Depression or anxiety: Which is best able to predict patterns of lateralisation for the processing of emotional faces?

Victoria J. Bourne

Department of Psychology

Royal Holloway, University of London

&

Matei Vladeanu

Institute of Psychiatry, Psychology and Neuroscience

King's College, University of London

Corresponding author (VB):

Department of Psychology

Royal Holloway, University of London

Egham, Surrey, UK

TW20 0EX

victoria.bourne@rhul.ac.uk

Abstract

Previous research has shown that both anxiety and depression are associated with strength of lateralisation for the processing of emotive faces, although these clinical measures have always been considered in separate studies. In the present study, we measure depression and anxiety, within the same non-clinical sample, and consider whether these variables can predict strength of lateralisation, measured using the chimeric faces test. There are two key findings from this study. First, for females only, anxiety is negatively associated with right hemispheric superiority for processing of negative emotional expressions. Second, there was only one finding for depression, showing a relationship with strength of lateralisation for the processing of fearful faces that differed according to sex.

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The processing of facial emotion typically occurs in the right hemisphere of the brain (e.g., Bourne, 2010), however atypical patterns of emotion lateralisation have been reported in individuals with both clinical and non-clinical depression (e.g., Bourne & Vladeanu, 2013; Lai, 2014; Surguladze et al., 2005) and individuals with both clinical and non-clinical anxiety (e.g., Bourne & Vladeanu, 2013; Monk et al., 2008). One limitation of this research is that anxiety and depression have typically been examined separately, even though they are often comorbid in clinical populations (Gorman, 1996) and highly correlated in non-clinical populations (Crawford & Henry, 2003). It is therefore difficult to know whether anxiety and depression are each independently associated with atypical emotion lateralisation, or whether previous research looking at the two distinct measures are actually identifying the same underlying relationship. In this paper, both anxiety and depression are considered within one non-clinical sample to consider whether each is distinctly related to strength of lateralisation for the processing of facial emotion, or whether the relationship exists for just one of the measures.

Patterns of lateralisation for the processing of facial emotion have been examined using a wide range of different methodologies. One frequently used and well validated paradigm is the chimeric faces test (see Bourne, 2010). The stimuli in this task are vertically split chimeric faces, with one hemi-face having a neutral expression and the other hemi-face having an emotional expression, typically one of the six basic emotions (anger, disgust, fear, happiness, sadness or surprise). When shown a pair of chimeras, where one is the mirror image of the other, participants are biased towards perceiving the chimera with an emotive left hemi-face as more emotive than the chimera with an emotive right hemi-face. This left hemi-face (visual field) bias is typically interpreted as reflecting a right hemisphere bias for the processing of facial emotion. Whilst there are conflicting theories regarding the lateralised processing of facial emotion, with some finding that positive emotions are lateralised to the left hemisphere and negative emotions are lateralised to the right hemisphere (see Bourne, 2010), the chimeric faces test has been found to be sensitive to individual differences in emotion lateralisation by a number of research groups (e.g., Bourne & Vladeanu, 2011, 2013; Rahman & Anchassi, 2012; Workman et al., 2000).

Bourne and Vladeanu (2013) examined the relationship between emotion lateralisation, using the chimeric faces test, and depression in a non-clinical sample, using the Beck Depression Inventory. They found a negative relationship, whereby females (but not males) with higher depression scores were more weakly lateralised to the right hemisphere, or even showed left hemispheric dominance. This relationship was particularly evident for the processing of the negative emotional expressions of anger, disgust and fear. Surguladze et al. (2005) conducted an fMRI study with patients diagnosed with major depressive disorder and found varying patterns of increased and decreased activation across the brain, depending on the emotional expression on faces being viewed. Interestingly, they also found a negative correlation between the magnitude of depressive symptoms and lateralised patterns of activation. Patients with more severe symptoms had reduced activation in the right fusiform gyrus when viewing happy faces, however there was no relationship with levels of activation in the left fusiform gyrus, and no correlations in either hemisphere when viewing neutral or sad faces. A recent meta-analysis (Lai, 2014) of ten fMRI studies with individuals who have clinical depression, showed that patients have increased activation in left limbic areas of the brain when viewing emotive faces. Taken together, the research suggests that both clinical and non-clinical depression is associated with a reduced right hemispheric dominance for the processing of facial emotion, possibly with a shift in processing to the typically non-dominant left hemisphere.

