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*Are domestic pigs (*Sus scrofa domestica*) able to use complex human-given cues to find a hidden reward?*

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Abstract

*Understanding human-animal interactions in livestock production systems is crucial for improving animal welfare. It is therefore of general interest to investigate how livestock animals obtain information from humans. By using an object-choice paradigm, we investigated whether domestic pigs (*Sus scrofa*) (n = 4) were able to use a variety of human-given cues, such as different pointing gestures, to find a hidden food reward. In Experiment 1, an experimenter pointed towards a baited location in front of the pig while the extent of the protrusion of his hand from the upper body was varied. Pigs had problems using pointing gestures that did not protrude from the upper body of the experimenter, but were able to successfully use a long cross pointing administered with the contralateral hand of an experimenter to find a hidden reward. In Experiment 2, an experimenter indicated a baited location that was behind the pig using either a pointing gesture, his body or his head orientation. All four individuals used the pointing gesture and one pig was able to use the head orientation to find the hidden reward. The results provide additional evidence of pigs' ability to use novel human-given cues as well as on the limits of their abilities, and will contribute to a better understanding of pigs' perception of their stockpersons and handlers.*

Keywords: *animal welfare, domestic pigs, human-animal interaction, human-given cues, object choice paradigm, pointing gesture*

Introduction

Understanding human-animal interactions in livestock production systems is crucial for progress in improving animal welfare (Hemsworth 2003), and experiments investigating those interactions can contribute to reducing stress during handling and transport (Jago *et al* 1999; Probst *et al* 2012) or during routine handling practices (Muns *et al* 2015). Previous studies have shown that early direct interactions between calves or heifers and their handlers (eg stroking) lead to positive physiological outcomes, including less stress and fear of humans (Boissy & Bouissou 1988; Stewart *et al* 2013). It is particularly important to know what type of stockperson behaviour may serve as stressor for the individual. Further, it is also relevant to investigate the information an animal obtains from the stockperson or handler, in general, as a stockperson's gesture or action might be comprehended by the individual in terms of referring to a positive or negative event. To improve human-animal interactions in production systems, it is therefore important to know what particular information farm animals extract from human behaviour. For instance, studies have shown that pigs (*Sus scrofa*) are sensitive to the posture of humans (Hemsworth *et al* 1986; Miura *et al* 1996; Nawroth *et al* 2013), although the particular kind of information that livestock animals use to guide their response behaviour is largely unknown. In general, a better understanding of the perceptive and cognitive capacities of livestock animals is necessary to better understand their normal behavioural expressions, needs, and motivations and to avoid exposing them to mental distress, eg through poor handling practices.

One commonly used test paradigm to investigate human-animal communicative capacities is a so-called object choice task. In this test, an individual has to choose between two or more locations, one of which covers a hidden food reward which is indicated by a human experimenter through a communicative cue (eg pointing gesture or head orientation; for a review see Miklósi & Soproni 2006). Besides dogs (*Canis lupus*) (Hare *et al* 2002; Udell *et al* 2008), other domesticated species, such as goats (*Capra hircus*) (Kaminski *et al* 2005), horses (*Equus caballus*) (Maros *et al* 2008; Proops *et al* 2010) and pigs (Nawroth *et al* 2014), appear to be able to use human pointing gestures to find a hidden food reward.

Procedural changes in the object choice task can help to shed light on how individuals use information provided by a human, eg through a pointing gesture. For example, the type of the pointing gesture can be modified in several ways. This is based on the presumption that the ability to generalise

