

485. Marchant, J.N., Whittaker, X. and Broom, D.M. 2001. Vocalisations of the adult female domestic pig during a standard human approach test and their relationships with behavioural and heart rate measures. *Appl. Anim. Behav. Sci.* 72, 23-39.

## Vocalisations of the adult female domestic pig during a standard human approach test and their relationships with behavioural and heart rate measures

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Accepted 7 November 2000

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### Abstract

Vocal communication in the domestic pig is generally not well documented. The aim of this experiment was to categorise and ascribe the function of the vocalisations of 67 Large White × Landrace gilts during a standard human approach test. At testing, each group of 3–5 gilts was moved to a handling area where each individual in turn was fitted with a heart rate monitor and introduced individually to a 2.4 m × 2.4 m test arena. After 2 min familiarisation, an unfamiliar human entered the pen and stood for 3 min against one wall. Behaviour and sound were recorded continuously with sound recordings transferred onto computer for analysis. Three categories of calls were initially identified: single grunts, single squeals and rapidly repeated grunts. Sixty-six gilts performed single grunts, whereas only 28 and 16 gilts performed the other two categories, respectively. Single grunts could be sub-divided into two types based on sound amplitude profile. These types differed significantly in duration. Gilts performed more short and long grunts per minute during the 3 min test period than during the familiarisation period. Most short grunts observed in a subset of 15 gilts were performed with the snout close to a pen surface or the human. The rate of short grunts during the test period was negatively correlated with the time taken to make contact with the human and positively correlated with the amount of locomotor behaviour carried out, the total number of interactions with the human and the total time spent within 0.5 m of the human. Most long grunts observed in a subset of 15 gilts were performed with the snout away from any surface. The rate of long grunts during the test period positively correlated with amount of

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locomotor behaviour and heart rate, after the effect of activity had been removed. Squeals could similarly be sub-divided into long and short types on the basis of amplitude profile. Gilts that squealed carried out more locomotor behaviour, interacted with the human more, had higher mean heart rates and lower heart rate rise when touched by the human, suggesting a higher degree of arousal. Rapidly-repeated grunts were associated with close human interaction. The results indicate that the domestic pig performs a number of distinct vocalisations during isolation. Short single grunts appear to be associated with investigatory behaviour. Long single grunts may be a form of contact call, the rate of which is related to physiological and behavioural activity. Squeals may have similar function but result from a higher level of arousal. Short, rapidly-repeated grunts appear to have either a greeting or threat function. With further research, certain pig vocalisations may be identified as providing useful additional information about an individual's welfare. © 2001 Elsevier Science B.V. All rights reserved.

*Keywords:* Pig-auditory system; Vocalisations; Approach test; Heart rate

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## 1. Introduction

In many species, vocalisations play an important function in the relaying of information between individuals. For example, they may serve a role in the recognition of individuals (Cheney and Seyfarth, 1982), kin (Rendall et al., 1996) or opposing groups (McComb et al., 1994). They can be used as a tool for assessing the fighting ability of competitors (Davies and Halliday, 1978; Clutton-Brock and Albon, 1979), as an aid to selecting a suitable mate (McComb, 1991) or to convey information about feeding opportunities (Harcourt et al., 1993).

The wild ancestor of the domestic pig lives in forest areas, in small matriarchal groups of about 1–4 females with their young (Frädrieh, 1974; Signoret et al., 1975). This social structure is retained by the feral pig (Kurz and Marchinton, 1972) and the modern domestic pig under free-ranging conditions (Jensen, 1988). In woodland habitat, the opportunity for visual communication is extremely limited and the pig has to rely on other cues for conveying information about its individual identity and the situation in which it finds itself. Hence, the pig has evolved highly-developed senses of smell (Signoret et al., 1975) and hearing, in terms of range of sensitivity (Heffner and Heffner, 1990) and ability to localise sound (Heffner and Heffner, 1989).

The role of olfactory communication in the domestic pig is relatively well-documented, with its importance reported in the conveyance of information during social (Meese and Baldwin, 1975; McGlone, 1988) and sexual behaviour (Signoret, 1970; Pearce et al., 1988; Pearce and Pearce, 1992) and in sow-piglet recognition (Horrell and Eaton, 1984; Morrow-Tesch and McGlone, 1990; Horrell and Hodgson, 1992a,b). The role of vocal communication in the domestic pig, however, is not so clearly defined. The pig can perform a wide range of vocalisations (Grauvogl, 1958; Kiley, 1972). However, there is some disagreement as to whether many of the vocalisations are context-specific and discreet (Grauvogl, 1958) or more generally applicable and continuous, in as much as they vary in duration, frequency and amplitude on a continuum which is in relation to the "excitement" or level of arousal being experienced by the individual in any given situation (Kiley, 1972). von Klingholz and Meynhardt (1979) reported that many vocalisations of wild boar appeared to be

non-specific as to the situations in which they were performed, although analysis of duration, dominant frequency and pitch contour did allow individuals to be identified. Also, vocalisations given as a warning and those associated with feeding and sexual behaviour were specific in structure and function.

More recent work has focused on mother-young vocalisations. It is now known that sow vocalisations can convey information about milk availability (Whittemore and Fraser, 1974; Jensen and Algers, 1983/1984; Algers and Jensen, 1985; Castrén et al., 1989; Blackshaw et al., 1996) and individual identity (Shillito Walser, 1986; Blackshaw et al., 1996). Piglet vocalisations can convey information about pain (White et al., 1995; Weary et al., 1998) and nutritional need (Weary and Fraser, 1995; Weary et al., 1996, 1997). However, there is still relatively little information about vocalisations in other situations.

