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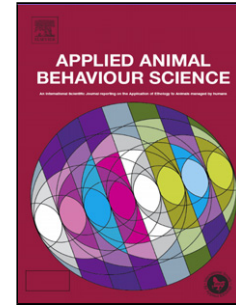
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Title page

Emotions after victory or defeat assessed through Qualitative Behavioural Assessment, skin lesions and blood parameters in pigs

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Highlights

Emotions after victory or defeat assessed through Qualitative Behavioural Assessment, skin lesions and blood parameters in pigs

- Aggression is a pig welfare issue but pigs' emotional experience of it is unknown

- Emotions of pigs which had just won or lost a fight were assessed through QBA

- The main dimensions were 'relaxed/tense' (valence) and 'active/listless' (arousal)

- Positive valence related to low arousal in winners but to high arousal in losers

- Physical injury and effort correlated with terms indicating emotional distress

Abstract

Aggression between pigs causes injuries and production losses and is a long standing animal welfare issue. Although the physiological impact of aggression has been well described, little is known about the emotional experience of aggressive interactions. Our aim was to investigate the emotional expression of winners and losers after a fight and how this relates to costs of fighting. Emotions were studied through use of Qualitative Behavioural Assessment (QBA), a method where participants qualitatively assess the emotional expression of animals seen live or on video. Eighteen pig farmers watched 28 short video clips of pigs which had just won (n=14) or lost (n=14) a fight. Farmers rated the pigs' emotions based on a pre-existing list with 21 descriptors of emotions, while being unaware of the contest outcome (winner/loser). Scores were analysed by a Principal Component Analysis (PCA), which resulted in two factors combining the 21 descriptors into four expressive quadrants. Factor 1 ranged from relaxed/content to tense/frustrated, thereby describing valence (explaining 43% of total variance), and factor 2 ranged from active/lively to listless/indifferent, describing arousal (explaining 16%). Winners (W) and losers (L) did not significantly differ in their expression of valence (W -0.19±-0.20; L 0.16±0.17; P=0.16) or arousal separately (W -0.07±0.22; L 0.06±0.18; P=0.51), but did in the valence-arousal interaction (P=0.02). In winners a high valence related to low arousal whereas in losers high valence related to high arousal. In addition, winners were observed as more negatively affected than losers by a high number of skin lesions (P<0.01). QBA scores significantly correlated with skin lesions (more lesions positively correlated with 12 descriptive QBA terms reflecting impaired welfare), blood lactate (curious r=-0.41; lively r=-.044; playful r=-0.40; positively occupied r=-0.39), blood glucose (distressed r=0.40; fearful r=0.39; playful r=-0.38) and the contest duration (sociable r=-0.39) (all P<0.05). This shows that skin lesions not only reflect physical injury but can also be associated with a negative emotional state, which adds value to their use as a welfare assessment tool. The use of QBA in this study sheds light on the complex ways in which animals emotionally perceive aggression and physical injury. Further studies of this kind will enable better understanding of the true welfare impact of aggressive interactions.

1. Introduction

Aggression between unfamiliar pigs is a longstanding animal welfare issue in commercial farming. Farm management often requires regrouping pigs into new social groups, which causes intense aggression between the pigs as they re-establish dominance hierarchies (Meese & Ewbank, 1973). As a consequence pigs receive skin lesions, are at greater risk of other injuries such as lameness, and may show a depression in productivity, reproduction, and immunocompetence (De Groot et al., 2001; Marchant-Forde & Marchant-Forde, 2005). The intensity and frequency of fighting varies greatly between individuals (D'Eath, 2002; D'Eath & Lawrence, 2004). The majority of the population proactively engages in repeated conflicts, which shows that pigs are highly motivated to fight regardless of previous fight outcomes or number of injuries (Desire et al., 2015). Despite the detailed knowledge on the physiological consequences of aggression, such as elevated cortisol and impaired immunity (De Groot et al., 2001), little is known about how pigs perceive aggression. Otten et al. (2002) suggested, based on stress physiology, that high ranked pigs which were defeated would show more emotional distress and fear compared to successful pigs. Yet, it is unknown how pigs perceive victory or defeat *per se* or how victory is perceived when it has been achieved at the cost of many injuries.

