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A Facial Expression for Anxiety

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Anxiety and fear are often confounded in discussions of human emotions. However, studies of rodent defensive reactions under naturalistic conditions suggest anxiety is functionally distinct from fear. Unambiguous threats, such as predators, elicit flight from rodents (if an escape-route is available), whereas ambiguous threats (e.g., the odor of a predator) elicit risk assessment behavior, which is associated with anxiety as it is preferentially modulated by anti-anxiety drugs. However, without human evidence, it would be premature to assume that rodent-based psychological models are valid for humans. We tested the human validity of the risk assessment explanation for anxiety by presenting 8 volunteers with emotive scenarios and asking them to pose facial expressions. Photographs and videos of these expressions were shown to 40 participants who matched them to the scenarios and labeled each expression. Scenarios describing ambiguous threats were preferentially matched to the facial expression posed in response to the same scenario type. This expression consisted of two plausible environmental-scanning behaviors (eye darts and head swivels) and was labeled as anxiety, not fear. The facial expression elicited by unambiguous threat scenarios was labeled as fear. The emotion labels generated were then presented to another 18 participants who matched them back to photographs of the facial expressions. This back-matching of labels to faces also linked anxiety to the environmental-scanning face rather than fear face. Results therefore suggest that anxiety produces a distinct facial expression and that it has adaptive value in situations that are ambiguously threatening, supporting a functional, risk-assessing explanation for human anxiety.

Keywords: anxiety, risk assessment, facial expressions, emotion, rodent model

The conserved status of flight behavior in vertebrate species (Edmunds, 1974) attests to its evolutionary value as a response to threat, but flight is not adaptive in all threatening contexts. For example, flight from a novel object, whose threat status is ambiguous, could lead to unnecessary expenditure of energy and might preclude discovery of new and valuable resources. Flight may also be maladaptive when a serious threat appears to be in the vicinity but its precise location is unclear, such as when the odor of a predator is detected. In this context, flight is as likely to lead to danger as to safety. For these reasons, flight behavior is typically reserved for use against clear threats when an escape route is available (R. J. Blanchard, Blanchard, & Hori, 1989), whereas ambiguous or potential threats elicit vigilance reactions, comprising the inhibition of ongoing behavior and heightened information gathering (D. C. Blanchard & Blanchard, 2008). Studies of innate rodent defensive responses, under naturalistic but controlled (ethoexperimental) conditions, have demonstrated the adaptive value of vigilance as a counter to ambiguous threats (Pinel & Mana, 1989) and suggest that one of its most important preprogrammed components is risk assessment, characterized chiefly by sniffing, cautious approach, and environmental scanning (marked by side-to-side head sweeps; D. C. Blanchard, Griebel, & Blanchard, 2003).

Anxiety has been proposed as the emotional component of risk assessment behavior in contrast to fear or panic, which is viewed as the emotional accompaniment of flight (D. C. Blanchard & Blanchard, 2008; D. C. Blanchard, Blanchard, & Rodgers, 1991). This functional separation of anxiety and fear is based on the observation that drugs with clinical effectiveness against generalized anxiety disorder preferentially modulate risk assessment behavior in rodents without systematically altering flight responses (D. C. Blanchard, Blanchard, Tom, & Rodgers, 1990; R. J. Blanchard, Griebel, Henrie, & Blanchard, 1997), whereas antipanic medicines preferentially modulate flight (Griebel, Blanchard, Agnes, & Blanchard, 1995). However, although this suggestion concerning anxiety as the specific emotional accompaniment of risk assessment might inform theoretical models of

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emotion, its dependence on evidence from rodent research means the risk assessment explanation for anxiety requires experimental validation in humans (Panksepp, 1998) so that its pan-specific generality can be assessed: this was our overall aim in this article.

Existing Research on Separability of Anxiety and Fear in Humans

Despite the considerable debate and even confusion among psychologists concerning the separability of anxiety and fear (Geer, 1965), evidence from several parts of the psychological literature suggests that they can be differentiated and, especially, have different functional properties. For example, the *Diagnostic and Statistical Manual of Mental Disorders* (4th ed., [*DSM–IV*]; American Psychiatric Association, 1994) distinguishes on a temporal basis between psychological illness characterized by recurrent discrete periods of intense fear (labeled as *panic disorder*) and illness in which the chief symptom is prolonged episodes of anxiety or worry (labeled as *generalized anxiety disorder*). Additionally, although both are classed in the *DSM–IV* as anxiety disorders, the different pharmacological responses of panic disorder and generalized anxiety disorder (e.g., Gould, Otto, Pollack, & Yap, 1997; Wade, Lepola, Koponen, Pedersen, & Pedersen, 1997) support the notion that they are distinct illnesses. This analysis suggests that anxiety and fear may be separable emotions.

In the field of individual differences research, the existence of questionnaires that putatively measure proneness to anxiety (e.g., State–Trait Anxiety Inventory; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) and questionnaires that putatively measure proneness to fear (e.g., Fear Survey Schedule; Wolpe, & Lang, 1977) implies that anxiety and fear are psychometrically separable. This implication is supported by the typically modest correlations reported between scores on fear questionnaires and scores on questionnaire measures of trait anxiety (e.g., $r = .38$; Hagopian & Ollendick, 1996), and when such correlations are statistically tested for their differences, scores on questionnaire measures of anxiety/neuroticism and fear turn out to be dissociable (Perkins, Kemp & Corr, 2007). However, this evidence must be tempered by the knowledge that personality questionnaires typically are limited by the fact that it is difficult to determine whether they measure the named construct, other than by the circular process of correlating their scores with those of other, similarly named questionnaire measures. Taken together, issues of this type mean that research questions such as those concerning anxiety and fear separability are unlikely to be answered by wholly psychometric means (Corr & Perkins, 2006).

Perhaps with these limitations in mind, attempts have been made to conduct psychophysiological tests of anxiety and fear separability that do not require the use of personality questionnaires. For example, investigations concerning the effects of psychological states upon perceptions of pain suggest that anxiety and fear have opposite effects on pain reactivity: threat of electric shocks (a putative anxiety condition) increases pain reactivity, whereas actual exposure to electric shocks (a putative fear condition) reduces sensitivity to a subsequent radiant heat pain stimulus (Rhudy & Meagher, 2000). Purely human-based studies of this type, however, are limited by their reliance on implicit acceptance of distinctions between the types of situations that human participants find to be anxiety-inducing and those that are putatively fear-inducing. Therefore, without an objective measure of what constitutes an anxiety-inducing or fear-inducing situation it is difficult to have confidence in the results of such emotion-induction studies as demonstrating that anxiety is a distinct emotion, separate from fear.

Experimental Methods for Studying Defensively Related Emotions in Humans

The discrete functional, defensive associations for anxiety and fear indicated by drug studies of rodent defense (D. C. Blanchard & Blanchard, 2008) suggest that they may be studied as separable emotional phenomena by exposing human participants to different types of threatening situations. This approach has obvious practical and ethical drawbacks, but studies using computer-generated simulations of defensive situations have provided some tentative support for the risk assessment explanation of anxiety in humans. For example, Mobbs et al. (2007, 2009) in functional magnetic resonance imaging (fMRI) studies used a maze paradigm in which a pursuing predator had the capacity to inflict harmless but unpleasant electric shocks; they demonstrated that distant threats activated prefrontal cortical areas, whereas close or imminently dangerous threats increased activity in the midbrain. As distant threats will, on average, be perceived by participants as more ambiguous than close threats and forebrain areas appear to have an important role in the mediation of anxiety (Mindus, Rasmussen, & Lindquist, 1994), these data could be interpreted post hoc as providing support for an association between anxiety and threat ambiguity in humans.