For wild boar in a woodland habitat, it can be hypothesised that vocalisations have important functions in helping to identify intruders and maintain contact between members of the same social group and also in relaying information about resource availability and for signalling danger. In a potentially threatening situation, such as social isolation and exposure to an unfamiliar environment and human, it may also be hypothesised that a domestic pig could adopt one of a number of strategies. The pig may vocalise in order to attract its group-mates, ward off its group-mates or to intimidate the potential threat or perhaps it may adopt a strategy of non-vocalisation so as not to draw attention to itself.

The aims of this experiment were to describe and, if appropriate, to categorise the vocalisations of sexually-mature, female, domestic pigs during the potentially threatening situations that occur during a standard human approach test — social isolation and presence of an unfamiliar human. The study also aimed to determine whether there were any relationships between vocalisations and measures of behaviour and physiology.

## **2. Materials and methods**

### *2.1. Animals and housing*

A total of 72 Large White × Landrace gilts (PIC, Abingdon, UK) were used. They arrived on farm at point-of-serve (age = 165 days) in three batches of 24, over a period of 3 months. After a 3-week isolation period on a separate site, they were moved on farm to the gilt service area. Here, they were housed in groups of six, in pens with a covered kennel area (9.8 m<sup>2</sup>), strawed dunging area (11.5 m<sup>2</sup>) and six individual feeding stalls, into which they were shut once a day for feeding. Water was available *ad libitum* from two nipple drinkers situated in the strawed area. A mature boar was housed in an adjacent pen and all gilts were served naturally during their second detected oestrus.

The gilts remained in the service area until at least 42 days after service, to ensure that they were pregnant. From here, they were moved to the dry sow house for the remainder of gestation, including the test period, until entry to the farrowing house. The dry sow house consisted of a central feeding passage with a row of free-access feeding stalls on either side, into which the sows were shut for a period of 30 min once per day for feeding. All feeding stalls had a strawed lying/dunging area behind and gates could be shut across the lying area from the back wall to every third feeding stall. Thus, it was possible to separate the house

into pens, with group sizes in multiples of three. All gilts were fed a restricted amount (between 2.5 and 3.0 kg) of standard gestation diet (energy content = 13.50 MJ/DE/kg), the exact amount depending on body condition. Water was available ad libitum, except over feeding, from nipple drinkers situated in the strawed area.

The gilts were to take part in an experiment comparing farrowing systems, one of which was a group-housing system for up to five animals. It was important that those animals to be introduced into the group system already formed a stable group and therefore, groups of 3–5 gilts were created on the basis of their predicted farrowing date, on entry into the dry sow house. Those gilts assigned to single housing at farrowing were similarly formed into groups of between 3 and 5 animals. Five gilts failed to hold to service and could not be assigned to a group. Thus, 67 gilts remained as experimental animals.

## 2.2. Experimental procedures

The human approach test was carried out on all 67 gilts between 72 and 86 days after service, so that stage of gestation had no confounding effect on the heart rate data (Marchant and Broom, 1995). At testing, each group of 3–5 gilts was moved to a handling area approximately 50 m away from the home pen. Here, each individual was separated in turn from its pen-mates and fitted with a Polar Vantage NV (Polar Electro Oy, Kempele, Finland) heart rate monitor (see methodology in Marchant et al., 1995), which was set to record and store successive inter-beat intervals. This degree of accuracy gave immediate information on changes in heart rate over successive beats and allowed information from three gilts to be stored within the memory of a single receiver before the memory capacity was full. Each gilt was then moved a further 20 m down a solid-sided race and introduced individually into a 2.4 m × 2.4 m test arena.

The test arena was solid-sided, with the floor marked into four squares and a semicircle of 0.5 m diameter around the point at which the human stood (see Fig. 1). All gilts were equally unfamiliar with the handling area, the test arena and wearing a heart rate monitor. In addition, since their arrival on farm, they had not been socially isolated. After a 2 min familiarisation period, an unfamiliar human entered the pen and stood motionless for 3 min against one wall, without responding to any contact by the pig. At the end of this 3 min period, the human approached the gilt from the front and reached out and touched her on the snout. The gilt was then moved back to the handling area, where the heart rate monitor was removed and she was re-introduced to her pen-mates. Throughout the experimental period, behaviour and sound within the test arena were recorded continuously using a camcorder with built-in microphone (Panasonic NV-G3B, Matsushita Electric Industrial Co. Ltd., Japan). The clocks on all the Polar Vantage receivers and the camcorder were synchronised to allow co-ordination of behavioural and physiological events.

The sound recordings were transferred onto a Macintosh laptop computer (Powerbook 145, Macintosh, USA) using SoundHandle (Version 1.0.3, Dale Veeneman<sup>©</sup>, USA), a basic sound analysis programme, and analysed to determine duration of vocalisations and amplitude profile. Although the programme did also allow frequency spectra and spectrograms to be displayed, the nature of the recording environment and the low quality of the recording equipment resulted in poor sound resolution and meant that qualitative analysis of these could not be carried out with the degree of accuracy required. For high quality