Research examining the association between non-clinical trait anxiety and clinical Generalised Anxiety Disorder has typically shown a positive relationship with emotion lateralisation (see Bourne &

Vladeanu, 2011, for a more detailed review of this literature). Using the chimeric faces test, Bourne and Vladeanu (2011) found that males with higher levels of trait anxiety were more strongly lateralised to the right hemisphere for the processing of all six of the facial emotional expressions. A similar relationship was reported by Monk et al. (2008) in an fMRI study with adolescents diagnosed with Generalised Anxiety Disorder. They found increased right prefrontal activation in participants when they were viewing angry faces. Therefore, it appears that individuals with higher levels of anxiety are likely to be more strongly lateralised to the right hemisphere for the processing of facial emotion.

Considering the previous research, distinct patterns of emotion lateralisation appear to be reported for individuals with high (or clinical) levels of anxiety and depression. For those with higher levels of depression a reduced right hemispheric superiority for the processing of facial emotion is often reported (Bourne & Vladeanu, 2013; Lai, 2014; Surguladze et al., 2005), whereas individuals with higher levels of anxiety tend to have increased strength of right hemispheric processing of facial emotion (e.g., Bourne & Vladeanu, 2013; Monk et al., 2008). Given that anxiety and depression are highly correlated in non-clinical samples (Crawford & Henry, 2003) and often comorbid in clinical samples (Gorman, 1996), it is difficult to reconcile these contrasting findings. One way to resolve this issue would be to examine depression and anxiety within the same study, to consider how they might each be associated with variability in emotion lateralisation.

To date, no research has examined lateralisation for the processing of facial emotion in relation to anxiety and depression within the same study. However, a small number of studies with alternative methodologies and non-facial stimuli suggest that this may be a fruitful line of enquiry. Sass et al. (2014) used a word based emotional Stroop task in an Event Related Potentials study, and they found that the N200 response, indicating the magnitude of the neural response to stimuli which indicates increased attention towards a stimulus or that a stimulus has greater salience, was significantly greater for women with high levels of both anxiety and depression when processing unpleasant stimuli in contrast to when processing pleasant stimuli. For control women or women with high scores only on the depression scale, there was no significant difference between responses to pleasant and unpleasant stimuli. Additionally, they found an increased P300 response to unpleasant stimuli in the right hemisphere in participants with higher levels of both anxiety and depression. Bruder et al. (1999) used a dichotic listening paradigm with non-emotive words and found that, for individuals with non-anxious depression, there was a right ear (left hemisphere) bias, whereas for individuals with anxious depression, there was a strong left ear (right hemisphere) bias. Liotti et al. (1991) used divided visual field presentation with simple geometric stimuli and found that patients with depression has slower responses when stimuli were presented to the left visual field (right hemisphere), whereas patients with anxiety showed the opposite pattern with slower responses for stimuli presented to the right visual field (left hemisphere). However, the stimuli used in these three studies were not facial. It therefore seems that the neuropsychological processing of stimuli may differ between individuals with comorbid anxiety and depression, and those with high scores on just one of the measures.

A clear gap in the current research is a study that examines emotion lateralisation in relation to both anxiety and depression, within the same sample. The present study will provide such an investigation by considering the relationship between emotion lateralisation, as measured using the Chimeric Face Test across all six of the basic emotions, and both anxiety and depression, as measured using the Depression, Anxiety and Stress Scale (DASS). An advantage of using the DASS is that it was designed to measure depression and anxiety within the same measure, and factor analyses have validated that each scale is distinct within the DASS, even though the scales are highly correlated within both non-clinical (Crawford & Henry, 2003) and clinical (Brown et al., 1997) samples. Additionally, there are advantages to using a single measure designed to measure both anxiety and depression, but separately. Previous research has shown that use of this single measure can provide a greater differentiation between anxiety and depression than when using two separate measures (Lovibond and Lovibond, 1995). As such, using the single measure of DASS may provide estimates of levels of self-reported anxiety and depression that are more clearly differentiated and have less overlap than using separate measures.

