Altered perception of emotional faces in young adults experiencing loneliness after controlling for symptoms of insomnia, anxiety and depression

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Highlights

- loneliness was related to positively valanced ratings of sad and angry faces
- loneliness was related to negatively valanced ratings of happiness
- loneliness was related difficulties in identifying happy faces
- This effect remained after controlling for insomnia, anxiety and depression

Altered perception of emotional faces in young adults experiencing loneliness after controlling for symptoms of insomnia, anxiety and depression

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Abstract

The evidence base concerning the relationship between loneliness and the perception of facial cues of emotion remains mixed. This study further examined the categorisation accuracy, and perceived emotional intensity and emotional valence of facial expressions of emotion in adults displaying high, medium, and low levels of loneliness, whilst controlling for symptoms of insomnia anxiety and depression. Using the University of California Loneliness Scale, participants were stratified into those experiencing high (N=83), medium (N=97), and low levels (N=93) of loneliness. Observing facial expressions of emotion from the Karolinska Directed Emotional Faces database, participants were assessed on their categorisation accuracy and ratings of emotional intensity and valence. After controlling for comorbid psychiatric symptoms, the experience of loneliness was characterised by: positively valanced ratings of angry and sad faces; difficulties in the identification of, and blunted ratings of emotional intensity and valance of happy faces. The outcomes present psychosocial implications for individuals experiencing loneliness.

Keywords

Loneliness, Emotion Perception, Face Perception

1. Introduction

Loneliness is an affective state, whereby a discrepancy exists between an individual's perceived social requirements and the extent to which these needs are satisfied through meaningful social interactions (Cacioppo and Hawkley, 2009; Rokach 2011). Whilst up-to 80% of the general population may experience transient bouts of loneliness, between 15-30% experience this feeling at a chronic level (Heinrich & Gullone, 2006; peltzer & Pengpid, 2019; Shiovitz-Ezra & Ayalon, 2009), with negative consequences for physical and psychological wellbeing. Indeed, the experience of loneliness has been related to a range of psychiatric symptoms including those pertaining to stress (Hawkley et al. 2003), anxiety (Cacioppo et al. (2006), depression (Cacioppo et al. 2015), poor sleep (Hom et al., 2020), and suicidal ideation (Stravynski and Boyer, 2001; Griffith, 2015). Similarly, socioemotional deficits are evidenced in lonely individuals in relation to the processing of social information, a crucial skill for successfully maintaining and developing social and interpersonal relationships (Adolphs, 2003). When evaluating socially relevant information from facial expressions, individuals focus on two key dimensions, valence (the extent to which something is considered positive or negative) and dominance (the extent of control over one's social circumstances) (Oosterhof & Todorov 2008; Singer et al., 2004; Saito et al., 2019; Todorov et al., 2008). Certainly, the accurate interpretation of facially expressed emotion remains vital for successful social interaction, whilst perceptual deficits may present negative psychosocial consequences.

Several studies have directly examined the perception of emotional faces in the context of loneliness. In a sample of students, Zysberg (2012) found loneliness to be associated with an attenuated ability to identify the emotions of target persons whilst observing a series of still images and video clips (i.e., Audio Visual Test of Emotional Intelligence: Zysberg et al., 2011). In a sample of low-income student adolescents, Vanhalst and colleagues (2017) employed a neutral to full-intensity facial emotion recognition task to examine the perceptual accuracy and intensity of facially expressed fear, happiness, and sadness in relation to loneliness. The results showed that, after controlling for symptoms of anxiety and depression, the experience of loneliness was related to an increased intensity rating of happy, sad, and fearful faces. Cheeta and colleagues (2021) attempted to differentiate deficits in the processing of emotional faces amongst individuals experiencing symptoms of depression, loneliness, or both. First year psychology undergraduate students categorised emotional faces depicting the six basic expressions as outlined by Ekman and Friesen (1971). The authors found loneliness to be related to increased categorising accuracy of sad faces but decreased accuracy of fearful faces, whereas those exhibiting depressive symptoms exhibited difficulties in identifying facially expressed happiness. Where depression and loneliness presented individually or co-occurred, participants were more likely to misperceive neutral expressions as sad (Cheeta et al., 2021). More recently, Saito and colleagues (2020) examined the role of loneliness in modulating automatic attention to facially expressed warmth and dominance in a sample of undergraduate students. Using eye-tracking and a target distractor paradigm, the authors determined that lonely individuals display an attentional bias for warm, but not dominant male faces (Saito et al., 2020). Whilst the aforementioned work describes altered emotion perception in relation to loneliness, Lodder and colleagues (2015) failed to evidence any relationships between loneliness and facially expressed emotion recognition task outcomes in Dutch students when presented it dynamic stimuli and a micro-emotion expression recognition task (Lodder et al., 2015). Similarly, after examining eye movements, Bangee and Qualter (2018) failed to determine any relationships between loneliness and the viewing patterns of facially expressed anger, fear, happiness, and

neutrality. Interestingly, lonely adults increased vigilance towards visual scenes depicting social rejection (Bangee & Qualter, 2018).