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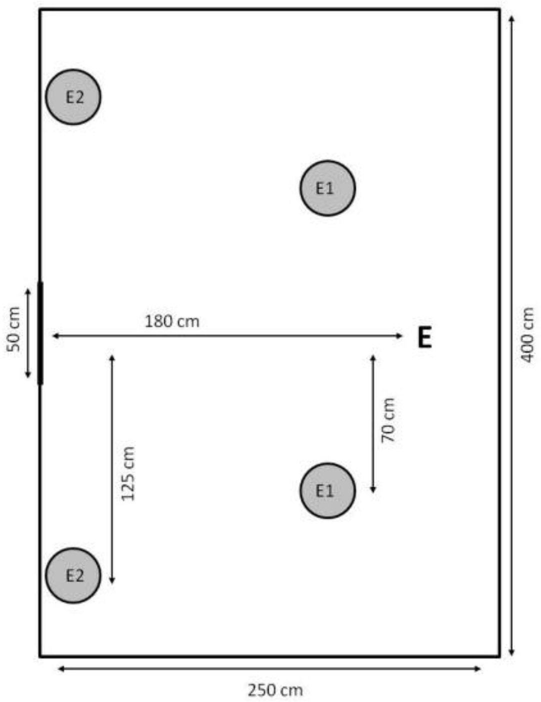
Figure 1



Measurements of the test area. E: Position of the experimenter in both experiments; E1: Position of bowls in Experiment 1; E2: Position of bowls in Experiment 2.

from the basic ipsilateral pointing gesture to novel forms, such as pointing gestures with the contralateral arm, might reveal representational understanding, such as the comprehension of the referential nature of these pointing gestures. Results from dogs suggest that they are sensitive to the relation between hand/arm and upper body of the experimenter; that is, they infer the directionality of the gesture by observing the direction in which part of the arm/hand protrudes from the upper body (Soproni *et al* 2002; Lakatos *et al* 2009). Another alternative is a pointing gesture towards potentially rewarded locations that are actually positioned behind the tested individual. A simple approach toward the movement of the hand (ie the use of stimulus enhancement) would therefore not yield a reward. Instead, an individual would have to move away from the experimenter, which is cognitively more demanding (Riedel *et al* 2008).

Domestic pigs at the age of seven weeks have been shown to use various pointing gestures as well as the body and head orientation of an experimenter to find a hidden food reward (Nawroth *et al* 2014). However, it was not clear if the performance in the tasks using the pointing gesture could be explained due to rapid learning or representational understanding. In the present study, we therefore wanted to investigate if and how pigs are able to use new and unfamiliar human-given cues by applying an object choice task that involved several modifications compared to Nawroth *et al* (2014) with regard to the gesture given by the human and the positions of the hiding locations. In Experiment 1, we varied the protrusion of the experimenter's hand from the upper body during pointing gestures on baited locations. It has been shown that dogs, but not children, had problems using pointing gestures that did not protrude from the upper body of the human, indicating that they only use protruding body parts as a cue (Soproni *et al* 2002; Lakatos *et al* 2009). In Experiment 2, the baited location was behind the tested pig. If pigs are able to generalise the gestural cue, they should be able to find the baited location in both experiments, at least when the gestures protruded the body of the experimenter.

Materials and methods

Four female pigs ([German Edelschwein × German Landrace] × Pietrain) aged ten weeks participated. They were kept in a group with five conspecifics. All pigs had previously participated in a study by Nawroth *et al* (2014). In this previous study, four out of the nine tested subjects never proceeded to the training phase or they lost motivation during test trials. One pig developed a strong side bias during the tests. Therefore, we tested the four remaining pigs that (i) did not develop a side bias and (ii) did not lose motivation to participate in any of the previous tasks. Pigs were housed in a barn at the Institute of Agricultural and Nutritional Sciences in Merbitz, Germany. Pigs were group-housed in pens (250 × 400 cm; length × width) on solid flooring with straw bedding. Temperature was maintained at approximately 23°C and artificial light was provided from 0700 to 1700h. The experiments were carried out at facilities of the Institute of Agricultural and Nutritional Sciences of the University of Halle-Wittenberg, Germany under license of the regional veterinary control board. Housing facilities met the German welfare requirements for farm animals. Pigs had *ad libitum* access to water and food via a hopper. All individuals were already habituated to a test area and the general set-up (for habituation training procedure and previous experience with human-given cues, see Nawroth *et al* [2014] supplementary material to papers published in *Animal Welfare* on the UFAW website: http://www.ufaw.org.uk/the-ufaw-journal/supplementary-material).

Experiment 1

In Experiment 1, we administered four pointing gestures which expressed differing degrees of hand protrusion from the torso. These same variations in pointing gestures have already been applied to dogs but to no other domesticated species (Soproni *et al* 2002; Lakatos *et al* 2009). The proximal pointing gesture has previously been used by Nawroth *et al* (2014).