Other evidence comes from analysis of behavioral effects of pharmaceutical compounds on human defensive reactions. Perkins et al. (2009) showed that 1 mg of the clinically effective anxiety-reducing drug lorazepam decreased the intensity of forwards/backwards oscillation in healthy adult men when they were trapped by two threat stimuli in a computerized simulation of a runway-based avoidance task. Forwards/backwards oscillation during entrapment in a closed runway is part of the rodent risk assessment repertoire (Griebel, Blanchard, Jung, & Blanchard, 1995); however, in the human translation of the runway paradigm, this behavioral analogue had the flaw that, unlike the rodent equivalent, it did not increase the information-gathering capacity of the participants, preventing conclusive demonstration of a functional association between risk assessment and anxiety in humans (D. C. Blanchard, Griebel, Pobbe, & Blanchard, 2011).

Facial Expressions of Emotion as an Experimental Tool

Facial expressions of emotion have attracted scientific attention for centuries. Notably, Darwin (1872) viewed them as evolved phenomena, whereas many researchers in the early-to-mid twentieth century (e.g., Mead, 1928) viewed such expressions as culturally determined. Modern psychologists have, however, returned to the Darwinian view that facial expressions of emotion are essentially innate. This conclusion is based on studies showing that facial expressions of emotions generalize across cultures (e.g., Ekman & Friesen, 1971).

The readily observed nature of facial expressions of emotion and their innate, evolved origins has led them to be perceived in modern times as a powerful tool for studying emotion (e.g., C. Harmon-Jones, Schmeichel, Mennitt, & Harmon-Jones, 2011). In the present research, we followed this strategy, adapting an actor–observer paradigm originally developed for research on the cross-cultural validity of facial expressions of emotion (Ekman, 1972) to make a first attempt at testing for a tripartite association in humans among anxiety, ambiguous threat, and human risk assessment behavior in a naturalistic form that plausibly has an information-gathering function.

In Experiment 1, we sought to investigate the functional significance of risk assessment behavior in humans, predicting that a human facial expression portraying environmental-scanning behavior would be preferentially matched to scenarios describing ambiguous threat. In Experiment 2, we then attempted to determine the social significance of risk assessment in humans, predicting that the putative facial expression for environmental scanning would be preferentially labeled by hypothesis-naïve observers as representing anxiety and not fear or any other major emotion.

Experiment 1: The Functional Significance of Risk Assessment in Humans

Method

Participants. Forty participants (20 men and 20 women) between the ages of 18 and 58 years ($M = 22.95$; $SD = 6.52$) were recruited by means of e-mail and paper advertisements on the campus of Swansea University in the United Kingdom. They included undergraduates, postgraduates, mature students, and members of the staff. All participants provided informed consent, and the study was approved by the Swansea University Psychology Department Ethics Committee.

Stimuli. Twenty-four brief emotive scenarios and nine facial images were created for this experiment (see the Appendix and Figure 1, respectively). The emotive scenarios were written following the format of the Blanchard Threat Scenario Questionnaire (D. C. Blanchard, Hynd, Minke, Minemoto, & Blanchard, 2001), describing situations that plausibly contain ambiguous threat and situations containing clear threat. Scenarios were also included that, at face value, were likely to elicit the emotions of happiness, sadness, anger, disgust, surprise, and interest/excitement. These latter emotions were not central to our research aim; however, scenarios representing them were necessary so that we could assess the observers' capacity to dissociate a putatively anxiety-related environmental-scanning facial expression from other important human facial expressions of emotion. Interest/excitement is not always listed as a basic facial expression of emotion but was included here because of the possibility that an environmental-scanning expression might be confused with the expectant facial expression that has been described in individuals who are interested or excited (Tomkins & McCarter, 1964). In order to determine whether a facial expression purporting to show a particular

Figure 1. Facial expressions posed in response to emotive scenarios. Images 1 and 6 were posed in response to scenarios describing ambiguous threat and clear threat, respectively. Image 3 was intended to be an expressionless control stimulus. The remaining images were posed in response to scenarios intended to convey happiness (Image 2), interest (Image 4), surprise (Image 5), anger (Image 7), sadness, (Image 8), and disgust (Image 9).

emotion was matched reliably across different situations purporting to elicit the same emotion, we designed the experiment so that the number of scenarios exceeded the number of facial images. Furthermore, as a safeguard against participants using a process of elimination to match facial images to scenarios, putative emotions were not represented equally among the scenarios: happiness, fear, anger, and anxiety were featured in four scenarios each, and the remaining emotions were featured in two scenarios each. Participants were not told of these differing frequencies of each putative emotion among the scenarios.

In order to create the facial expression images, eight volunteers who were not part of the participant cohort and were unaware of the experimental hypotheses each posed a facial expression of emotion while being videorecorded on a webcam run via Windows XP (Microsoft Corp.; Redmond, WA). In an attempt to maximize the naturalism of the posed facial expression images, we read each volunteer a scenario that contained the target emotional content and asked him or her briefly to imagine being in that scenario and then immediately pose whichever facial expression he or she would deploy if the scenario was real. Eight video clips, each 5 s in duration, were generated by this process, and a single still frame was captured from each of the video clips. We used both still and video clips in this experiment to test whether mode of facial image representation affected recognition.

Twenty four 3 × 3 matrices were compiled using Adobe Premiere software (Adobe Systems, San Jose, CA), with Matrices 1–12 being composed of still images and Matrices 13–24 of video clips (looped so that they would play repeatedly). The images were ordered in this way so that participants would start the task with the less informative image format (stills; see Figure 1) and then progress to the more informative image type (video, which can be downloaded at https://sites.google.com/site/adamperkinsphd), allowing a test of whether participants' ability to match facial images to scenarios was boosted by the availability of video material. The matrix location of each face was shuffled pseudorandomly in order to increase unpredictability (i.e., no face featured in the same position on two consecutive matrices). Image 3 in Figure 1 was not intended to portray an emotion and was included as a neutral control face. The 24 facial image matrices were then inserted into a computerized slide show that displayed an emotive scenario and 3 × 3 matrix of facial expression images on each slide. Two versions of this slide show were created so that the order in which the scenarios were presented was counterbalanced. Thus, Slides 1–12 of Slideshow A displayed Scenarios 1–12 accompanied by Matrices 1–12 and Slides 13–24 of Version A showed Scenarios 13–24 accompanied by Matrices 13–24. In Slideshow B, scenario order was reversed so that Matrices 1–12 were accompanied by Scenarios 24–13 and Matrices 13–24 by Scenarios 12–1.

Procedure. Participants were seated alone in front of a computer monitor displaying the slideshow (they were randomly allocated to Version A or B), and as each slide was displayed, they read the scenario and selected whichever facial expression they judged to match it most closely. If they judged that none of the facial expressions matched the scenario, they were permitted to indicate no match. They then wrote down on their answer sheet a label for the facial expression of emotion shown on the face they had just selected. Participants controlled the transition from slide to slide and were allowed to take as much time as they wanted on each slide.

Statistical analysis. Repeated-measures analyses of variance (RM ANOVAs) with planned pairwise contrasts were used to compare face-scenario matching success rates across scenario type. Owing to concerns about whether the data satisfied the assumptions underlying ANOVAs, we verified the probability values using nonparametric resampling methods (permutation tests).