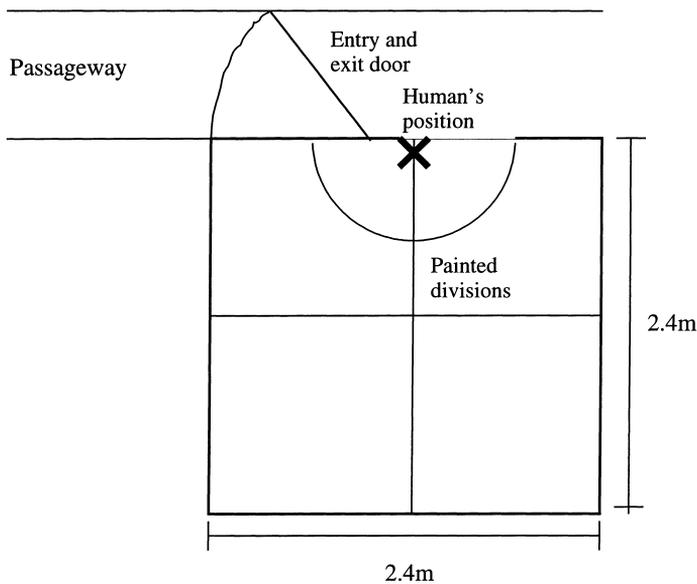


Fig. 1. Plan of test arena, showing painted floor divisions, point of entry for pig and human and position of human during test period.

recordings, equipment such as a Beyer Dynamic MCE86 N microphone and a Sony DAT TCD-7 digital audio tape-recorder would be required.

Behaviour of all gilts was analysed on video playback to determine

1. time taken to move the pig from the handling area to the test pen,
2. the amount of locomotor behaviour, in terms of the number of squares crossed per minute, during the familiarisation period,
3. the amount of locomotor behaviour, in terms of the number of squares crossed per minute, during the test period,
4. time taken for the pig to approach within 0.5 m of the human,
5. time taken for the pig to make physical contact with the human,
6. total number of physical contacts with the human, such as biting, licking and nosing,
7. proportion of total time spent within 0.5 m of the human,
8. number of bouts and mean bout length spent within 0.5 m of human,
9. proportion of total time spent within each square, during the familiarisation and the test periods.

- Due to equipment constraints, the behaviour of a subset of only 15 randomly-selected gilts was analysed to determine, at the time each vocalisation was performed, whether,
10. the position of the pig's head was held UP (horizontal or above horizontal, with nasal disc away from any substrate), DOWN (below horizontal, with nasal disc away from any substrate), PROXIMAL-UP (nasal disc in contact with or within 5 cm of a substrate, head horizontal or above) or PROXIMAL-DOWN (nasal disc in contact with or within 5 cm of a substrate, head below horizontal),
  11. the pig was walking or standing stationary.

When the whole group had been tested, they were moved back to their home pen in the dry sow house. The heart rate data were downloaded from the receivers by 'wire-free' contact via a Polar Interface (Polar Electro Oy, Finland) onto a PC. The data were displayed in graphical and numerical form using Polar Heart Rate Analysis Software (Version 4.00, Polar Electro Oy, Finland) and analysed to determine

1. mean heart rate over the familiarisation period in beats per minute (bpm),
2. mean heart rate over the test period (bpm),
3. heart rate change when the human entered the pen at the end of familiarisation, in terms of bpm and percentage change,
4. heart rate change when the human approached and touched the pig, in terms of bpm and percentage change.

### 2.3. Statistical analysis

For the mean heart rate values during familiarisation and testing, the heart rate data were averaged over the whole 2 or 3 min period by counting the number of inter-beat intervals and dividing by the time to give the mean heart rate in beats per minute. For the changes in heart rate in response to the human, a mean inter-beat interval was calculated from the 10 consecutive inter-beat intervals preceding the event and this value (in milliseconds) was then converted into bpm by dividing it into 60,000. The same procedure was carried out for the 10 consecutive inter-beat intervals following the event. The change in heart rate was calculated as the difference between the two bpm values. The percentage change was also calculated.

During the approach test, some animals did not approach within 0.5 m ( $n = 5$ ) or make physical contact with the human ( $n = 17$ ), within the 180 s assigned to the test. Where this did occur, these gilts were omitted from these behavioural parameters rather than given an arbitrary score of 180 s as to do this may have given misleading statistical results.

Comparisons of vocalisation rates, behaviour and heart rate between familiarisation and test periods and comparisons of heart rate values before and after entry and approach of the human were carried out using paired Students *t*-tests. Comparisons between gilts performing certain types of vocalisation were carried out using two-tailed unpaired Student's *t*-tests. Relationships between vocalisations, behaviour and physiology were investigated using Pearson's product-moment correlation. Data were transformed as appropriate when the assumption of normality was not fulfilled.

## 3. Results

A total of 3214 vocalisations were recorded over the 5 min familiarisation and test periods combined. The number of distinct vocalisations given by individuals over this period varied greatly and ranged between 0 and 164. However, only one of the 67 gilts remained completely silent. Behavioural and physiological responses to human presence also showed a wide variability between individuals (see Tables 1 and 2). This was even though the gilts were from similar genetic and environmental backgrounds, had not been

Table 1

Mean values and range of gilt behavioural measures during a standard human approach test

Behavioural measure	Mean value	Range
Time taken to move from handling area to test arena (s)	76.2	40.2–234.0
Squares crossed per min (familiarisation)	6.32	3–13
Squares crossed per min (test)	3.68	1–10
Time to approach within 0.5 m of human (s)	37.31	0–176.8
Time to make contact with human (s)	42.86	2.33–169.5
Total number of contacts with human	3.52	0–9
Proportion of 3 min test spent within 0.5 m of human	0.25	0–0.61
Number of bouts within 0.5 m of human	2.76	0–7
Mean bout length within 0.5 m of human (s)	18.74	0–66.14

socially isolated since their arrival on the farm and had each been exposed to a similar quantity and quality of human contact.

Three categories of calls were initially identified by ear; single grunts, single squeals and rapidly repeated grunts. The most common category of vocalisation was single grunts and indeed, all 66 vocal gilts performed single grunts, whereas only 28 (42%) and 16 (24%) gilts performed squeals and rapidly repeated grunts, respectively. Eight (12%) gilts performed all three categories of vocalisation.