The formation of strong social bonds with other people remains vital a vital human need, providing intimacy, and a sense of belonging (Cacioppo et al. 2006). In those experiencing loneliness, the unmet need to belong may trigger implicit cognitive processes which attempt to correct and facilitate the regulation of social behaviour (Leary, 2004; Lodder et al., 2016). Here, according to social monitoring system theories, lonely adults exhibit cognitive biases of attention, interpretation and memory related to stimuli depicting social isolation and rejection (Cacioppo & Hawkley, 2009). Indeed, hypervigilance of the social environment may aid the identification of social cues (e.g., positive and/or negative emotional information in faces) used to avoid rejection and gain inclusion (Qualter et al., 2015). Alternatively, selective attention towards such cues serves to increase the likelihood that such cues are interpreted in a threatening manner. As a result, precipitating avoidance of potentially threatening situations and impairing the opportunity for lonely individuals to develop positive social relationships (Cacioppo & Hawkley, 2009).

To date only five studies yielding mixed outcomes, have directly examined the perception of emotional faces amongst individuals experiencing loneliness (Bangee & Qualter, 2018; Cheeta et al., 2021; Saito et al., 2020; Vanhalst et al., 2017; Zysberg et al., 2011). This may stem from variation in methodological considerations pertaining to task approach, key outcome variable(s) (e.g., categorisation accuracy, emotional intensity ratings) and the facial stimuli presented (e.g., all six basic or a select few emotions). Most studies sought to identify impaired categorization accuracy of emotional faces in lonely adults (Cheeta et al., 2021; Zysberg et al., 2011). Sampling young adolescent school children, only one study examined both accuracy and perceived intensity of emotional faces in relation to loneliness (Vanhalst et al., 2017). Likewise, whilst a single study (Cheeta et al., 2021) used all six basic expressions as outlined by Ekman and Friesen (1971), consistency amongst the remaining studies, each employing a mixture of four emotional expressions, varied substantially (Bangee & Qualter, 2018; Vanhalst et al., 2017; Zysberg et al., 2011).

In order to advance the understanding of face perception in relation to the experience of loneliness, we expand upon previous work by examining the categorisation accuracy (i.e., whether the displayed emotion was correctly identified), intensity (the strength of the emotion signal strength), and valence (i.e., the extent to which each expression was negatively aversive) of all six cross-culturally accepted facial expressions of emotion in adults displaying high, medium and low levels of loneliness (Ekman & Friesen, 1976). Moreover, as the experience of loneliness and perceptual alterations of emotional faces both occur in those experiencing symptoms of insomnia, anxiety and depression (Akram et al., 2020; Kyle et al., 2014; Langenecker et al., 2005; Leppänen et al., 2004), symptom severity of these conditions were controlled for. Considering experimental research to date has yielded mixed evidence concerning the perception of emotional faces in relation to loneliness, this work is an exploratory investigation, with no a priori hypotheses**.**

2. Methods:

2.1 Participants

The study was approved by the Sheffield Hallam University Research Ethics Committee (Protocol number: ER28407811), and all participants provided online informed consent. Students from two UK universities were recruited through institutional course participation schemes, social media groups and faculty emails. This resulted in a sample of N = 294 individuals who either began or clicked on a hyperlink to the survey which was delivered using the Qualtrics platform (Qualtrics, Provo, UT). Only complete cases were used in the analysis due to the ethical right to withdraw from the survey at any time. The data were also examined for duplicate responses based on matching IP addresses, where none were found. Therefore, N = 273 respondents (mean age= 19.80 ± 2.86 years, range 18–48, 81% female) providing complete data (final response rate = 93%) for the variables of interest (i.e., perceptual face ratings and symptoms of insomnia, anxiety, and depression) were entered into the final analysis. Students who requested course credit were remunerated on completion. All participants reported: normal to corrected-to-normal vision, the absence of prosopagnosia, being ≥ 18 years old.

2.2 Facial stimuli

Fifty-six facial photographs of eight individuals (50% female) displaying the emotional expressions of fear, anger, disgust, happiness, sadness, surprise, and neutrality were gathered from the Karolinska Directed Emotional Faces database (Lundqvist, Flykt, & Ohman, 1998). In the present study, we chose to use all six cross-culturally accepted facial expressions of emotion (Ekman & Friesen, 1976). These six expressions are commonly used to examine the perception of emotional faces in the context of psychiatric disorder (Batty & Taylor, 2003). In line with previous studies controlling for potentially distracting and confounding factors, we cropped the hair and neckline from each image (Akram et al., 2018; Duchaine et al., 2003; Ferrari et al., 2018; Lindenberg et al., 2019; Pittenger et al., 1975). Thus, leaving a series of oval-shaped neutral facial images (see Figure 1).