Results

Visual analysis of movements displayed in the anxiety face versus fear face. The video of the putative fear face displayed no movements that could be construed as facilitating environmental scanning: throughout the 5-s clip, the eyes are fixed on the camera and the plane of the face does not change. The video of the putative anxiety face displayed three distinct scanning movements of the eyes; viewed from the perspective of the observer, the eyes dart from low left to high left to the center right of the screen. Simultaneously, the head swivels from left to right approximately 30°. The darting eyes in the putative facial expression for anxiety are consistent with the notion that such a facial expression may facilitate environmental scanning, as they allow the eyes to cover a wider sector of the vicinity than a fixed-gaze facial expression such as the putative facial expression for fear. The head swivel seen in the video should further boost the effectiveness of the eye darts while also aiding stereophonic localization of sounds. These movements together could plausibly be interpreted as resembling rodent environmental-scanning behavior that serves to allow maximum scanning ability with minimal physical movement to aid concealment.

Matching of scenarios to facial images. We found facial expression images were correctly matched in 89% of emotive scenario presentations, and, within each of the eight scenario types, the facial image most frequently matched was that which had been generated by the eight actor–volunteers in response to that type of scenario (Figure 2). A facial image intended to be expressionless (Image 3, Figure 1) was matched to an emotive scenario in less than 1% of scenario presentations, and "no match" was declared in only one of the 960 scenario presentations. A RM ANOVA (with a single factor of scenario type) revealed there were significant differences in the degree to which scenarios were matched to their putative facial expression, $F(7, 273) = 3.08$, $p = .004$; permutation test $p < .003$. We used planned pairwise contrasts to compare the success rate for matching the putative environmental-scanning face (Image 1, Figure 1) to the ambiguous threat scenarios with the rates of success at matching expected facial images to the other seven scenario types. The scenarios intended to convey happiness were associated with a higher rate of successful matching to their expected facial expression than the scenarios describing ambiguous threat (99% vs. 90%), $F(1, 39) = 9.06$, $p < .005$; no other pairwise contrasts versus the ambiguous threat scenarios approached significance, all Fs < 2.91, ps > 0.09.

The observed pattern was not affected by adding the gender of the participant or the version of the slideshow the participant judged as a between-subjects factor in the analyses; the Scenario Type × Gender interaction and Scenario Type × Version interaction did not approach significance, $F(7, 266) = 0.76$, $p = .62$,

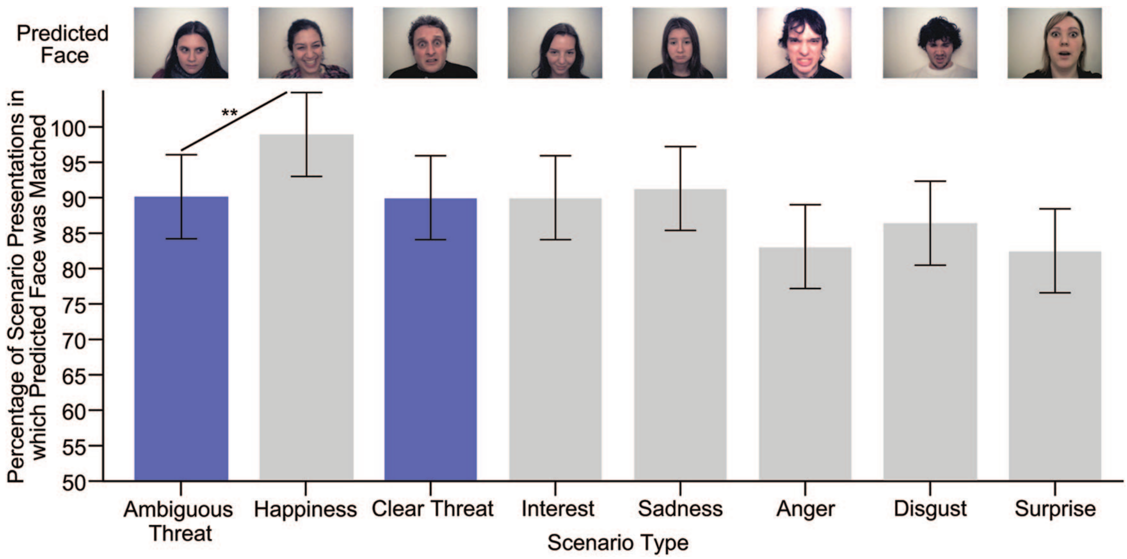

Figure 2. Bar chart showing matches between facial expression images and types of emotive scenarios. Error bars indicate a within-subjects confidence interval computed as described by Masson and Loftus (2003) and calculated using the mean square error from the one-way within-subjects analysis of variance.

and $F(7, 266) = 0.55$ $p = .79$, respectively. The data were rescored to give separate matching success rates for still and video face displays. A two-way RM ANOVA (Format × Scenario Type) showed that the main effect of format (video vs. still) was not significant, $F(1, 38) = 0.35$, $p = .56$, and Format × Scenario Type interaction was also nonsignificant, $F(7, 266) = 1.35$, $p = .23$. These results remained substantially unchanged when the analyses were restricted just to the four scenarios (ambiguous threat, clear threat, happy, and sad) for which four exemplars were used: the scenario main effect was still significant, $F(3, 117) = 7.9$, $p < .001$], and both effects involving format did not approach significance, both Fs < 1.7, ps $> .20$.

Discussion

Viewed as a whole, results of Experiment 1 support our prediction concerning an association between risk assessment behavior and ambiguous threat. Since rodents also show an association between risk assessment behavior and ambiguous threat and our participants were not told of the hypothesis being tested in this study, these results can be viewed as providing tentative yet credible evidence for the pan-specific validity of risk assessment as a functional and conserved response to ambiguous threat. Additionally, the general ease with which participants were able to match emotive scenarios to appropriate facial expressions provides further support for the value of the actor–observer paradigm as a tool for probing the emotional life of humans.

Experiment 2: The Social Significance of Risk Assessment in Humans

Having found in Experiment 1 that in humans, as in rodents, environmental-scanning behavior is specifically associated with ambiguously threatening situations, we now sought to determine its social significance in humans. That is, does environmental-scanning behavior specifically signal anxiety to observers and not fear or any other plausible major emotion? Additionally, in Experiment 2 we sought to determine whether participants who had not been exposed to the source material (i.e., emotive scenarios) used to generate the facial expressions of emotion in Experiment 1 could nevertheless match appropriate emotion labels to the facial images. This step was necessary to allay the concern that the text of the scenarios had acted as a prompt when the participants in Experiment 1 were deciding which emotion labels to apply to which facial images.

In Experiment 1, we had asked each of the 40 participants to generate a label to describe each facial expression that they matched to a scenario (Table 1). In Experiment 2 we asked human participants who had not participated in the previous experiment and who were unaware of our hypotheses to attempt to match facial expression labels generated by the participants in Experiment 1 back to the images of facial expressions that were used in Experiment 1. We predicted in this second experiment that the facial expression displaying environmental scanning would be labeled significantly more frequently with the word *anxiety* or its Oxford English Dictionary (OED) synonyms (*worry*, *concern*, *unease*, *nervousness*) than the word *fear* or its OED synonyms (*panic*, *fright*, *horror*, *terror*). To obtain a double dissociation in facial labeling, we also predicted that our putative facial expression for fear (Image 6, Figure 1) would be labeled significantly more frequently with the word *fear* or its OED synonyms than with the word *anxiety* or its OED synonyms.

