the maze as opposed to finding another exit, sensu Fullard et al. (1984): the degree to which a behaviour is continued in the face of obstacles). This type of persistence/flexibility may be connected to 'mode-switching' (Helfman, 1990). Persistence in this context involves the continued pushing of the now closed door, whereas flexibility is shown by giving up this unrewarding behaviour and trying to find another exit.

In three experiments, we attempted to find out whether individual pigs who score high in one type of persistence also score high in the other types, and whether individual pigs' resistance to distraction is stable across time.

6.3 Material and methods

Three experiments were carried out (see table 6.1). In all three experiments, we worked with female and entire male (Large White x Landrace) x Large White crossbred pigs. Pigs were individually ear-notched on the day of birth. They were weaned at 4 weeks of age. Piglets of less than 5 kg body weight were not weaned, and therefore not involved in experiments which took place after weaning. The behaviour of the animals was recorded using the Keybehaviour and Keytime programs (Deag, 1993).

Table 6.1: Overview of the tests used in the three experiments

experiment	age (wks)	set-up	task
1	3	RW	dis.
	10	T-MZ	dis.
	10	T-MZ	R1
	10	T-MZ	R2
2	6	T-MZ	dis.
	10	T-MZ	dis.
3	10	Y-MZ	dis.
	10	Y-MZ	R

RW = runway
MZ = maze
dis. = distraction
R = reversal

6.3.1 Test procedure

6.3.1.1 Experiment 1

This experiment consisted of two tests, the 'runway' (RW, one day) and the 'maze' (MZ, three days).

91 pigs from 9 litters, aged 3 weeks at runway test (pre-weaning) and 10 weeks at maze test were used in this experiment The same pigs were used in both tests.

The runway test

This test was carried out to assess responsiveness and distractibility at ca. 3 weeks of age while piglets were still with their mothers in farrowing crates. On the day before the test, the pigs were weighed and allotted to pairs (heaviest with lightest, second heaviest with second lightest etc.). Tests were conducted pair by pair, by alternating between the pigs of a pair. The tests started at 1000 hr. No piglets were tested during a suckling bout (from beginning of udder massage to end of suckling).

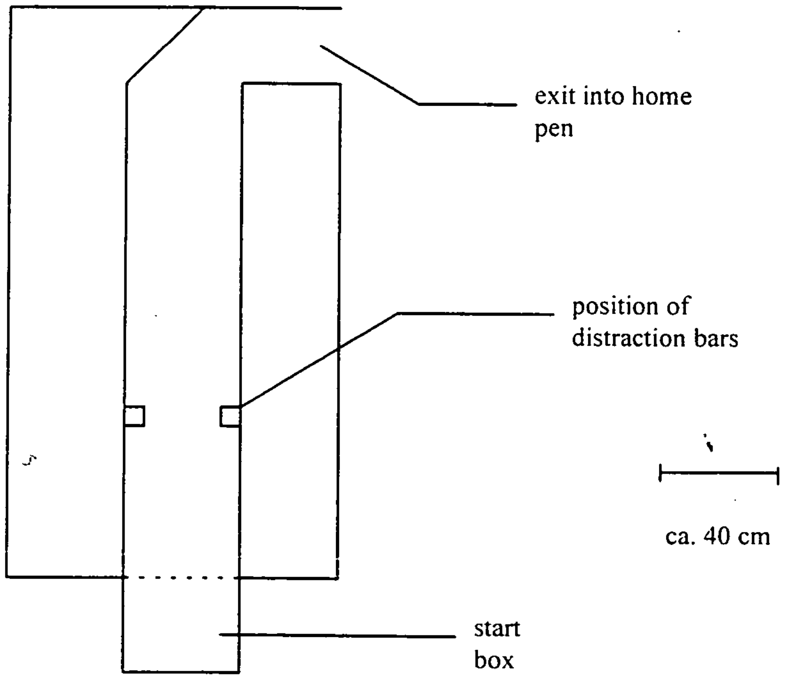

Figure 6.2: The runway used in experiment 1

The handler (different handlers, mostly unfamiliar to the piglets) picked up the first piglet from the pen and placed it into the start box, closed the lid, and opened the door to the runway immediately afterwards (Figure 6.2). After the pig had run through the runway into its home pen, the handler picked up the second pig of the pair and placed it into the start box and so on. This was done to ensure a break between a piglet's leaving the runway and being picked up, in order to avoid the development of a connection between leaving the runway and being handled. As soon as a piglet had completed two runs in less than 4 seconds, but not sooner than the third run, distraction bars (50 x 4 x 1.5 cm, white with black stripes) were introduced into the runway. The responsiveness of the piglets to the distraction bars was recorded as

I (ignore):	no reaction
L (look):	piglet turns its head to face at least one of the distraction bars, but does not touch it
N (nose):	piglet touches at least one distraction bar with its snout.
A (avoid):	piglet moves away from the bar which it has turned to face

I (in contrast to L, N, and A) was taken as an indication of low responsiveness, L and N as indicating low and high distractibility, and A was interpreted as a fear-related behaviour.

The maze test

The task for the pigs was a T-maze (figure 6.3), with one exit closed, the other one open to allow access to a food reward and to the litter mates. The exits were not visible from the decision point.

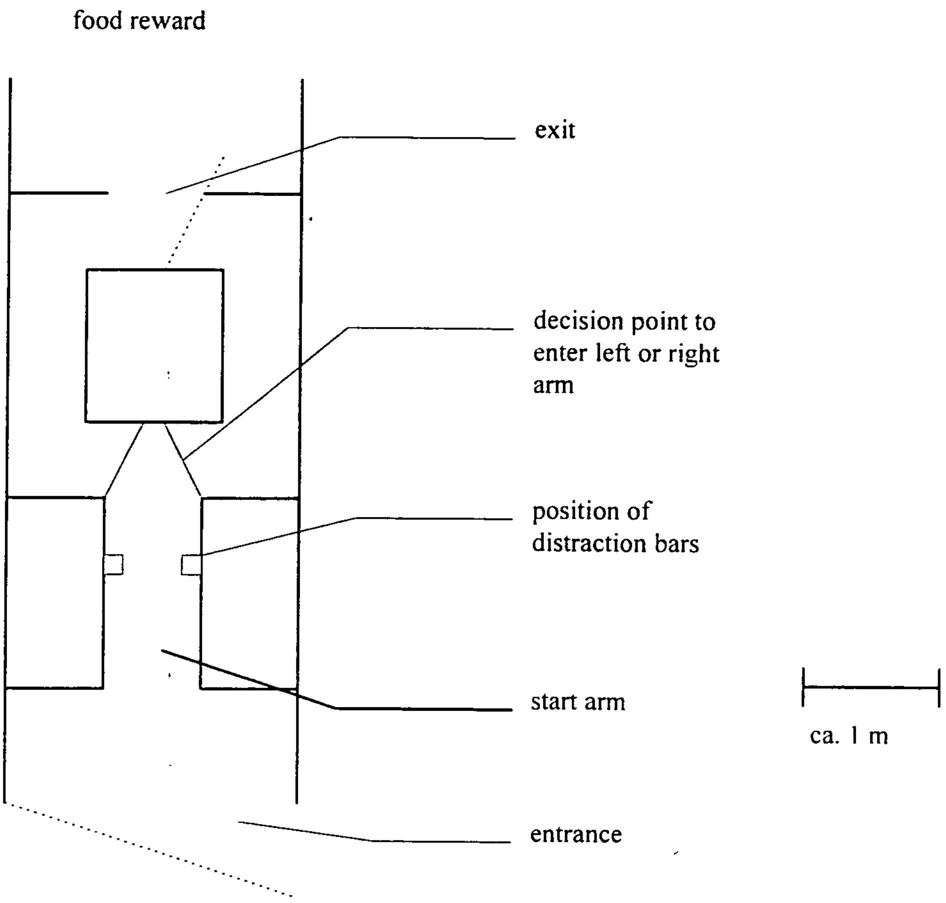

Figure 6.3: The maze used in experiments 1 and 2

These tests were carried out at ca. 10 weeks of age on three test days to assess responsiveness, distractibility, place-tenacity and routine formation

three test days: day 1 (1500 hr): training and distraction

day 2 (0900 hr): first reversal (R1)

day 3 (1500 hr): second reversal (R2)

On the day before the first test day, the pigs were individually spray marked and weighed. To avoid any bias due to the potential effect of body weight on feeding motivation, they were tested in pairs, the heaviest with the lightest, the second heaviest with the second lightest and so on. The two pair members were tested alternately, one was rewarded for going through the right arm of the maze, the other for going through the left arm. The two pigs who were being tested and a third (companion) pig were moved to a holding pen, from which the test pigs were taken to walk through the maze, and to which they were returned afterwards. Food was provided at the exit of the maze throughout the experiment. After having exited the maze, pigs were allowed to feed for ca. 10 seconds. Not all litters were handled by the same person, due to staff shortage. The distance from the holding pen to the entrance of maze was ca. 6 m long, the distance from the exit of the maze back to the start box was ca. 12 m long.

Feeding regime: Pigs were fed to appetite three times a day (0800, 1200 and 1600 hr) for one week prior to the first test day. The feeders (at least one trough space per pig) were placed into the pen at the times mentioned above and removed when the last pig had finished eating. A very important side effect of this method was that the pigs got used to having large meals, which helped them to stay motivated throughout the test.

On the first test day, the pigs were fed at 0800 hr, but the 1200 hr meal was omitted. The testing started at 1500 hours (7 hours after start of previous meal). Pigs were fed to appetite after the last pigs had been tested. On the morning of day 2, pigs were not fed at 0800 hr. The testing started at 0900 hr (ca 15 hours after the previous meal). Pigs were fed to appetite after the last pigs had been tested and at 1600 hr. On day 3, the pigs were fed at 0800 hr, but not at 1200 hr; the testing started again at 1500 hr (7 hours after the start of the previous meal).

Procedure: On day 1, each pig was guided through the maze, entering the incorrect arm first, to familiarize the pigs with the setup. After the pig had completed two consecutive runs with time to first decision (correct or incorrect) of less than 8 seconds, distraction bars (white bars with black stripes, similar to the ones used in test 1; 50 cm long, 4 cm wide, 1.5 cm thick) were attached to both sides of the start arm. There was only one run with the distraction bars in the start arm. One post distraction run was performed.

On day 2, the pigs had to complete two correct runs in a row (a maximum of five runs before the reversal was the limit) before the doors to the exit of the maze were reversed (R1). After the reversal, there a maximum of six runs for each pig. The task was considered to be learned when the pig completed two correct runs in a row. If, however, the sixth run was the first correctly reversed one, a seventh run was performed to show whether the pig showed some consistency in its reversal behaviour.

On day 3, the procedure for day 2 was repeated, resulting in a second reversal (R2), back to the original reward location.

Pigs who did not meet the criteria for a particular test (minimum speed in two consecutive runs, two consecutive correct runs etc.) were excluded from the analysis concerned. Hence the difference in sample size in the various parts of this experiment.

We chose the criterion of two consecutive correct runs for the following reasons. First of all, pilot studies showed that after several correct runs, pigs became likely to spend more time in the experimental setup. In the runway, they would start to nose the walls and floor, in the maze, they would perform similar exploratory behaviour, accompanied by an increased likelihood of entering the 'incorrect' arm of the maze. Mendl et al. (1997) pointed out the role of the experimental setup as stimulus for exploratory behaviour. During the course of the test, the maze itself and its investigation appeared to become a stimulus which competed with the food reward for the pigs' attention. The second reason was one of time scale. By keeping strict limits on the duration of each test run, we were able to test an entire litter in each session. This ensured that all pigs had the same 'history' when they were tested.

Behaviours recorded:

- response to the distraction bars as in the runway test (Ignore, Look, Nose, Avoid)
- total time spent in the maze
- place-tenacity: number of errors (entering the non-rewarded arm) before leaving the maze (in the first run, and as a total of all runs until the learning criterion was reached)
- number of runs to achieve two consecutive error-free runs after the first and second reversal
- routine formation: pigs who completed the maze error-free in two consecutive runs within the six-run limit of the test are referred to as 'non-routine formers'; those who did not reach this criterion are being referred to as 'routine formers'

6.3.1.2 Experiment 2

65 pigs from 7 litters were used in this experiment, once at the age of 6 weeks, and once again at the age of 10 weeks. The feeding regime, experimental setup and procedure were the same as on day 1 of the maze test in experiment 1 (figure 6.3), except for the fact, that both exits of the maze were open and allowed access to food and litter mates. Behaviours recorded are I, L, N, and A, as in the runway and first day of the maze test. The distance between the start pen and the entrance of the maze was less than 1 meter, as was the distance between the exit of the maze and the holding pen.

6.3.1.3 Experiment 3

73 pigs from 7 litters were tested in a maze at 10 weeks of age. The holding pen was next to the maze to keep handling to minimum. The same person (familiar to the pigs) handled all the pigs in all the tests. As in experiment 2, the start pen was in

close proximity to both the entrance and the exit of the maze. The maze (figure 6.4) was Y-shaped, with both exits being cat-flap type transparent perspex doors (40 x 70 x 1.5 cm) hanging down from hinges. One door was locked, the other one could be

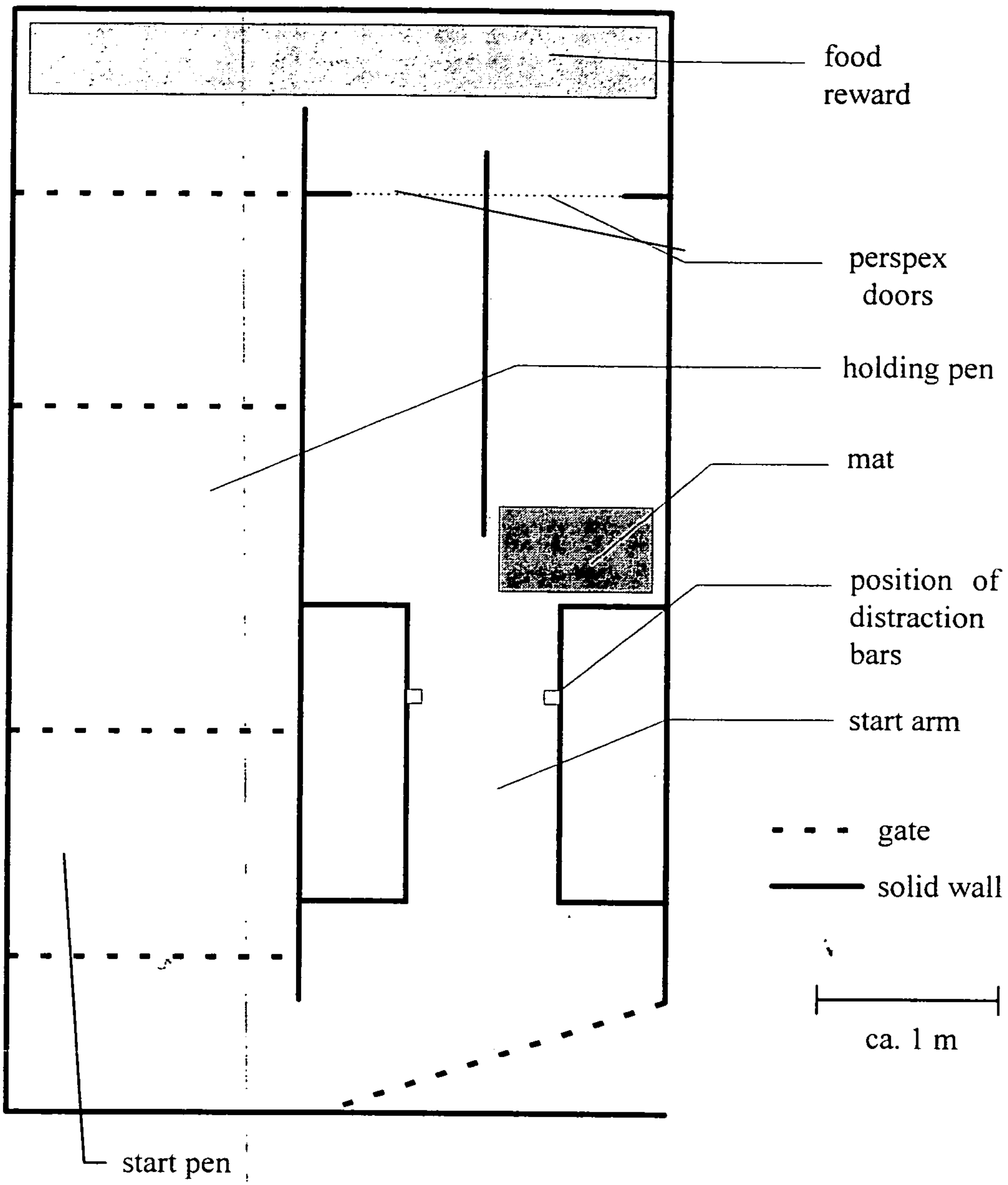

Figure 6.4: The maze used in experiment 3

pushed open. The pigs could not see whether a door was locked or not. The test was carried out on two consecutive days. On day 1, the pigs were trained to use the perspex door and to choose the correct arm of the maze.