Previous research examining the relationship between depression and emotion lateralisation has tended to report a negative relationship, showing a reduction in the typical right hemisphere bias and a shift towards left hemispheric processing is perhaps the most frequent finding (Bourne & Vladeanu, 2013; Lai, 2014). In contrast, research examining the relationship between anxiety and emotion lateralisation has typically found a positive relationship, with an increased use of the right hemisphere when processing emotive faces (see Bourne & Vladeanu, 2011). As such, it is predicted that depression and anxiety may differentially predict strength of lateralisation, with higher levels of depression predicting a reduced right hemisphere bias, and anxiety predicting an increased right hemisphere bias. However, given that depression and anxiety are likely to be highly correlated, it is unclear how these relationships might look when considered together, within the same sample. Given that previous research has frequently reported sex differences in individual differences examinations of emotion lateralisation (e.g., Bourne & Vladeanu, 2011, 2013; Rahman & Anchassi, 2012) sex differences in the relationships will also be considered. .

Methods

Participants

There was a total of 204 participants (101 male, 103 female) with a mean age of 21.4 years (SD = 3.0). All were right handed by self-report and this was confirmed with a handedness questionnaire (Dorthe et al., 1995). On this measure scores range from -42 (strongly left handed) through to +42 (strongly right handed). Mean handedness score was 31.0 (range: 12-42, SD = 7.0). None reported any prior head injuries or diagnosis of anxiety or depression. Ethical approval was obtained from the Departmental Ethics Committee.

Chimeric faces test

The chimeric faces test is a behavioural test of strength of lateralisation for the processing of emotional faces. Chimeras are formed from vertically split facial stimuli and paired together such that one half face is emotive (anger, disgust, fear, happy, sad or surprised) and the other half is neutral. These chimeras were formed using the Ekman emotive stimuli (Workman et al., 2000; Bourne, 2010), with one male and one female poser. Faces were presented in mirror image pairs, with one presented above the other, in greyscale on a white background. Participants were asked to decide which of the two chimeras was more emotive, and to respond by pressing the upwards arrow on a keyboard if they thought it was the top face, or the downwards arrow if they thought it was the lower face. Responses were made using their dominant (right) hand. Faces remained onscreen until participants responded, although they were asked to respond as quickly and as instinctively as possible.

There were twenty four trials for each emotion, and the order of presentation was randomised between participants. Each emotion was presented within a block of trials, and the order of the six emotion blocks was randomised between participants, as was the placement of upper and lower stimuli within each trial. From the participant's responses, a laterality quotient was calculated for each of the six emotions separately in the following way: (Number of LVF choices - (Total number of trials - Number of LVF choices))/Total number of trials. Quotients ranged from-1 (left hemisphere, right visual field bias) through to +1 (right hemisphere, left visual field bias).

Depression, Anxiety and Stress Scale (DASS)

The short form of the Depression, Anxiety and Stress Scale (DASS-21) was used, and this version of the scale has been well validated in previous research (e.g., Brown et al., 1997; Crawford & Henry, 2003). The measure contains 21 items, with seven items specifically relating to each of the three sub-scales of depression, anxiety and stress. Only the depression and anxiety scales were used in this study. Participants are asked to read statements and to consider the extent to which the statement has applied to them over the past week. Responses are coded on a four-point Likert scale, ranging from 0 (did not apply at all) through to 3 (applied to me very much, or most of the time). Consequently, scores on each scale range from 0 to 21, with higher scores indicating higher levels of depression or anxiety.

Design and analysis

Initial analyses used one-sample t tests to compare laterality quotients to 0 (i.e., no bias) and independent t tests to examine sex differences in all of the variables included in this study. The main analyses used hierarchical multiple regression models to predict laterality quotients. Block one contained the main effect variables of sex, depression and anxiety block two contained the two-way interactions between the variables, and block three contained the three-way interaction interactive predictors (means centred). Six regression models were run, one for each of the basic emotions.

Results

One-sample t tests showed a significant left visual field (right hemisphere) bias across all six of the laterality measures for males, and for all emotions other than happiness for females (see Table One). Males were significantly more right hemisphere dominant than females for processing happy emotional expressions. All other sex differences were not significant (see Table One).