### 3.1. Single grunts

All single grunts ( $n = 2112$ ) were then analysed using SoundHandle and were subdivided into two types based on amplitude profile. The first type (short) had a single rapid peak in amplitude, which then declined gradually (see Fig. 2a). The second type (long) also had a rapid peak in amplitude followed by a slight decline and then a second peak and decline (see Fig. 2b). These types differed in mean duration (mean duration, 294 versus 886 ms,  $t_{56} = 28.42$ ,  $P < 0.001$ ,  $n = 57$ ) but appeared to be of similar amplitude and frequency although qualitative analysis was not possible.

When the distribution of the various call durations was separated into short and long calls on the basis of amplitude structure, there was a clear overlap in duration between 400 and 600 ms (see Fig. 3). Thus, duration alone gave insufficient information to categorise all single grunts. Gilts performed less of these short and long single grunts per minute during

Table 2

Mean values and range of gilt physiological measures during a standard human approach test

Physiological measure	Mean value	Range
Mean heart rate during familiarisation (bpm)	128.2	102.0 to 155.5
Mean heart rate during test (bpm)	118.9	93.3 to 148.3
Change in heart rate on entry of human (bpm)	+5.0	–36.4 to +26.3
Change in heart rate on entry of human (%)	+4.3	–25.9 to +22.9
Change in heart rate on touch of human (bpm)	+15.4	–4.1 to +33.2
Change in heart rate on touch of human (%)	+13.9	–3.4 to +31.9

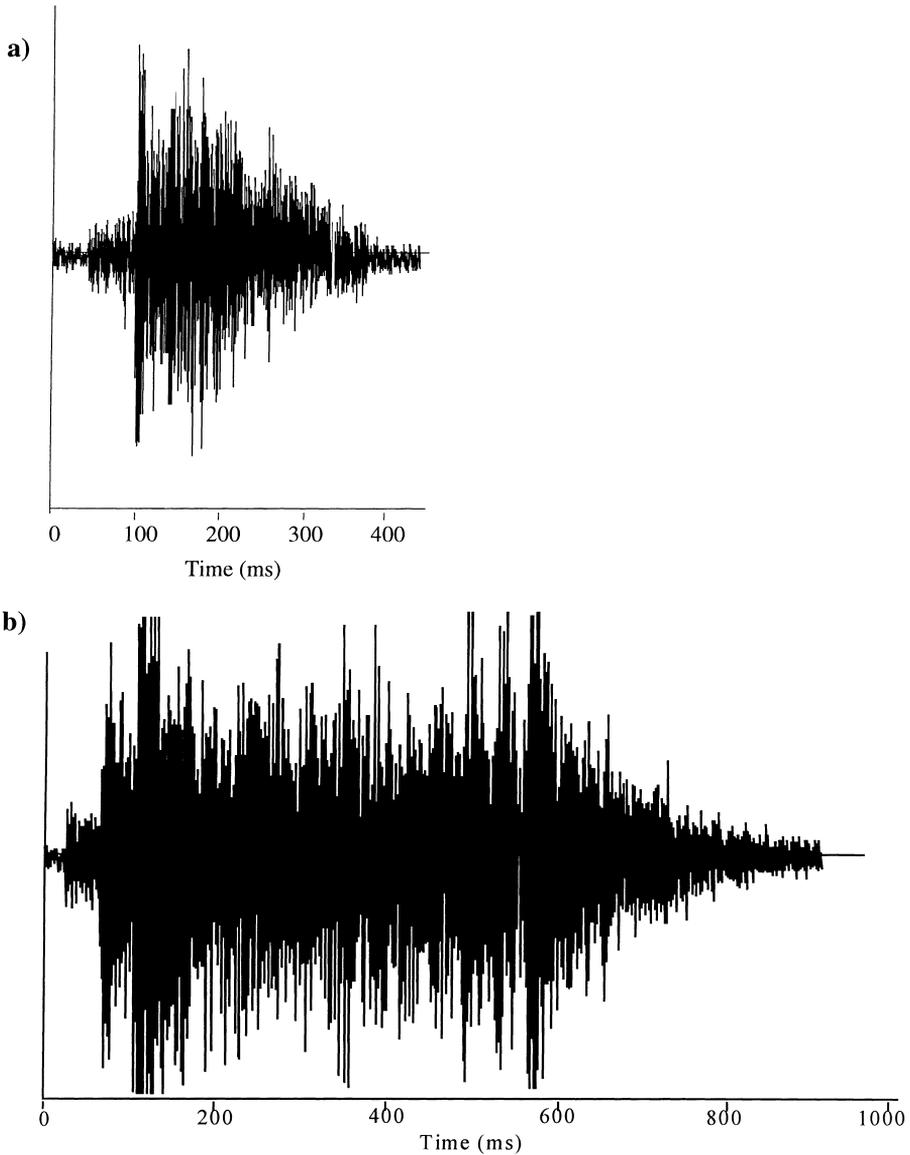


Fig. 2. Amplitude profile for (a) a typical single short grunt and (b) for a typical single long grunt.

the 2 min familiarisation period, compared with the 3 min test when the human was present (mean number, short = 1.43 versus 6.01,  $t_{66} = 7.86$ ,  $P < 0.001$ ,  $n = 67$ , long = 0.92 versus 2.92,  $t_{66} = 7.51$ ,  $P < 0.001$ ,  $n = 67$ ). The mean duration of short calls did not change between familiarisation and test periods (mean duration, 287 versus 289 ms,  $t_{52} = 0.28$ , ns,  $n = 53$ ), whereas the mean duration of long calls increased during the test period (mean duration, 815 versus 936 ms,  $t_{37} = 3.56$ ,  $P < 0.001$ ,  $n = 38$ ). The mean