Understanding animals' emotions is an important goal in animal science (Mendl et al., 2010) to, amongst others, better assess animal welfare and to bring affective neurosciences into context (Murphy et al., 2014). Animal emotion has also been acknowledged in the Welfare Quality® protocol. In this animal welfare assessment tool the animals' emotions are included through use of Qualitative Behavioural Assessment (QBA). QBA is described as a 'whole animal' assessment approach that characterizes animals through their expressive body language (Wemelsfelder et al., 2000, 2001). It is important that observers do not describe what physical behaviour the animal is performing (e.g. walking, lying), but the expressive manner, or style, in which it is performing the behaviour (e.g. relaxed, tense). This approach has generally shown acceptable reliability and validity as an indicator of animal emotion (Wemelsfelder & Mullan, 2014). QBA has been applied as an indicator for animal welfare in various species, to reflect differences between treatment groups (e.g. cattle: Stockman et al., 2011; 2012; pigs: Temple et al., 2011; Rutherford et al., 2012; horses: Fleming et al., 2013), to assess

human perception of animals (Wemelsfelder et al., 2012; Duijvesteijn et al., 2014), and human behaviour towards animals (Ellingsen et al., 2014). The animal can be observed either live or from video and the scoring method can rely upon observers selecting their own terms (Free Choice Profiling) or by means of a list of pre-selected terms (Wemelsfelder et al., 2001). The advantage of QBA is that it can be applied from video, enabling the observation of specific moments which otherwise would be difficult to observe (e.g. rapidly after an aggressive encounter), and does not require the animal to undergo certain training or a test which could obscure the animal's initial emotional response.

The objective of this study was to investigate whether pigs which have just won or lost a fight differ in their expression of emotion and whether this can be detected by using QBA with a pre-selected list of terms. In addition we related QBA scores to the number of skin lesions to reflect the severity and type of aggression (Turner et al., 2006), and to blood lactate and blood glucose to reflect the physiological effort and fatigue (e.g. Briffa & Sneddon, 2007). Short video clips of pigs which had just won or lost a fight were shown to a group of pig farmers who were unaware of this distinction between pig groups, and scored the pigs for their behavioural expression using a list of 21 pre-selected descriptors of emotions. We hypothesized that winners would be more positive in their valence of affect and more active than losers (Otten et al., 2002). Furthermore, we hypothesized that measures of physical injury and cost would be predictive of subsequent emotional state irrespective of fight success.

2. Methods

The QBA was carried out based on video footage obtained from a previous experiment on aggression in pigs. The details of this experiment are described in Camerlink et al. (2015) and will therefore only be described briefly here. The work on animals was approved by SRUC's Animal Ethics Committee (no. ED AE 21-2014) and the UK Government Home Office legislation (project licence PPL60/4330).

2.1. Obtaining video footage

Video footage was collected from pigs which had just experienced a fight in an experimental setting. Pigs were kept in litter groups from birth (approximately 12 sibs together) without being mixed with

unfamiliar pigs. They were kept in a pen measuring 1.9×5.8 m (ca. 1.1 m^2 / pig) with a solid floor and light straw bedding. At 10 weeks of age pigs were staged into a dyadic contest in a separate and novel test arena, with contests balanced for aggressiveness, sex and body weight. Dyads were formed between unfamiliar pigs of equal body weight (<5% difference). For the contest, the two contestants were moved one by one out of their home pen and entered the test arena simultaneously. The contest was ended when a clear winner was apparent, which was when the loser retreated without showing aggression for the following 2 minutes. Contests lasted on average 5 minutes. The pigs were returned to their home pen within 2 minutes of the end of the contest.

A camera (Canon Legria HF M52 with a wide angle lens) placed on a tripod at the height of the pen (as close as possible to pig eye-height) was switched on from the moment that the pig returned to its home pen and recorded for 15 minutes thereafter. The camera enabled recording of high-quality colour footage and sound. Pigs were marked for identification with blue animal marker spray.

2.2. Injury and physiological costs of aggression

Skin lesions were counted by a single observer on the front, middle and rear of the body on a continuous scale. Skin lesions on the middle and rear were combined as they typically relate to the receipt of aggression whereas lesions on the front indicate involvement in reciprocal aggression (Turner et al., 2006). Skin lesions (only those which were bright red in colour and without scab formation) were counted live at the end of the contest day. On the QBA video footage the skin lesions were either not visible or very poorly visible due to the light, distance, and hair type (e.g. spots and patches of dark hair). In Figure 1 an average example of the footage is given, showing that QBA participants were unaware of the amount of skin lesions.

Immediately prior to the dyadic contest and at the end of the contest, before return to the home pen, a drop of blood was sampled from the ear vein to obtain values of blood glucose and blood lactate of winners and losers. Values (in mmol/L) were obtained via a glucose meter and lactate meter developed for humans (see Camerlink et al., 2015 for a full description). Blood glucose and lactate indicate the fight intensity (fatigue) and can influence the behaviour during and directly after a contest (e.g. Briffa

& Sneddon, 2007). The proportional change in mmol/L blood glucose and blood lactate (post value : pre value) was used for analyses.