Method

Participants. Eighteen participants (seven men and 11 women) between the ages of 22 and 71 years ($M = 33.22$; $SD = 13.34$) were recruited by means of e-mail and paper advertisements on the campus of Swansea University in the United Kingdom. They included undergraduates, postgraduates, mature students and

Table 1
Frequency of Emotion Labels Generated During Experiment 1 in Response to the Eight Putative Facial Expressions of Emotion and the Neutral Control Face

Fear face		Environmental-scanning face		Happy face		Sad face		Surprise face		Interest face		Angry face		Disgust face		Neutral face	
Label	Freq	Label	Freq	Label	Freq	Label	Freq	Label	Freq	Label	Freq	Label	Freq	Label	Freq	Label	Freq
Fear	(37/34)	Worry	(17/15)	Happiness	(52/55)	Sadness	(27/31)	Surprise	(18/27)	Happiness	(6/17)	Anger	(62/55)	Disgust	(31/34)	Disappointed	(1/1)
Scared	(12/18)	Anxiety	(8/11)	Joy	(10/15)	Disappointed	(9/1)	Shock	(15/17)	Flirtatious	(3/5)	Annoyance	(2/3)	Anger	(3/7)	Worry	(1/1)
Shock	(14/8)	Apprehension	(4/7)	Laughter	(10/4)	Upset	(0/4)	Startled	(2/1)	Interest	(3/4)	Rage	(2/2)	Revulsion	(2/2)	Anger	(1/0)
Fright	(7/4)	Suspicion	(6/5)	Enjoyment	(2/2)	Gutted	(0/2)	Anticipation	(2/0)	Excitement	(3/2)	Fury	(2/1)	Surprise	(0/3)	Cautious	(1/0)
Terror	(5/4)	Concern	(4/5)	Glee	(1/0)	Annoyance	(1/0)	Curiosity	(1/0)	Anticipation	(4/0)	Argumentative	(1/0)	Annoyance	(0/2)	Excitement	(1/0)
Surprise	(4/0)	Wary	(4/5)	Hilarity	(0/1)	Depressed	(1/0)	Excitement	(1/0)	Shy	(1/3)	Disbelief	(0/1)	Argumentative	(1/0)		
Panic	(3/1)	Confusion	(2/6)	Mirth	(0/1)	Scared	(1/0)	Fright	(0/1)	Lust	(2/1)	Fear	(1/0)	Disappointed	(0/1)		
Disgust	(1/1)	Nervous	(2/4)	Surprise	(1/0)	Unhappy	(1/0)	Happiness	(1/0)	Saucy	(2/1)	Hate	(0/1)	Concern	(0/1)		
Anger	(1/0)	Uncertainty	(2/3)					Nervous	(1/0)	Smugness	(1/2)	Horror	(1/0)	Confusion	(1/0)		
Wary	(1/0)	Scared	(2/3)					Sadness	(1/0)	Anger	(2/0)	Malice	(0/1)	Fear	(1/0)		
Horror	(0/1)	Cautious	(3/1)					Unhappy	(0/1)	Friendly	(2/0)	Surprise	(1/0)	Gutted	(1/0)		
Revulsion	(0/1)	Fear	(2/2)							Intrigued	(0/1)			Indignation	(0/1)		
		Fright	(2/1)							Expectation	(1/0)			Shock	(1/0)		
		Surprise	(2/1)							Glee	(0/1)			Sadness	(0/1)		
		Curiosity	(1/2)							Hope	(1/0)			Upset	(0/1)		
		Anticipation	(1/2)							Inquisitive	(0/1)						
		Intrigued	(1/1)							Joy	(1/0)						
		Unease	(0/2)							Optimism	(1/0)						
		Unnerved	(2/0)							Pleased	(1/0)						
		Afraid	(0/1)														
		Anger	(1/0)														
		Expectation	(1/0)														
		Startled	(0/1)														
		Thinking	(1/0)														
		Unsure	(1/0)														

Note. Freq = frequency with which each label was generated in response to the image of a particular face is shown in parentheses: first for stills, then for clips.

members of the staff. All participants provided informed consent, and the study was approved by the Swansea University Psychology Department Ethics Committee.

Stimuli. The nine facial expressions shown in Figure 1 were each printed onto a separate sheet of A4 (210 × 297 mm; 8.3 × 11.7 in.) paper along with an extra page that had "NO MATCH" written on it. Each page was labeled with a number as in Figure 1 with the no-match page marked as Number 10. The 40 observers in Experiment 1 had generated an emotion label for each of the 24 scenario/facial expression pairings, giving a theoretical total of 960 emotion labels. However, a considerable amount of label duplication occurred between participants (additionally 37 labels were illegible and were discarded). When duplicate labels and different versions of the same word (e.g., *anxiety–anxious–anxiousness*) were combined, 64 unique emotion labels remained. Table 1 shows these 64 emotion labels and their pattern of generation in relation to the facial images presented.

Procedure. All nine photographs plus the no-match sheet were laid out on a table in front of the participant. The experimenter read each of the 64 unique emotion labels generated during Experiment 1 to the participant who indicated the number of the image that he or she judged to match it (or said "No match"). Each label and number pair was written down by the experimenter.

Results and Statistical Analyses

We concentrated on the 10 verbal labels that are OED synonyms of anxiety and fear (five labels for each). Matches of these emotion labels to facial images in Experiment 2 were as shown in Table 2. The matching was consistent with our predictions and thus fits the risk assessment explanation for anxiety. The label *anxiety* was matched by 78% (14/18) of participants to the facial image displaying environmental scanning (i.e., the putative facial expression for anxiety), and a similar number of matches were obtained for the four OED synonyms of anxiety. Neither the label *fear* nor any of its four OED synonyms was matched to this environmental-scanning face by any of the participants. Conversely, the label *fear* was matched by 72% (13/18) of participants to the putative facial expression for fear, and its four OED synonyms were matched with the fear face at an even higher rate (i.e., by 16 or 17 of the 18 participants). While the label *anxiety* was matched to the fear face only rarely (by 22% of the participants), none of the four OED synonyms of anxiety was ever matched to the fear face.

To test this predicted double dissociation of label–face matching statistically, we began by coding the chosen faces for each of the 10 labels in Table 2 as 1 or 0; this coding was based on whether the chosen face was matched (1) or was not matched (0) to the anxiety face. We then performed a Cochran's Q repeated-measures test for binary data (Conover, 1999) across the 10 verbal labels and found clear statistical evidence ($Q = 101.2$; $df = 9$; $p < .0001$) for concluding that the verbal labels are not all equivalent in terms of matching to the anxiety face. This reflects the fact that the five anxiety labels all have high match frequencies (11/18 participants or more), and the five fear labels all have low match frequencies (all 0/18). However, when we repeated this analysis but restricted it to the five anxiety labels only, there was no significant divergence of matching across the five anxiety labels (11/18 to 14/18; $Q = 2.1$, $df = 4$, $p > .7$).