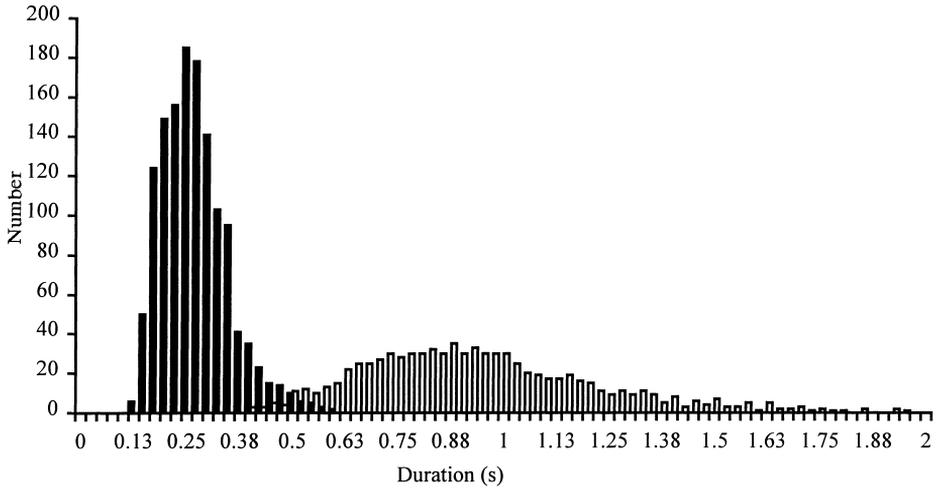


Fig. 3. Frequency distributions of all single grunts, differentiated into short (■) and long (□) on the basis of amplitude profile.

duration of long calls was positively correlated with rate of long call performance ( $r_{59} = 0.42, P < 0.001, n = 61$ ).

The behaviour of a subset of 15 gilts was analysed during 431 long and short single grunts. While performing the 238 short calls and the 193 long calls, gilts were walking on about half of the occasions and stationary on about half of the occasions, for both call types. However, the position of the head and snout varied, with 68.6% of short calls being performed with the snout in proximity to either the pen surfaces or the human and 67.9% of long calls being performed with head held up and away from any surface or the human (see Fig. 4). The performance rate of short calls during the test period was correlated with the

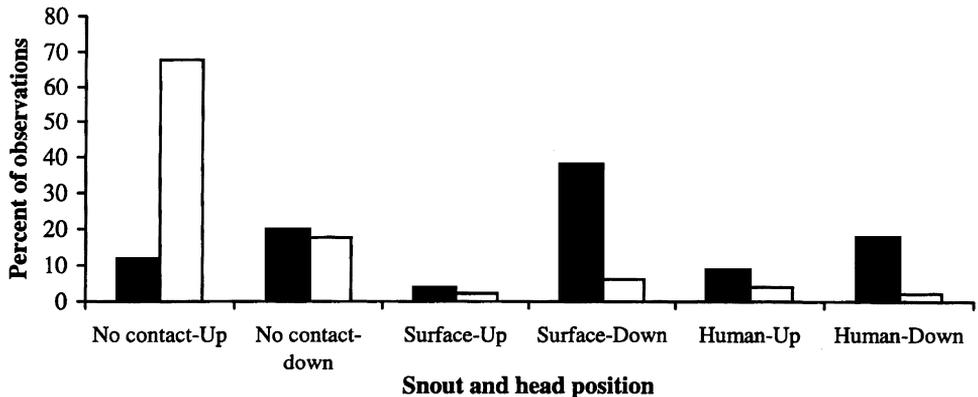


Fig. 4. The percent of observations of gilt head and snout positions during performance of short (■) and long (□) single grunts.

amount of locomotor behaviour carried out ( $r_{64} = 0.25$ ,  $P < 0.05$ ,  $n = 66$ ), the time taken to interact with the human ( $r_{48} = -0.29$ ,  $P < 0.05$ ,  $n = 50$ ), the total number of interactions with the human ( $r_{48} = 0.44$ ,  $P < 0.001$ ,  $n = 50$ ) and the total time spent within 0.5 m of the human ( $r_{58} = 0.32$ ,  $P < 0.01$ ,  $n = 60$ ). The rate of long vocalisations during the test period positively correlated with the amount of locomotor behaviour during the familiarisation period ( $r_{59} = 0.34$ ,  $P < 0.01$ ,  $n = 61$ ) and the test period ( $r_{59} = 0.50$ ,  $P < 0.001$ ,  $n = 61$ ) and mean heart rate during the test period, with the effect of locomotion removed ( $r_{59} = 0.49$ ,  $P < 0.001$ ,  $n = 61$ ).