- run 0: handler guides pigs through the maze, to the incorrect arm (door closed) first. The correct door is held fully open at 90°, pigs have no contact with door when leaving the maze.
- run 1: Correct door is held fully open (90°), pigs are alone in the maze.
- run 2: Correct door is held ca. 30° open, the pigs need to be in contact with the door while leaving the maze
- run 3: Correct door is held ca. 15° open,
- run 4 onwards: Correct door is closed, but not locked.

As soon as a pig had completed two consecutive runs with correct door reached within 7 seconds (starting with run 4), a distraction bar identical to the one described for experiments 1 and 2 was introduced into the start arm. The first possible distraction run was run 6.

On day 2, the pigs were given practice runs identical to run 4, until they had completed two consecutive, error-free runs, at which point the previously unlocked door was locked, and the previously locked one was unlocked (reversal). If the pig did not leave the maze within 4 minutes, it was guided through the correct exit.

To facilitate the distinction between the two arms of the maze, a black rubber mat (ca. 3 cm high) was situated in the decision area of the maze. For a given pig, the mat was always located at the same side of the maze (left or right). Hence it marked the incorrect arm of the maze during the training and distraction runs, and the correct exit after the reversal.

The test was filmed on video tape, and the following behaviours were recorded at a later date.

a) distraction: reactions as in exp. 1: ignore (I), look (L), nose (N), avoid (A)

b) reversal:

- place-tenacity: number of times the incorrect arm of the maze was entered ('error')
- behaviour tenacity: duration of behaviours directed towards the incorrect door (includes nosing, sniffing, and time spent very close to the door; the video recordings did not allow for a more specific definition)
- number of runs to reach 'error-free criterion' (two consecutive error-free runs)

All pigs learned to exit the maze without help. Those who did not reach the 'error-free criterion' were called 'routine formers', those who reversed their previously learned behaviour were non-routine formers.

6.3.2 Data handling

Pigs who did not meet the criteria for specific test (distraction, reversal) were excluded from the analysis. Specific information can be found in the relevant sections. As a result, the sample sizes vary depending on which test was analyzed.

The data were not normally distributed. The analyses were therefore carried out using the appropriate nonparametric statistics (Siegel & Castellan, 1988).

6.4 Results

6.4.1 Experiment 1

6.4.1.1 Reaction to a change in the environment (distraction bars)

All pigs reached the criterion for the distraction in both tests (RW: leaving the runway in 4 seconds or less, in two consecutive runs; MZ: time to first decision, whether correct or not, less than 7 seconds in two consecutive runs). There was no sex difference in the way the pigs reacted to the distraction bars (χ^2-tests, $p>0.1$).

The proportions of pigs who showed the same response in the maze as they did in the runway were 45%, 44%, 20%, and 0% for I, L, N, and A (table 6.2). There was a general increase in looking (from 9 to 26 pigs) and avoidance behaviour (from 2 to 22), accompanied by a decrease in nosing from the runway to the maze (from 44 to 12). Similar numbers of pigs ignored the distraction in both tests (31 to 26). If pigs who showed 'avoid' are excluded, the proportions of pigs who show consistency are 61%, 67%, and 27% for I, L, and N.

Table 6.2: Consistency and change of the response in the distraction tests from the runway (3 weeks old) to the maze (10 weeks old; experiment 1)

		maze				
		ignore	look	nose	avoid	total
runway	ignore	14	7	2	8	31
	look	1	4	1	3	9
	nose	9	15	9	11	44
	avoid	2	0	0	0	2
	total	26	26	12	22	86

Table 6.3: Consistency of responsiveness across time, from the runway (3 wks old) to the maze (10 wks old; excluding pigs who showed avoidance behaviour in either of the two tests; experiment 1)

		MZ		
		not respond	respond	total
RW	not respond	14	9	23
	respond	10	29	39
	total	24	38	62

If only responsiveness is considered, i.e. whether the pigs reacted to the bars or not, 69% were consistent across tests. This proportion is significantly larger than expected by chance (table 6.3; binomial test, one-tailed, $z = 2.92$, $p<0.01$).

6.4.1.2 Reversal

12 pigs did not reach the criterion for the reversal, 2 (from 2 litters) in R1, 10 (from 7 litters) in R2, no pig failed to reach the criterion on both days. It appeared to be more difficult for the pigs to reach the criterion necessary for the second reversal test, as seen in the proportion of pigs achieving it on the second run of day 2 or 3 (76 % for R1 and 47% in R2), or within 5 runs (98% for R1, 88% for R2). This indicates that the level of task performance at the time of the reversal was not the same in both tests.

7 pigs from 5 different litters shifted directions in the first run after the doors had been reversed (maze). They never saw that their usual exit was closed. 3 of them did this in the first reversal test, 4 in the second reversal, no pig did it both. We omitted these pigs from the relevant analyses.

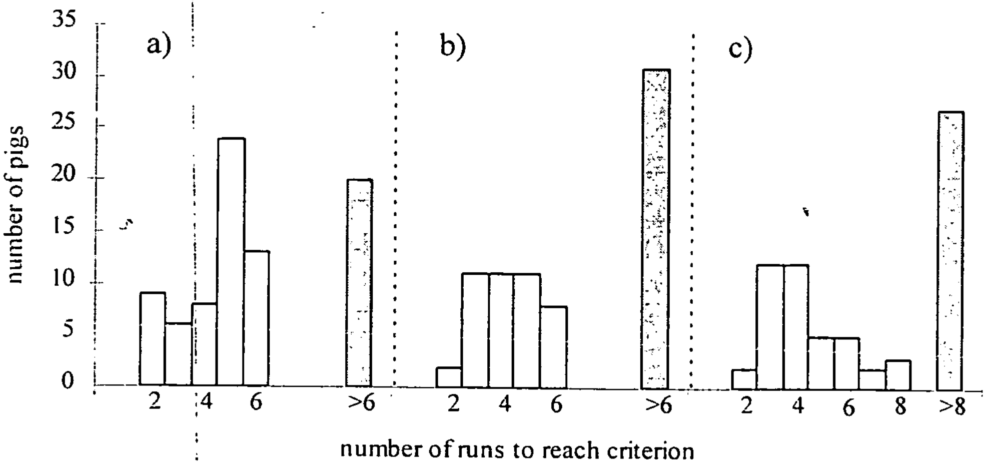

Figure 6.4: The number of runs needed to reach the criterion of two consecutive error-free runs for a) experiment 1, 1st reversal, b) experiment 1, 2nd reversal, and c) experiment 3.

Most pigs learned to run the maze without errors (i.e. reached the criterion of two consecutive correct runs) after reversal, but R2 appeared to be more difficult than R1 (75 % reached the criterion within six runs in R1, 58 % in R2; figure 6.4a, b).

The Spearman rank order correlations between the first and second reversal were nearly zero, and not statistically significant (frequency of errors in first run: r_S=-0.04; total frequency of errors: r_S =-0.05; number of runs to criterion: r_S =0.01). Whether or not the pigs learned the reversal task without error in R2 could not be predicted from their performance in R1. Only 47% of individuals who had formed a routine in R1, also formed one in R2 (61% of those who learned to run the maze error-free in R1 did so again in R2. There was a relationship between the number of errors during the first run after the reversal in R2 and routine formation: Pigs who learned to run the maze error free in R2 had - during the first reversal run - visited the incorrect arm of the maze more often than those who did not learn (Mann-Whitney, $p<0.01$). The same relationship was not found in R1 (figure 6.5).

6.4.1.3 Relationship between behaviour in the distraction and reversal tasks

Neither responsiveness (I versus L, N) nor distractibility (L versus N) were related to place-tenacity, not in the first run after the reversal in R1 and R2 nor in the total of the six runs after the reversal in R1 and R2 (Mann-Whitney tests, $p>0.1$), nor did we find a relationship between responsiveness/distractibility and routine formation in either reversal (χ^2-tests, $p>0.1$).

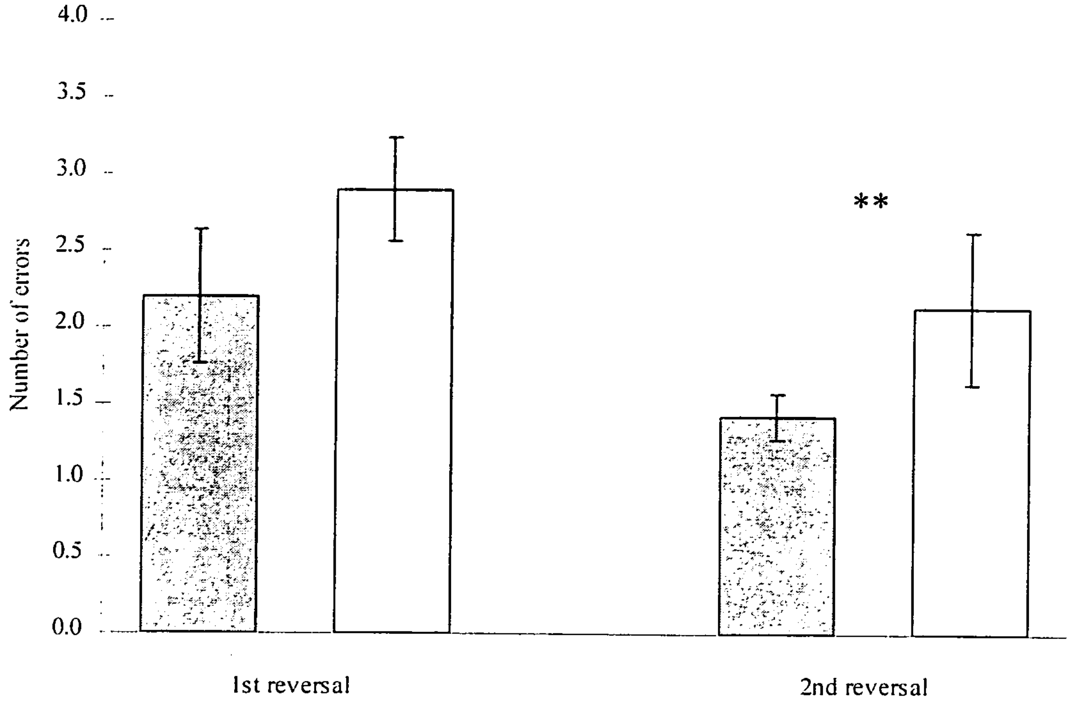

Figure 6.5: Place-tenacity (number of entries to the incorrect maze-arm in the first run after reversal) in the 1st and 2nd reversal in Experiment 1 for pigs who later learned to run the maze error-free (no-routine formers, white bars), and for those who did not (routine-formers, grey bars).

6.4.2 Experiment 2

Only one pig did not meet the criterion for distraction (in test 2). It was omitted from the sample. We observed no apparent avoidance behaviour, such as that observed in experiment 1. The categories ignore, look and nose consisted of 54%, 38%, and 8% of the pigs in test 1, and of 62%, 23%, and 15% in test 2.

Of those pigs who showed I, L, N in the first test, 80%, 32%, and 40% showed the same behaviour in the second test. When responsiveness was tested (I versus L/N), then 71% were in the same category in both tests, (80% for 'ignore', 60% for 'look/nose'; binomial test, z=3.22, p<0.01; table 6.4).

Table 6.4: Consistency and change of the response in the distraction tests at 6 wks (test 1) and 10 wks of age (test 2; experiment 2).

		test 2			
		ignore	look	nose	total
test 1	ignore	28	4	3	35
	look	12	8	5	25
	nose	0	3	2	5
	total	40	15	10	65

6.4.3 Experiment 3

6.4.3.1 General:

8 pigs from 5 litters did not meet the distraction criterion. Of those 65 pigs who did, 39 did not respond, 16 looked towards at least one of the bars, and 10 nosed at least one of the bars in the distraction run. No pig showed avoidance behaviour at the bars.

One of the 73 pigs did not meet the reversal criterion. Of those pigs who did, 4 pigs from 4 litters chose the reverse arm on the first reversal run, before they had a chance to learn that the arms had been reversed. Their data were not included in the analysis. Following reversal, most pigs learned to run the maze error-free (53% within 6 runs, 60% within 8 runs), and it appeared that those who did, did so faster than the pigs in experiment 1 (figure 6.4c). A χ^2-test on the number of pigs who learned within 2, 3, 4, 5, and 6 runs, revealed a significant difference between the three maze experiments (χ^2= 20,77; p<0.01).

6.4.3.2 Interrelationship between different aspects of persistence

We found that pigs who responded to the distraction bars did not differ in their place-tenacity from those who did not respond (Mann-Whitney test, n.s.).

Pigs who were highly distracted by the bars (i.e. nosed them) were unlikely to form routines (i.e. learned to run the maze error-free within 8 runs), whereas those who showed low levels of distraction (looked at the bars without nosing them) were likely to form routines (χ^2-test for I, L, N: $\chi^2 = 7.74$, df=2, $p<0.05$; χ^2-test for L versus N: $\chi^2=6.84$, df=1, $p<0.01$; table 6.5).

Table 6.5: The interrelationship between the type of response to the distraction bars and the level of routine formation (failure to learn to run the maze error-free within six runs after reversal; in experiment 3)

	routine	no routine	total
no response	14	21	35
look	**11**	**4**	15
nose	**2**	**8**	10
total	27	33	60

Responsiveness/distractibility and behavioural tenacity (duration of pushing closed door) were not related (Mann-Whitney tests, n.s.).

We found no linear relationship between routine formation and behavioural tenacity (Spearman rank order correlation, $r_S=0.05$), but behavioural and place-tenacity were highly correlated (Spearman rank order correlation, $r_S=0.72$, $p<0.001$)

Sex differences:

Sex differences were found in place-tenacity in Experiment 1 (second reversal; frequency of turning into the incorrect arm of the maze in the first run after reversal: 1.7±0.27 and 2.0±0.19 for males (n=33) and females (n=40), respectively; Mann-Whitney test, W=1058.5, $p<0.05$) and experiment 3 (frequency of turning into the incorrect arm of the maze in the first run after reversal: 3.1±0.55 and 5.0±.56 for males (n=27) and females (n=41), respectively; Mann-Whitney test, W=760.0.