[Insert Table One about here]

Depression and anxiety were highly correlated ($r = .53$, $p < .001$). However, the tolerance value was .72 (greater than 0.2) and the variance inflation factor was 1.38 (less than 10), therefore multicollinearity was not deemed to be a problem within the dataset.

The regression analyses are summarised in Table Two. The overall model was significant for the sadness model, and approaching significance for all other emotions, with between 6.2% and 8.3% of the variability explained. Block one, containing the main effect predictors was significant for the happiness, sadness and surprise models. Sex was a significant predictor of strength of lateralisation for the processing of happiness, with males being more strongly lateralised. Anxiety was a significant predictor of sadness and surprise lateralisation, with higher levels of anxiety predicting weaker patterns of right hemispheric lateralisation. This effect was also approaching significance for anger.

[Insert Table Two about here]

Block two, containing the three two-way predictor variables showed that the interaction between depression and sex was a significant predictor of strength of lateralisation for the processing of fearful expressions only. The correlation between depression and lateralisation for processing fearful faces was negative for males and positive for females (see Table Two), although both statistics were not significant and they did not differ significantly from each other ($z = 0.96$, $p = .169$).

For all four of the negative emotions, the interaction between anxiety and sex was significant. The patterns was the same across all four analyses: there was no significant correlation for males and a significant negative correlation for females (see Table Two). These correlations differed significantly for anger ($z = 2.21$, $p = .014$), disgust ($z = 2.77$, $p = .003$), fear ($z = 2.18$, $p = .015$), and sadness ($z = 2.22$, $p = .013$).

All other interactions were not significant.

Discussion

There were two key findings to emerge from this analysis. First, when looking at depression and anxiety, the majority of the significant findings relate to the anxiety measure only, and mainly when taking into account the sex of the participant. For the processing of negative emotions only, females who have higher levels of anxiety tend to be more weakly lateralised to the right hemisphere (a negative relationship), whereas there is no relationship for males. Second, there is only one significant finding to emerge involving the depression scale; a slight (not significant) negative relationship for males and a slight (not significant) positive relationship for females. This interaction is significant for the processing of fearful faces only.

Previous research had tended to show that anxiety is positively related with emotion lateralisation (e.g., Bourne & Vladeanu, 2013; Monk et al., 2008), whereas other studies depression is negatively associated with emotion lateralisation depression (e.g., Bourne & Vladeanu, 2013; Lai, 2014; Surguladze et al., 2005). The present study was novel in being the first to consider both anxiety and depression within the same study, due to the high correlations between the two measures in non-clinical participants (Crawford & Henry, 2003) and co-morbidity in clinical populations (Gorman, 1996). However, it should be noted that the depression and anxiety scores in our sample are somewhat higher than in previous reports (e.g., Crawford et al., 2011, where depression = 2.57 and anxiety = 1.74). This might result from our sample being drawn from different populations. It has been shown that students are more likely to experience high levels of both anxiety and depression (Eisenberg et al., 2007). Our sample was drawn from a student population, whereas the participants in the Crawford et al. (2011) study were drawn from the general population, and therefore it is not necessarily unexpected that our reported depression and anxiety levels are higher.

We also found that anxiety and depression were significantly correlated within our sample; however, when including both variables within the analysis, only anxiety was a significant predictor of emotion lateralisation. It is therefore possible that the previous research showing a relationship between depression and emotion lateralisation was actually measuring the relationship between anxiety and depression. Interestingly, we found a negative relationship between anxiety and negative emotion lateralisation for females only. This finding replicates our previous research looking at the relationship between depression and lateralisation (Bourne & Vladeanu, 2013), suggesting that these findings may indeed have actually reflected the relationship between anxiety and lateralisation.