We then recoded the same data on the basis of matches to the fear face. Once again, testing with Cochran's Q across all 10 labels provided strong statistical evidence for rejecting the hypothesis that all the 10 labels are matched to the fear face in the same way ($Q = 125.9$; $df = 9$; $p < .0001$). When we restricted the analysis just to the five fear labels, we obtained evidence of significant variation in matching frequency across the labels ($Q = 10.8$, $df = 4$, $p = .03$). This occurs because the fear label itself is not matched as often to the fear face (13/18 times) as are the four other labels (each matched by 16/18 participants or more). Finally, we looked at the fear face matching frequencies for the five anxiety labels;

Table 2
Matches of Anxiety- and Fear-Related Emotion Labels to Facial Expression Images in Experiment 2

Emotion labels	Environmental scanning	Fear face	Other faces	No match
1. Anxiety	14/18	4/18	0/18	0/18
2. Worry	14/18	0/18	4/18	0/18
3. Concern	13/18	0/18	2/18	3/18
4. Unease	14/18	0/18	1/18	3/18
5. Nervous	11/18	0/18	4/18	3/18
6. Fear	0/18	13/18	5/18	0/18
7. Panic	0/18	17/18	1/18	0/18
8. Fright	0/18	17/18	1/18	0/18
9. Horror	0/18	16/18	2/18	0/18
10. Terror	0/18	16/18	2/18	0/18
Q_{all} ($df = 9$)	101.2^{****}	125.9^{****}		
Q_{anx} ($df = 4$)	2.1	16.0^{**}		
Q_{fear} ($df = 4$)	n/c	10.8^{*}		

Note. $N = 18$. Cochrane's Q tests the variation in binary match/no match to specific faces across levels of the emotion label as a repeated-measures factor. Q_{all} = comparisons across Labels 1–10; Q_{anx} = comparisons across Anxiety Labels 1–5; Q_{fear} = comparisons across Fear Labels 6–10. Q is distributed as chi-square with *df* as shown. n/c = Q not computed as there was no variation in anxiety matches across the fear labels.
* $p < .05$. ** $p < .01$. **** $p < .0001$.

there was also significant variation among the labels in this analysis (Q = 16.0; *df* = 4; *p* = .003). This effect occurred because the anxious label was matched to the fear face occasionally (by 4/18 participants), whereas none of the other labels ever was (matched by 0/18 participants in every case).

To illustrate the above statistical results graphically, we performed a multidimensional scaling with PROXSCAL, in SPSS Version 18, using the profiles of frequencies of the nine faces (plus the no-match category), chosen as matches to the 10 labels (fear and its four synonyms plus anxiety and its four synonyms). The chi-square dissimilarity metric was used to compute the dissimilarities between profiles for pairs of labels, showing separation between anxiety and fear labels but generally greater dispersion for the anxiety labels than the fear labels (Figure 3).

Finally, to go beyond the formal constraints of the OED synonyms for anxiety and fear, we plotted the frequency of matches of all emotion labels that were matched to the putative facial images for environmental scanning and fear during Experiment 2, again obtaining a pattern of findings consistent with the risk assessment explanation for anxiety (Figure 4). This plot further supports the risk assessment explanation for anxiety by showing that labels that are outside the list of OED synonyms for anxiety but that plausibly describe risk assessment were preferentially matched to the facial expression for environmental scanning. For example, *suspicion* was matched to the facial expression for environmental scanning by 16 of the 18 participants but was not matched to the facial expression for fear by any of the participants. Similarly, the labels *apprehension* and *wary* were matched to the facial image for environmental scanning by 15 of the 18 participants but were not matched to the facial expression for fear on any occasion.

Discussion

Results of Experiment 2 suggest that facially displayed risk assessment behavior signals anxiety in humans, as this expression was preferentially matched with the label of anxiety and its OED synonyms, but not with fear or its OED synonyms. These results show our participants interpreted the facial expression for environmental scanning in a way that is emotionally congruent with rodent drug results that show risk assessment behavior is related to anxiety (D. C. Blanchard et al., 1990). As our participants were not told of this rodent-based hypothesis beforehand, we argue that our result is unlikely to be an interpretative inference and instead represents a scientifically meaningful emotion–expression association between risk assessment behavior and anxiety in humans. Moreover, the tendency of participants preferentially to associate the environmental-scanning facial expression with OED synonyms of *anxiety*, such as *worry* or *concern*, but not with *fear* or its OED synonyms suggests that this association is not a semantic quirk peculiar to the word *anxiety* but instead represents a general property of words that plausibly describe the feelings that accompany the cautious, risk-assessing behavior elicited by ambiguously threatening situations but not by clear threats.

It is interesting that the two central verbal labels (*anxiety* and *fear*) were the most atypical of the two sets of labels, in terms of their matching to the faces: the *anxiety* label was occasionally

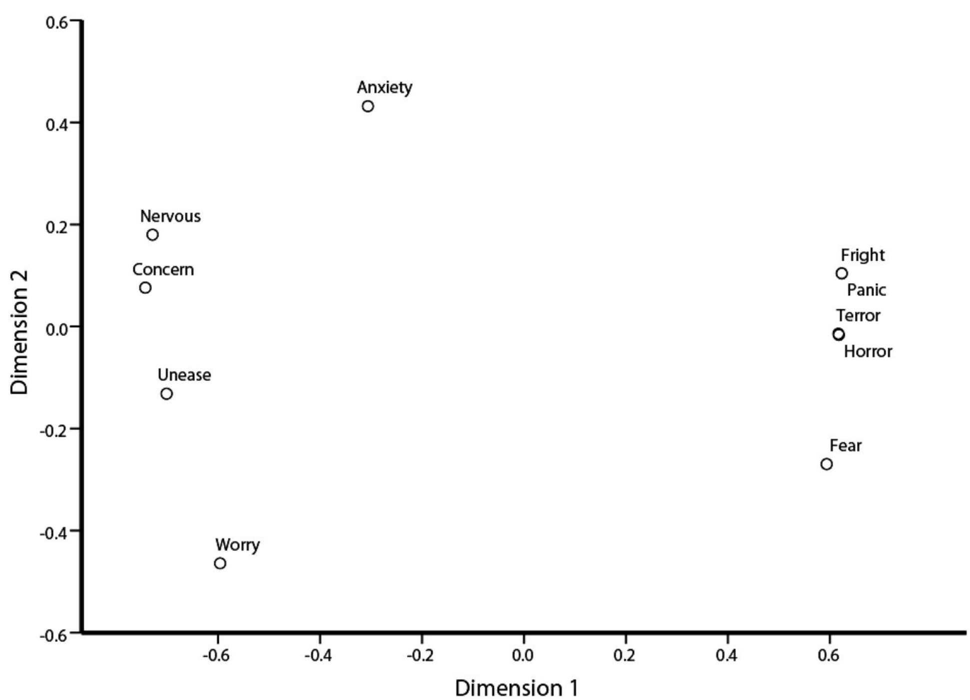

Figure 3. A multidimensional scaling plot in two dimensions representing the dissimilarities between the profiles of face matching choices for the emotion labels to which faces were matched. Each point corresponds to one of the five anxiety or five fear synonyms in the Oxford English Dictionary. The more separated the points the more dissimilar are the profiles of face matches made to the labels concerned. Horror and terror as well as fright and panic are located at the same points.

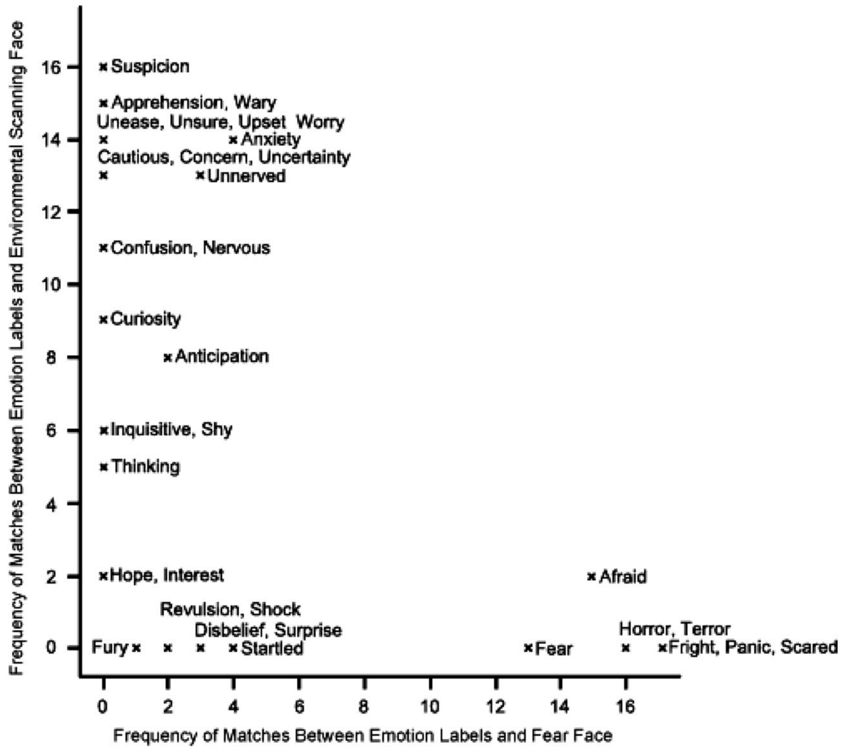

Figure 4. The frequency of matches of all emotion labels to the putative facial images for environmental scanning and fear during Experiment 2.