Insert Figure 1

2.3 Materials

2.3.1 Anxiety

The 7-item Generalized Anxiety Disorder Scale (GAD-7; Spitzer et al., 2006) is a validated practical self-report anxiety questionnaire used in primary care. The tool asks respondents how often, during the last 2 weeks, they have been bothered by each of the seven core symptoms of generalized anxiety disorder. Responses choice are 0 = “not at all”; 1 = “several days”; 2 = “more than half the days”; and 3 = “nearly every day”. Total scores range between 0 and 21 with cut offs of ≥5, ≥10, and ≥15 indicating mild, moderate, and severe anxiety levels, respectively. The GAD-7 has been shown to exhibit good reliability, as well as criterion, construct, factorial, and procedural validity (L we et al., 2008; Spitzer et al., 2006). Cronbach’s alpha in the current study was α =.92.

2.3.2 Depression

The 9-item patient health questionnaire (PHQ-9; Kroenke et al., 2001) is a brief self-report depression scale used to assess depressive symptoms in the general population. Each of the nine depressive symptoms corresponds to the depression criteria of the DSM-V (American Psychiatric Association, 2013). Respondents are required to indicate how much, during the previous 2 weeks, the symptom has bothered them on a scale of: 0 = “not at all”, 1 = “several days”, 2 = “more than half of the days” or 3 = “nearly every day”. Total scores indicate depression severity and range from 0 to 27 with higher scores indicating higher levels of depression. The scale has been shown to demonstrate good criterion and construct validity (Kroenke & Spitzer, 2002; Kroenke et al., 2001). Cronbach’s alpha in the current study was α =.91.

2.3.3 Insomnia

Insomnia symptoms were assessed using the Insomnia Severity Index (ISI; Bastien et al., 2001). The ISI consists of seven items examining the severity of insomnia symptoms over the past 2 weeks including difficulty initiating and maintaining sleep and awakening too early. Items are scored on a 5-point likert-type scale, with total scores ranging from 0 to 28. Higher scores suggest greater insomnia severity. Total scores between 0 and 7 indicate no clinically significant insomnia, 8 and 14 subthreshold insomnia, 15 and 21 clinical insomnia (moderate severity), and 22 and 28 clinical insomnia (severe). Assessment of internal consistency yielded a Cronbach’s alpha of .89.

2.3.4 Loneliness

The third version of the University of California Loneliness Scale (UCLA3) was used in the present study (Russell et al., 1978; 1996) as a measure of loneliness. It which consists of 20 items (e.g., "I am unhappy doing so many things alone", "I feel completely alone", and "I feel isolated from others") rated on a 4-point scale of (1 = never, 4 = often). Loneliness scores are calculated by summing the items (after reverse scoring) and ranged from 20–80, with higher scores indicating increased loneliness levels. Cronbach's alpha was α = 0.94.

2.4 Procedure

Participants completed an online questionnaire, in which they were presented with the series of 56 images in randomized order. For each face displayed, participants were asked to select (categorise) the corresponding emotional expression (fear, anger, disgust, happiness, sadness, surprise, and neutral). Subsequently, participants were asked to rate intensity and valence on a 100-mm visual analogue scale. The intensity scale was anchored at *not very intense* and *extremely intense*. Whereas valence was anchored at *extremely negative* and *extremely positive*. Each face was displayed until a response was made. Following the completion of the face-task, participants completed the GAD-7, PHQ-9, ISI and UCLA. The experiment lasted approximately thirty minutes. An example trial is presented in Figure 2.

Insert Figure 2

2.5 Statistical Analyses

SPSS (version 27, IBM Corp., Armonk, New York, United States) was used to perform formal statistical analyses of the raw data and first order correlations amongst all variables. Prior to formal analyses, the dataset was carefully screened for the presence of abnormal response patterns and completion times (range = 17-100mins, mean = 37mins), where neither were respectfully observed. Next, loneliness groups were determined using Cacioppo's approach (Cacioppo et al., 2002; Cacioppo et al., 2000) by selecting participants based on the UCLA to be among the upper (lonely group: total score ≥ 54-80), middle (middle loneliness group: total score ≥46 and ≤54) or lower (non-lonely group: total score ≤38) quintile of the distribution.

Total ratings of accuracy were summated for each expression. For each trial, correct responses yielded a score of 1 whereas incorrect responses were scored as 0. Therefore, accuracy scores ranged between 0 to 8, with higher scores indicating greater categorisation accuracy of the assessed expression. Next, mean expression intensity and valance ratings were calculated, and ranged between a possible 0 to 100 score. Here, higher scores indicated an increased perception of expression intensity, and positive valance respectively. All scores were calculated for each loneliness group.