2.3. Selection of video fragments

A total of 136 clips of post-contest behaviour were available (1:1 winner/loser). An observer unaware of the outcome of the contests (i.e. no knowledge of which pig won or lost) selected the videos based upon the following requirements: the pig should be visible; the footage should be of good quality; and selected footage should be of ∼1 min duration within the first 5 min after the pig had returned to the home pen. After initial selection, 64 videos were re-evaluated on quality and variation in emotional expression (with the observer still being blind for which clips showed winners or losers) and ranked 1 – 3 based on suitability based on all of the above criteria. This resulted in 27 clips with rank 1 (best suitable), including 13 winners and 14 losers. The number of skin lesions for winners and losers was checked for balance by a separate person (to retain blinding of the main observer), in order to ensure that differences in emotional expression would be due to the outcome of the fight rather than the injuries. One of the 27 clips was added twice for testing intra-observer reliability, resulting in 28 clips in total. In the first 5 sec of each clip an arrow was added which pointed towards the pig which was to be observed (depicted in Figure 1).

2.4. QBA participants

Pig farmers were targeted as they form a large homogeneous group experienced in observing pigs. Pig farmers from the province North-Brabant in the Netherlands were contacted for participation. Participants were recruited in person by exploiting authors' contacts with large pig farms and a farmers' study club. Seventeen pig farmers (12 women, 5 men; aged between 23 and 69 (average 43) yrs), divided over two sessions, participated during the same week. All had many years of working experience with pigs (>21 yrs n=6; 10-20 yrs n=5; <10 yrs n=5) and had mostly a similar degree of education (college n=11; high school n=5; university n=1). The sessions were held in the evening in different but similar meeting rooms at a farm. There were no significant differences in the QBA scores

between the two sessions and data were therefore analysed jointly (differences calculated for the PCA factors, see 'Data analyses'; Factor 1, $P = 0.34$; Factor 2, $P = 0.55$).

2.5. Qualitative Behavioural Assessment (QBA) procedure

The score form originated from the Welfare Quality® assessment protocol for pigs, with the additional term 'curious' based on the research of Duijvestijn et al. (2014). The list therefore contained the descriptors: 1: active, 2: relaxed, 3: fearful, 4: agitated, 5: calm, 6: content, 7: tense, 8: enjoying, 9: frustrated, 10: sociable, 11: bored, 12: playful, 13: positively occupied, 14: listless, 15: lively, 16: indifferent, 17: irritable, 18: aimless, 19: happy, 20: distressed, and 21: curious. The descriptors were translated into Dutch to enable better understanding for all participants. All descriptors were listed on an A4 sheet with a visual analogue scale (VAS) score line of 125 mm length for each descriptor. The left extremity (0 or minimum) of the score line indicated that the observer perceived the emotion to be entirely absent and the right extremity (maximum) indicated that the emotion was expressed maximally. The participants marked the line with a vertical stripe corresponding with how they judged the intensity of the emotional expression on this spectrum.

Before the QBA started, a list of descriptors in which the meaning of each descriptor was briefly characterized was provided to the participants. Participants were then given time to discuss these terms, and adjust their characterization where necessary, in order to reach a common understanding of the terms. Participants were told that the pig which was to be observed had just returned from a fight, but they were unaware of the study's interest in winners and losers, and these concepts did not feature at all in their instructions. A practice clip was shown to familiarize the participants with the method. After each QBA clip, the participants completed the VAS for all 21 terms (in ∼1.5 – 2 minutes). A break was introduced after 14 videos. The QBA sessions lasted approximately 3 hours. The participants were asked to fill in an additional questionnaire requesting their age, gender, education and years of experience with pigs.