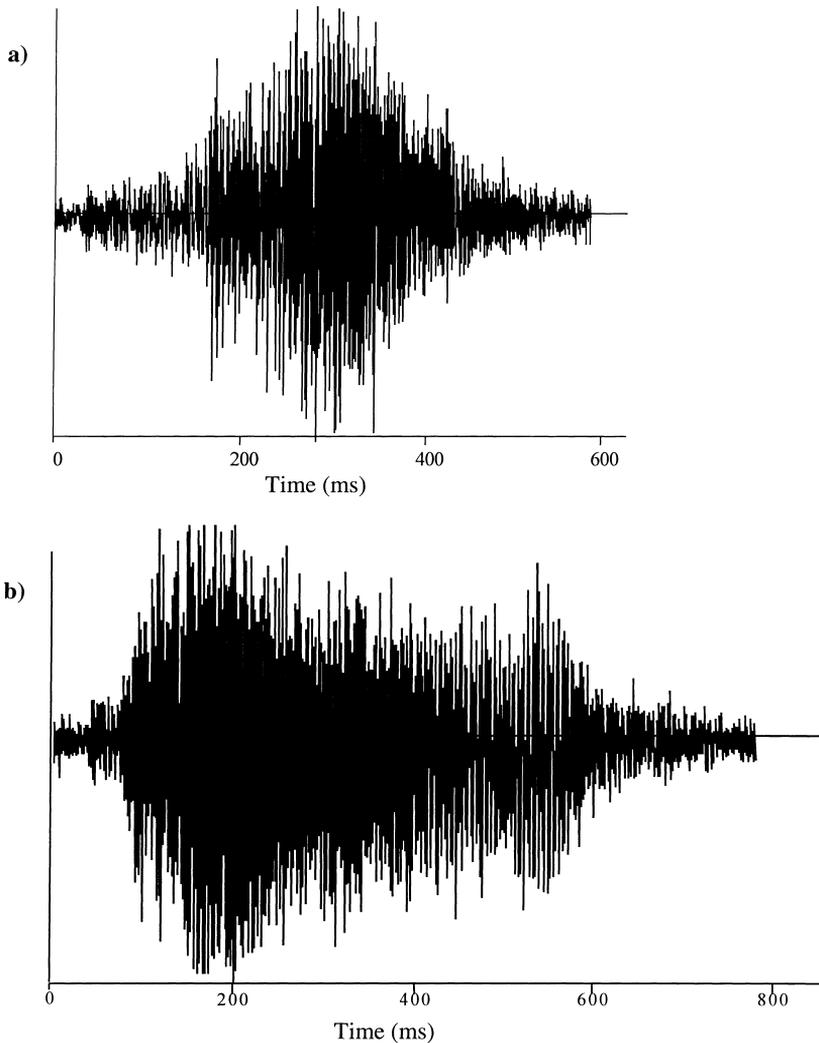


Fig. 5. Amplitude profile for (a) a typical single short squeal and (b) for a typical single long squeal.

### 3.2. Single squeals

Single squeals were performed by 28 of the 67 gilts (42%) over the 5 min experimental period but by only 3 of these gilts during the familiarisation period. Further analysis of all squeals ( $n = 743$ ) using SoundHandle, revealed that they could also be sub-divided into two types based on amplitude structure. The first type (short) had a single, more gradual peak in amplitude than a grunt, which then declined gradually (see Fig. 5a). The second squeal type (long) also had a gradual peak in amplitude followed by a slight decline and then a second peak and decline (see Fig. 5b). These types significantly differed in mean duration (mean duration, 341 versus 920 ms,  $t_{26} = 17.32$ ,  $P < 0.001$ ,  $n = 27$ ). When the distribution of the various squeal durations was separated into short and long on the basis of amplitude structure, there was again a clear overlap in duration between 400 and 600 ms (see Fig. 6).

Short squeals were longer than short single grunts (mean duration, 339 versus 303 ms,  $t_{27} = 2.68$ ,  $P < 0.05$ ,  $n = 28$ ) but the durations of long squeals and long single grunts were not significantly different (mean duration, 935 versus 937 ms,  $t_{24} = 0.04$ , ns,  $n = 25$ ). Gilts which squealed were quicker to approach (mean time, 22.0 s versus 66.6 s,  $t_{65} = -3.52$ ,  $P < 0.001$ ,  $n = 62$ ) and make contact (mean time, 55.6 s versus 93.5 s,  $t_{65} = -2.29$ ,  $P < 0.05$ ,  $n = 50$ ) with the human, spent more time within 0.5 m of the human (proportion of total time, 0.29 versus 0.21,  $t_{65} = 2.07$ ,  $P < 0.05$ ,  $n = 62$ ), made more contacts with the human (mean number of contacts, 3.3 versus 2.1,  $t_{65} = 2.09$ ,  $P < 0.05$ ,  $n = 50$ ) and crossed more squares per minute during the test (mean number of squares crossed, 4.3 versus 3.2,  $t_{65} = 2.46$ ,  $P < 0.05$ ,  $n = 67$ ). They also had higher mean heart rates during the test, with the effect of locomotion removed (mean heart rate, 119.2 versus 117.9 bpm,  $t_{65} = 2.20$ ,  $P < 0.05$ ,  $n = 67$ ) and had a smaller heart rate rise when touched by the human (mean heart rate rise, +12.3 versus +17.5 bpm,  $t_{65} = -2.37$ ,  $P < 0.05$ ,  $n = 67$ ) than gilts which did not squeal.

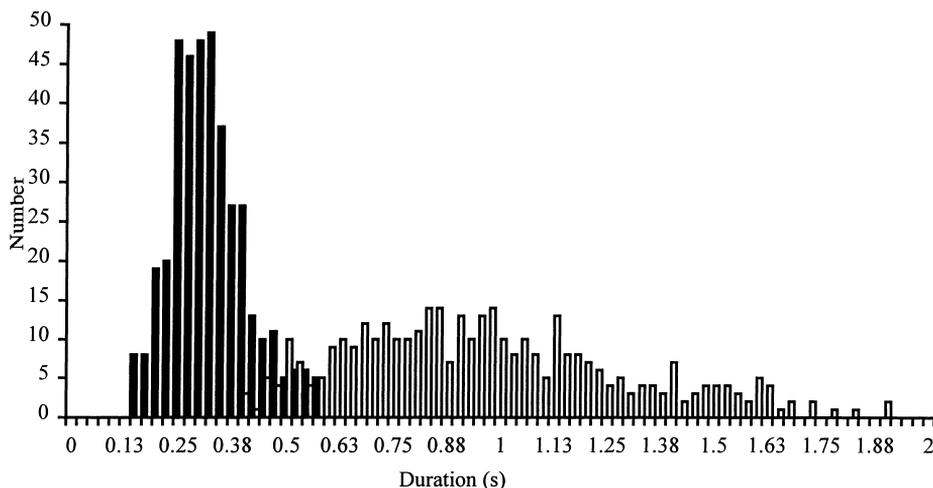


Fig. 6. Frequency distributions of all single squeals, differentiated into short (■) and long (□) on the basis of amplitude profile.