A series of 3 Group (low, medium, high) x 7 Expression (fear, anger, disgust, happiness, sadness, surprise, and neutral) Bonferroni corrected mixed model analysis of variance (MANOVA) was employed with accuracy, intensity, and valance ratings as dependant variables. This was conducted to assess main effects of Group, Expression, and the Group x Expression interaction. Interaction effects were decomposed using one-way analysis of variance (ANONA) tests, to determine group (low, medium, high) differences in ratings of categorisation accuracy, expression intensity and valance for each facial expression. Where significant differences in perceptual judgments were observed, insomnia, anxiety, and depression were entered as covariates in a subsequent ANCOVA analysis. Finally, independent *t* tests compared accuracy, intensity, and valance ratings between those exhibiting high and low levels of loneliness. Significance was considered at the $p<.05$ level.

3. Results

The results determined that N=83 individuals were allocated to the high loneliness group, N=97 to the medium group, and N=93 to the low group. The statistics describing the means and standard deviations of the examined variables are reported in Table 1. A dose response increase in symptoms of insomnia ($F[2,270]=22.51$, $P=.001$), anxiety ($F[2,270]=47.33$, $P=.001$) and depression ($F[2,270]=74.78$, $P=.001$) was observed in relation to increased levels of loneliness. Pearson's bivariate correlations between each expression and questionnaire measure are provided in Table 2.

Insert Tables 1 & 2

3.1 Categorisation Accuracy

The results revealed a significant main effect of expression (F[6,1670] = 710.88, p > .001) but not group (F[2,270] = 1.88, p = .15). Whilst no significant group x expression interaction (F[12, 1620] = 0.74, p = .71) was observed, tests of between-subjects effects determined a dose response reduction in the categorisation accuracy of facially expressed happiness with increased loneliness (i.e. low vs. medium vs. high). After controlling for symptoms of insomnia (F = 0.30, p = .94), anxiety (F = 0.32, p =.93) and depression (F = 0.74, p = .62) as covariates in an analysis of covariance (ANCOVA) test, loneliness remained the only predictor of categorisation accuracy of happy faces (F = 2.59, p = .002). Finally, those in the high loneliness group performed significantly worse than the low group when categorising happy faces (t = 2.83, p = .005, Cohens *d* = .42).

3.2 Emotional Intensity

Whilst the results revealed a significant main effect of expression (F[6,1620] = 298.52, p > .001), no main effect of group (F[2,270] = 2.00, p = .14) or group x expression interaction was (F[12,1620] = 1.43, p = .15) observed. Likewise, no group (low, medium, high) differences in emotional intensity ratings were observed individual expression. However, when comparing individuals exhibiting high and low levels of loneliness, those in the high group demonstrated significantly lower intensity ratings for expressions depicting either a neutral (t=2.04, P=.042, Cohens *d* = .39) or happy face (t=2.43, P=.016, Cohens *d* = .31).

3.3 Emotional Valance

The results revealed no significant main effect of group (F[2,270] = 1.42, p = .24). However, the main effect of expression (F[6,1620] = 1150.23, p > .001) and group x expression interaction (F[12,1620] = 3.29, p > .001) were statistically significant. Here, tests of between-subjects effects determined a dose response increase in positive valance ratings of sad and angry faces with increased loneliness (i.e., low vs. medium vs. high). In contrast, ratings of happy faces were blunted with a dose response increase in loneliness. After controlling for symptoms of insomnia (F=0.84 P=.553), anxiety (F=0.51, P=.830) and depression (F=1.33, P=.235) as covariates in an analysis of covariance (ANCOVA) test, this pattern of results remained the same, with no significant effects of insomnia, anxiety, or depression. Likewise, when comparing individuals exhibiting high and low levels of loneliness, the high loneliness group demonstrated significantly more positive valance ratings for sad (t=-3.18, P=.002, Cohens *d* = .48) and angry (t=-2.49, P=.014, Cohens *d* = .37) expressions, and lower ratings for happy faces (t=2.53, P=.012, Cohens *d* = .38).

4. Discussion

This study examined the categorisation accuracy, and perceived emotional intensity and emotional valence of facial expressions of emotion in adults displaying high, medium, and low levels of loneliness, whilst controlling for symptoms of insomnia anxiety and depression. The current outcomes suggest that, after controlling for psychiatric symptoms: greater levels of loneliness are associated with positively valanced

ratings of faces depicting anger and sadness; difficulties in the identification of, and blunted ratings of emotional intensity and valance of happy faces. Here, we provide partial support for previous work evidencing the experience of loneliness to be related to select deficits in the processing of facially expressed emotions (Cheeta et al., 2021; Vanhalst et al., 2017). Whilst adding to the sparse literature on the perception of emotional faces and loneliness, the varying use of task and sample populations limits any direct comparison.