2.6. Data analyses

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The distance between the left extremity of the VAS score line and the vertical stripe made by the participant was measured in mm (0 – 125 mm). Data were analysed using SAS version 9.3 (SAS Institute, Cary, Inc.). The pig (video) was considered as the experimental unit. All 21 terms describing emotional state were entered into a Principal Component Analysis (PCA) with correlation matrix and orthogonal rotation. The PCA resulted in two factors with a distinctively higher Eigenvalue than the rest. These factors had an Eigenvalue of 9.1 and 3.3 whereas the remaining 19 factors had a value between 0.1 and 1.7. The two highest factors were retained for further analysis whereas the remaining factors were omitted. The loadings on the factors are given in Table 1 with the corresponding factor map (Figure 2). Intra-observer reliability was assessed by Pearson correlations between the factor scores of video 4 and video 28, which were the same video clip. The difference between winners and losers was tested in a logistic regression model (Logistic Procedure) with binary distribution, where the response variable was the contest outcome (winner/loser), and the fixed factors were either the two factors extracted from the PCA and their interaction or, in a separate model, the physiological measures (lactate and glucose), skin lesions and contest duration. The least square means with SEM were extracted through a General Linear Model (GLM) with contest outcome (winner/loser) as a fixed factor. GLMs with the PCA factors as response variables were also used to analyse the demographics of the participants (gender and age as fixed factors) and for analysing the interaction between contest outcome and skin lesions on the PCA factors. Non-normally distributed data (skin lesions and contest duration) were transformed to reach normality of the residuals and homogeneity of variances. Hereto skin lesions were square root transformed and contest duration was log transformed. The original QBA terms and the PCA factors were related to the skin lesions (square root transformed values), physiological measures, and contest duration (log transformed) by Pearson correlations. Quoted values are (untransformed) means with standard errors.

3. Results

3.1. The expression of emotions after victory or defeat

The Principal Component Analysis (PCA) combined the 21 descriptors of emotions into two distinct factors (Table 2). In the rotated factor map (Figure 2) the dimension on the x-axis (factor 1) ranged from relaxed/content to tense/frustrated, which can be summarized as indicating the level of valence (the variance explained by factor 1 was 43.3%). The dimension on the y- axis (factor 2) ranged from lively/active to listless/indifferent, which can be summarized as indicating the level of arousal (which explained 15.7% of the variance).

Winners and losers did not significantly differ in their expression of valence or arousal. Losers had an average factor 1 (valence) score of 0.16 ± 0.17, whereas winners scored -0.19 ± -0.20 ($P = 0.16$). For factor 2 (arousal) losers scored 0.06 ± 0.18 and winners -0.07 ± 0.22 ($P = 0.51$). The outcome of the contest did influence the score that pigs had with respect to the interaction between factors 1 and 2 ($P = 0.02$). For losers, a positive valence (e.g. relaxed/content) was associated with a high state of arousal, but for the winners, a positive valence was associated with a low state of arousal (Figure 3). This interaction places winners and losers in different quadrants of the model of affect (Figure 3). Losers fell just in the upper right quadrant of arousal and valence (Q1), which is associated with positive activity (or pleasure and high arousal), whereas winners fell just within the lower left quadrant of the factor map (Q3), which is associated with negativity and passiveness (or displeasure and low arousal).

Moreover, winners with more skin lesions received a lower score on factor 1 (valence) than losers with a high number of skin lesions (interaction skin lesions × contest outcome $P = 0.008$; Figure 4), although this interaction is based on limited numbers of pigs. For factor 2 (arousal) such an interaction was absent ($P = 0.78$).

3.2. Emotional expression of fight costs

The amount of skin lesions received on the front of the body did not differ between winners and losers but lesions on the middle and rear tended to be higher for losers ($P = 0.06$; Table 2). Skin lesions showed significant correlations with factor 1 (valence), and with 12 out of the 21 separate QBA descriptors (Table 3), despite skin lesions not being visible on the footage. Pigs with more skin lesions on the front of the body were given a higher score (present to a greater extent) on overall mood (factor

1), and the terms distressed, fearful, tense, irritable, and frustrated, and a lower score on the terms calm, relaxed, indifferent, content, enjoying, and happy. Skin lesions on the middle and rear were related to a higher score on bored and a lower score on indifferent. Winners and losers did not differ in their proportional change in blood glucose and blood lactate after the fight (Table 2), but higher blood values were reflected in more negatively valued QBA scores. A strong increase in lactate related to lower scores on curious, lively, playful and positively occupied ($P<0.05$; Table 3) whereas a strong increase in blood glucose related to a higher score on fearful and distressed and a lower score on playful. The observed winners and losers did not differ in the duration that they had spent in a contest ($P = 0.81$), but pigs which had been in contest for longer (i.e. fought for longer) were scored as being less sociable ($P = 0.04$; Table 3).

3.3. Participants

There was strong intra-observer reliability for factor 1 (valence), shown by a high correlation between video 4 and 28, which was the same clip ($r_p = 0.74$; $P <0.001$). However, participants were not consistent in the way that they scored the level of arousal for the same video clip ($r_p = 0.35$ for video 4 and 28; $P = 0.17$). Factor 1 tended to be given a higher score by older participants ($P = 0.06$), but was not affected by gender ($P = 0.47$). Factor 2 was unaffected by age ($P = 0.46$) or gender ($P = 0.37$).

