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Journal

International Journal of Comparative Psychology, 11(1)

ISSN

0889-3675

Authors

Blackshaw, Judith K
Blackshaw, Alan W
McGlone, John J

Publication Date

1998

DOI

10.46867/C48K5R

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STARTLE - FREEZE BEHAVIOUR IN WEANED PIGS

Judith K. Blackshaw and Alan W. Blackshaw
The University of Queensland, AUSTRALIA

John J. McGlone
Texas Tech University, USA

ABSTRACT: Pigs may express a startle response and then freeze after they have heard an auditory stimulus. The objective of this study was to induce startle-freeze behaviour, describe it and to seek potential variables that might influence it. A startle-freeze response lasting 1 to 12 seconds was produced in 36 pigs 5-6 weeks old penned in 12 groups (3 pigs per group), using a cymbal (26 cm radius) to produce a sound of 110 dB intensity. This was repeated at 4 minute intervals for 8 stimuli over 28 minutes. The duration of the startle-freeze response decreased over presentations and all pigs had ceased to respond by the seventh stimulus. The frequencies of social interaction, ingestion and lying or sitting behaviours before freezing decreased after the freeze period, and standing or walking increased. The behaviours shown before and after immobilisation were not independent ($\chi^2_4 = 101.9, p < 0.001$). The social status of each group was determined from videotape records. The dominance rank of the pig was significantly related to the onset of immobilization; the most dominant pigs responded to the noise first, often 1 to 2 seconds ahead of lower ranked pigs ($\chi^2_6 = 15.74, p < 0.05$). In conclusion, pigs show a clear startle-freeze response to a novel auditory stimulus, they habituate rapidly and the onset of startle-freeze behaviour depends upon their social status.

The first protective response given to sudden sound is a startle or "auditory startle" response. Any general massive body flexion in animals in response to sudden intense stimulation is referred to as a startle. The "auditory startle" is specifically in response to a sudden sound (Salzen, 1979). Marks (1987) referred to it as a momentary fear of a sudden stimulus. Inhibition, freezing and crouching follow

Address correspondence to Judith K. Blackshaw, Department of Veterinary Science and Animal Production, The University of Queensland, St Lucia, 4072 Queensland, Australia.

auditory startle and are responses to sounds intermediate between those that will elicit the full startle and the orientating reflexes (Salzen, 1979).

Ratner (1967) observed that animals freeze and become temporarily immobile when a novel or threatening stimulus is presented. There is evidence that this freeze response is a type of fear reaction to a novel stimulus (Archer, 1979). Marks (1987) referred to freezing as attentive immobility when an alerted individual remains motionless and monitors the source of danger, ready for flight or fight in an instant. Archer (1979) showed that when a bell was sounded in an open field situation, chickens froze and did not emit distress calls.

Fear shows a diverse group of behaviour patterns including those leading to avoidance of a stimulus and immobility responses (Hinde, 1970, pp 349-351). Thus, flight and immobility are broad behavioural categories induced by novel and potentially fear-inducing situations; both categories include several different types of response.

The types of immobility which occur in fear-inducing conditions are overlapping (Archer, 1979). The first type is freezing which is a relatively short-lived period of immobility shown by many species of animal. It may be accompanied by a crouching posture. There is a further type of immobility, tonic immobility which occurs in a wide range of vertebrate and invertebrate species in response to physical restraint (Archer, 1979).

It is important to differentiate between freezing immobility (often called immobility) and tonic immobility. Gallup (1974) reviewed animal hypnosis or tonic immobility, and pointed out that some form of physical restraint is usually necessary for the tonic immobility responses. However, Marks (1987) quoted experimental work which indicated tonic immobility could be reliably elicited by sudden noise, or being thrust into new surroundings or by suddenly turning an animal on its back.

Tonic immobility is longer-lived than freezing immobility and the animal remains responsive to external stimulation. It is brought about by the tonic action of both extensor and flexor muscles involved in struggling, and the animal's attempts to escape (Archer, 1979; Salzen, 1979).

Both tonic immobility and freezing are defensive reactions that begin abruptly in the face of danger (Marks, 1987). Freezing is preparatory or an intention movement of flight while tonic immobility is a terminating reaction to being caught. This might explain why freezing is more common than tonic immobility. Also during freezing, the animal is in the alert posture typical for that species, whereas tonic

immobility often leaves the animal in unusual postures (Marks, 1987).

Ratner (1967) gave a clear account of the sequence of stimuli and responses associated with decreasing defensive distance between the position of the threatening stimulus and the animal. First the animal freezes to a typical visual or auditory stimulus which is at a distance. As the distance between the threatening stimulus and the animal decreases, the animal tries to escape, or flee and finally reaches tonic immobility. Any stimulus that functions as a threatening stimulus elicits a sequence of responses as a function of the distance between the stimulus and the animal.