The experience of loneliness may incumber the necessary skill set required to initiate and maintain effective social interactions and relationships (Jones, Hobbs, & Hockenbury, 1982), which may underlie perceptual and attentional deficits when decoding social cues in the current context (Hall et al., 2009). In contrast, deficits of this nature may contribute to the experience of loneliness due to social withdrawal and/or peer exclusion. The social monitoring system theory suggests that loneliness leads to increased vigilance for positive and negative social information in the environment (Cacioppo & Hawkley, 2009; Qualter et al., 2015). Lonely individuals are expected to identify contextually salient information concerning social inclusion/exclusion with greater accuracy and sensitivity when compared to their non-lonely counterparts (Cacioppo & Hawkley, 2009). In previous work, loneliness appears to be related to increased categorisation accuracy of sad faces but decreased accuracy of fearful faces (Cheeta et al., 2021) and increased intensity ratings of happy, sad, and fearful faces (Vanhalst et al., 2017). In contrast, Zysberg (2012) identified loneliness to be associated with deficits in identifying emotions presented in images and short video clips. Likewise, the current outcomes determined that lonely individuals presented perceptual differences (i.e., reduced intensity and valance) and difficulties in identifying happy faces. Nevertheless, the social monitoring theory is largely based on loneliness-related constructs in studies examining social exclusion (Chen et al., 2017) and belongingness needs (Pickett et al., 2004). For example, students who identify as being socially excluded and report greater belongingness needs are evidenced to display increased vigilance towards both positive and negative facial expressions as measured by eye-tracking (Chen et al., 2017). Likewise, individuals reporting increased belongingness and few friends display greater levels of categorisation accuracy of low-intensity facial emotions (Pickett et al., 2004; Gardner et al., 2005). More crucially, Satio and colleagues (2020) determined that warm and friendly faces capture the attention of lonely adults quicker than competent faces. Here, increased attentional allocation for positive expressions in those experiencing loneliness may subsequently influence perceptual judgments, perhaps explaining greater accuracy for, and lower intensity and valance ratings of, happy faces in the current study.

As social inclusion and rejection may be inferred from both positive and negatively oriented expressions, faces depicting sadness, anger and happiness are possibly more salient for those experiencing loneliness (Lodder et al., 2016; Spithoven et al., 2017; Vanhalst et al., 2017). Whilst prior work found increased intensity ratings of sad, and fearful faces (Vanhalst et al., 2017), the current outcomes differed where lonely individuals perceived anger and sadness in a more positive manner when compared to controls. Like anxiety and depression, loneliness may be associated with a positive bias when making emotional judgments where the misperception of potentially threatening information may reflect cognitive and affective processes which contribute to their adaptation to difficult interpersonal situations (Arce et al., 2009). That said, the mean valance of anger and sadness remained in the low end of the spectrum, each falling below thirty-four of a possible one hundred. Additionally, it is important to highlight that emotional intensity and valance

represent different constructs, particularly as those experiencing loneliness were more sensitive to the latter. In the current context, perceived valence concerns the extent to which facial expressions were considered positive or negative, whereas emotional intensity the perceived strength of the emotional state presented (Feldman Barrett & Russell, 1999). Nevertheless, it is important to note studies which failed to evidence perceptual alterations of emotional faces amongst individuals experiencing loneliness (Bangee & Qualter, 2018; Lodder et al., 2015). Given the mixed evidence to date, the extent to which the accuracy and perception of specific facial expressions of emotion differ amongst lonely and non-lonely individuals remains inconclusive. Moving forward, eye-movements should be recorded during the observation of facially expressed emotion to further explore the relationship between monitoring of social inclusion/exclusion and the perception of emotional faces.

Several strengths and limitations of the current work should be noted. In relation to stimuli presentation and participant response times, we allowed participants to rate each face in their own time. Consequently, it is theoretically possible that amongst some lonely individuals, any initial implicitly biased response may have explicitly shifted to a more neutral position with time. However, given substantial variation in enforced response times in previous studies, between 500ms to 20 seconds (Bangee & Qualter, 2018; Cheeta et al., 2021; Saito et al., 2020; Vanhalst et al., 2017; Zysberg et al., 2011), the current perceptual alterations evidenced in the absence of time restrictions may provide a novel contribution to the literature. Next, the present sample was comprised entirely of students who were predominantly female, we are therefore unable to extrapolate the outcomes to the general population. Moreover, the cross-sectional design employed prevents the causality of the relationships identified from being conclusively defined. The currently used stimuli employed naturally occurring facial stimuli, gathered from a standardized stimulus set comprised of well-validated facial expressions displayed by trained actors (Lundqvist et al., 1998). Rather than selecting a limited number of expressions, all six facial expressions of emotion as determined by Ekman and Friesen (1976) were used. However, whilst no categorisation accuracy differences were observed in relation to facially expressed fear, the mean ratings appeared markedly low for each group. This may be attributed to a degree of structural overlap between the expressions of fear and surprise (i.e., raised eyebrows, widened eyes, opening of the mouth and tension in the surrounding muscles; Ekman & Friesen, 1971). Finally, considering overlapping cognitive processes (i.e., symptom consistent cognitive biases of attention and interpretation) and perceptual differences in emotional faces in relation to the experience of loneliness and psychiatric symptoms, we controlled for insomnia, anxiety and depression.