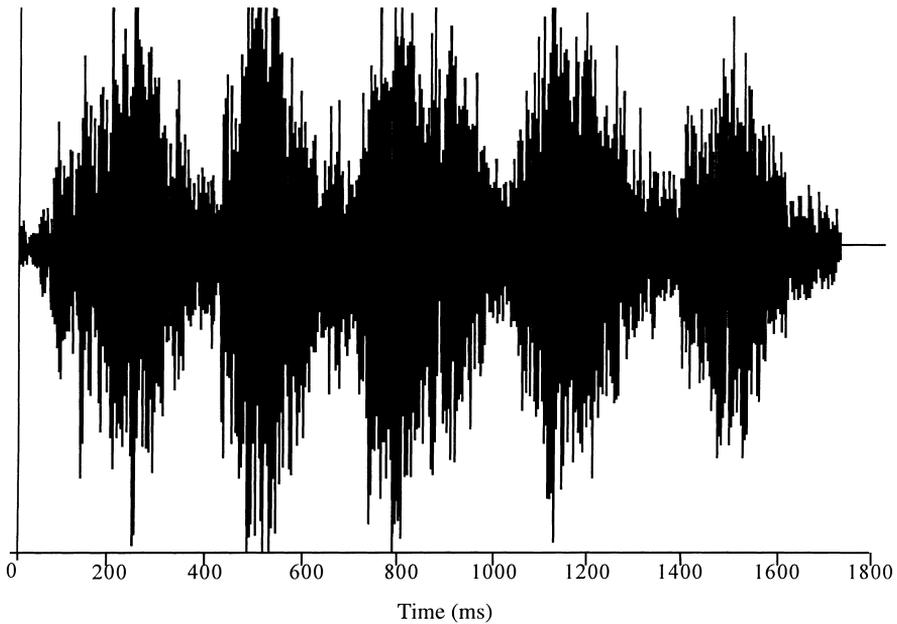


Fig. 7. Amplitude profile for a typical series of rapid repeated grunts.

### 3.3. Repeated grunts

Short, rapidly-repeated grunts were performed by 16 out of the 67 gilts (24%) and only when the human was present. The number of grunts in each calling bout was between 3 and 9, and bouts were often multiple, being separated only by short intervals for the gilt to inspire (see Fig. 7). The behaviour of the gilt during this type of vocalisation was characteristic. She would always be close to and facing the human, with her head held up and the mouth open. Often, this vocalisation was associated with physical contact, with the gilt using her snout and all of these 16 gilts made contact within the 3 min test period. These gilts were quicker to make contact (mean time, 37.4 s versus 90.3 s,  $t_{65} = -3.95$ ,  $P < 0.001$ ,  $n = 50$ ) and made more contacts (mean number of contacts, 4.1 versus 2.2,  $t_{65} = 3.59$ ,  $P < 0.001$ ,  $n = 50$ ) than the gilts which did not perform repeated grunts. The duration of each grunt within a repeated series was shorter than the duration of single grunts (mean duration, 234 versus 279 ms,  $t_{15} = 5.24$ ,  $P < 0.001$ ,  $n = 16$ ).

## 4. Discussion

The domestic pig performs a number of distinct vocalisations during social isolation and exposure to an unfamiliar human and the total number of vocalisations performed per pig shows a wide unimodal distribution. Only one gilt was silent throughout the 5 min experimental period but she did spend a higher than average proportion of time within

0.5 m of the human. Thus, it would seem unlikely in this test situation, that the pig may adopt a strategy of non-vocalisation. However, this does not discount the existence of such a strategy to remain inconspicuous in an environment more representative of natural habitat, i.e. one with vegetation providing cover.

Single grunts were the most common vocalisation, as has been documented elsewhere (Fraser, 1974, 1975a; Schrader and Todt, 1998). Kiley (1972) characterised 13 different vocalisations, from a sample size of over 200 calls recorded from various sized pigs in different situations. The single grunts recorded in this study correspond, in terms of duration, to those described as “common grunts” and “long grunts”. They also correspond with the short and long grunts performed by growing pigs in an open field test, as described by Fraser (1974). Kiley (1972) summarised the situations in which short and long grunts arise as being broadly similar with both having a common function in indicating location when isolated. However, her study arranged together types of call from very different situations and lacked the detail necessary to assign the precise function which closer examination of acoustic parameters may reveal. The results of this study may indicate that short and long grunts have somewhat different functions within this particular test situation.

Short, single grunt rates were negatively associated with the time to interact with the human and positively associated with the amount of locomotor behaviour carried out, the total number of interactions with the human and the proportion of total time spent within 0.5 m of the human, i.e. with behaviour related to investigation. Although this type of call may relay information about location of individuals to other group members, as Kiley (1972) suggests, it may also serve an additional function. During two-thirds of these vocalisations, the snout was in contact with or proximal to the pen surfaces or the human. It is therefore possible that the pig was engaged in olfactory investigation of aspects of its environment. Exhalation of air through the nose and mouth of the pig when grunting probably disturbs volatile compounds from the substrate surface, which can then be detected using the highly developed nose and vomero-nasal organ.