4. Discussion

The assessment of animal welfare is often based on the severity of injuries and not on how the injuries are perceived by the animal within the context of the situation. As such, the effect of aggression between pigs has been described in terms of injury and physiological response, but is only poorly understood in terms of the emotional experience of the animal. Through a qualitative behavioural assessment (QBA) we studied the emotional expression of pigs which had either just won or lost a fight. The emotional expression described two dimensions, valence and arousal. Winners and losers did not differ in their expression of valence or arousal, but significantly differed in the interaction between valence and arousal.

4.1. The expression of emotions after victory or defeat

We hypothesized that winners would show positive valence and high arousal, relating to the upper right quadrant (Q1) which is expected to occur with the acquisition of a reward or fitness benefit (Mendl et al., 2010). Losers were expected to be tense and depressed (negative valence) and more passive (low arousal; Q3). Although winners and losers did not differ in their expression of valence or arousal separately, the interaction between both showed, opposite to our hypothesis, that for winners a positive valence was associated with low arousal (Q3) whereas for losers a positive valence was associated with high arousal (Q1). This reinforces the importance of investigating how affective states interact with each other (Mendl et al., 2010). In humans, winning has been associated with positive emotions, increased satisfaction, pride, and confidence, whereas losing resulted in negative emotions and higher levels of anger, stress and depression (McAuley et al., 1983; Wilson & Kerr, 1999). In pigs, defeat had previously been found to relate to inactivity and distress (Otten et al., 2002). The result that winners are perceived as being more passive when they are in a positive mood, whereas losers are perceived as being more active when in a positive mood (or more passive when in a negative mood) may have explanations from both the winner's and the loser's perspective. Losers are generally more involved in post-conflict social behaviour than winners, as has been observed in primates (De Waal & Aureli, 2006; Clay & De Waal, 2013) and bottlenose dolphins (Yamamoto et al., 2015), and they may have been more inclined to seek social support (pigs: Reimert et al., 2014). Both scenarios could lead to losers being perceived by observers as both more (socially) positive and active. Winners on the other hand may have been more confident to settle down, and could therefore have been less active while being positive in their valence.

However, it is important here to take into account the strength of the factor scores observed in the current study. The average PCA factor scores for winners and losers were close to zero (Fig. 3), meaning that on average pigs were not scored as having a strong emotional expression. During the QBA the participants did make use of the full score line to assess the emotions (ranges given in Table 2). The expression of emotion may therefore have been strong for individual pigs, but on average did not deviate greatly from neutrality. This implies that either there was little variation beyond a few pigs, or that the variation in emotional expression between individuals may be too large to detect significant

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differences in a QBA with 28 videos, irrespective of the number of observers. One aspect which may influence variation in the emotional expression is the social status that the animal has within its group. Effects of dominance rank on stress physiology are context and species dependent (Sapolsky, 2005) with contradicting results in studies on dominance and aggression in pigs (Fernandez et al., 1994; Otten et al., 1999). Another aspect is personality, which influences the variation in behaviour and in particular the expression of aggression (e.g. Dingemanse et al., 2010). A larger sample size with more winners and losers with different characteristics would allow examination of how personality and social status affect the emotions associated with winning and losing.

4.2. Emotional expression relates to the costs of aggression

Twelve out of the 21 QBA terms moderately correlated with the number of skin lesions (scored live after the contests) even though the skin lesions were not clearly visible on the footage. Skin lesions are increasingly applied as an indicator of welfare in pigs (e.g. Carroll et al., 2015). A higher number of skin lesions on the front of the body, which indicates involvement in reciprocal aggression (Turner et al., 2006), was correlated with scores indicating impaired welfare (e.g. lower general mood (factor 1), fear, distress, and tension). With the majority of the separate QBA descriptors being significantly correlated with skin lesions, QBA seemed to better pick up the response to having skin lesions than the response to victory or defeat. This suggests that pigs are more affected by physical pain/discomfort than defeat of social rank. However, the interaction between contest outcome and the number of skin lesions did influence QBA scores, with winners being observed as more negatively affected by having many skin lesions. The number of pigs with a high number of skin lesions was however small. Emotions can be influenced by pain and vice versa (e.g. Wiech & Tracey, 2009) and the amount of skin lesions, being physical injury, may therefore relate to emotional state.