Procedure

Two bowls (20-cm diameter) were placed 150 cm from the entrance and 140 cm apart with the experimenter kneeling between both bowls approximately 30 cm behind the midline (see Figure 1). Prior to each test session, individuals received two training trials. Pigs were allowed to enter the area with both bowls present and either the left or the right bowl was baited with a grape. This was done to ensure that they recognised that only one food bowl was baited. Once they had received the reward, they were sent from the test area into an adjacent resting area. In test

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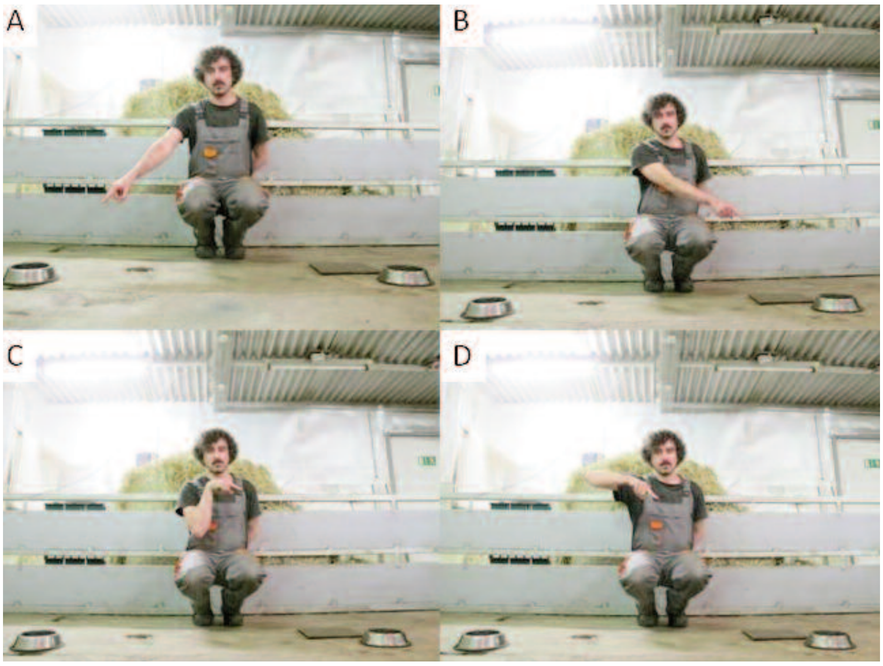
Figure 2

Images of the different human-given cues in Experiment 1: A) proximal pointing; B) long cross pointing; C) short cross pointing; and D) elbow cross pointing.



trials, pigs were allowed to enter the area from the adjacent resting area via an opaque plastic corridor of 1.5 m length. Pigs were allowed to choose one bowl in each trial. When subjects approached the correct bowl, they were allowed to feed from it. When subjects approached the incorrect bowl, they received no reward. After each choice, either correct or incorrect, pigs returned to the resting area. We administered the following four conditions with each individual pig (see Figure 2).

Proximal pointing

As soon as the pig entered the corridor, the experimenter pointed with his ipsilateral arm towards the baited bowl. The distance between the tip of the experimenter's index finger and the baited bowl was approximately 30 cm. The experimenter remained in this position until the subject made a choice.

Long cross pointing

As soon as the pig entered the corridor, the experimenter outstretched his contralateral arm and pointed straight towards the baited bowl. The distance between the tip of the experimenter's index finger and the baited bowl was approximately 45 cm. The experimenter remained in this position until the subject made a choice.

Short cross pointing

As soon as the pig entered the corridor, the experimenter pointed with his contralateral arm towards the baited bowl. No parts of the arm protruded the experimenter's upper body. The distance between the tip of the experimenter's index finger and the baited bowl was approximately 80 cm. The experimenter remained in this position until the subject made a choice.

Elbow cross pointing

As soon as the pig entered the corridor, the experimenter pointed with his contralateral arm towards the baited bowl. The experimenter's elbow protruded from his upper body. The distance between the tip of the experimenter's index finger and the baited bowl was approximately 80 cm. The experimenter remained in this position until the subject made a choice.