To conclude, the current study determined perceptual alterations occur amongst individuals experiencing high levels of loneliness when observing facial expressions of emotion. More specifically, increased loneliness was associated with: accentuated valance ratings of faces depicting anger and sadness; difficulties in the identification of, and blunted ratings of emotional intensity and valance of happy faces. More crucially, these outcomes remained consistent after controlling for comorbid psychiatric symptoms of insomnia, anxiety, and depression. Whilst the underlying mechanisms remain unclear, this work adds to the limited number of studies examining the perception of facially expressed emotions in relation to loneliness. Further research in this understudied area is encouraged.

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Tables and Figures

Table 1.

Means ± SD

	Loneliness Groups			Sig.			High vs. Low Risk$^{\Delta}$		
	High N = 83	**Medium** N = 97	**Low** N = 93	***Mean*^{2}**	***F***	**P**	***t***	**P**	**Cohens *d***
Insomnia	12.73 ± 6.43	10.23 ± 6.02	6.75 ± 5.43	798.11	22.51	.001**	-6.70	.001**	1.00
Anxiety	11.37 ± 5.58	7.10 ± 5.17	3.84 ± 4.66	1247.58	47.33	.001**	-9.76	.001**	1.46
Depression	15.31 ± 5.97	9.66 ± 6.11	5.01 ± 4.54	2328.95	74.78	.001**	-12.96	.001**	1.04
Loneliness	60.01 ± 6.11	45.54 ± 4.02	30.55 ± 4.94	19074.05	750.06	.001**	-35.31	.001**	5.30
Accuracy									
Fear	2.35 ± 1.44	2.46 ± 1.47	2.40 ± 1.41	0.30	0.14	.865	0.23	.822	.04
Anger	7.13 ± 1.35	7.33 ± 1.07	7.45 ± 0.84	2.26	1.88	.154	1.90	.059	.29
Disgust	7.17 ± 1.14	7.00 ± 1.38	7.15 ± 0.99	0.80	0.57	.567	-0.11	.910	.02
Happiness	7.59 ± 0.96	7.63 ± 1.11	7.89 ± 0.34	2.46	3.23	.041*	2.83	.005**	.42
Sadness	5.13 ± 1.61	5.32 ± 1.68	5.31 ± 1.59	0.97	0.37	.694	0.74	.459	.11
Surprise	7.33 ± 1.16	7.36 ± 1.04	7.47 ± 0.80	0.54	0.53	.590	1.00	.323	.14
Neutral	6.59 ± 1.46	6.42 ± 1.56	6.84 ± 1.08	4.15	2.18	.115	1.30	.197	.20
Intensity									
Fear	57.83 ± 14.06	57.28 ± 13.14	60.08 ± 14.70	206.35	1.06	.349	1.04	.301	.16
Anger	59.76 ± 15.20	61.05 ± 15.50	62.81 ± 15.38	206.16	0.872	.419	1.32	.190	.20
Disgust	74.34 ± 13.91	72.54 ± 13.85	74.59 ± 12.82	117.74	0.643	.526	0.12	.901	.02
Happiness	59.42 ± 16.99	62.53 ± 16.17	65.22 ± 14.65	736.45	2.902	.057	2.43	.016*	.39
Sadness	48.53 ± 15.39	48.90 ± 15.36	50.84 ± 14.33	139.57	0.618	.540	1.03	.304	.16
Surprise	57.50 ± 14.01	60.22 ± 14.30	61.67 ± 14.64	389.61	1.898	.152	1.93	.056	.29
Neutral	34.07 ± 21.58	34.34 ± 24.42	41.15 ± 24.06	1474.21	2.677	.071	2.04	.042*	.31
Valance									
Fear	30.06 ± 9.31	29.45 ± 11.16	27.38 ± 9.32	177.85	1.78	.171	-1.91	.058	.29
Anger	26.69 ± 12.26	26.10 ± 12.93	22.34 ± 10.94	505.58	3.47	.033*	-2.49	.014*	.37
Disgust	25.06 ± 13.88	24.34 ± 13.66	21.80 ± 11.40	264.94	1.57	.211	-1.71	.089	.26
Happiness	71.87 ± 13.58	72.72 ± 12.69	76.28 ± 9.38	495.09	3.46	.033*	2.53	.012*	.38

Sadness	33.08 ± 10.20	31.18 ± 10.75	28.46 ± 9.03	475.88	4.74	.010**	-3.18	.002**	.48
Surprise	50.81 ± 8.14	50.04 ± 8.65	49.20 ± 8.00	57.54	0.84	.433	-1.33	.186	.20
Neutral	45.60 ± 7.96	45.97 ± 6.61	46.06 ± 7.13	5.19	0.10	.905	0.41	.686	.06

Note:

Δ, Between groups (high vs. low risk) independent *t*-test analyses.