$p<0.03$), and in behavioural tenacity in experiment 3 (time spent near closed exit in seconds in the first run after the reversal: 19.2±1.99 and 28.5±2.47 for males ($n=27$) and females ($n=41$), respectively; Mann-Whitney test, $W=737.5$, $p<0.02$). In all cases, females were more persistent than males (figure 6.6). There were no sex differences in routine formation or responsiveness/distractibility (χ^2-tests, n.s.).

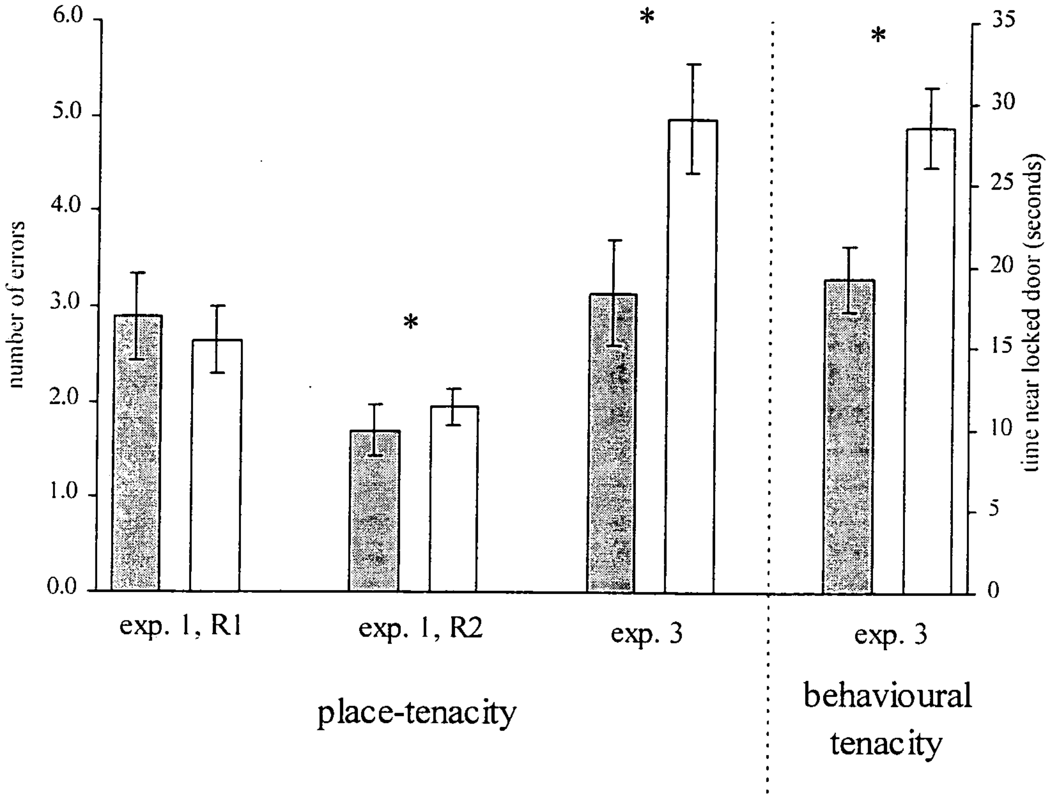

Figure 6.6: Sex differences in place- and behavioural tenacity in experiments 1 and 3. White bars represent females, gray bars represent males.

6.5 Discussion

A requirement for the study of temperament is the existence of variation between individuals. In the experiments reported in this paper, we found sufficient variation between individuals to warrant an investigation of the consistency of this variation, within situation across time, and across situations. Such a consistency could point to the potential existence of temperament traits connected to persistence of behaviour.

The maze task was chosen as a means to investigate persistence of behaviour, because it presents individual animals with a novel behaviour which they learn to be successful. The success (or lack of success) of this behaviour can be easily manipulated by the experimenter by closing a previously open exit, which allows the testing of the persistence of an individual in performing a learned behaviour. The paramount requirement for this to work is of course that the animals are able to learn the task and indeed do so. In our experiments, the majority of pigs learned to run through the runway or mazes quickly and reliably enough for a distraction and a reversal task to be meaningful. We also found after the reversal of the arms, that, while a proportion of the test animals failed to learn to run the maze without error (routine formers), they all learned to exit the maze.

For a behavioural response to be considered part of a temperament trait, it has to show consistency within individual across time. At first, the reactions of the pigs to the distraction bars in the runway and the maze in experiment 1 do not look very consistent. This is mainly due to the pigs who showed fear-related behaviours (i.e. avoidance) in response to the distraction bars in the maze. Why did the pigs show this behaviour in the maze, but not in the runway? A developmental effect is unlikely, since pigs tested at the same age in experiments 2 and 3 did not show this behaviour. It is more likely to be a result of the test environment. In the runway test, the handling was only at the beginning of the test, while in the maze in experiment 1 pigs were also handled after they had left the maze, which may have increased the general level of 'stress' imposed on them. This may have increased their predisposition to show fear-related behaviour, which, in turn, may have masked differences in responsiveness/distractibility. If we exclude pigs who showed this sort of behaviour from the sample, the consistency across time was much higher, 69% of the pigs either responding in both tests or not responding in either. We found the same level of consistency in experiment 2 (71% agreement between the two tests), where pigs showed no fear response to the distraction bars.

Pigs appeared to be more consistent in whether they responded or not ('responsiveness') than in the type of response they showed when responding, or, in other words, in the level of 'distractibility' they showed ('look' or 'nose'). This lack of stability in the type of response shown cannot be attributed to a mere age effect, since the changes were opposite in experiment 1 and 2. In experiment 1, the number of pigs who looked at the bars increased (from 9 to 16), the number of pigs who stopped to nose the bars decreased (from 44 to 12). The opposite relationship was found in experiment 2, where 'looking' decreased (from 25 to 15), and 'nosing' increased (from 5 to 10) in the second test. A possible explanation for these results lies in the differences in motivational background in the two experiments. The proportions of responders who looked at to those who nosed the distraction bars were 15:85, 75:25 in runway and maze in experiment 1, and 83:17 and 60:40 in the two tests in experiment 2. This points to a similarity between the maze in experiment 1 and the two tests in experiment 2 on one hand, in contrast to the behaviour in the runway test in experiment 1. We expect the level of distraction to depend on the level of motivation to complete the ongoing behaviour. An individual who is highly motivated to perform an ongoing goal-oriented behaviour is less likely to interrupt this behaviour than an individual who is less motivated. In the runway test in experiment 1, the motivation to complete the task was to return to the home pen, in the other three situations, the motivation was to reach a food reward while being hungry. It cannot be ruled out that the design of the setup (runway versus maze) or age (three weeks versus 6 and 10) was responsible for the differences in response type, but the differences appear to be just as easily explained by differences in levels of motivation. This hypothesis remains to be tested in an appropriate experiment.

The other behaviour which we tested for cross-time consistency was the place-tenacity in the two reversals in experiment 1. We found no strong consistency in any behaviour recorded in the two tests. Neither the number of errors in the first reversal run, nor the total number of errors, nor the number of runs needed to reach the criterion were correlated between the two reversals. Only 58% of the pigs tested were consistent in whether they learned to run the maze error-free or not. But that does not necessarily mean that the behaviour in a maze is not consistent across time. The two reversals in experiment 1 differ in that the pigs were naive in the first one, and experienced in the second one. The second reversal is therefore, strictly speaking, not a repetition, but a different situation. This might be a possible reason for the lack of consistency within animals between tests.

From the results discussed above, the responsiveness to changes in the environment, i.e. whether an individual responds to a change or not can be said to be consistent across time, more so than type of response (look versus nose) or place-tenacity in a reversal task, even though these cannot be ruled out on the basis of the results obtained in our experiments.

The second requirement individual differences have to meet before they can be regarded as reflecting differences in an underlying temperament trait is cross-situational consistency.

Firstly, we investigated the relationship between the behaviour in response to the distraction and the behaviour in response to the reversal task. Benus et al. (1991) studied how these behavioural responses clustered in house mice. They reported that selection for short attack latencies lead to individuals who are less responsive to changes in their environment and more inflexible/routine forming in their behaviour than those selected for long attack latencies (Benus et al., 1987). We did not find a similar relationship between responsiveness and routine formation.

There was, however, a relationship between the type of response (distractibility) of those pigs who responded to the novel stimulus and their likelihood to form routine-like behaviours in exp. 3. Pigs who only looked at the bars were likely to be routine formers whereas pigs who stopped to nose the bars were more flexible in their behaviour. Pigs who 'looked' at the bars did so while walking/running past. They did not interrupt their ongoing behaviour, thereby showing resistance to distraction. 'Nose' pigs, on the other hand, interrupted their behaviour and performed a completely unrelated one (exploration), before continuing the initial behaviour. Thus the type of response to a stimulus is probably a better reflection of high and low levels of persistence than whether a response occurs or not, because a lack of response may simply be due to the animals' not seeing the distraction bars. This relationship between reaction to a novel stimulus and routine formation is similar to the results found by Benus et al. (1987, see above).

However, this relationship between distractibility (response-type) and routine formation was not found in experiment 1. A possible explanation is the small number of runs before the reversal (a minimum of 6 as opposed to 9 in experiment 3), or that the test situation was perceived differently by the pigs in the two experiments, as indicated by the high levels of fear-related avoidance behaviour in experiment 1. Or maybe the mat helped the non-routine formers to distinguish between left and right, therefore giving them more control over their decision in the maze.

The only other relationship between measures we interpreted as reflecting different levels of persistence was a high correlation between the persistence to re-visit the closed door/incorrect arm of the maze after the reversal (place-tenacity), and the time spent interacting with the now locked door (behavioural tenacity). These two behaviours could both be interpreted as the resistance of a conditioned response to extinction. This interpretation is backed up by the connection between revisiting the incorrect arm of the maze during the first run of the second reversal, and the number of runs needed to achieve two consecutive, error-free runs. Pigs who achieved these runs more quickly had revisited the closed arm of the maze more often immediately following reversal than those who did not achieve these runs within the six runs of the test. This was not the case in the first reversal, when the pigs were not yet familiar with the concept of 'reversal'.

The resistance to accept new and conflicting information also differs from the other aspects of persistence we recorded in that it revealed significant sex differences. Given the effect of testosterone on many aspects of persistence (Andrew 1972), it was surprising to find that female pigs were more persistent in this set of behaviours than males. Given the complex interactions between sex differences and learning , depending on task sequence (Bergersweeney et al., 1995), organizational (in utero) levels of gonadal hormones (Galea et al., 1996) and seasonal changes in hormone levels (Galea et al., 1994), we would not like to interpret the sex differences we found based on the experiments described in this paper, apart from the fact that their existence sets apart the revisiting (place- and behavioural tenacity) of the closed exit from the other types of persistence

After having discussed the temporal and cross-situational consistency of the different types of persistence, we would like to make some general comments about the maze, and the potential effects the setup had on the behaviour of the pigs..

In Experiment 1, all pigs left the maze unaided after the exits had been reversed. In experiment 3, 9 pigs did not leave the maze within the 4 minute time limit, and had to be led out of the maze. We have three potential explanations for this. First, there is the clear difference between the open and closed wooden doors in experiment 1 as opposed to the identical appearance of the unlocked and locked perspex doors in experiment 3. The change from open to closed was much more marked in the wooden doors. Being able to see the outside of the maze through the locked door is a second factor which might have contributed to the failure to look for/find the other exit. A third possibility is that the presence of the mat in experiment 3 helped the pigs to distinguish between the arm of the maze which was connected with the food reward and the unrewarded arm, which in turn led to the pigs' persistence in choosing the previously rewarded arm. Pigs who needed help and those who did not, showed no difference in any of the other behaviour we recorded in this experiment. Rather than being a sign of extreme persistence, the failure to exit the maze may be a result of confusion. A similar phenomenon was reported by van Rooijen & Metz (1987), who showed that high levels of arousal can impair the ability of pigs to make proper choices in a T-maze. This was our rationale behind aiding the pigs after what might appear to be a relatively short period of time (4 minutes) in the maze.

We found a relatively high number of pigs to switch sides spontaneously in experiment 1 at the point of the first reversal. The pigs could not see the exit from the decision point, so that it can be assumed that it was independent of the reversal of the exit doors. The errors could have been a result of the pigs' difficulty to distinguish between left and right. This is, however, unlikely, since pigs have been shown to have persistent side-preferences (van Roojien & Metz, 1987). Krechevsky (1932), on the other hand, suggested that the arms of a maze should be distinctly different, requiring the test animal to not just to see a difference, but to "...do something with it". To achieve this in experiment 3, we used a mat on the floor, about three centimeters high, which assured that the pigs noticed the difference between the two arms of the maze. The similarly high number of alternations in experiment 3, however, seems to indicate that they were not a result of a difficulty to distinguish between left and right. It could be an example of sampling behaviour, as described in other species (e.g. humming birds, Hurly, 1996). Looking at the learning curve, it seems that pigs who learned to run the maze error-free after reversal did so faster than those in experiment 1. Since other aspects of the maze had been changed as well, we do not know the extent to which the mat contributed to the learning process being faster. Another possibility is that the criterion for the reversal (two correct runs in a row) was not strict enough, and led to pigs being tested who had not learned the task. In a similar experiment with older pigs who had a larger number of training runs (20 compared with a minimum of 8 in experiment 1 and of 10 in experiment 2), such alternations had indeed not been observed (Mendl et al., 1997).

A further difference between experiment 1 one hand and experiments 2 and 3 on the other was the relatively high level of apparently fear-related avoidance behaviour shown by the pigs during the distraction run in experiment 1. In experiments 2 and 3 we shortened the distance between the waiting pen and the maze. This reduced the amount of handling, particularly after the run, when the pigs had to be moved away from the food reward back to the waiting pen. Also, the same, familiar handler moved the animals in all the tests in experiment 3. We do not know which of these changes (or a completely different one) was responsible, for the fact that, unlike in experiment 1, pigs showed no fear related behaviour in the distraction test in experiments 2 and 3. At least some of the differences between the results obtained in these experiments might be a result of the different levels of fear experienced by the pigs.

6.6 Conclusion

We found persistence to be shown in three aspects of behaviour:

- the responsiveness to changes in the environment, which was consistent across time
- the type of response to novel stimuli, which was related to routine formation
- the resistance to extinction of a conditioned response, which revealed significant sex differences.

These three areas were apparently not interrelated. Thus, although each of these aspects of persistence fulfil specific requirements for being regarded as personality traits, they have to be considered independently rather than as a set of aspects of one trait, persistence.

Acknowledgements

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Chapter 7

Is there a link between personality traits in pigs?

7.1 Abstract

Individual differences in certain areas of behaviour (the 'active/passive dimension', aggressiveness, and aspects of persistence) have been found to be relatively stable within individual and context, both across time and across situation. The aim of this study was to find out whether these personality 'traits' are clustered to form personality 'types' as appears to be the case in studies of mice.

A series of 4 tests was carried out on 74 female and entire male pigs. At the age of 2.5 weeks, the pigs were tested for tonic immobility ('active/passive dimension'; TI). At the age of 10 weeks, the same pigs were tested for their reaction to a change in the environment to assess persistence in performing ongoing behaviour. At the same age, the pigs were subjected to a reversal task in a maze to assess persistence in performing a behaviour which is no longer rewarded. One week later, at the age of 11 weeks, two attack latency tests were carried out to assess aggressiveness.