These responses appear early in ontogeny. Borchelt and Ratner (1973) described the ontogeny of both freezing and tonic immobility in the bobwhite quail (*Colinus virginianus*) in response to handling and the visual presence of the experimenter. Freezing was more common than tonic immobility at 9-10 days and by 15 days the first strong responses of tonic immobility appeared with a median duration of 60 seconds and occurred with a mean duration of 10 seconds.

In the rat Bolles and Wood (1964) observed freezing to a sudden noise at 23 days of age and Fox (1970) saw freezing in the cat following an auditory stimulus from 13 days. The development of inhibition, freezing and crouching follows a standard pattern in altricial birds and involves developing responsiveness first to auditory and then to visual stimulation (Salzen, 1979). Salzen (1979) concluded that the early appearance of inhibition and freezing to auditory stimuli seemed to be associated with early auditory responsiveness and unlocalised stimulation. He also commented that in precocial mammals inhibition and crouching develop with the startle response and this is evident if there is a disturbing stimulus and the parent is absent.

The trend of recent work has been to use the tonic immobility response as an indication of fear which might be induced in domestic hens by transport (Scott *et al.*, 1998) high stocking density (Andrews *et al.*, 1998), group size (Bilcik *et al.*, 1998) and forms of restraint such as shackling and diverse hooding devices (Jones *et al.*, 1998). However, there are no comments in any of these studies on the presence or absence of the initial startle-freeze response. Also, most of the recent work has been done with domestic hens.

One paper (Dawson and Revens, 1946) described an alarm response in pigs in which an electric sparking device (which produced a distinct, though not loud, hissing and crackling sound) was used to scare pigs away from the feed trough.

Animals can habituate to a variety of stimuli and habituation of

simple and complex defensive responses is very similar across species. Habituation refers to the decrement in response as discrete stimuli are repeated and is largely independent of motivational states, biological cycles or age (Marks, 1987). Hinde (1970, pp 577-579) commented that sometimes the difference between habituation and extinction is difficult to define.

Intensively housed pigs startle and freeze when a strange, often loud, noise occurs, and they take a short time to begin moving again (Blackshaw, pers obs). We found no discussion in the scientific literature of this response in pigs.

The aims of this experiment were to document the startle-freeze behaviour in young weaned pigs, in response to a loud noise, to determine how many presentations of the stimulus were needed before the pigs no longer responded and to explore the possibility that position in the dominance hierarchy might influence freezing behaviour.

METHOD

Subjects

Three blocks of 4 pens (1.2 m x 1.2 m) each containing 3 pigs from different litters (PIC Camborough - 15 crosses), 5 to 6 weeks old were tested (n = 36 pigs). The pigs in each pen were visually isolated from the other pens, with wooden boards between adjacent pens. At weaning (28 d of age) pigs from three litters were identified individually and placed in each nursery pen. Time lapse video recorders, filming at 0.83 frames/sec for 24 hours were used to assess the food competition dominance hierarchy.

Procedure

Food competition dominance. Groups of weaned pigs were food restricted; the trough was not refilled the evening before the food competition dominance rank was assessed. The pigs were fed next morning and agonistic behaviour (including fighting, biting, head thrusting, threat, displacement at the feed trough) was recorded on the time lapse video recorder. Each pig was marked so that the initiator and recipient of the behaviours could be identified. Matrices were generated for each group and the pigs were ranked according to the winning of agonistic encounters at the feed station (Beilharz and Cox, 1967; Signoret, Baldwin and Hafez, 1975).

Startle - freeze response. The startle-freeze response was generated with a 26 cm (radius) cymbal suspended from a wire loop equidistant from the 4 pens. The sound intensity in the centre of the 4 pens was 109 to 110 dB, measured with a "Realistic" sound level meter (Tandy Corporation, Cat. No. 33-2050) which had a range of measurement 50-126 dB and accuracy of ± 2 dB at 114 dB sound level. The sharp sound was tested for repeatability and intensity in the test room. Eight single strikes with a wooden drumstick (noise stimuli) were generated at 4-minute intervals and the response in each pen recorded on videotape (30 frames/sec) using colour cameras with video and audio recording. For viewing, videotapes were played in slow motion (down to 0.8 frames/sec).

Observations

As each pig had been identified and ranked, it was possible from the videotapes to record for each pig:

1. the behaviour immediately before the startle-freeze sequence; lie or sit, stand or walk, feed-with head in the trough, drink (or at the drinker) and social interactions (while lying or standing)
2. the length of the freeze behaviour in seconds
3. the order of on-set in which each pig in the group showed freeze behaviour and the order in which they resumed activity after freezing
4. the behaviour (as above) the pigs resumed after freezing
5. the length of time and number of exposures taken for habituation to the noise.