It is interesting that there were very few findings for the depression variable in this study, even within the zero order correlations. In addition to this being explained by the shared variance with anxiety, it is possible that this may be due to different ways of measuring depression across studies. For example, Bourne and Vladeanu (2013) used the Beck Depression Inventory, whereas in the present study we used the Depression, Anxiety and Stress Scale. If these scales measure different aspects of depression, then this might, at least in part, explain the discrepant findings. Lovibond and Lovibond (1995) compared these two measures of depression and found that they were correlated ($r = .74$). However, their factor analyses suggested that the Beck measure includes a wider range of items that they claim may not be strongly related to depression (e.g., irritability, weight loss and insomnia). As such, they propose that the DASS depression scale is more targeted to measuring depression, whereas the Beck Inventory contains additional items that may reflect non-depressive affective states. As such, it is possible the previous research using the Beck Depression Inventory (e.g., Bourne & Vladeanu, 2013), identified relationships between depression and emotion lateralisation that did not actually reflect depression, but instead other affective states (e.g., irritability). They support this claim statistically as their alpha coefficient was higher for the DASS than for the BDI, indicating higher reliability and less variability in the responses to the items within the DASS. Given that the present study found only one relationship between depression and emotion lateralisation, using what is potentially a more specific measure of depression, it is possible that there is indeed no relationship between depression and emotion lateralisation, but that other aspects of affective states may be associated with variability in emotion lateralisation. Further research is clearly needed to further disentangle the relationships between depression, mood and other affective states.

Our previous work on anxiety and lateralisation (Bourne & Vladeanu, 2011) found results that initially appear to be somewhat different to the findings of our present study. We had reported no significant relationship for females and a significant positive relationship for males. Interestingly, the sex difference is the same, with a more negative relationship for females than for males, however the slope is different. Previously, for males, there was a significant positive correlation, which has negatively shifted to become no relationship in the present study. Whereas for females, previously there was no correlation, which has negatively shifted to become a significant negative correlation. As such, it could be seen that the direction of the sex difference is the same across both studies (i.e., a more negative relationship for females than males), but the slope differs across the two studies. There is no clear explanation for why this might be, other than the use of different measures of anxiety. In their paper Lovibond and Lovibond also looked at the correlation between the DASS anxiety scale and the Beck Anxiety Inventory and found that they were highly correlated ($r = .81$). In our 2011 paper we used the State Trait Anxiety Inventory, but to our knowledge the relationship between this measure and the DASS anxiety scale has not been examined. Therefore it is difficult to speculate as to how findings may differ between these two measures.

The main finding for the interaction between anxiety and the sex of the participant was consistent across all four of the negative basic emotions, and the one finding for depression was for the fear variable only. This pattern of differences across the emotions is not necessarily surprising given that the processing of negative emotional expressions tends to be impaired in individuals with higher levels of depression and anxiety. A recent meta-analysis of emotional face processing in major depressive disorder showed that the processing of a range of emotions, including fear, are impaired in clinical samples (Dalili et al., 2015). Further, the enhanced activation in the left amygdala in response to emotive faces in depressed patients was found to be greater for fearful faces than for other emotional expressions (Sheline et al., 2001). Research with individuals with high levels of non-clinical anxiety has also shown a bias towards oversensitivity for categorising blended emotional stimuli as fearful (Bishop et al., 2015) and greater orienting towards fearful facial stimuli (Fox et al., 2007). Consequently, it seems that the atypical patterns of lateralisation for processing specific emotions identified in this study, maps onto the emotional expression that are atypically processed in individuals with high, or clinical, levels of anxiety and depression.

Finally, it is interesting to consider the possible direction of the relationship between high levels of anxiety and atypical lateralisation. Is it that individuals with atypical patterns of lateralisation are more vulnerable to anxiety, or that people with high levels of anxiety process emotive faces differently in the brain? Balconi and Ferrari (2013) found that repeated Transcranial Magnetic Stimulation over the left dorsolateral prefrontal cortex reversed the atypical lateralisation found in individuals with high levels of anxiety, suggesting that the direction of the relationship is that atypical neuropsychological processing is the precursor. However, in a sample of patients with depression, Fu et al. (2008) found that atypical patterns of activation normalised following successful Cognitive Behavioural Therapy suggesting that the relationship may exist in the other direction. It is therefore possible that the relationship is actually bidirectional, although further research is necessary to truly understand the relationship between emotion lateralisation and anxiety.

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Table One: Descriptive statistics, one-sample t tests and independent t tests for all variables included in this study.