The data had both categorical and continuous components. The behaviour in TI, for instance, could be expressed as becoming immobile versus not becoming immobile, and in duration of immobility. Consequently, factor and principal component analysis were not considered appropriate for this type of data. In order to analyse the data without making assumptions about their distribution, we carried out a series of 132 non-parametric tests. Instead of the 6.6 significant results with an α of 0.05 expected by chance, we found only one significant link, namely slow-learning males being more aggressive than fast learning males ($p<0.05$), and 4 statistical tendencies ($p<0.1$). Low aggressive pigs and slow learning males tended to be more active (shorter TI) than high aggressive pigs and fast learning males. Active animals (not immobile in TI) tended to be less distracted, and high responsive males and slow learning males more aggressive.

Based on these results we suggest that in the pigs studied here there were no strong links between the three personality traits investigated, and that the personality of an individual pig ought to be regarded as a 'combination of traits'.

KEYWORDS: Strategies, aggressiveness, active/passive, responsiveness, flexibility

7.2 Introduction

'Temperament', or 'personality' as explanations of individual differences in behaviour have received a lot of attention in applied ethology (e.g. Manteca & Deag, 1993, Mendl & Deag, 1995). It has been shown that individual differences in specific aspects of behaviour remain consistent across time, and could therefore be regarded as a property of the individual, a predisposition to behave in a certain way given a certain situation (Lyons et al., 1988; Grandin, 1993; Erhard & Mendl, 1997).

Some studies focus on a single personality trait, such as aggressiveness (Coss & Biardi, 1997) or fearfulness (Lyons et al., 1988; Boissy & Bouissou, 1995), but an increasing number of studies are investigating to what extent these 'traits' are connected to form personality 'types' (Mather & Anderson, 1993, for pigs see Lawrence et al., 1991, Hessing et al., 1993, Jensen et al., 1995a, Forkman et al., 1995). The assumption here is that for any personality 'type' it is possible to predict an individual's position on one constituent personality trait by its position on another personality trait. This approach views 'traits' and 'types' in a hierarchical way. An example from human psychology is the concept of the 'Big Five' personality dimensions (or types): neuroticism, extraversion, openness, agreeableness, conscientiousness (Deary & Matthews, 1993). An individual who scores high in the personality trait 'self-discipline', for instance, is assumed to belong to the type 'conscientious'. Since the type 'conscientious' shares specific personality traits, it is likely that the same individual will also score high in the traits 'competence', 'order', and 'achievement striving'.

A similar hierarchical structure has recently been identified in rodents. In a series of studies on selection lines of mice (selected for short (SAL) and long attack latencies (LAL); see also van Oortmerssen & Bakker, 1981), Benus (1988) found a link between the personality traits 'activity in response to a challenge', aggressiveness, flexibility of behaviour and responsiveness to external cues in the environment, which pointed to the existence of two personality types in male mice, namely 'active copers' and 'passive copers'. They found that male SAL mice ('active copers') were more aggressive towards intruders into their territory, less distracted by changes in their environment, and more likely to form routines in a maze task (i.e. learn a reversal task more slowly) than male LAL mice ('passive copers'). Although they are usually referred to as 'behavioural strategies', active and passive coping could be regarded as personality types, linking the personality traits of 'activity in response to challenges', aggressiveness, persistence, and responsiveness.

Since Benus's (1988) work on 'coping strategies' in mice, there has been an increasing number of studies searching for similar phenomena in pigs. Hessing et al. (1993) tested pigs in a variety of different situations and reported a link between the pigs' reaction to manual restraint (the backtest), aggressiveness, and the behaviour in other challenging situations (Hessing et al., 1995), findings which were in agreement with the 'coping strategy' theory of Benus (1988). Jensen (1994), Jensen et al. (1995a), Forkman et al. (1995) and Spoolder et al. (1996) investigated the consistency of individual differences within and between situations, and did not find a similar link between personality traits in pigs.

To answer the question as to whether pigs show behavioural characteristics which resemble personality traits (predicting behaviour in similar situations, sensu Erhard et al., 1997a, and Erhard & Mendl, in press) and whether these cluster to form personality types (predicting behaviour over a wide range of situations, sensu Benus 1988), we designed tests for specific personality traits, such as aggressiveness (Erhard & Mendl, 1997; Erhard et al., 1997b), active/passive response to challenges ('tonic immobility' (TI); Erhard et al., 1997a, Erhard & Mendl, in press), and responsiveness to changes in the environment (persistence of behaviour; chapter 6).

In these studies we showed cross-time consistency of individual differences within specific contexts, i.e. an aggressive encounter, non-social challenging situations (the tonic immobility test), and a changing environment, which suggested that we were measuring personality traits in pigs. We then set out to investigate whether these traits clustered together in pigs in a way predicted by the active/passive coping theory based on studies on mice by Benus (1988), as was suggested by Hessing et al. (1993).

The main questions we wanted to answer were:

1) Is there a connection between the active/passive dimension on one hand and aggressiveness on the other, as suggested by Hessing et al. (1993) and rejected by Forkman et al. (1995)? To answer this question, we compare the reaction of pigs to the tonic immobility test (Erhard et al., 1997a) with their attack latency in a resident-intruder situation (Erhard & Mendl, 1997).

2) Are aggressiveness and the active/passive dimension linked to response to changes in the environment (distractibility, flexibility of behaviour, learning speed in a reversal task) in a similar way as in mice? The attack latency in a resident-intruder test and the reaction to tonic immobility (TI) is compared with the response to a novel stimulus introduced into a maze, and with the behaviour in a reversal task in a modified T-maze.

Our approach is in agreement with the suggestions made by Jensen (1995). We first established intra-situational consistency of the behaviour shown in the tests we used (TI, attack latency, and a maze task; see above), suggesting that the behaviour shown in these tests reflects personality traits (Erhard & Mendl, 1997, Erhard et al., 1997, Erhard et al., 1997, Erhard & Mendl, in press, chapter 6). In the present study we investigate the links between the behaviour in these tests, i.e. between these personality traits.

7.3 Material and methods

7.3.1 Animals and housing

In this study we used 74 (Large White x Landrace) x Large White pigs from 7 litters, 43 females and 31 entire males. Shortly after birth, pigs were ear-notched, and had their eye teeth clipped. Apart from that, they were not handled until the tonic immobility tests at 2.5 weeks of age. The pigs were weaned at 4 weeks of age, and were kept unmixed in litter groups throughout the experiment.

7.3.2 Behaviour tests

7.3.2.1 Tonic immobility (2.5 weeks of age)

This test provides a measure of an individual's position on the active/passive dimension of behaviour.

Immediately after the end of a suckling bout, an entire litter of piglets was put into a transport box and moved into a separate test room. After they had settled down (up to about 10 minutes), they were individually tested for tonic immobility. Each pig was lifted out of the box by its hind legs, turned on its back onto a V-shaped wooden cradle, and a sand-filled bag (15x20 cm, ca. 500g) was put onto its chin. As soon as the piglet struggled, the bag was removed, and the latency recorded. Pigs, which struggled immediately when turned on their backs were recorded as having a latency of zero seconds (non-TI). Pigs who did not respond within 5 minutes were recorded as having a response latency of 5 minutes, and the test was terminated.

The distribution of the data has a categorical aspect (pigs who become immobile (TI) and those who do not (non-TI)), and a continuous aspect (duration of immobility). Another potential category consists of the pigs who stayed immobile for the duration of the test (five minutes). It is not clear whether they are in a different category or merely represent the extreme end of a continuous distribution.

For a more detailed discussion of the test see Chapter 4.

7.3.2.2 Maze test (10 weeks of age)

This test was used to assess specific aspects of flexibility and persistence, and consisted of two parts (day 1 and day 2). On day 1, we tested the degree to which pigs respond to changes in the intra-maze environment, on day 2, we assessed how pigs react to a reversal of the two arms of the maze.

We trained pigs to run through a Y-maze. Both exits of the maze were cat-flap type perspex doors (40 x 70 x 1.5 cm) hanging down from hinges. One door was locked, the other one could be pushed open. The pigs could not see whether a door was locked or not. Half of the pigs were allocated to the right door as being correct, the other half to the left door. The order of testing was then balanced, so that a 'left-rewarded' run by pig A was followed by a 'right-rewarded' run by pig B. The test was carried out on two consecutive days. On day 1, the pigs were trained to use the perspex door (by starting with an open door which was gradually closed from run to run) and to choose the correct arm of the maze. As soon as a pig had completed two consecutive runs in which the correct door was reached within 7 seconds (starting with the first run when both doors were closed), a distraction bar (50 x 4 x 1 cm, white with black horizontal stripes) was introduced into each side of the start arm for one run only.

On day 2, the pigs were given practice runs identical to the ones on day 1 (both doors closed), until they had completed two consecutive, error-free runs, at which point the previously unlocked door was locked, and the locked one unlocked (reversal). Following the reversal, if the pig did not leave the maze within 4 minutes, it was guided through the correct exit. If a pig had not reached the 'error free' criterion after the eighth reversal run, it was allocated 10 runs as learning speed, and treated as a 'slow learner'. The test was filmed on video tape, and recorded at a later date using KEYTIME® (Deag, 1993).

The following behaviours were recorded:

1) response to distraction bars: ignore (I), look at (L), nose (N) the distraction bars.

- responsiveness: <u>respond</u> (L/ N) versus <u>not respond</u> (I)
- distractibility: <u>low</u> versus <u>high</u> (L vs. N; pigs who 'looked at' the bars did not interrupt their ongoing behaviour, while pigs who nosed the bars did)

2) reversal:

- number of times the incorrect arm of the maze was entered (within one run) after reversal ('error'); "place-tenacity"
- duration of behaviours directed towards the incorrect door after reversal (includes nosing, sniffing, and time spent very close to the door); "behaviour-tenacity"
- number of runs to reach 'error-free criterion' after reversal (two consecutive error-free runs)
- all pigs learned to exit the maze without help. Those who did not reach the 'error-free criterion' were called 'slow learners', those who reversed their previously learned behaviour were 'fast learners'.

Learning speed was expressed as the number of runs needed to reach the 'error-free' criterion (continuous with an upper limit) and as whether or not they reached the criterion within eight runs (1/0)

7.3.2.3 The attack latency test (AT; 11 weeks of age)

The tests of aggressiveness were done in the home pen of a litter and involved encounters between one 'resident' pig and an 'intruder' pig from another litter. The test methodology is identical to that described in Erhard and Mendl (1997; see also for detailed discussion of the test), and is briefly summarised here.

For the purpose of the test, the home pen of the resident litter was divided in half by a solid door. One pig (the 'resident') was placed in the dunging area, while the rest of the litter were retained in the lying area. The intruder pig (2-3 weeks younger and of approximately two thirds of the resident's body weight) was then introduced into the dunging area. The experiment was terminated immediately after an attack had occurred, or, if no attack occurred, after 3.5 minutes. This was done to prevent animals from experiencing fights, and for ethical reasons, to prevent injury. An attack was defined as at least one quick bite; mere chewing of the intruder was not counted as attack. The procedure was repeated on the following day, the residents being paired with intruders from a different litter.

The time from when the resident first made contact with the intruder to when it attacked (attack latency, AL) was used as measure of aggressiveness. Resident pigs who did not attack were given an attack latency of 210 seconds.

The distribution of the data has a categorical element (attackers versus non-attackers) and a continuous element (attack latency). Significantly more pigs attacked on the second than on the first day (Erhard & Mendl, 1997). Therefore, we analysed the two test days separately in this study.

7.3.3 Data handling

Pigs who did not meet the criteria for a specific test (e.g. if they did not reach the minimum speed in two consecutive runs for the distraction test, or two consecutive correct runs for the reversal, or if they were attacked by the intruder first) were excluded from the analysis. As a result, the sample sizes vary depending on which test was analysed.

The investigation of complex interrelationships between variables is not straightforward. Benus et al. (1991) carried out research on selection lines, which allowed them to carry out two-sample analyses, Hessing et al. (1993) achieved the same by dividing their sample into extremes and intermediate animals, and then comparing the extremes. They were, however, heavily criticised by Jensen et al. (1995) for choosing apparently arbitrary cut-off points. Forkman et al. (1995) and Spoolder et al. (1996) used correlations and multivariate statistics (principal components analysis) to analyse their data.

Our research on personality traits showed that the distribution of behaviour shown in the tests we developed can be seen as a combination of categorical and continuous. In tonic immobility, for instance, there are pigs who do not become immobile (non-TI), and those who do (TI). Within this latter group, the pigs differ in the duration of immobility (Erhard & Mendl, 1997). This type of data is not appropriate for factor analysis or principal components analysis. The only way to analyse the data without making assumptions about the shape of their distribution is to analyse them separately as continuous and as categorical data, thus conducting a large number of tests. The relationship between tonic immobility and aggressiveness, for instance, was analysed by calculating a Spearman rank order correlation, by a Mann-Whitney test comparing the attack latencies of non-TI and TI-pigs, by a Mann-Whitney test comparing the duration of immobility of non-attackers and attackers, and by a Chi-square test comparing TI/non-TI with attack/no attack. This set of 4 tests was carried out for each of the two attack latency tests, on the entire data set and for females and males separately, resulting in 24 tests to compare TI and attack latency.

We carried out 44 statistical test on the complete data set, and again the same for males and females separately (a total of 132 tests). The data were not normally distributed. We therefore used Spearman rank order correlation, Mann-Whitney, and Kruskal-Wallis tests in the analysis (Siegel & Castellan, 1988).

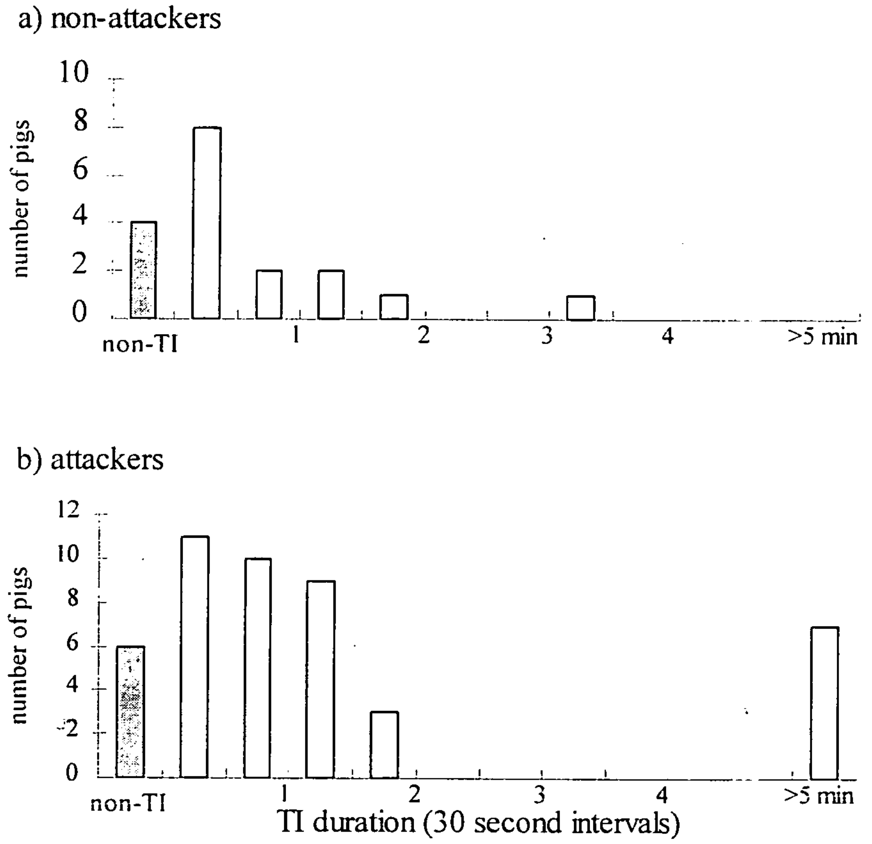
As a result of this approach, the levels of significance in the relationships found to be significant have to be treated with caution. One in twenty tests is expected to reveal a significant result (at $p<0.05$) by chance (see discussion).