cross-matched to fear face, whereas the other anxiety-synonym labels never were; the *fear* label was matched to the fear face less often than the other four fear labels were, although the nonmatches for all fear labels were never to the anxious face. This might suggest that the anxious face we used was better described as reflecting unease, concern, worry, or nervousness rather than the general label of anxiety; conversely the fear face appeared to be better described by verbal labels suggesting extreme fear (horror, terror, panic, or fright) rather than fear more generally. This might suggest that further work is needed to check whether a less extreme fear facial expression would be as well separated from the environmental-scanning face as the present, more intense fear face appears to be.

General Discussion

We found that scenarios describing ambiguous threat were preferentially matched to still and video images of a facial expression that had been previously posed in response to a scenario describing ambiguous threat. This facial expression contained two behaviors (eye darts and head swivels) that plausibly increase the area of the vicinity covered by the eyes and thus perform an environmental-scanning function. Since this facial expression was also preferentially labeled in Experiment 2 by naïve observers as signaling anxiety and not fear or any other major emotion, the implications of our results are threefold. First, they are congruent with findings in rodents suggesting that anxiety is explicable as an adaptive risk assessment reaction to ambiguous threat (D. C. Blanchard et al., 1991). Second, they suggest anxiety and fear are separable emotions in humans, in line with findings obtained using personality questionnaires (Perkins et al., 2007) and in contrast to circumplex accounts of human emotion (e.g., Posner, Russell, & Peterson, 2005). Third, since we used a facial expression paradigm to study risk assessment behavior, our results may also provide a facial expression for anxiety that should be added to the generally accepted facial expression repertoire, as well as offering some insights concerning the production of facial expressions of emotion.

Evolutionary Implications

Our discovery that apparent environmental-scanning behavior displayed facially in response to ambiguous threat signals anxiety to conspecifics fits Darwin's (1872) theory that some facial expressions of emotion evolved from functional movements. This theory has previously been supported by the finding that the facial expressions for fear and disgust are not only social signals of affect but also have functional value, as a means of increasing and decreasing sensory input, respectively (Susskind et al., 2008). Not all facial expressions of emotion have plausible functional significance, but the anxious facial expression we have identified seems to fit this latter category as, in line with rodent data (D. C. Blanchard & Blanchard, 2008), it was preferentially matched to ambiguous threat by naïve observers and has an eye-darting, head-swiveling element that is likely to aid the localization of an ambiguous threat. Thus, it seems fair to propose that the environmental-scanning facial movements initially evolved by natural selection as a means of aiding the investigation of ambiguous threat and only secondarily acquired meaning as a social signal of anxiety. In contrast, it is credible that the intensely focused, non-swiveling, fixed-gaze facial expression for fear might have originated as a means of accelerating production of an appropriate defensive response to a threat once it has been localized.

Should these two hypotheses turn out to be supported experimentally, the anxious and fearful facial expressions may ultimately be accepted as mutually supporting components of an evolved behavior pattern that equips individuals to adapt to the differing intelligence-gathering demands of different but often rapidly interchanging threat contexts, namely, ambiguous threat and clear threat, respectively. Moreover, our finding that human observers appear to be sensitive to the differing functional significance of these two facial expressions implies that there may also be survival value in the ability to glean, silently and rapidly, indirect information regarding the type of threat present, merely by observing the facial expressions of conspecifics. More generally, this idea is in line with recent ethological findings that seagulls monitor the vigilance behavior of other gulls in their group to decide whether to sleep, implying that vigilance in general has a social element and indicating that adaptive behavior at the level of an individual can lead to collective vigilance/relaxation reactions, such as panic in a herd or waves of sleep (Beauchamp, 2011).

Implications for Research on Facial Expressions of Emotion

A distinct facial expression for anxiety does not feature in the most widely accepted list of basic facial expressions of emotion (namely, happiness, anger, disgust, sadness, fear, and surprise; Ekman, 1999), yet our participants readily associated a facial expression portraying rodent-style environmental scanning with anxiety as opposed to fear or any other major emotion. This may be explained by the historical tendency among scientists to view anxiety and fear as interchangeable emotions (Geer, 1965), leading previous generations of facial expression researchers to assume that the classical facial expression for fear also represented anxiety. It is interesting to note that Charles Darwin was not one of these: he distinguished anxiety from fear using a rationale that prefigures the rodent findings on threat ambiguity and emotion, as he associated anxiety with the expectation of suffering and fear with actual danger (Darwin, 1872).

Findings in the Context of Neuroscience and Rodent Models

More generally, results may also allay the concern that human psychological processes are too complex to be explained by rodent models (Matthews, 2008), as our human findings can be aligned post hoc with two prominent neuroscientific models of anxiety and fear that are based primarily on rodent data. The threat imminence continuum theory (Fanselow & Lester, 1988) associates initial detection of a remote threat (the postencounter) with anticipatory anxiety mediated chiefly by forebrain regions (Bouton, Mineka, & Barlow, 2001) but aligns situations that are imminently dangerous (the circa strike) with fear and active escape efforts controlled by midbrain areas (Phelps & LeDoux, 2005). Conversely, the defensive direction principle in revised reinforcement sensitivity theory (RST) portrays anxiety as elicited by threats that require approach (i.e., create a goal conflict) and fear by threats that need not be approached (Corr, 2008; McNaughton & Corr, 2004) with these reactions being mediated chiefly by septohippocampal and dorsal periaqueductal gray activity, respectively.

Both these theories are congruent with our finding that anxiety and fear are associated with ambiguous and clear threat scenarios, respectively. This impression is reinforced when scenario content is considered in detail: scenarios preferentially associated with the risk assessment facial expression, labeled as representing anxiety, described potentially threatening situations such as "You can smell smoke in your house but aren't sure where it is coming from." This scenario has a plausible post hoc fit to the anxiety-related postencounter in the threat imminence continuum theory because the threat has been detected but is not imminently dangerous. In terms of the defensive direction theory, it should also elicit anxiety because unexpected smoke in one's residence will usually demand investigation to verify its dangerousness, generating an anxiety-related approach–avoidance goal conflict. In contrast, the scenarios that were preferentially associated with the facial expression for fear all described imminently dangerous situations such as "You are crossing a road; your mind is somewhere else when you suddenly hear a motor being revved very powerfully. You look round and see that a speeding car is about to hit you." This scenario has a plausible fit with the fear-related circa strike in the threat imminence continuum theory as it contains a clear threat (the car) that is about to contact the body with likely lethal force (the car is described as *speeding*). It can also be aligned with a fear-related simple avoidance situation in the defensive direction theory because the scenario does not contain a requirement to approach the car.