*, Sig at P < .05; **, Sig at P < .01

Table 2

Corelations between loneliness, insomnia, anxiety, and depression with ratings of categorisation accuracy, intensity and valance ratings for each emotional expression.

	Fear	Anger	Disgust	Happiness	Sadness	Surprised	Neutral
[Categorisation Accuracy]							
Loneliness	-.01	-.14*	-.01	-.15*	-.04	-.10	-.06
Insomnia	-.09	-.10	-.02	-.10	-.02	-.06	-.07
Anxiety	-.12*	-.17**	.03	-.13*	-.07	-.09	-.17**
Depression	-.05	-.20**	-.01	-.18**	-.02	-.11	-.16**
[Intensity Ratings]							
Loneliness	-.05	-.08	.01	-.13*	-.05	-.12	-.13*
Insomnia	.10	.08	.12*	.02	.10	.04	.01
Anxiety	-.03	-.05	.07	-.08	-.10	-.06	-.06
Depression	.05	.01	.11	-.08	-.01	-.04	-.10
[Valance Ratings]							
Loneliness	.11	.16**	.07	-.13*	.20**	.06	.01
Insomnia	.09	.06	.02	-.02	.09	.03	.02
Anxiety	.06	.07	-.02	-.07	.12	.01	-.03
Depression	.04	.06	-.04	-.11	.10	.04	-.06

Note: Loneliness, UCLA3: University of California Loneliness Scale; Insomnia, ISI: Insomnia Severity Index; Anxiety, GAD7: Generalized Anxiety Disorder Scale; Depression, PHQ-9: Patient Health Questionnaire.