However, what appears to be investigation of the human and what appears to be investigation of the pen may in truth be very different behaviours, with very different functions. This and the fact that a third of the short grunts occur without the snout close to a surface means that other functions could also be assigned to these vocalisations, including arousal, warning, contact or greeting. Examination of the data reveals that the behaviour patterns of the gilts varied considerably in terms of total time spent in close proximity to the human, number of bouts and mean bout length in proximity to the human and the amount of locomotor behaviour and yet all but one gilt performed short grunts. Much more detailed behavioural analysis is required in future studies to establish exactly what the pig is doing throughout the test period and in particular, at the time a short grunt is performed, before a function can be firmly assigned.

Long, single grunt rates were positively associated with the amount of locomotor behaviour and also with mean heart rate during the test period, with the effect of locomotion removed. Schrader and Todt (1998) reported clear correlations in domestic pigs between circulating adrenaline concentrations and motor activity and specific acoustic parameters, including vocalisation rates. Thus, the association between heart rate and vocalisation rate in this study could be due to a temporal but independent increase in both

parameters in response to an increase in circulating adrenaline. Alternatively, it is likely that the performance of long, single grunts imposes an energetic cost, as observed in roaring contests in red deer (Clutton-Brock and Albon, 1979), and thus it is this energetic cost which may directly increase heart rate.

Three-quarters of long grunts were performed with the head held up and away from any vertical or horizontal surface, perhaps to ensure that the call had maximum carrying distance. If so, this would seem to indicate that this type of vocalisation was a contact call used when the pig became isolated from its group. A similar type of call has been described when the sow is separated from her piglets at weaning (Pajor et al., 1999). Sows which showed strong maternal qualities performed more calls and calls of longer duration, suggesting a greater level of “distress” at separation (Pajor et al., 1996). In our study, the relationships between calling rate and call duration and heart rate, may support the theory that long grunt vocalisation rate may be related to emotional disturbance caused by social isolation. By emitting these calls, with the head raised, the sow may be attempting to project her voice over greater distances and make contact with the rest of the group members.

Squeals could also be divided into long and short types on the basis of amplitude structure. The durations of these closely corresponded with the durations of short and long grunts. Although short squeals were longer than short grunts, this may be due to the fact that the vocal chord tension needed to produce these higher frequency sounds was greater and thus, the vocal chords required more initial energy to vibrate, resulting in an overall increase in duration. Sows that squealed spent more time near the human, carried out more locomotion, had higher heart rates during the test and, subsequently, a ‘dampened’ and therefore smaller heart rate change when touched by the human. This relationship between squealing and locomotion has also been observed in socially-isolated piglets (Fraser, 1975a) and growing pigs (Fraser, 1974). These results support the theory that the type of call performed is related to its “level of excitement” (Kiley, 1972) or arousal and as this level increases, assuming the same causation, grunts become squeals.

However, a squeal may indeed be relaying very different information to a grunt and it would be improper to assume that squeals and grunts do have a common causation without further experimental investigation. Another possible function is the relaying of information about the degree of stress being encountered by an individual. During routine husbandry tasks, squeals are a common vocalisation. It is known that the frequency of squeals can convey information about the extent of pain during castration (White et al., 1995; Weary et al., 1998) and that pigs show aversive behavioural reactions and accelerated heart rate in response to playback of squeals (Rohn, 1996). Fraser (1975b) has also shown that the environment in which they are placed influences the rate at which isolated piglets squeal. Isolation combined with spatial restriction within an unfamiliar environment elicited the greatest number of squeals, compared with no spatial restriction or remaining in the home pen. In our experiment, the pig is isolated initially in a totally unfamiliar environment. However, when the human enters the pen, gilts that squeal spend more time in close proximity to the human. This suggests that those pigs that are finding isolation particularly stressful, may be using the human as a familiar ‘reference point’ in an otherwise unfamiliar environment and therefore choosing to spend time in close proximity to the human on the basis of familiarity.

Short rapidly-repeated grunts have been described as serving a “greeting” function (Kiley, 1972). Certainly in this study, this type of vocalisation was only carried out when the human was present and with the gilt in close proximity. Gilts which performed this type of call did approach the human more quickly, had a shorter interval between approaching within 0.5 m and making physical contact and made more physical contacts than gilts which did not. This corresponds to the “greeting” theory but does not discount a function of “threat”. Subsequently, in the farrowing house, gilts that performed these vocalisations during the test had a higher score for aggression directed at the stockman during routine litter procedures (Marchant, unpublished data).

To conclude, socially-isolated gilts were more vocal when a human was present. This may have been due to the fact that the human was a source of stimulation or familiarity in an otherwise barren and unfamiliar environment or because the human induced a greater level of arousal and hence greater vocal responses (Kiley, 1972). The social isolation itself did not appear to be particularly disturbing to most gilts and the most frequent vocalisation was short single grunts which may be associated with investigatory behaviour. The next most frequent were long single grunts, which may be a form of contact call, the rate of which is related to heart rate and locomotor activity. Rapidly-repeated grunts appear to have either a greeting or threat function. Further research is required, perhaps encompassing playback experiments within specific test situations, in order to assign exact functions to the vocalisations described but with this, certain pig vocalisations may be identified as potentially providing useful additional information about an individual’s welfare.

## Acknowledgements

The authors would like to thank Amanda Burfoot at ADAS Terrington, Norfolk for her assistance with this study and Dr. Anthony Podberscek and two anonymous referees for their useful comments on an earlier draft. This study was funded by the UK Ministry of Agriculture, Fisheries and Food (Grant: AW0106). SAC receives financial support from the Scottish Office Agriculture, Environment and Fisheries Department.

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