These theories have both been supported in humans by studies using simple computer simulations of defensive situations (Mobbs et al., 2007, 2009; Perkins et al., 2009): by describing naturalistic behavioral results that are broadly congruent with both theories, the present experiment might ultimately pave the way for research comparing their relative predictive capacity with regard to brain activation and facial expression production. For example, should a means be found to videorecord the facial expressions of participants who are undergoing fMRI (an anxiety-inducing process for the uninitiated), competing predictions could be tested. If the threat imminence continuum theory is correct, forebrain regions will increase their activation as the anxious facial expression is produced, whereas if the defensive direction principle is valid, the facial expression for anxiety will be accompanied chiefly by increased septohippocampal activation.

Implications for Social Relations

Although humans, like rodents, are under evolutionary pressure to avoid basic threats such as predators, the special importance in human life of social cohesion means we face an additional layer of more subtle but arguably equally important evolutionary pressure, to avoid threats to our social status or standing. For example, it is plausible that ancestral humans who were disliked by their peers might have been denied resources in times of hardship or even been ostracized from the social group, with likely dire consequences for their survival. Conversely, humans with a particularly poor ability to detect signs of deception in others might be at greater than average risk of being cheated out of valuable resources. Since it is plausible that social threats tend to be more ambiguous and subtle than clear threats such as predators, our finding that a distinct facial expression for anxiety that is elicited by ambiguous threat may have special relevance for psychologists specifically interested in the dynamics of social interactions.

These considerations make it seem likely that anxiety, but not fear, would be especially common when attempting to deceive in a social context, such as when bluffing or lying, with the result that individuals who can conceal anxiety in social settings may gain some kind of tactical advantage. However, by the same logic, it is equally plausible that the ability to detect anxiety in humans would be tactically advantageous (e.g., by being able to detect anxiety caused by lying). Viewed together, it seems probable that a situation has developed where facial signs of anxiety have evolved to be more subtle than those of other less tactically relevant emotions, but the capacity of humans to recognize them has evolved to keep pace, hence the ease with which our participants were able to recognize facial signs of anxiety. Similar arguments have already been advanced for the general co-evolution of deception and detection of deception (Trivers, 2011), and the existence of a facial expression arms-race involving anxiety is congruent with anecdotal accounts of shoplifters drinking modest amounts of alcohol before a crime spree to relax their faces, in an attempt to prevent their criminal intent being communicated to store detectives via an anxious, "shifty" facial expression. Similarly, the impassive "poker face" practiced by card players would also appear to have specific tactical value as a means of reducing facial signs of anxiety that would otherwise impede their ability to bluff, having been dealt a poor hand of cards.

Implications for Theoretical Models of Emotion

In a more general social psychology context, our results appear to be at odds with circumplex theories that attempt to explain all human emotions as cognitive interpretations of neural sensations arising from two fundamental dimensions, namely, valence and arousal (see Figure 5; Russell, 1980). Since some circumplex theorists locate anxiety and fear in the same, high-arousal negative-valence quadrant of the emotional factor space (e.g., Posner et al., 2005), these models imply they are rather similar phenomena; yet according to our data, anxiety and fear have different facial expressions, different eliciting stimuli, and different functional associations.

Our findings appear more compatible with a motivation-direction framework within social psychology that distinguishes between emotions using their motivational direction. For example, E. Harmon-Jones and Allen (1998) found anger was associated with electroencephalographic asymmetry consistent with approach motivation despite its negative affective valence. Further results congruent with this finding have been obtained using other methodologies, such as affective modulation of the startle eye blink (Amodio & Harmon-Jones, 2011) and a facial expression paradigm (C. Harmon-Jones et al., 2011).

The split between anxiety and fear that we have identified can therefore potentially be integrated with motivation-direction models because although anxiety and fear may appear similar in valence and arousal (both being negative and arousing), they are opposite in motivational direction: we found the putative anxious face was associated with ambiguously threatening situations that require approach to threat whereas the putative fear face was associated with clearly threatening scenarios that require avoid-

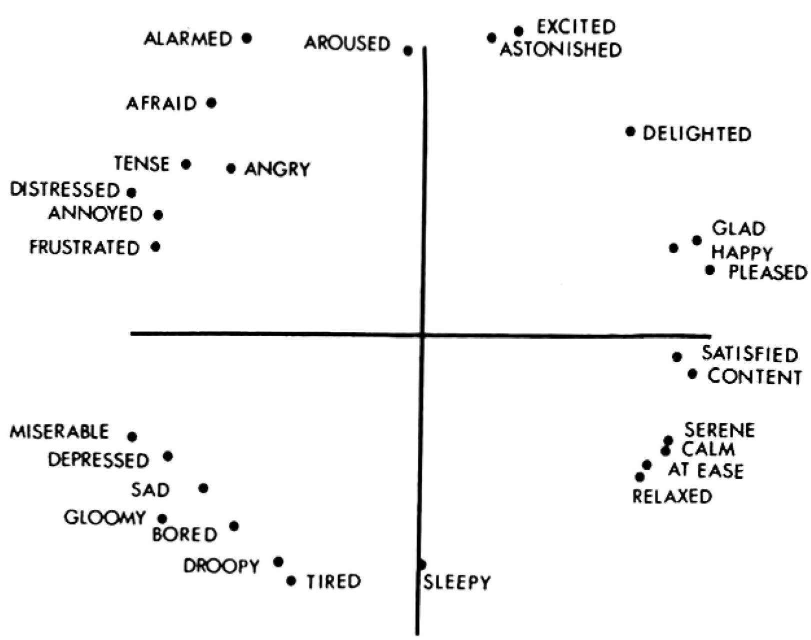

Figure 5. Example of self -report emotion data conforming to a circumplex model of emotion. From "A Circumplex Model of Affect" by J. A. Russell, 1980, *Journal of Personality and Social Psychology, 39,* p. 1168. Copyright 1980 by American Psychological Association. Reprinted with permission.

ance. Ultimately, by including motivational direction in cognitive accounts of emotion, it may be feasible to find common ground between such models and rodent-based models of discrete emotions with discrete neural substrates.

A well-known example of the latter type of model is the RST of personality (Corr, 2008; Gray & McNaughton, 2000; McNaughton & Corr, 2004) that attempts to use rodent learning research to explain human personality, postulating that individual differences in reactivity to different classes of reinforcing stimuli underlie important human personality dimensions, such as neuroticism and extraversion. RST portrays anxiety and fear as both being negative emotions, yet associates them with eliciting stimuli of opposite motivational directions: anxiety with threats that require approach (i.e., that present a goal conflict) and threats that may be simply avoided (that present no goal conflict; McNaughton & Corr, 2004). In the light of work over the last decade or so suggesting that some emotions may be negative in valence yet approach-based (e.g., Amodio & Harmon-Jones, 2011; E. Harmon-Jones & Allen, 1998), it is possible therefore to reconcile these two scientific endeavors by viewing anxiety as a second candidate, along with anger, for an approach-based but negatively valenced emotion.

Limitations and Future Directions

This latter consideration points to a conceptual limitation of our work in that functional theories of emotion such as RST tend to concern distinctions between anxiety and fear in behavior and experience, but this research focused only on the reading of emotional expressions. Neither the actors nor observers in our research were induced to feel the relevant emotions. An interesting future step would therefore be to examine whether the differences in facial expressions are also represented in emotional experiences or behaviors. This strategy would be especially informative with regard to the facial expression for fear as the strong theoretical association between fear and simple avoidance behavior means that the fear face should be a precursor to an avoidance response such as fighting, fleeing, or freezing. In contrast the facial configuration seen in Image 1 of Figure 1 not only represents the putative facial expression for anxiety but also contains the concomitant physical defensive response, namely, environmental scanning.