A greater increase in blood lactate related to lower QBA scores on positive activity (less lively, positively occupied, playful, and curious) which reflects the fatigue. A greater increase in blood glucose was associated with greater tension and fearfulness and less playfulness. Previous QBA studies on cattle showed that a higher plasma lactate concentration correlated with the terms 'anxious' and 'nervous' (Stockman et al., 2012) and a higher plasma glucose concentration was seen in animals

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which were scored as 'agitated' (Stockman et al., 2011), the latter being similar to our results. A greater change in lactate and glucose correlated in this study with a longer contest duration (Camerlink et al., 2015). Therefore animals with a greater change in blood values will have fought for longer and potentially have experienced negative states for a prolonged time, which seems to be reflected in the QBA scores.

4.3. Implications for practice

The importance of studying emotions alongside physiology has been increasingly acknowledged in animal welfare science (Désiré et al., 2002; Boissy et al., 2007a; Mendl et al., 2010). Initially, affect in animals has been studied clinically, bringing insight mainly into the neuroscience underlying affective states (Boissy et al., 2007b), but with little impact into the development of practical ways to study welfare and emotions in livestock. QBA offers a method to capture emotional experience without necessarily affecting the animal (e.g. no exposure to test situations), and, moreover, assesses the animal as a whole, which allows interpretation of the factor scores and/or separate QBA scores within the context of the full expressive pattern. Although QBA has been subject to discussion, and investing time in training assessors is essential to achieve good levels of inter-observer reliability, particularly in on-farm situations (Minero et al., 2016), QBA has shown to be a useful tool in the assessment of animal welfare (reviewed in Fleming et al., 2016). Moreover, as this study shows, QBA is able to demonstrate the utility of other measures, such as skin lesions, which by themselves do not attempt to assess affective state. Pigs can show distinct positive and negative emotions through their behaviour (reviewed in Marino & Colvin, 2015) and body language, for example ear position (Reimert et al., 2013), and differences in emotional expression of pigs can be detected through QBA (Temple et al., 2011; Rutherford et al., 2012; Wemelsfelder et al., 2012). This study contributes to the validation of QBA as a reflection of animal welfare, in particularly through the relationship between QBA scores and skin lesions.

5. Conclusions

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Differences in the emotional expression of winners and losers could be observed using a whole animal approach through qualitative behavioural assessment (QBA). Winners and losers did not differ in their expression of valence or arousal separately as judged by pig farmers in a QBA, but did differ in the valence-arousal interaction. In winners a positive valence was associated with low arousal whereas in losers positive valence was associated with high arousal. These results should be interpreted with care as the scores only marginally differed from each other. Skin lesions correlated with factor 1 scores, as well as with 12 out of the 21 separate QBA descriptors, in which pigs with more skin lesions received scores reflecting impaired welfare. Higher blood lactate and glucose values related to a lower score on positive active behaviour (e.g. liveliness, play) and more fear and distress. The current results show the added value of using QBA alongside measures of physiology or injury, as it aids in the interpretation of the complex ways in which animals perceive their situation emotionally and in terms of welfare.

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Tables

Table 1. Loadings on the factors extracted by the principal component analysis, after orthogonal rotation, of QBA scores of all participants for all videos. Values between 0.30–0.50 are in italics, values above 0.50 are in bold. The variance explained by factor 1 was 43.3% and for factor 2 15.7%. The latter column gives the mean QBA score (SE: ± 2, for all terms) with the range of the visual analogue scale (VAS) score in mm.

	Factor 1	Factor 2	VAS score
Content	**0.91**	0.11	64 (0-125)
Relaxed	**0.91**	0.05	64 (1-124)
Enjoying	**0.89**	0.17	59 (1-124)
Happy	**0.81**	*0.31*	57 (1-123)
Calm	**0.79**	-0.11	66 (1-125)
Sociable	*0.5*	0.21	67 (1-123)
Positively occupied	*0.48*	**0.6**	55 (2-123)
Playful	*0.4*	**0.66**	49 (1-123)
Curious	*0.35*	**0.68**	59 (0-124)
Indifferent	0.18	*-0.49*	47 (1-123)
Lively	0.05	**0.87**	66 (1-125)
Listless	-0.08	**-0.61**	28 (0-122)
Active	-0.09	**0.83**	70 (0-124)
Aimless	-0.11	*-0.44*	41 (1-120)
Bored	-0.18	-0.09	37 (1-123)
Distressed	**-0.61**	-0.26	33 (1-123)
Fearful	**-0.73**	-0.21	38 (0-123)
Agitated	**-0.86**	-0.02	51 (0-124)
Irritable	**-0.87**	0.04	50 (1-122)
Frustrated	**-0.88**	0.02	50 (0-124)
Tense	**-0.88**	-0.09	46 (0-124)

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Table 2. Means with SE and range for skin lesions and the proportional change of blood glucose and blood lactate for winners and losers.