Analyses

The data set included 36 pigs from 12 replicate pens with each pen including pigs of socially dominant, intermediate and subordinate status. Regression analysis was used to assess freeze period (seconds) time over number of cymbal strikes ($n = 8$). Linear, quadratic and cubic coefficients were calculated. Parametric and non-parametric analyses of social status effects on order of movement after freezing yielded identical conclusions. The chi-square analysis with social status in rows and order of freeze behaviour in columns was assessed using General Linear Models Procedure (SAS, 1988).

RESULTS

The strike on the cymbal produced a pronounced startle-freeze response, which decreased over subsequent presentations. Figure 1 shows the mean startle-freeze duration (seconds) with repeated exposures to the auditory stimulus ($n = 8$, 4 minutes apart), for 36 pigs. The end of the startle-freeze sequence was marked by movement of the pig's head, which occurred whether the pig was standing, sitting, or lying. The behaviours before and after immobilization were significantly different ($\chi^2_4 = 101.9$, $p < 0.001$). Freezing, on presentation of the stimulus, disrupted the frequencies of social interaction (51 vs 9), ingestion (50 vs 23) and lying or sitting (137 vs 98), but standing or walking were increased greatly (50 vs 158) after freezing.

Position in the hierarchy did not influence ($p > 0.05$) individual pig behaviour (lie or sit, stand or walk, ingestion and social interaction) before the sound stimulus, immediately after the freeze behaviour or 10 second later. Also, when rank was not considered, there was no differences in behaviour ($p > 0.05$) before or immediately after freezing in individual pigs, 10 seconds later.

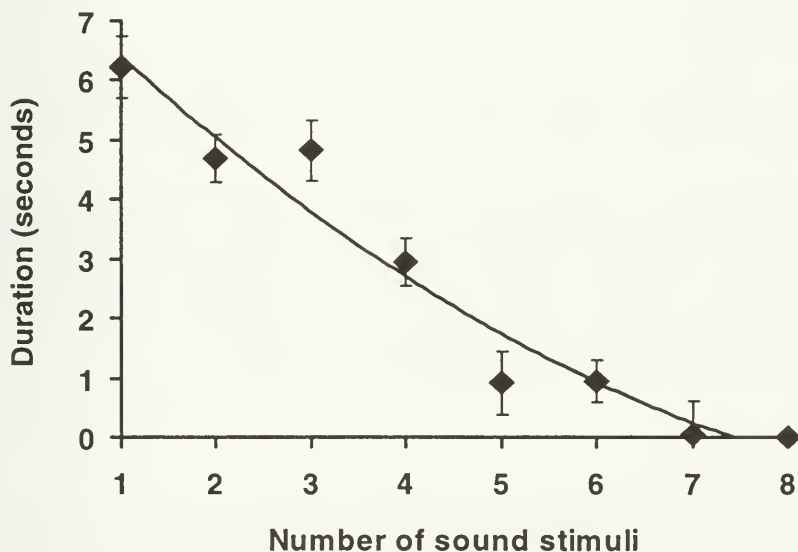


Figure 1. Startle-freeze duration (seconds) with repeated exposures to the sound of a cymbal. Shown is the mean results for 36 pigs. Each auditory stimulus ($n = 8$) was 4 minutes apart. The regression equation for the cubic effect was: $Y = 6.297 + 0.1129X - 0.375X^2 + 0.034X^3$, ($r^2 = 0.96$).

When individual startle exposures (corresponding to the cymbal strikes) were examined, there was no relationship between the rank of the pig and the behaviour before or immediately after freezing or 10 seconds later.

The latency of onset of freezing was highly related to the position of the pig in the hierarchy (Table 1). The dominant pigs usually responded to the noise stimulus first, this was often 1 to 2 seconds ahead of the lower ranked pigs who were more often last to freeze ($\chi^2_6 = 15.74, p < 0.05$). The order of pigs resuming activity directly after freezing was independent of dominance rank and the length of the freeze response was not related to dominance rank.

Table 1. Numbers of observations for pigs of each social status (n=12) and their order of startle-freeze behaviour (first, second or third to freeze or "no response" for pigs in which the behaviour waned) in response to 8 presentations of the auditory stimulus (1 per 4 minutes). The number of freeze behaviours possible was 288 ($\chi^2 = 15.74, p < 0.05$).

Hierarchy	Order of Freeze Behaviour			
	1	2	3	No response
Dominant	33	13	3	47
Intermediate	38	11	6	40
Subordinate	33	6	16	42
Total	104	30	25	129

Eventually, as habituation occurred, no pigs exhibited freezing behaviour. Figure 2 shows the percentage of pigs no longer responding to each successive presentation of the stimulus. By presentation 5 (after 16 minutes), 67% of the pigs no longer responded and by stimulus 7 (24 minutes) all the pigs had ceased to show a response.