Methodological limitations of our work include the use of a facial expression paradigm to study defensive reactions, placing an exaggerated focus on risk assessment movements that involve the head, when rodent studies not only associate risk assessment anxiety with head-based environmental scanning behavior but also with whole-body movements such as approach-withdrawal oscillation (Griebel, Blanchard, Jung, et al., 1995). The measurement of naturalistic whole-body human defensive reactions under ethical laboratory conditions was beyond the means of the present project. However, some headway is beginning to be made in this area, with innovative findings revealing that threatening stimuli (images of angry faces) reduce body sway, supporting the presence of a freeze response to threat in humans (Roelofs, Hagenaars, & Stins, 2010). Ultimately, it may be feasible to develop a virtual reality-based experimental technique for studying human defense that combines the naturalism of a facial expression study with the capacity of a maze or runway task to measure gross defensive movements. Such a technique would allow detailed measurements of the entire human defensive repertoire in a single experimental design.

Other practical limitations of our research include the use of one facial expression image per emotion. For example, it is perhaps possible that the facial image for environmental scanning (Image 1, Figure 1) may have conveyed anxiety because of the physical appearance of the individual who posed it rather her facial expression per se. These criticisms may be countered by the finding that the success at matching faces to emotive stimuli was almost completely uniform across facial images, with only the facial image for happiness being matched to its respective stimuli with significantly greater success than the other facial images (Figure 2). Additionally, the configuration of our putative facial expression for anxiety shown in Image 1 (Figure 1 and Movie 1, which can be downloaded at https://sites.google.com/site/adamperkinsphd) is, by any reasonable analysis, a credible human analogue of the environmental-scanning behavior that is innately elicited from rodents by ambiguous threat and is modulated by anti-anxiety drugs. Nevertheless, the topic could be explored in more detail in future research by filming multiple individuals displaying environmental-scanning behavior and attempting to test statistically whether factors such as hairstyle, head shape, and gender affect the reliability of portrayal.

Other interesting future studies that could be derived from the present research include exploring the effects of gaze direction on facial expression recognition, since facial expression type has been found to interact with gaze direction in determining amygdala response with regard to anger and fear faces (Adams, Gordon, Baird, Ambady, & Kleck, 2003). Other future experiments might assess behavioral inhibition, which has long been associated with anxiety in rodent studies (Gray, 1982); therefore, one option for future research on this topic would be to make electromyographic recordings of facial muscle activity in an individual attempting to pose a facial expression for risk assessment: if such a facial expression represents anxiety, it should be associated with relatively inhibited activity in the facial muscles compared with the facial expression for fear. This latter prediction has preliminary (if circumstantial) support from the finding that socially anxious children generally show reduced facial activity and are less able to pose recognizable facial expressions of emotion than average children (Melfsen, Osterlow, & Florin, 2000).

Implications for Psychopathology

This finding that children who are prone to anxiety show a different pattern of facial activity than average nonanxious children in turn suggests that future research on the causes of emotional expression in general might benefit from investigation into whether individual differences in affective personality traits predict individual differences in the propensity to display particular facial expressions of emotion. In this vein, revised RST researchers (Gray & McNaughton, 2000) have used findings on rodent defense to make predictions concerning human personality, postulating in particular that trait individual differences in proneness to simple avoidance/fear and risk assessment/anxiety may constitute separable personality traits. Applied to facial expressions of emotion, this theory arguably predicts that individuals with a trait tendency to experience fear or anxiety should also be more prone to displaying the respective facial expressions for these emotions.

It has been suggested that generalized anxiety disorder (GAD) is caused by alterations in the functioning of brain systems that govern risk assessment (D. C. Blanchard et al., 2003); this suggestion stems from the capacity of drugs with clinical effectiveness against GAD preferentially to alter rodent risk assessment behavior (D. C. Blanchard et al., 1990). By linking anxiety to risk assessment, our results support the GAD–risk assessment hypothesis, implying that normal anxiety has risk assessment value but when the risk assessment process is exaggerated, it might render individuals so cautious that they cannot conduct a normal daily life. The GAD–risk assessment hypothesis is already supported post hoc by a variety of observations, such as the tendency for individuals with GAD to display symptoms of hypervigilance (American Psychiatric Association, 1994), the capacity of the anxiety-causing drug yohimbine to induce a tense and anxious facial expression (Holmberg & Gershon, 1961), and the presence of an anxious, roving gaze as an observed symptom of anxiety in the Rating Scales for Affective Symptoms (Silfverskiöld, Rosén, Risberg, & Gustafson, 1987). Combining these findings with the present work, a valuable future experiment might be to determine if patients with GAD are more likely to display the environmental-scanning facial expression that we have identified in a wider range of contexts and at a lower level of threat than average individuals and then cease to display this expression when treated with anxiolytic drugs.

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(*Appendix follows*)

Appendix

Emotive Scenarios Used in Study 1

Scenario	Putative emotion
1: You are reminiscing with your friends about the holiday of a lifetime that you all had last year.	Happiness
2: You are hill walking and come across a dead, rotting sheep on the pathway; it is surrounded by flies and covered in maggots.	Disgust
3: You are crossing a road; your mind is somewhere else when you suddenly hear a motor being revved very powerfully. You look round and see that a speeding car is about to hit you.	Fear
4: You think something good may be about to happen.	Interest
5: You fail an exam.	Sadness
6: You are having a heated dispute with someone.	Anger
7: You are sleeping in bed during the night but wake up thinking you have heard a suspicious noise. You get up to check it out.	Anxiety
8: You are sitting quietly in your bedroom reading a book when suddenly a book falls off the bookshelf above your head and lands with a thump on the desk in front of you.	Surprise
9: You are walking your dog in the park. A young boy repeatedly kicks your dog really hard for no reason.	Anger
10: You are having a great time with your friends.	Happiness
11: You are walking across a field in the country when suddenly there is the noise of galloping hooves; you look over your shoulder and see that a large bull is charging straight toward you at top speed.	Fear
12: Alone at home one night, you have settled down to read a book when you hear the front door opening and footsteps in the hallway. You don't know who it could be as your housemate is away and not due back for several days.	Anxiety
13: You can smell smoke in your house but aren't sure where it is coming from.	Anxiety
14: You are walking alone in an isolated but familiar area when a menacing stranger suddenly jumps out of the bushes with a knife to attack you.	Fear
15: You are watching your favorite comedy show.	Happiness
16: Even though you told him not to, your sibling borrowed your new laptop and then carelessly spills a cup of coffee on the keyboard.	Anger
17: You are hurrying along a corridor, and as you turn the corner, you nearly bump into someone coming the other way.	Surprise
18: You go to visit an elderly relative who lives on her own in an isolated house. When you get to her front door, you find that it is ajar; as you push the door fully open to enter the house, you call out her name, but there is no reply.	Anxiety
19: You have just bought a brand new car. You park it in a side street and run an errand. When you return to your car 5 min later, you find a couple of young boys about 9 or 10 years old spray painting obscenities on the side of your car.	Anger
20: A good friend of yours has moved away to the other side of the world, and you may never see him or her again.	Sadness
21: You encounter someone whom you find attractive.	Interest
22: You are sitting in a room in a tall building, and you look out of the window to see a plane flying toward you, about to crash straight into where you are sitting.	Fear
23: You open a can of tuna, and it is full of worms.	Disgust
24: A friend tells you a good joke.	Happiness

Note. Scenarios were presented in series via a computer slideshow. Threat scenarios were modeled after those in the Blanchard Threat Scenario Questionnaire used in initial attempts to study human defense (D. C. Blanchard et al., 2001).

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