	Male (N = 101)				**Female (N = 103)**				**Sex difference**	
	Descriptive statistics		**One sample t tests**		**Descriptive statistics**		**One sample t tests**		**independent t tests**	
	M	**SD**	**t**	**p**	**M**	**SD**	**t**	**p**	**t**	**p**
Anger	.28	.54	***5.28***	***< .001***	.25	.56	***4.62***	***< .001***	.40	.691
Disgust	.21	.56	***3.79***	***< .001***	.23	.53	***4.39***	***< .001***	-.29	.775
Fear	.27	.56	***4.77***	***< .001***	.24	.54	***4.53***	***< .001***	.32	.751
Happiness	.31	.58	***5.28***	***< .001***	.11	.62	1.78	.079	***2.36***	***.019***
Sadness	.28	.44	***6.32***	***< .001***	.17	.51	***3.33***	***.001***	1.66	.099
Surprise	.27	.55	***4.90***	***< .001***	.20	.60	***3.33***	***.001***	.87	.384
Depression	4.24	3.77	-	-	4.35	3.36	-	-	-.22	.823
Anxiety	4.19	3.21	-	-	4.14	3.22	-	-	.12	.908

Significant findings are presented in bold and italicised.

Table Two: Summary of regression analyses for each emotion separately (significant findings are in bold and italicised).

		Anger		Disgust		Fear		Happiness		Sadness		Surprise	
Zero order correlations		r	p	r	p	r	p	r	p	r	p	r	p
Males	Depression	-.006	.952	.073	.465	-.085	.398	-.089	.379	.042	.679	-.091	.363
	Anxiety	.041	.683	.113	.259	.046	.646	-.082	.413	.012	.903	-.137	.173
Females	Depression	-.002	.987	-.062	.535	.051	.607	-.064	.520	-.004	.969	-.114	.250
	Anxiety	***-.267***	***.006***	***-.310***	***.001***	***-.258***	***.009***	-.187	.058	***-.294***	***.003***	***-.295***	***.003***

		Anger			Disgust			Fear			Happiness			Sadness			Surprise		
Model statistics		R^2	F	p	R^2	F	p	R^2	F	p	R^2	F	p	R^2	F	p	R^2	F	p
Overall (ANOVA)		.062	1.9	.079	.065	2.0	.063	.067	2.0	.056	.064	1.9	.069	***.083***	***2.5***	***.016***	.065	1.9	.065
Block 1 (change statistics)		.019	1.3	.279	.015	1.0	.392	.013	0.9	.452	***.045***	***3.1***	***.026***	***.050***	***3.5***	***.017***	***.052***	***3.7***	***.013***
Block 2 (change statistics)		***.042***	***3.0***	***.034***	***.047***	***3.3***	***.022***	***.054***	***3.8***	***.011***	.019	1.3	.276	.032	2.3	.080	.010	0.7	.549
Block 3 (change statistics)		.001	0.2	.664	.004	0.8	.389	.000	0.0	.986	.001	0.1	.736	.001	0.3	.592	.003	0.5	.463
Predictor statistics		β	t	p	B	t	p	B	t	p	β	t	p	β	t	p	β	t	p
Block 1:	Sex	-.033	-.4	.664	.019	.3	.802	-.027	-.3	.731	***-.199***	***-2.4***	***.018***	-.114	-1.7	.083	-.072	-.9	.358
	Depression	.012	1.0	.335	.013	1.0	.307	.007	.6	.571	-.001	-.1	.943	.018	1.7	.096	.003	.2	.819
	Anxiety	-.027	-1.9	.056	-.024	-1.7	.089	-.022	-1.6	.119	-.025	-1.6	.106	***-.033***	***-2.8***	***.006***	***-.041***	***-2.8***	***.005***
Block 2:	Depression * sex	.042	1.7	.100	.021	.8	.403	***.066***	***2.6***	***.010***	.025	.9	.379	.027	1.2	.220	.015	.6	.559
	Anxiety * sex	***-.080***	***-2.8***	***.005***	***-.084***	***-3.0***	***.003***	***-.090***	***-3.2***	***.002***	-.040	-1.3	.200	***-.063***	***-2.6***	***.010***	-.041	-1.4	.159
	Dep. * anxiety	.005	1.3	.189	.002	.5	.636	.001	.4	.675	.006	1.7	.096	.001	.4	.676	.002	.5	.632
Block 3:	3 way interaction	-.003	-.4	.664	.006	.9	.389	.000	.0	.986	.003	.3	.736	-.003	-.5	.592	.006	.7	.463

Significant findings are presented in bold and italicised.