DISCUSSION

A loud auditory stimulus (109-110 dB) produced a clear startle-freeze response in pigs which was repeatable and all pigs tested responded, at least once, to the stimulus. It appeared to be an attentive yet fearful response, similar to that described by Gallup (1974) and Archer (1979). No record could be found in the literature which described this behaviour in pigs, and the only paper which described an

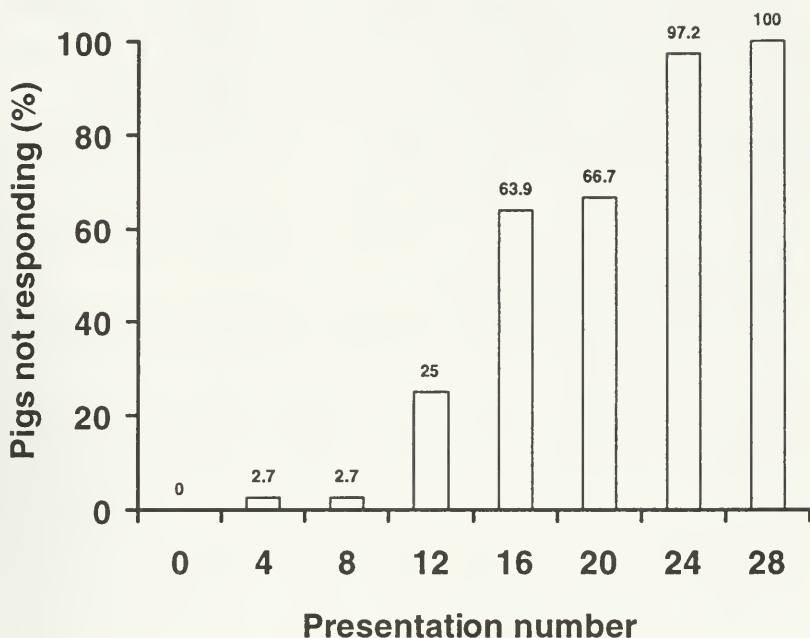


Figure 2. Percentage of pigs ($n = 36$) which did not respond to the auditory stimulus at each presentation.

alarm response in pigs was that of Dawson and Revens (1946). The sequence of responses in the pig to auditory stimuli did not progress from the startle-freeze response to tonic immobility. The length of freezing was much shorter in the pig (1 to 12 s) than the final response (tonic immobility or death feigning) of many species, to fear. Ewell and Cullen (1981) described tonic immobility in the rabbit (180 to 183 s and 61 to 63 s), Satterlee *et al.* (1993) found that Japanese quail immobilized for 102 to 201 s, and chickens were immobilized for 51 to 154 s (Gallup *et al.*, 1970). The bobwhite quail showed freeze behaviour lasting 10 seconds at 9-10 days which by 15 days progressed to tonic immobility (Borchet and Ratner, 1973).

The domesticated pig's response to a novel sound stimulus, which most likely has an element of fear involved, did not progress to tonic immobility. Pigs have few natural predators in the wild and their response to novel stimuli is often to run away (unless cornered). With this alarm-response strategy, the initial startle and short freeze period perhaps allows the pig to orientate before fleeing if the danger increases.

Why does the top ranking pig freeze first? Perhaps it is evidence of a defense mechanism, which protects the social structure of a group, in which the high status animal is the most important social force. This suggests that there may be an association between alertness and dominance. The dominant pig is the one which others in the group attend to and recognise. Ewbank and Meese (1971) showed this in their experiment in which the high status animal could be removed for up to 25 days and safely returned, whereas low status pigs were attacked severely after only 3 days absence.

The response to the auditory stimulus decreased with progressive exposure. After the seventh presentation of the stimulus no pigs responded. The orientating response waned gradually. This is a normal response to a stimulus, which initially elicits an orientating response and is repeated at intervals. If the stimulus is without consequence, first there is a reduction in those physiological components of the response associated with generalised sensory alerting. This changes to a localised orientating response, which either wanes or becomes an adaptive response and the specific features of the stimulus (in this case noise) which invoked the initial response, tend to be reduced (Hinde, 1970, pp 131-132). The pigs showed this progression of responses, as the stimulus was of no consequence to them and their behaviour patterns were not disrupted.

This study is the first to record the orientating response of startle-freeze behaviour in pigs. The response is easy to elicit and therefore it would be interesting to look at the behaviour in larger group sizes.

ACKNOWLEDGEMENTS

This work was supported by the state of Texas line item for efficient pork production and by the U.S.D.A. We thank Dr. Eric Fried, Mr. Anthony Wilson and Mr. Kent Tisdell for technical assistance associated with percussion sounds. The study was carried out when the first two authors were at Texas Tech University in Lubbock, Texas.

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