	Winner	Loser	P-value
Lesions front (n)	29 ± 9 (1-86)	25 ± 4 (0-55)	0.27
Lesions mid + rear (n)	7 ± 2 (0-25)	17 ± 5 (0-65)	0.06
Blood lactate (mmol/L)	6.1 ± 1.8 (0.4-22.3)	4.6 ± 1.6 (0.4-21.7)	0.48
Blood glucose (mmol/L)	1.2 ± 0.1 (0.9-1.9)	1.2 ± 0.1 (0.8-1.5)	0.62

Table 3. Correlations between QBA terms, and the two PCA factors, and the amount of skin lesions on the front and middle + rear of the body, the change in blood lactate and glucose, and the contest duration. Only QBA scores with tendencies or significant correlations are given, with significant correlations in bold.

	Lesions Front	Lesions Mid+Rear	Blood lactate	Blood glucose	Contest duration
Distressed	**0.51**[*]	0.11	0.32	**0.40**[*]	0.12
Fearful	**0.49**[*]	0.13	0.26	**0.39**[*]	0.21
Tense	**0.48**[*]	0.06	0.23	0.35[†]	0.24
Irritable	**0.40**[*]	0.09	0.13	0.27	0.23
Frustrated	**0.39**[*]	0.10	0.12	0.27	0.31
Irritated	0.32[†]	0.01	0.16	0.25	0.20
Active	0.16	0.35[†]	-0.33[†]	-0.18	-0.05
Bored	0.08	**0.41**[*]	-0.28	-0.25	0.32[†]
Lively	0.07	0.32	**-0.44**[*]	-0.25	-0.07
Curious	-0.10	0.25	**-0.41**[*]	-0.32	-0.09
Playful	-0.20	0.25	**-0.40**[*]	**-0.38**[*]	-0.15
Positively occupied	-0.23	0.19	**-0.39**[*]	-0.33[†]	-0.21
Sociable	-0.28	0.01	0.06	-0.06	**-0.39**[*]
Happy	**-0.38**[*]	0.06	-0.27	-0.31	-0.20
Enjoying	**-0.38**[*]	-0.02	-0.21	-0.27	-0.23
Content	**-0.43**[*]	-0.03	-0.18	-0.28	-0.28
Indifferent	**-0.43**[*]	**-0.53**[*]	0.05	-0.08	0.15
Relaxed	**-0.44**[*]	-0.04	-0.15	-0.27	-0.25
Calm	**-0.48**[*]	-0.24	-0.07	-0.21	-0.29
Valence (factor 1)	**-0.40**[*]	0.00	-0.25	-0.33[†]	-0.26
Arousal (factor 2)	0.27	0.36	-0.27	-0.08	0.01

[†]$P <0.10$; [*]$P <0.05$

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Figure captions

Figure 1. Example of the video footage used for the QBA. The arrow indicated at the start of each clip which pig was to be observed.

Figure 2. Factor map of the PCA. Dimension 1 on the X-axis reflects valence (negativity/positivity) and dimension 2 on the Y-axis reflects arousal (activity).

Figure 3. PCA score plot for the interaction between factor 1 (valence) and factor 2 (arousal). Winners are depicted as grey dots with a solid trend line and losers are depicted as open circles with a dotted trend line. The triangles give the average value for winners (black) and losers (white). Q1-4 indicate the different quadrants in the model of affect.