7.4 Results

In the result section, we will focus on relationships which were found to show statistical significance ($p<0.05$) or a tendency ($p<0.1$). Relationships not referred to in the text were not statistically significant.

TI and aggressiveness

Figure 7.1 shows the frequency distribution of TI for pigs who attacked (attackers) and did not attack (non-attackers) in the second attack latency test. Comparing the TI durations (in seconds, non-TI pigs were treated as having an immobility duration of 0 seconds) of pigs who attacked in the second attack latency test with those who did not, we found that non-attackers tended to have shorter durations of immobility (Mann-Whitney test, $p<0.08$). Also, all pigs with very long TI (5 minutes) attacked on at least one of the test days (table 7.1). This indicates that long AL may co-occur with to short TI.


a) non-attackers

b) attackers

Figure 7.1: Tonic immobility for pigs who a) did not attack and b) did attack in the second attack latency test.

Table 7.1: Proportion of non-TI, TI (TI< 5 minutes), and long-TI pigs (TI> 5 minutes) for pigs who attacked in neither of the two ATs, in one or in both.

	non-TI (%)	TI <5 min (%)	TI >5 min (%)
no attack	25	75	0
attack one day	8	70	23
attack both days	15	74	12

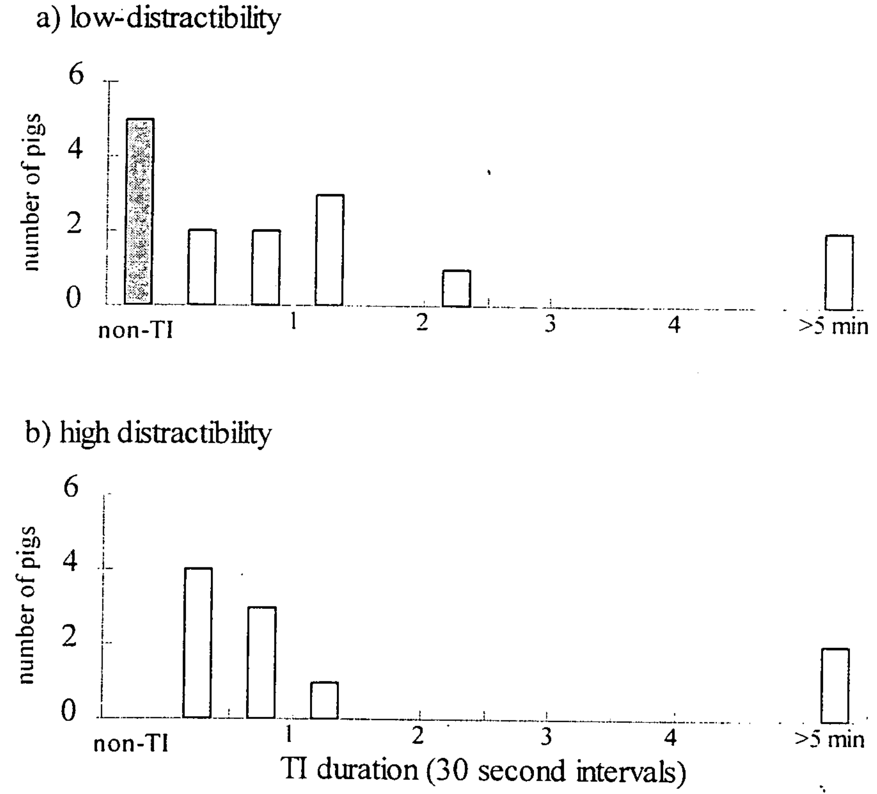


Figure 7.2: Tonic immobility of pigs with a) low ('look at') and b) high distractibility ('nose') in response to the distraction bars.

TI and distractibility (look versus nose)

Pigs with high distractibility (those who stopped to nose the distraction bars), had all become immobile in the TI test (10 out of 10), whereas one third of the pigs with low distractibility (looked at bars) were non-TI (5 out of 15; Fisher's exact test, $p<0.06$; Figure 7.2). This might indicate that high distractibility is linked to high susceptibility to TI. There was no difference in duration of immobility (non-TI pigs having duration of 0 seconds) between those who nosed and those who looked at the distraction bars (Mann-Whitney test, $p>0.10$).

TI and learning speed in the maze

Slow learning male pigs (those who did not learn to run the maze error-free after reversal) tended to have shorter TI than fast learners (Mann-Whitney test, $p<0.08$; see Figure 7.3). This was not the case for females and if all pigs were analysed together.

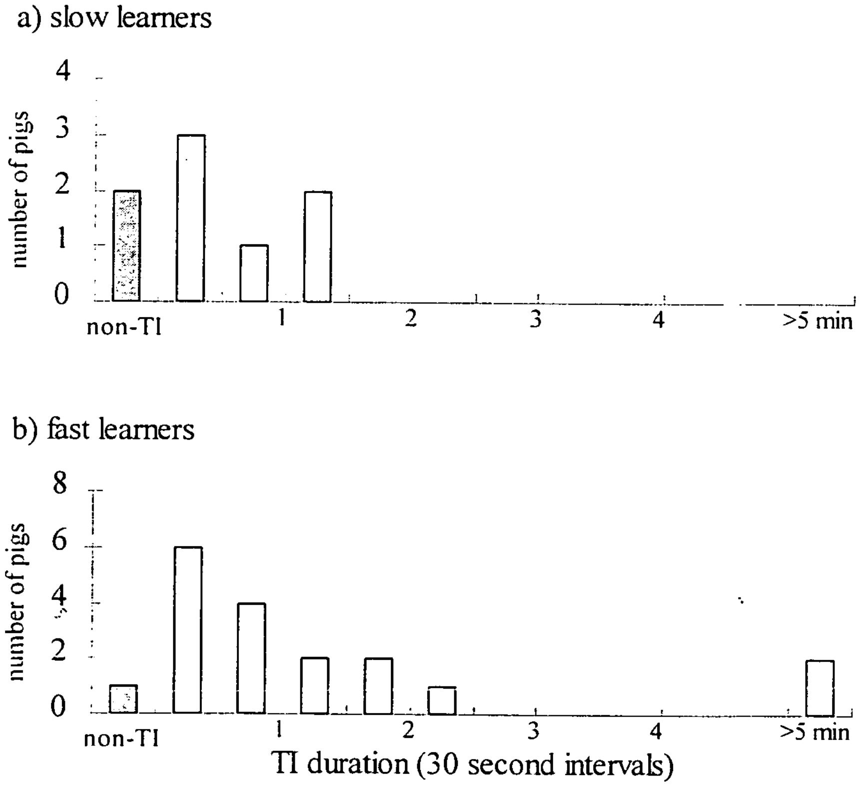


Figure 7.3:. Tonic immobility of male pigs who were a) slow or b) fast at learning the reversal task error-free

Aggressiveness and responsiveness (nose/look at versus ignore)

Comparing pigs who responded to the distraction bars with those who did not respond, we found that 'responders' tended to attack faster (Mann-Whitney test, $p<0.07$). This relationship was found only in the first AT and only in male pigs. The effect is mainly due to differences in AL within those pigs who attacked. When the same analysis was carried out using only the pigs who did attack, the difference in attack latency was significant (Mann-Whitney test, $p<0.003$; see Figure 7.4). Thus, highly responsive pigs seemed to have shorter AL.

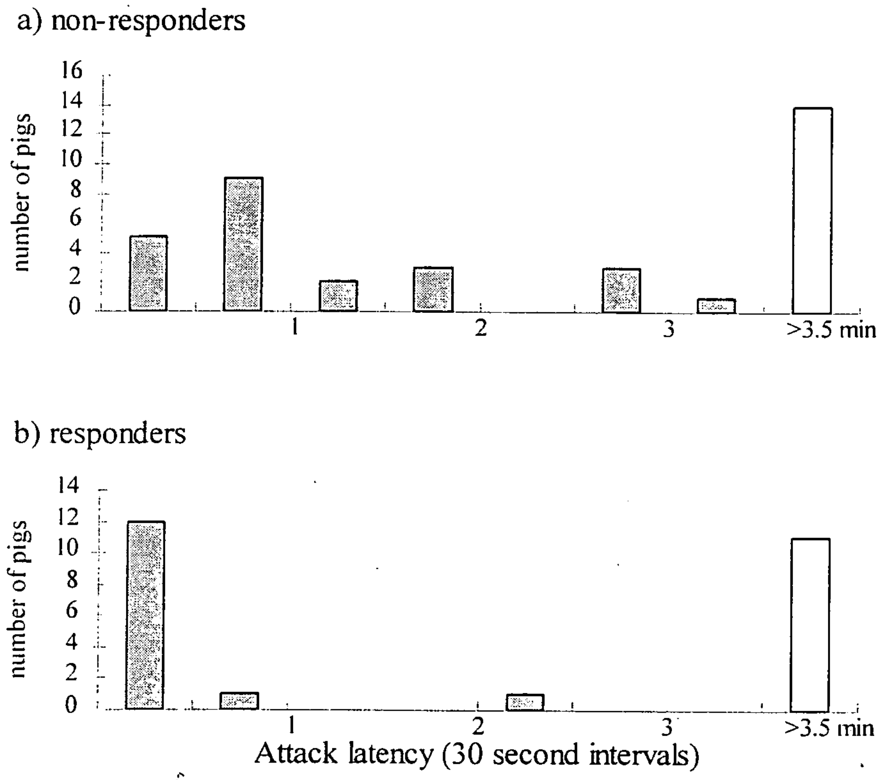


Figure 7.4: Attack latency of pigs who a) did not respond to the distraction and b) responded to the distraction in the maze

Aggressiveness and learning speed

Slow learning pigs (those who did not learn to run the maze error-free after reversal) had significantly shorter attack latencies in the first AT than fast learners

(Mann-Whitney, p<0.05; see Figure 7.5). This effect was only found in male pigs, and it was no longer significant in the second AT (p<0.08).

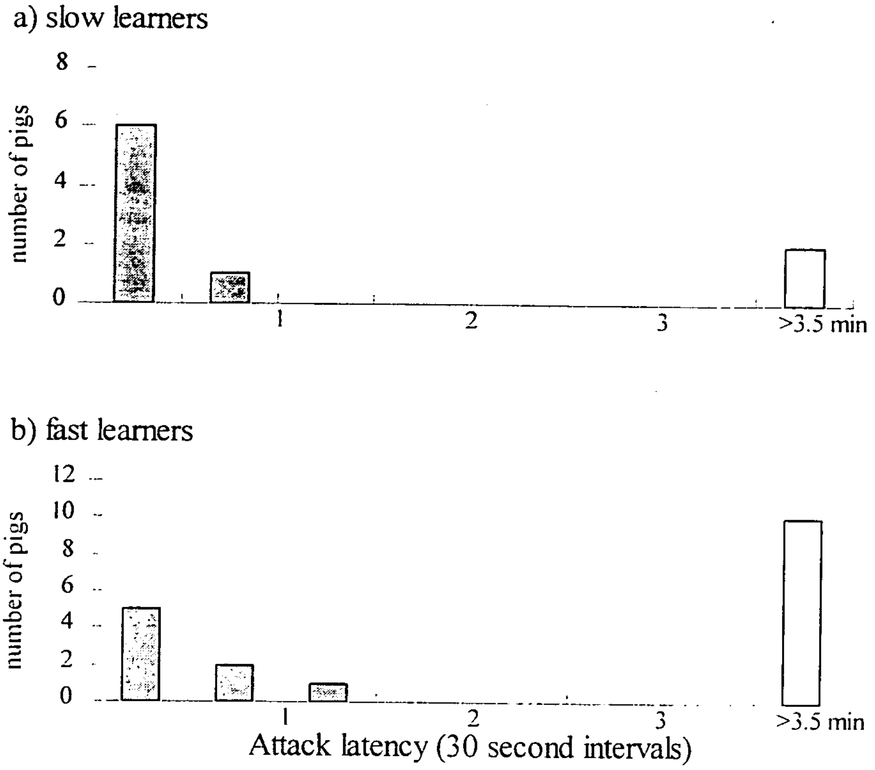


Figure 7.5: Attack latency of male pigs who were a) slow or b) fast at learning the reversal task error-free

7.5 Discussion

The only significant link between the various personality traits analysed was between attack latency (aggressiveness) and learning speed in a reversal task. Having carried out 132 individual tests, one would expect 6.6 significant results by chance. The obvious conclusion is therefore: Based on the specific tests carried out and the pigs we used in this experiment, there is no evidence for a link between the A/P dimension, aggressiveness and persistence of behaviour in growing pigs.

We feel, however, that it would be premature to completely dismiss the one significant link and the statistical tendencies found in the analysis. Buss (1989) discusses the distinction between a single measure of behaviour in a specific situation, and an aggregation of information, e.g. an average over different responses, or over situations, or over time. He gives examples of how such aggregation can increase the correlation between observer ratings. We validated single test situations by assessing the consistency of individual behaviour across time and situation. It is possible that personality traits, assessed across a wide range of situation would have revealed significant links. We therefore discuss those links between the traits, which showed a statistical tendency as if they had been significant, to see whether they will then support the hypothesis of 'coping strategies'.

Links between the active/passive dimension and aggressiveness

The first question we set out to answer was whether we would find a link between the active/passive dimension and aggressiveness in pigs, similar to that found by Hessing et al. (1993). Previous studies suggested that TI (tonic immobility) can be used as an indicator of whether pigs adopt a more active or a more passive behaviour in a challenging situation. The active/passive dimension was represented by struggling/freezing in response to manual restraint, fast/slow movement through an unfamiliar environment, and fast/slow decision making to bring about change in a challenging situation, an emergence test (Erhard et al., 1997a, Erhard & Mendl, in press). Pigs who did not attack in the second or either of the two attack latency tests (AT) tended to have a shorter duration of immobility than pigs who attacked on at least one of the test days.

That the link between aggressiveness and TI was found in the second AT, and not in the first confirms the difference between the two test days, probably due to a priming effect (Potegal, 1991), which increased the number of attackers from the first to the second AT (Erhard & Mendl, 1997). Since pigs were more likely to attack on the second test, this test may reveal better information on low levels of aggressiveness than the first test, i.e. it is possible that those who do not attack in the first test *may be* low-aggressive, but those who still do not attack in the second test *are* low-aggressive.

This result appears to contradict the theory of 'coping strategies', and the findings of Hessing et al. (1993), according to which the more aggressive pigs ought to be more active (short TI) than the others. Previous studies, however, suggested that more active or more passive behavioural strategies were reflected in the susceptibility to TI (whether pigs showed an immobility response or not) rather than in the duration of immobility shown (Erhard et al., 1997a, Erhard & Mendl, in press). Non-TI and TI-pigs did not differ in aggressiveness, the data therefore may not contradict the active/passive coping strategy dichotomy, but do not provide support for it either.

Since this result is the direct opposite of what Hessing et al. (1993) found when they compared the behaviour in the backtest with aggressiveness in a group situation, it warrants a closer comparison of the test situations. In our tonic immobility test, the immediate reaction of pigs to being turned on their backs is recorded. In the backtest of Hessing, however, the piglets are restrained in this position for one minute. The number of escape attempts in the backtest is therefore a combination of the latency to the first escape attempt, the duration of the inter-bout intervals, and the number of escape attempts. It therefore takes the reaction of a piglet to being restrained, and to the failure to succeed in the first and subsequent escape attempts into account. This information is not included in our TI test.