*, Sig at P < .05; **, Sig at P < .01

Figure 1. Example set of facial expressions

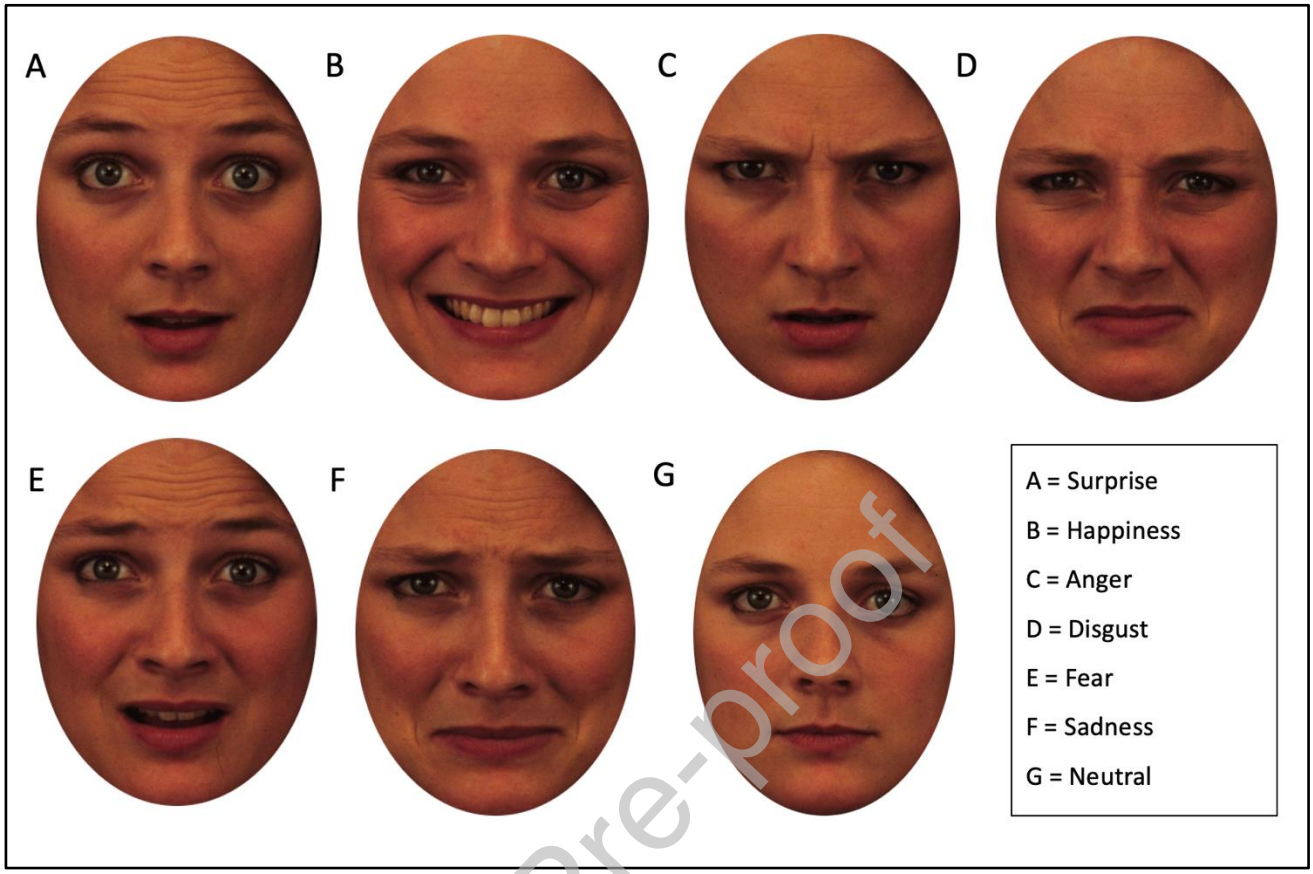
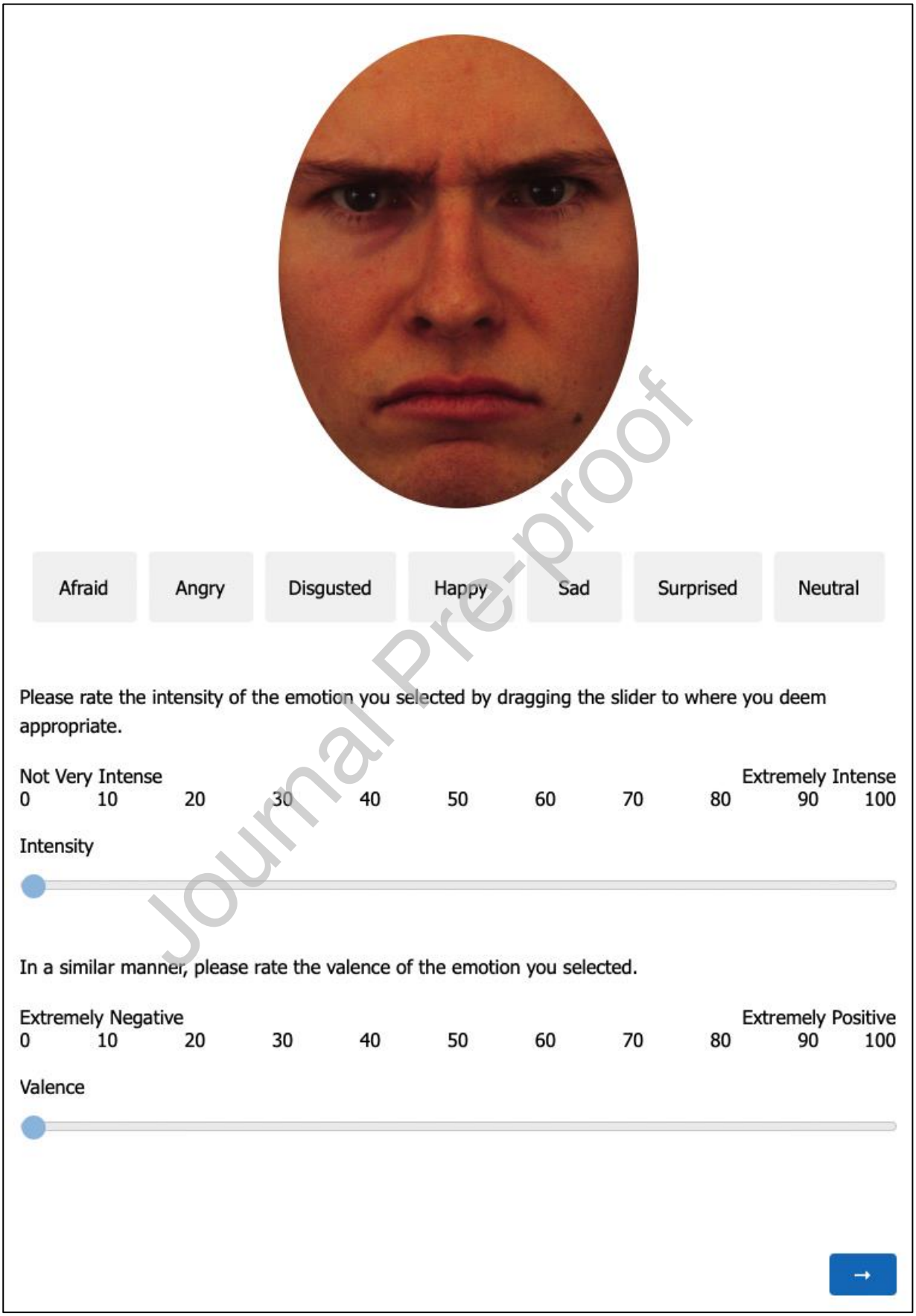


Figure 2. Example trial



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