Figure 4. Interaction between contest outcome (winner/loser) and the number of skin lesions for the level of valence (factor 1), including the linear trend line (winners: solid line; losers: dotted line).
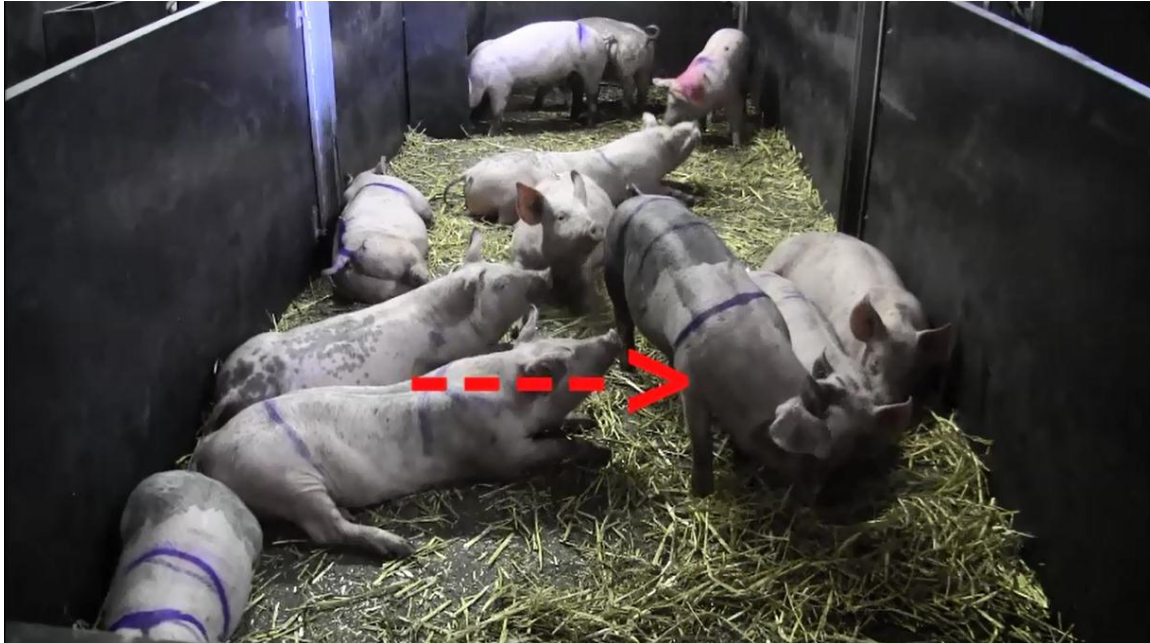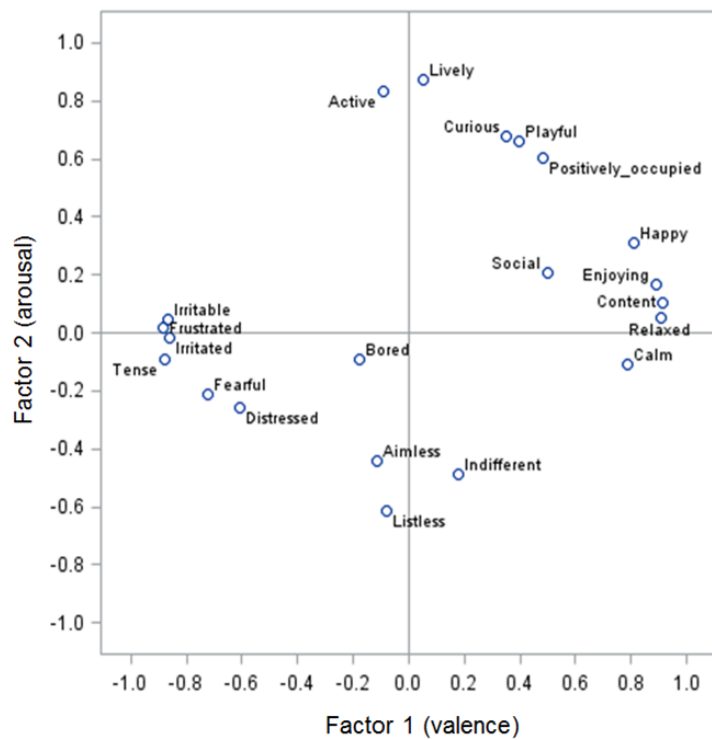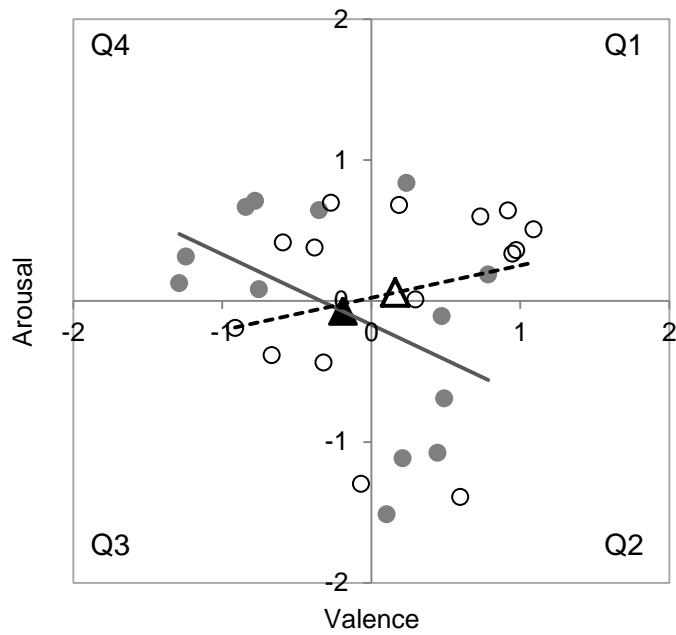
Figures

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Figure 1

Figure 2

Figure 3

Figure 4