Another possibility for the difference in the results between Hessing's and our study is that the experience in the five backtests carried out by Hessing et al. (1993) may have affected non-resistant and resistant pigs in different ways. Resistant pigs had at least six unsuccessful escape attempts in the first three weeks of their lives (Hessing et al., 1993). During these escape attempts, they were subject to severe, and probably very aversive handling, and it is possible that this experience with early handling may have affected their behaviour later in life (Hemsworth et al., 1991, Albonetti & Farabollini, 1993).

Handling, however, does not only change specific behaviours, it can also affect interactions between behaviours. Henderson (1967), for instance, found that the genotypic correlations between ambulation and defecation in an open field changed with early handling from -0.59 to +0.29 to 0, depending on the handling treatment ('undisturbed, moderately disturbed or shocked in infancy', respectively). It is therefore possible, that the initial differences between resistant and non-resistant types of pigs are increased by repeated 'back testing'.

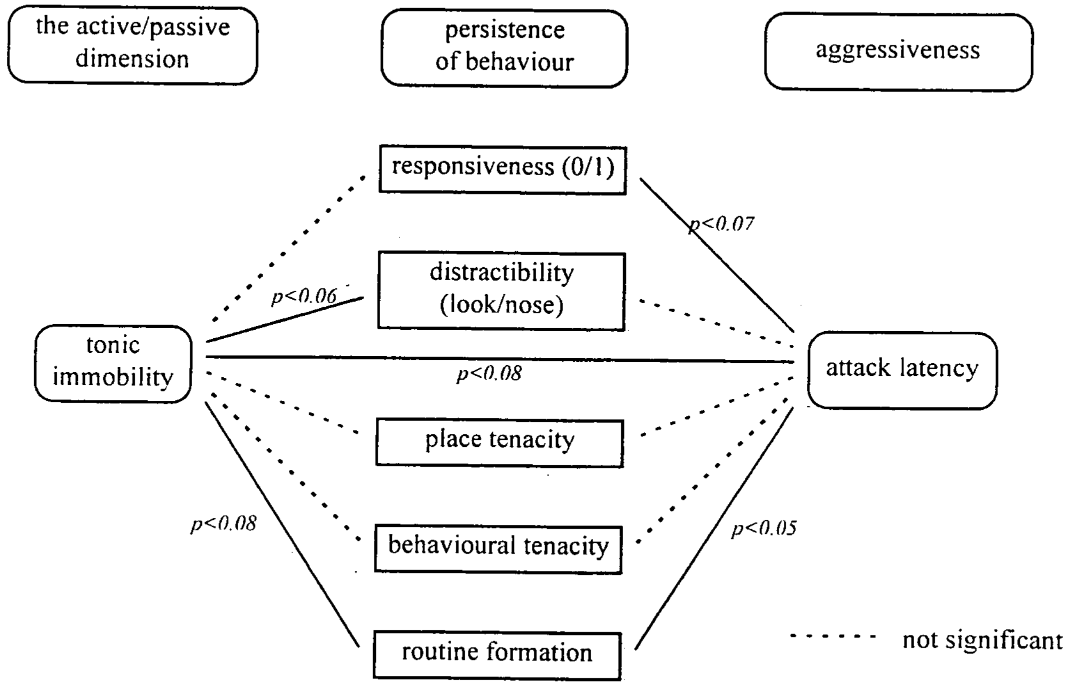


Figure 7.6: Comparisons between the personality traits 'active/passive dimension', 'aggressiveness', and various aspects of 'persistence'.

Links between other personality traits

To investigate the link between the other personality traits, we compared TI and AT with five aspects of persistence, namely responsiveness to a distraction (response/no response), distractibility (look at distraction bar versus nose it), place tenacity (the number of time the closed exit of a maze is revisited before the test animal leaves the maze through the correct exit after a reversal), behavioural tenacity (the amount of time spent near the closed exit after reversal of the maze task), and speed of learning a reversal task in a maze. We found one significant link and three tendencies in the ten relationships we investigated (see figure 7.6).

Links between the active/passive dimension and persistence

Non-TI pigs (active) only looked at the distraction, while 50% of the TI-pigs nosed the bars. Since the pigs who 'looked' at the bars did not interrupt their ongoing behaviour, but were persistent in their running towards the exit of the maze and the food reward, this relationship (not statistically significant!) can be regarded as supporting the active/passive strategy hypothesis (*'active animals are persistent'*).

Slow learning male pigs (did not learn to run the maze error-free after reversal) tended to have shorter TI latencies than those who learned the reversal task. This result is again in agreement with the 'active/passive' hypothesis (*'active animals form routines'*). One has to treat this result with caution, however, since it is based on a very small number of pigs. The statistical tendency rests on only a few pigs who had long TI (more than 5 minutes) or were non-TI.

There was no link between TI and responsiveness to the distraction bars, nor between TI and behavioural tenacity after reversal.

Links between aggressiveness and persistence

Aggressiveness was linked to responsiveness, in that responders who attacked, did so faster than non-responders (again, not statistically significant!). This is interesting in two ways. First of all, it is opposite to what one would expect from the theory of active/passive behavioural strategies (*'aggressive animals are low-responsive'*). Pigs who are responsive to changes in the environment should, according to Benus (1988), be less aggressive. The second interesting aspect is that the difference is within attackers, which may be an indication that 'non-attackers', rather than just having a long attack latency outwith the time limit of the test, really are 'non-attackers', i.e. belong to a different category than those who do attack.

Slow learning male pigs attacked faster in both ATs than fast learners. This is again in agreement with the active/passive theory (*'aggressive animals form routines'*).

Lack of support for the existence of personality types

To summarise, we found that some behavioural traits tended to be linked, some in agreement with the active/passive hypothesis, others opposing it. The effects were often weak (tendencies only), or based on a small number of animals. They also were often not reversible (e.g. all 'long TI' pigs attack, but not all attackers have long TI), and sometimes even contradictory (within the male pigs, for instance, we found that slow learning pigs had shorter TI and shorter AL. For the entire dataset, however, short TI was linked to long AL). Based on these findings, our study suggests that the active/passive personality type dichotomy is not found in pigs, even though there seem to be clear and stable differences in several of the personality traits that make up this dichotomy in mice (Erhard et al., 1997a, Erhard & Mendl, in press).

We base this conclusion on the following arguments:

- the few relationships we found were to be expected by chance given the large amount of statistical tests we carried out.
- some of these relationships even contradicted the hypothesis (TI - AT, responsiveness - AT)

There are several possible explanations for our results. First of all, our tests may not have given valid information on the personality traits we studied. This argument can be discarded, since we validated our tests individually, and found them to be reliable and predictive of behaviour across a time interval of up to two months

(Erhard & Mendl, 1997, Erhard et al., 1997a, Erhard et al., 1997b). It is possible that the absence of links between the personality traits is due to the genetic 'make-up' of the pigs we used in this study. Gray (1979) discusses the effect of inbreeding on emotionality in rodents, and how for instance sex-differences in open-field defecation can be reduced, disappear or even be reversed by selective breeding. In small populations, random genetic drift can lead to distinct differences between populations (Falconer, 1984). The pigs used in modern pig production (and hence in most behavioural experiments) are usually hybrids, derived from relatively uniform selection lines. It may therefore not be possible to extrapolate results obtained in one pig population to another population. Another possibility is that early experience may affect the link between traits. Tests which involve a large amount of handling (such as the back test by Hessing et al. (1993), or the maze test described in this paper), or an important experience (e.g. effects of winning or losing a fight) may affect the behaviour of individuals later in life as well as the relationship between personality traits (Henderson, 1967).

The final explanation for our results, however, has to be that personality traits in pigs are not linked to form personality types.

7.6 Conclusion

Even after careful searching, only a few, weak links between the personality traits could be found. They may be too many to completely dismiss any link between personality traits, but they are not strong enough either to suggest the existence of distinct personality types. Since some of the links found were in disagreement with the 'active/passive' hypothesis, we suggest that active and passive behavioural strategies may exist as a personality trait in pigs, but not as a personality type in line with the active/passive 'coping strategies' suggested for mice.

Instead of regarding pigs as belonging to one of two 'types' (one-dimensional variation), we should understand their personality as a 'combination of traits', i.e. they can be rated along a number of dimensions. An individual's personality may not be sufficiently described by its position in a few dimensions, but is likely to be a relatively unique combination of several personality traits (Buss, 1989).

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Chapter 8

General Discussion

8.1 Introduction

The aim of this thesis was to investigate whether aggressiveness, the active/passive (A/P) dimension and persistence can be considered to be personality traits in pigs. To do this, behavioural tests had to be developed. The behaviour shown in these tests can be assumed to reflect personality traits if it reveals underlying dispositions of the test animals to behave in a specific way, and if it is consistent across time and across situation.

Attack latency in a resident-intruder situation was found to be consistent across a four-week interval, and it predicted the behaviour after mixing unfamiliar individuals. Pigs with a long attack latency fought less vigorously, were less likely to chase losers, and integrated into the new group faster than pigs with short attack latency.

The susceptibility to tonic immobility (TI) predicted the level of 'activity' in behaviour across a 2 month interval. The differences in level of activity were found in the reaction to manual restraint, in the speed of moving in an unfamiliar environment, and in the speed of decision making in an emergence situation.

Persistence of behaviour was represented in two apparently unrelated aspects. The responsiveness to changes in the environment (distraction test) was consistent across a four week time period. The level of response, i.e. whether the test pig interrupted its ongoing behaviour or not, was stable across situation, namely predictive of learning speed in a reversal task. The two aspects of persistence were not interrelated. There either is no universal personality trait of 'persistence', or the tests used in this thesis were not sensitive enough to reveal it.

Looking at the interrelationship between aggressiveness, the A/P dimension and aspects of persistence, I found no consistent evidence for personality types. The individual personality traits appeared to be independent.

8.2 Data collection

Since personality is a theoretical construct which is not directly accessible to measurement, the gathering, analysis and interpretation of data is particularly difficult. In the study of human personality, interviews and questionnaires are often used. It is possible to ask questions, and then analyse and interpret the answers. This is not possible with farm animals. That is, however, not necessarily a disadvantage, since human subjects have been found to state attitudes and intentions which do not correctly describe how they behave in real life situations. Sometimes people are consistent in how they answer specific questions, regardless of the question itself. These 'personal' ways of answering are called 'response sets' (Liebert & Spiegler, 1991). Examples are response acquiescence (tendency to agree with statements), response deviation (tendency to give an uncommon answer), and social desirability (giving answers which are perceived to be socially desirable). 'Social desirability' may, for instance, explain why Bennet (1998) found no correlation between people's stated 'willingness to pay' for legislation to ban the use of battery cages and the magnitude of their purchase of free-range or battery eggs. Appropriate behavioural tests may therefore provide more valuable information than interviews and questionnaires.

8.2.1 Data gathering

One way of asking questions is to set behavioural tests. One can regard the test as a question and the behaviour of the animal as the answer to the question. Human psychology has made great efforts to investigate how the way a question is asked affects the answer given, and then how a specific answer is interpreted. This information is, to a large extent, still missing when it comes to behavioural tests for farm animals. As a result, even tests which claim to test for the same behaviour (e.g. tests for fearfulness) differ to a great extent in aspects of their set-up, and it is not known how these differences affect the behaviour of the animals (Boissy & Bouissou, 1995).

There is not much information available on how specific aspects of a behavioural test affect the behaviour of pigs. In the absence of scientific evidence, it may be possible to use the changes in the experimental set-up other researchers have used in relation to the results of previous experiments to make assumptions about the effects of specific aspects of the test environment on the behaviour of pigs. In the case of aggression tests, this is possible, because a series of attack latency tests was carried out and published by a group of researchers who worked closely together, so that one may assume that changes from one experiment to the next are due to experience of the experimenters. The interpretations derived from this approach are not conclusive, since in most cases the experiments differed by more than one aspect. Ideally, the conclusions drawn from the comparison of the methods and results in the different experiments ought to be tested in specific experiments.

Table 8.1 summarises aspects of the test environment used in tests for aggressiveness. The following discussion is based on the tests listed in the table.

Hessing et al. (1993) tested their pigs in groups of 6 to 8, and were criticised for it by Jensen et al. (1995a). When animals are tested in a group, it is very difficult, if not impossible, to determine which aspect of their behaviour reflects their individual characteristic, and which is due to effects of the group. Strong effects of group on the aggressive behaviour of individual pigs after mixing have for instance been found by Erhard et al. (1997b). As a consequence, other tests for aggressiveness were carried out on individual animals (Jensen et al., 1995b, Forkman et al., 1995). These will be discussed in the following section in more detail. It has to be said, though, that social isolation may have a different effect on very young piglets, as compared to older ones. It is possible, that individual testing imposes a higher level of fear on young test animals than on older ones. By testing them in a group, this effect may be reduced.

Table 8.1: An overview of experiments measuring aggressiveness in pigs

	Hessing et al. 1993	Jensen 1994 (1)	Jensen 1994 (2)	Jensen et al. 1995b	Forkman et al. 1995	Erhard & Mendl 1997
test pig						
sex	female, cast. male	female	female	female, cast. male	female	female, entire male
age at weaning (wks)	n/a	6	6	6	8	4
age at testing (wks)	1 and 2	1, 5, and 9	7	5	9	7 and 11
opponent						
sex	female, cast. male	female	cast. male	?	cast. male	female, entire male
size (% body weight of test pig)	same age	90%	≤50%	considerably smaller, sometimes same weight	95% (≥86%)	2-3 weeks younger, ca. 60%
test environment						
arena	novel	novel	novel	novel	home pen	home pen
habituation	none	30 min before, then 5 min in small compartment	< 5 min	none	n/a	n/a
order in arena	same time	same time	test pig first	opponent first	test pig first	test pig first
duration of test (min)	30	30	≤15	≤15	≤10	≤3.5
No. of pigs per test	2-3	1	1	1	1	1
No. of opponents per test	2-3	1	1	1	1	1
handling prior to test	males castr. 3 days before first test	weighed, ear-tagged	other tests immediately prior to test	open field test 2 wks prior to aggression test	two other tests within one week prior to the aggression test	several tests, the latest test 1-2 wks prior to testing; day of testing: weighed

ds = dataset n/a = non applicable

8.2.2 Behavioural tests

This section discusses the importance of the methodology for the performance of behaviour tests, using aggressiveness as an example. Throughout this thesis, aggressiveness is used as a term for a personality or temperament trait. It is not directly accessible, and has therefore to be assessed through the behaviour which it influences. Aggressiveness is defined as the propensity to perform aggressive behaviour, and is typically assessed by recording the level of aspects of aggressive behaviour. When one develops a test for aggressiveness, one has to chose an aspect of behaviour, which gives information on the test animal rather than on an opponent, or on the relationship between the two. The requirements for the test can be summarised as

- being predictive of aggressive behaviour
- reflecting aspects of the individual test animal's aggressiveness
- being ethically acceptable

8.2.3 Ethical aspects of the study of aggression - parameter recorded and duration of test

Huntingford (1984) emphasised that as a general rule of animal experimentation, but particularly in studies of aggression, care has to be taken that a maximum of information can be gained by causing the minimum of suffering. She suggested, for instance, that attack latency should be used instead of intensity of attack, since it has been shown that the two are highly correlated (Brain & Poole, 1974). In disagreement with this, Rushen (1987) showed in a series of experiments on 5-week old pigs that the duration of fights and frequency of bites were significantly greater when two pigs in a pair were of similar weight (less than 0.5 kg difference in body weight) than when they were of different weight (difference greater than 3.0 kg). The latency to fight, however, was not affected by difference in body weight. Thus, the information gained by observing a fight may reveal information about the relationship between the two contestants, such as size difference, whereas attack latency is more a reflection of an individual animal's propensity to perform aggressive behaviour, i.e. its aggressiveness. It is therefore not only possible to interrupt the aggressive encounter immediately after the first bite, and to thereby minimise the amount of aggressive behaviour performed, it may even improve the quality of the information gathered in the test, since attack latency appears to be more a property of an individual than aspects of fighting behaviour.