In all the trials, the experimenter was looking straight ahead and adopting a neutral facial expression. Each pig received six sessions on six consecutive days, with 20 trials each, and every session consisted of five trials for each of the four conditions, resulting in 30 trials for each condition in total. Side and cue type were counterbalanced across a session with the exception that no side or cue type was provided more than three times in succession. When pigs were distracted or no longer motivated (eg did not enter the test area for more than three minutes), a session was terminated and completed the following day. After the end of all test sessions, twelve control trials were conducted to rule out other factors, eg odour cues, influencing pigs' decision-making ('control near'). We presented the control trials *en bloc* as previous pilot tests have shown that subjects are likely to develop side biases when no cue at all was provided during test sessions. In these control trials, the experimenter remained motionless without indicating the baited bowl.

Data scoring and analysis

We conducted binomial tests to analyse whether individual pigs chose correctly beyond the level expected through chance (ie 21 times or more out of 30 trials; two-tailed $P = 0.043$). We also analysed individual learning effects by comparing the first against the last 15 trials, using an exact Chi-squared test. All choices could be classified unambiguously as correct or incorrect, so that we did not calculate inter-observer reliability.

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Table 1 Individual performance of pigs in test and control conditions.

Subject	Proximal 30 trials	Long cross 30 trials	Short cross 30 trials	Elbow cross 30 trials	Control near 12 trials	Point 30 trials	Body 30 trials	Head 30 trials	Control far 12 trials
P	**30**	**27**	16	11	6	**28**	17	**21**	7
R	**30**	**23**	17	16	8	**25**	12	13	5
T	**30**	**30**	14	11	6	**28**	17	17	5
U	**30**	**26**	16	**7**	6	**22**	11	14	6

Numbers in bold indicate performance significantly above (21 or more correct trials in test condition, 10 or more trials in control condition; two-tailed $P < 0.05$; binomial test) or below the level of chance (9 or less correct trials in test conditions, 2 or less correct trials in control condition; two-tailed $P < 0.05$; binomial test).

Results

All pigs used the proximal and the long cross pointing significantly more than would be seen by simple chance to find the hidden reward (see Table 1). None of the individuals performed above chance with the short cross and elbow cross pointing, ie where the hand of the experimenter did not protrude from his torso towards the correct direction (all Ps > 0.05). One pig ('U') performed significantly below the level of chance during administration of the elbow cross pointing ($P < 0.01$). None of the pigs' performances changed between the first and last 15 trials (all Ps > 0.1).

Experiment 2

In a second experiment, we administered different human-given cues towards one of two locations that were located behind the individual (see Figure 1).

Procedure

Two bowls were placed directly at the line of the entrance and therefore behind the pig when it had fully entered the area (see video ESM2; supplementary material to papers published in *Animal Welfare* on the UFAW website: http://www.ufaw.org.uk/the-ufaw-journal/supplementary-material). The bowls were positioned 250 cm apart with the experimenter about 180 cm behind the mid-line kneeling between both bowls (see Figure 1). Prior to each test session, individuals received two training trials. The general procedure for training and test trials were similar to Experiment 1. During presentation of the following three human-given cues, the experimenter remained in a squatting position.

Pointing

As soon as the pig entered the corridor, the experimenter pointed with his ipsilateral arm towards the baited bowl. The distance between the tip of the experimenter's index finger and the baited bowl was approximately 150 cm. The experimenter remained in this position until the subject made a choice.

Body orientation

As soon as the pig entered the corridor, the experimenter turned his body and head towards the baited bowl. The distance between the experimenter and the baited bowl was approximately 210 cm. The experimenter remained in this position until the subject made a choice.

Head orientation

As soon as the pig entered the corridor, the experimenter turned only his head towards the baited bowl. The distance between the experimenter and the baited bowl was approximately 210 cm. The experimenter remained in this position until the subject made a choice.