Apart from the amount of aggressive behaviour performed, the duration of the test is another aspect affecting the welfare of the pigs involved. If the test is terminated immediately after the occurrence of an attack, it has to be decided when it will be terminated if no attack occurs. Pigs are social animals, and prolonged periods of isolation may be the cause of suffering. In a resident-intruder situation, the resident will be in its familiar environment, but isolated from its littermates. The opponent, on the other hand, will not only be isolated, but also in an unfamiliar environment, which is likely to cause distress.

This is, however, not exclusively an ethical issue. In this context it is important to consider the role of time as an intervening variable. Time does not just pass, but changes the test situation in the process. Prolonged isolation may result in frustration in the test pig, which in turn may lead to frustration-induced aggression (Benton, 1981). In the opponent pigs, it may be the cause of fear and distress and affect their behaviour in such a way that it may in turn have an effect on the test pigs. Even though cut-off points are, to a certain extent, arbitrary, the duration of a test is not necessarily highly correlated with its validity. A test pig, who attacks within a few seconds of the first contact may do so for entirely different reasons than a test pig who attacks after, say, a few hours.

There is, of course, also the practicality of the test to be considered. A short test is more likely to be used on a larger scale, for instance by commercial breeding companies who wish to gain information on the aggressiveness of their animals than a test which takes a long time to carry out.

8.2.4 Test duration in studies of aggressiveness in pigs

Comparing the maximum durations in tests of aggressiveness in the literature, one cannot help but noticing a trend towards shorter tests (table 8.1). Hessing et al. (1993), and Jensen (1994, experiment 1) tested for a maximum of 30 minutes. Jensen (1994, experiment 2) and Jensen et al. (1995a) reduced the maximum duration to 15 minutes, Forkman et al. (1995) further reduced it to 10 minutes. These durations were chosen arbitrarily, presumably as a trade-off between feasibility and loss of information on late attackers. The gradual reduction in the time limit indicates that the optimal maximum test duration had not yet been found. In our study, we reduced the time limit further to 3.5 minutes. I made this decision mainly as a response to the behaviour of a number of opponent pigs in a pilot study, who became very agitated, and tried to escape from the test arena after approximately four to five minutes. From a practical and animal welfare point of view, the shorter the test the better. From a scientific point of view it is important that the results obtained in the test (attack latency) are predictive of aggressive behaviour. By categorising pigs according to their attack latency into high and low aggressive pigs, and by mixing them into different combinations of these categories, we were able to demonstrate that a duration of 3.5 minutes is indeed sufficient to distinguish between high- and low aggressive pigs (Erhard et al., 1997).

8.2.5 Assessing individual characteristics - the test environment

The immediate test environment, consisting of the nature of the test arena (level of familiarity), the order in which the pigs enter the arena, and the characteristics of the opponent pig, can affect the outcome and interpretation of a behavioural test in several ways (see also Hagelsø & Studnitz, 1996). If the opponent attacks first, the information on attack latency of the test animal is lost. If the opponent is not recognised as a target for aggression, the test animal may not attack. In the test described in previous chapters of this thesis (Erhard & Mendl, 1997; Erhard et al., 1997), we attempted to assess aggressiveness directed towards an unfamiliar pig, the aggression being elicited by the unfamiliarity of the opponent. It was therefore necessary to reduce elements of the test environment which might have caused frustration, fear or pain to the test pigs, and hence aggression of a different motivational background (Benton, 1981; Archer, 1988).

To summarise the requirements for the test, the opponent pig ought to be inhibited in its expression of aggressive behaviour, and the test pig ought to be as little affected by the test situation as possible, thus generating an asymmetry between the two animals. These asymmetries can be unrelated to an individual's behavioural strategy (uncorrelated asymmetries; e.g. ownership of territory) or related (correlated asymmetries; e.g. difference in body size; see Archer, 1988).

All three factors, familiarity with arena, order of appearance, and weight difference contribute to the relative advantage or disadvantage of the test pig over the opponent. If the advantage is too far on the side of the opponent, it may attack, and the information on the test pig is lost, if, on the other hand, the advantage is too far on the test pig's side (e.g. opponent too small), the opponent may no longer present a stimulus for aggression (figure 8.1).

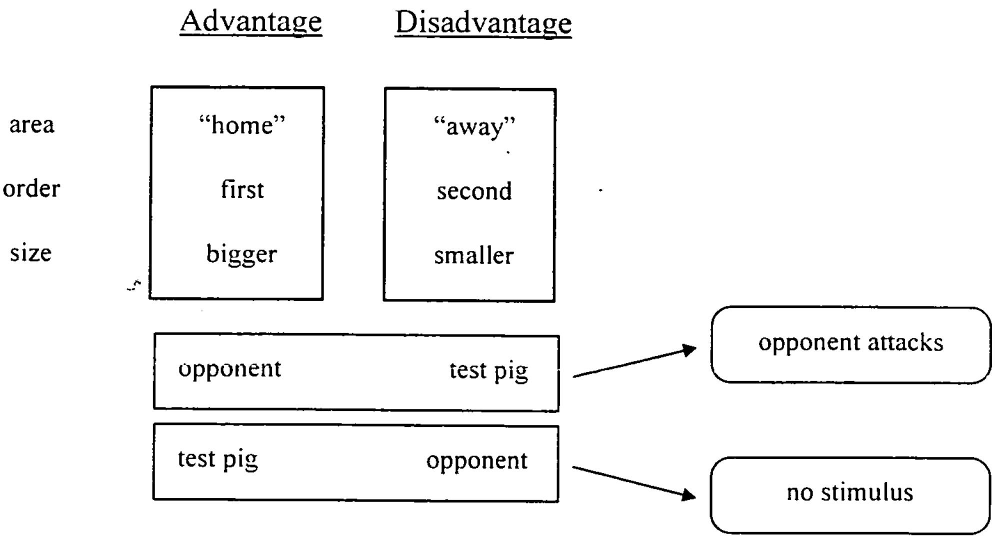

Figure 8.1: The effect of extreme differences between test pig and opponent on the behaviour in an attack latency test

8.2.6 Familiarity of the test arena

The test arena affects animals in several ways. Misslin & Cigrang (1986) showed that being forced into an unfamiliar environment (forced exploration) causes distress. This distress may alter the behaviour in the test, which is why in many studies attempts have been made to reduce the stress experienced by the animals. Hessing et al. (1993) tested their piglets in groups without habituation period, Jensen (1994) exposed the test pigs to the test environment for 30 minutes in the morning before the afternoon testing. Both approaches have disadvantages. When animals are tested in a group, their behaviour cannot be regarded as independent, and forced exposure to a stressor, such as an unfamiliar environment may lead to the animals' making a connection between the unpleasant experience and the test arena, and thus affect their behaviour in this arena. With increased exposure to the arena, it will become more familiar and loose its negative effect of forced exploration. There is, however, no information of how long or how often pigs have to be exposed to a novel environment before it becomes familiar. A solution to this problem is to test animals in their home pen (Forkman et al., 1995). The resident pig will have the 'home' advantage and will have had a minimum amount of handling prior to the test.

8.2.7 Order of appearance in the test arena

This effect of 'home' versus 'away' (Scott & Fredericson, 1951; Rodgers & Randall, 1986) is the underlying principle of 'resident-intruder' tests. The 'resident' is at an advantage over the 'intruder'. A related effect may be achieved by the order of appearance in an arena or the relative familiarity of an arena. The individual who enters the arena first may not 'feel' like a resident, but the animal who enters second will 'know' that it is an intruder. Order of testing is therefore likely to at least affect the behaviour of the second animal in the arena, putting it at a disadvantage. Another aspect of the test environment which determines the balance between the two individuals is their relative size. A larger animal has an advantage over a smaller animal (Rushen, 1987).

8.2.8 The opponent

Aggressive behaviour cannot be performed in a vacuum, it always has a target. It is therefore important to minimise the effect this target has on the behaviour of the test animals.

The effect of the opponent on the test animal's behaviour has been subject of extensive investigation in rodents (Brain & Poole, 1974; Brain et al., 1981; Martinez et al., 1989, Hilakivi-Clarke & Lister, 1992). Brain et al. (1981) discussed the use of inanimate objects or other animals as targets, and emphasised the importance of validation of the techniques. Similarly, Huntingford (1980) points out the importance of the type of target for aggression for the understanding of the underlying system.

While there is a large amount of information on the effect of opponents on the behaviour of a test animal in rodents, this information is not available for pigs. In the studies by Jensen (1994), Jensen et al. (1995), and Forkman et al. (1995), the intruders were between less than half and the same body weight of the test pig (table 8.1). By testing resident pigs against opponents of a wide range of size-differences, we found that intruder pigs who had less than half the body weight of the test pigs were less likely to be attacked than relatively larger opponents (Erhard & Mendl, 1997). This may mean that opponents have to be of a minimum size in order to serve as appropriate targets for aggression. The experiments carried out as part of this thesis do not provide information on whether the minimum body size mentioned above is the minimum relative to the opponent (e.g. 55%), or whether it is absolute, e.g. 15 kg.

When Jensen et al. (1995) and Forkman et al. (1995) used opponent pigs of more than 86% of the test pigs body weight, they found that in between 10 and 16% of their tests, the opponent pigs attacked first. This means that not only is there a minimum, but there is also a maximum size (or relative size) of the opponent. We found that opponents of approximately two thirds of the test pig's body weight provided the same proportion of test pigs attacking as found by Jensen (1994), Jensen et al. (1995), and Forkman et al. (1995) with a relatively small proportion (4%) of opponent pigs attacking first (Erhard & Mendl, 1997). The optimum relative size of opponent for test pigs of approximately 35 kg may therefore be approximately 60%.

8.2.9 Implications of the test set-up for the interpretation of the behaviour

Depending on the situation, an attack may have a variety of underlying motivations. Aggression can be territorial, pain-elicited, protective, or drug-induced, to name just a few (Benton, 1981; Archer, 1988). If a specific aspect of aggressiveness is to be assessed, one has to ensure that the test environment elicits this specific type of aggression. Partly this can be done by careful design, but it ought to always be validated by re-testing the individual animal in the situation which is to be predicted (Erhard et al., 1997).

Testing an animal in its home pen, for instance, means that a specific kind of aggression may be performed, namely territorial aggression. If the test is used to assess 'aggressiveness' in general, it has to be shown that the result of the test can be generalised across other situations. For the purpose of this thesis, I focused on aggression of growing pigs after mixing, and showed that attack latency in a resident-intruder situation predicts aggressive behaviour when unfamiliar animals are mixed. It is possible that both the test situation as well as the mixing put great emphasis on this type of aggression, which Hart (1985) referred to as 'territorial-social aggression' (aggression directed towards intruders in the pens, home areas, or social group). Before the attack latency in a resident-intruder situation can be used as measure of general 'aggressiveness' (if indeed such a trait exists), it has to be shown that it predicts aggressive behaviour in a variety of other situations.

8.3. Data analysis

Studies of personality types in animals have used varying analytical approaches. These approaches appear to depend partly on the distribution of the data, but also on the difficulties of carrying out the specific experiments required. While the correlational approach is probably the most widely used, the genetic lines approach is largely restricted to species of small animals with a large number of offspring and a short generation interval, such as insects, and some species of rodents and birds.

8.3.1 The correlational approach

One of the earlier papers on the interrelationship between the behaviour shown in different situations was Billingslea (1940), who investigated what he called 'salients of individuality' (weight, curiosity, activity, persistence, and emotionality). He ranked animals according to their performance, and calculated a correlation matrix. This method is still widely used in studies of personality, in humans as well as in animals.

One problem with the use of correlation coefficients for behavioural data is, that they were developed for data with continuous distributions. In behavioural studies, however, there is often a lower or upper limit for the data, e.g. because an individual animal does not perform a specific behaviour within the maximum observation time. In this case (upper or lower limits), the correlation coefficient tends to be higher compared with data which do not have these limitations (Dr Elisabeth Austin, BIOSS, personal communication and unpublished computer simulations). Many behavioural tests involve latencies in combination with upper time limits, or frequencies of behaviour, with some individuals not performing it. If a very large proportion of the sample fall into these categories, the value of a correlation coefficient may be reduced.

8.3.2 The genetic lines approach

The most widely cited contemporary study on personality types in mice is the one of Benus and co-workers (e.g. Benus, 1988, Benus et al., 1991), who used lines of mice, which had been selected for several generations for short and long attack latencies, respectively. They then compared individuals from these two lines in various tests, assessing responsiveness to changes in the environment, flexibility of behaviour etc. They tested for personality types ('coping strategies') by comparing the performance of individuals from the two lines in a series of behaviour tests.

Many studies have used selection lines to investigate potential links between behaviours shown in various behavioural tests. Savage & Eysenck (1964) summarise results of over 30 experiments carried out on mice selected for high/low 'emotionality' and on 'reactive' and 'non-reactive' strains. They report that strain differences can be found in many other situations.

A major weakness of the use of selection lines is that they are based on a relatively small part of the original population. In small sub-populations, random genetic drift can lead to a decrease of genetic variability within a sub-population, which may make it significantly different from the original population (Falconer, 1984). Another explanation for links between behaviours in various tests is that the individuals initially chosen for the selection lines may have had these specific links, which, however, were a property of the individuals having these genes rather than of the 'true' link between the behaviours.

8.3.3 The phenotypic extremes approach

Lawrence et al. (1991) investigated the relationship between several tests by correlations first, then selected extreme animals in one test and compared their behaviour in another test. Hessing et al. (1993) followed a similar route by selecting animals who showed extreme behaviour in a handling test, and then compared the behaviour of these two extremes in a series of other tests. The selection is based on the phenotype of the animals, not on the genotype. The advantage of working on phenotypic extremes as opposed to selection lines is that the animals chosen are still part of the original population of animals investigated. It also reduces the problems of defining a cut-off point by omitting a proportion of the population between the two extremes. The categorisation is valid as long as the 'true' cut-off point lies somewhere in this section of the population.

The major disadvantage of investigating genotypic or phenotypic extremes, however, is that they ignore a major part of the population, whereas the correlational approach uses the complete range of individuals.

8.3.4 Multivariate statistical tests

Jensen (1994) used factor analysis to analyse the interrelationship between different behaviours, Forkman et al. (1995) and Spoolder et al. (1996) used principal components analysis.

All these approaches have their strengths and shortcomings. Correlations only test for linear relationships. They cannot be used to compare parameters which have an underlying categorical or other non-continuous distribution. Genetic lines may make differences greater than they actually are, since in small populations, random drift can lead to strong differentiation between populations, and eventually uniformity within the lines (Falconer, 1980). Selecting individuals by phenotype avoids this problem, but it is still only the extremes of a population which are investigated.

Multivariate analyses are performed on complicated data sets as an exploratory instrument. Their strength lies in the detection of relationships which then need to be explored in more detail. A main difficulty with this type of analysis is that it results in new components or factors, which are not always easy to explain and interpret, as pointed out by Jensen (1994), Forkman et al. (1995), and Spoolder et al. (1996). Also, as Liebert & Spiegler (1993) point out, factor analysis requires the researcher to make a series of subjective decisions, such as the choice of mathematical procedure and the naming of the factors.

Another point to be taken into account when performing multivariate, or indeed any statistics, is the importance of the distribution of the data. Many behavioural data are a combination of a categorical and a continuous distribution. In latency tests, for instance, there are animals which do not perform the behaviour within the time limit of the test. This is sometimes interpreted as being a very long latency (Forkman et al., 1995), whereas it could be significant that the behaviour was not performed (e.g. Scott & Fredericson, 1951, Erhard et al., 1997b, and Erhard & Mendl, in press).

In some tests, it may therefore be necessary to analyse the behaviours on several levels. Erhard et al. (1997a) found that the behaviour of pigs in a handling procedure could be divided into reaction and no reaction. They showed that those pigs who reacted could be split into those who struggled and those who froze. When the three groups were compared as to how they performed in a different handling test (tonic immobility), it became apparent that there was only a difference between the two response types, non-response pigs appeared like a combination of the two types. It is possible, that the pigs who did not react were actually 'freezers' or 'strugglers', but weren't identified as such, because they did not respond.

The relationship between the behaviour in the two tests suggested that dividing the responses to the handling test into 1, 2, and 3, according to their assumed strength (no reaction, mild reaction (struggle), strong reaction (freeze; or vice versa)) did not reflect the underlying difference between the categories. It was more predictive to categorise them into 'react yes' and 'react no', and then the 'yes' individuals into 'struggle' and 'tense'. A linear approach would not have revealed this effect.

In another test, comparing pigs who showed immobility in response to restraint (tonic immobility) with those who did not show immobility, it became apparent that in this case it was the performance or non-performance of a behaviour which was predictive of the future behaviour of the pigs in a series of other behaviour tests (Erhard et al., 1997a, Erhard & Mendl, in press).

A third example which may point to more than quantitative differences between fast and slow responders was reported in chapter 6 of this thesis. In the attack latency test, pigs could be divided into those who attacked and those who did not attack within the time limits of the test. Pigs who did not attack could be regarded as 'slow attackers' who did not have enough time available in the test to perform the behaviour. On the other hand, they could be qualitatively different from 'attackers' in that they were not motivated to attack at all. The relationship between attack latency and reaction to the distraction bars illustrates this difference between qualitative and quantitative differences. Comparing male pigs who responded to the distraction bars with those males who did not respond, we found that 'responders' tended to attack faster. A Mann-Whitney test revealed a statistical tendency of $p<0.07$. The effect was mainly due to differences in attack latency within those pigs who attacked. When the same analysis was carried out using only the pigs who did attack, the difference in attack latency was significant (Mann-Whitney test, $p<0.003$; Chapter 6, Figure 6.4). The importance between performance and non-performance of a behaviour has already been pointed out by Scott & Fredericson (1951).

Since there is not yet enough information on the various behavioural tests, it is not possible to pre-determine how the data should be handled. Depending on the specific behaviour or the specific test, each approach to the non-performance of a behaviour (non-information, sensu Forkman et al., 1995, or important information, sensu Scott & Fredericson, 1951) can be valid. At early stages in the development of a behavioural test it is not known whether, for instance, the fact that an individual did or did not become immobile in the tonic immobility test is more informative than the duration of immobility. It may therefore be necessary to analyse the same data several times, by using a categorical approach on several levels, and a categorical, ordered or not, in order to find out the real relationship between two parameters. This, of course, raises the question of statistical significance. If a sufficient number of tests is carried out, some significant relationships may be found by chance, or, rather, significance levels become meaningless.

Looking at data from different angles may be called 'fishing'. For exploratory data analysis, however, it is important to attempt to obtain the maximum amount of information, particularly when the data are complex (Martin & Bateson, 1992). In this thesis, a number of different tests were used which had not yet been described in detail for pigs. A very extensive analysis seemed therefore justified. Once tests have become sufficiently standardised and widely used and validated across a range of situations, it may be possible to pre-determine how they ought to be analysed. It may then be possible to decide whether the behaviour in e.g. an attack latency test ought to be regarded as categorical (attack/no attack) or continuous (attack latency).

The main problem with 'fishing' is the danger of finding significant results by chance (Martin & Bateson, 1992). This was particularly important for the analysis in Chapter 6, in which 132 individual statistical tests were carried out in the search for links between personality traits. Given the particular type of results, however (mostly statistical tendencies, partly contradicting each other), there was no danger of falsely assuming the existence of links between the traits analysed.

8.4. Interpretation of data

8.4.1 An attempt at explaining the existence of personality traits in pigs

Individual differences in aggressiveness, on the A/P dimension, and in flexibility and routine formation were found to be measurable and consistent across time, and it was suggested that they may be personality traits (chapters 2, 3, 4, 5, and 6). According to the theory of evolution, the more successful phenotype eventually replaces the less successful phenotypes. Why is it then that there is this considerable variation in the behaviour of pigs?

A phenotype results from the interaction between the environment (prenatal and postnatal) and the genotype (Pirchner, 1979). The behaviour used to assess aspects of personality is therefore likely to be affected by both the genotype and the environment.

One explanation is that the less adaptive trait/strategy is not 'non-adaptive enough' or the selection intensity not severe enough to have an effect on its presence in the population (neutrality; Clark & Ehlinger, 1987). Another possibility is that differences in a specific personality trait provide individuals with an advantage in different situations. Adaptiveness is not only relevant for natural selection, but also for artificial selection in domestic animals. Evolution favours successful phenotypes, and so does animal breeding.

How can a phenotype be successful? Evolutionary success is often defined as number of grandchildren. In farm animals, two phenotypes can be 'successful' by achieving the same level of performance in the environment they are selected in, or if they are selected for different performances.

An example for the first mechanism is a study by Mendl et al. (1992). Investigating individual differences in social behaviour in sows, Mendl et al. (1992) found that dominance rank in a group of adult female pigs depended to a certain extent on the order in which they were introduced and on the age of the individuals, older pigs and those who were introduced first being higher ranking than younger pigs, who were introduced later. But within the lower ranking animals, they found two distinct groups, which the authors called low- and no-success, depending on their ability to displace other pigs. No-success pigs never displaced another pig, were least aggressive, and most inactive. Low-success pigs, in contrast, were able to displace some individuals, were aggressive, and on the receiving end of the highest levels of aggression by other pigs (see also Cook et al., 1996, for a similar phenomenon in sheep).

When 'success' was measured not in immediate behavioural term (successful displacement of other pigs), but in evolutionary terms (offspring), Mendl et al. (1992) found that low-success pigs had a lower weight of live-born piglets at first parturition than both high-ranking and no-success pigs. This is an example for the relative merit of different strategies in different situations. The aggressive strategy worked for high ranking individuals, the non-aggressive strategy for those lower in the hierarchy. Low-ranking aggressive individuals, in contrast, were less successful. This study provides an evolutionary explanation for the existence of aggressive and low-aggressive individuals within a population, in the same way as the active/passive coping strategy in mice is said to have evolved, because an active strategy is successful for mice who stay in their home territory, while the passive strategy is said to be more successful when mice disperse (van Oortmerssen & Busser, 1988).

For differences in the A/P dimension, a similar system is conceivable. An animal which does not become immobile when chased by a predator may have a better chance to get away whereas once caught, a momentary immobility followed by a quick escape response may be successful (Arduino & Gould,1984). Depending on the situation, selection may work in opposite directions. It was found that pigs who are resistant to tonic immobility were more difficult to hold, but easier to move than those who were not resistant (Erhard et al., 1997). If pigs were selected for 'ease of handling', then individuals of different temperament would have been selected, depending on the situation in which their ease of handling was assessed.

The second way in which two different phenotypes can be successful is if they are selected for different traits. In modern animal breeding, it is common to select paternal and maternal lines for different traits. Maternal lines, for instance are selected for aspects of fertility, whereas paternal lines are selected for aspects of growing performance (Pirchner, 1979). If different performance parameters are linked with specific aspects of personality, these lines ought to differ in their personality. The pigs used for experiments in this thesis came from a back-cross programme, in which the mothers were Large White x Landrace crosses, while the fathers were Large White.

8.4.2 The absence of personality types

The initial hypothesis, that there are personality types in pigs, was based on the work of Benus and co-workers in mice, and on the studies of Hessing et al. (1993) in pigs. This hypothesis had to be rejected based on the work described in this thesis.

The existence of distinct personality types in house mice was explained by the selection of animals in two different situations, staying in and leaving the familiar environment (Oortmerssen & Busser, 1988). Active copers were more successful in the familiar environment, passive copers in the unfamiliar one. There is no evidence for a similar dichotomy in the behaviour of wild boar, and therefore no reason to expect two distinct personality types based on the evolutionary history of the domestic pig. In modern pig breeding, however, the majority of pigs are hybrids of carefully selected maternal and paternal lines. Since paternal and maternal lines are selected for different parameters, it may be possible that they differ in personality as well, and may even show links between traits. Since the pigs used in this thesis were the results of a back cross (Large White x Landrace) x Large White, potential personality types in the paternal or maternal lines could have been lost.

Studies carried out on selection lines, whether they were derived from direct selection for personality aspects (as in the case of active/passive coping mice), or from selection for production parameters (as in the case of modern domestic pigs) will only ever provide information on these lines. Research carried out on outbred populations may reveal different results.

8.5 Implications

Implications for behavioural experiments

Individual differences in behaviour can be a help as well as a hindrance. They increase the within treatment variation, and therefore the sample size needed to detect differences between treatments. However, if these differences are stable across time, i.e. a property of the individual animal, then they lose their unpredictability. Experiments aiming at manipulating behaviour can be designed taking the personality of the animals into account, which would reduce the sample size required for the detection of statistically significant differences.

Often, the animals cannot be subjected to the experimental procedure before the treatment is imposed, since this would affect their behaviour. It would, for instance, not be feasible to mix pigs in order to assess their aggressiveness, and then use them again in an experiment on mixing, since they will have had different experiences in the first mixing (winning or losing fights). The experiments discussed in this thesis, however, have shown that behaviour of individuals in one situation can be predicted by their behaviour in a different situation. It was, for instance, possible to predict elements of aggressive behaviour after mixing by individual attack latency in an intruder test (Chapter 3), or the speed of movement in an unfamiliar environment by the susceptibility to tonic immobility (Chapters 4 and 5).

In most experiments in animal behaviour the groups of animals are already standardised, usually for sex, age and body weight. This is very important for experiments on nutrition and feeding behaviour, where these three factors are known to have a great impact. In experiments on aggression, however, it would be sensible to standardise for aggressiveness; in experiments which investigate the effect of specific treatments on activity level, it would be sensible to standardise for the active/passive dimension of personality. This would improve the quality of the data, and, by reducing the sample size required, animal welfare.

Implications for animal welfare and animal production

Another result which has implications for animal welfare is the effect of the presence of high aggressive pigs on the level of aggression and on the speed of group integration after mixing. It suggests that a reduction in the proportion of high aggressive pigs in the pig population will reduce the levels of aggression after mixing and the speed of group integration. Selecting animals to fit into a specific environment has raised serious ethical questions.

An argument which is often brought forward against the genetic modification of behaviour is that this would amount to breeding animals which are 'too dull to suffer'. The comparison between attack latency and other aspects of personality (Chapter 7), however, suggested that pigs with long attack latency do not have inferior cognitive abilities than short attack latency pigs. In fact, long attack latency pigs were more likely to be fast learners than slow learners in a maze task. The long attack latencies were not a result of a general lack of responsiveness to the environment. Genetic selection which favours long attack latencies would therefore not necessarily result in 'inferior' or 'unnatural' pigs. This statement, however, is based on a relatively small sample (70 pigs) of one population of crossbred pigs. Studies on larger populations investigating phenotypic and genotypic correlations between aggressiveness and other personality traits are necessary to ensure that a selection for long attack latencies would not have adverse effects on other aspects of the pigs' personality.

A further implication of the results reported in this thesis is that it does not seem possible to carry out ONE behavioural test which perfectly categorises an individual and which predicts the behaviour of this individual across a wide range of situations and contexts. Also, a specific type of pig cannot always be identified as desirable for farming purposes. Compared to more passive pigs, those who behaved in a more active way in the TI test, for instance, were more difficult to hold while they were given an injection, but were easier to move through an unfamiliar environment (Chapter 4).

Implications for cognition

The behaviour of animals is often seen as a reflection of their underlying motivation (e.g. Dawkins, 1990). Attack latency may be seen as a reflection of the strength of motivation to perform aggressive behaviour, or of the motivation to remove an intruder from the immediate environment. Whether and to what extent animals are prepared to interrupt an ongoing behaviour to investigate a novel object may be seen as a reflection of the motivation for novelty relative to that for performing the ongoing behaviour. The interpretation of activity level in an open field as an indicator of the level of fear follows this line of argument. However, in Chapter 4, I suggested a model which regards the level of activity in the response not as an indicator of the motivation of the individual, but as the result of an underlying propensity to behave in a more active or more passive way once the motivation is present. Other behaviours may show individual variation as a result of differences in the cognitive processes leading to the behaviours concerned.

Cognitive processes include the reception of stimuli, the processing of information (which in turn is affected by learning and memory and the actual processing procedure), and decision making. Dukas (1998) suggested three limitations on the processing of information. Firstly, the amount of information which can be processed at any one time is limited. Secondly, effective information processing cannot be sustained for extended periods of time. And thirdly, the reactivation of memories of past experiences may be limited. Differences in behaviour may reflect the way in which these constraints affect the behaviour of individual animals in different ways, or how individual animals respond to these constraints in different ways.

One example for dealing with constraints posed by the abundance of information is the extrinsic/intrinsic control of behaviour described by Benus (1988; also Verbeek, 1998). An individual can either try to gather a large amount of information, process it, and then make a decision (extrinsic), or restrict the input of information by filtering it, i.e. perform the behaviour in a more pre-determined way, which is largely independent of the external stimuli (intrinsic). The first approach will be slower and is more appropriate when the environment changes frequently, so that the information which is collected and processed is new. The latter approach is more appropriate in a stable environment, where a behaviour once found to be successful is likely to remain successful.

In chapter 6 of this thesis I report results from maze tests which suggest that a similar phenomenon may be present in pigs. Pigs differed in how they responded to the distraction (novel object) in the runway/maze (no reaction, look, nose). This can be interpreted in much the same way as the intrinsic/extrinsic control of behaviour described by Benus (1988). The link between level of response to the novel object ('look at' versus 'nose') and learning speed lends further support to this interpretation. If all pigs had used cognitive processes in the same way, they ought to have learned the reversal task at similar speed. It could be argued that the number of runs (maximum of eight) was not sufficient to allow conclusions about potential biologically significant differences between fast- and slow-learning individuals. But since learning speed was linked to the level of reaction to the novel object on the previous day, it is possible that the differences are of biological significance.

The experiments reported in this thesis were not specifically designed to investigate the background of differences in the ways cognitive processes occur in pigs. It can be said, however, that there is likely to be a degree of individual variation in cognitive processes, and that studies on cognition should not merely be done on the species level alone, but take the personality of the individuals investigated into account.

8.6 Conclusions

From the experiments presented in this thesis, together with other studies on aspects of personality in animals, the following conclusions can be drawn:

1. Personality traits or dimensions appear to exist in pigs

   Individual differences in aggressiveness, and in the active/passive dimension were found to be consistent across time and situation. These traits are already apparent at a relatively young age of 2.5 weeks for the active/passive dimension, or 4 weeks for aggressiveness. Elements of persistence were also stable across time and context.

2. Personality types, linking traits together were not found in the population of pigs studied. Traits appeared to be independent.
3. The importance of the methodology was shown for the behaviour the animals show in tests as well as for the interpretation of the behaviour

8.7 References

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