In all trials, the experimenter was looking straight ahead and wearing a neutral facial expression. Each pig received six sessions with 15 trials and each session consisted of five trials for each of the three conditions, resulting in 30 trials for each condition in total. Side and cue type were counterbalanced across a session with the proviso that no side or cue type was provided more than three times in succession. When pigs were distracted or no longer motivated (eg did not enter the test area for more than three minutes), a session was terminated and completed the following day. After all test sessions, twelve control trials were conducted to rule out other factors influencing pigs' decision-making ('control far'). In these control trials, the experimenter remained motionless without indicating the baited bowl.

Data scoring and analysis

Data scoring and analysis was the same as in Experiment 1.

Results

All individuals performed significantly above chance in the 'Pointing' condition (see Table 1 and video ESM2; http://www.ufaw.org.uk/the-ufaw-journal/supplementary-material). None of the pigs performed above chance in the 'Body orientation' condition. In the 'Head orientation' condition, pig 'P' chose the correct bowl 21 out of 30 trials ($P = 0.043$). All other individuals remained at the level of chance. Pig 'R' slightly improved its performance in the 'Body orientation' condition (first half: 3/15 trials correct, second half: 9/15 trials correct; exact $P = 0.06$). The performance of the other pigs did not change between the first and the last 15 trials (all Ps > 0.1).

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Discussion

Two experiments were conducted to investigate pigs' use of human-given cues to find a hidden food reward. Pigs in Experiment 1 had problems using pointing gestures that did not protrude from the upper body of the experimenter. However, they easily generalised to use long cross pointings, a gesture with which they were previously unfamiliar. In Experiment 2, pigs had to move away from the experimenter to gain a reward. Thus, a simple hand-food association was not sufficient to perform above the level of chance. Here, all four individuals used a sustained human pointing gesture and, in addition, one pig was able to use the human head direction as a cue. The results from the two experiments confirm previous positive findings on the good performance of pigs to use human-given cues (Nawroth *et al* 2014) and show that pigs encounter similar constraints in using these cues as dogs, namely the need for protrusion of some body parts in the direction of the rewarded location, (Soproni *et al* 2002; Lakatos *et al* 2009). However, more research is needed to assess if pigs, which are not bred for companionship, share some of the same capacities to communicate with humans as dogs do.

Despite the presentation of novel pointing gestures and baiting locations, performance of all individuals was at a high level from the beginning of the experiments while only one pig showed signs of learning. Pig 'R' improved its performance in Experiment 2 when the body orientation of the experimenter was directed towards a baited location. The performance increased from 3/15 correct trials in the first half to 9/15 correct trials in the second, indicating a potential initial avoidance behaviour towards the experimenter's body orientation, which was, however, not observed in the other pigs.

To ensure that pigs' performance in Experiment 2 was not simply due to following the shortest path between the experimenter's hand and the nearest bowl, further tests are necessary. In addition, pigs had extensive experience in using pointing gestures prior to the experiments (a total of 220 test trials for each subject), but all pigs already showed a performance significantly above the level of chance when tested the first time with a sustained proximal pointing cue (see Nawroth *et al* 2014). However, it would be of interest if naïve pigs would also be able to interpret the cues presented in the current research. Future studies should also implement additional test variations that may provide insights into the specific mechanisms at work, ie if pigs actually comprehend the referential nature of the pointing gesture.

A direct implementation of our results into handling practices is difficult as training and habituation are time-consuming. However, previous research has shown that even subtle changes in human posture (Hemsworth *et al* 1986; Nawroth *et al* 2013) and short exposure towards human contact (Tallet *et al* 2014; Muns *et al* 2015) can alter pigs' behaviour. In addition, positive interactions have recently been shown to alter pigs' emotional state (Brajon *et al* 2015). Thus, understanding what pigs comprehend, specifically, as regarding human behaviour is crucial for the development of new handling practices. As an indirect implementation, our results can contribute to extend knowledge regarding basic cognitive capacities of pigs and inspire further research on the underlying mechanisms, which will help to gain a better understanding of human-animal interaction and to improve handling practices.

In conclusion, the results provide further evidence regarding pigs' ability to use novel human-given cues as well as on the limits of their abilities, whereas the particular mechanism at work has to be further evaluated. This line of research will contribute to a better understanding of pigs' perception of their stockpersons and handlers and will, thus, improve welfare in the long term (Hemsworth 2003; Waiblinger *et al* 2006).

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