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Examining the sex difference in lateralisation for processing facial emotion: Does biological sex or psychological gender identity matter?

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ABSTRACT

The research examining sex differences in functional lateralisation has shown varying results. While some provide evidence for males being more strongly lateralised than females, a number have shown either no relationship or the opposite pattern of findings. In this study we consider whether psychological gender identity might clarify some of the conflicting results in this area of research. Eight five participants (39 males) aged from 18 to 49 years old were tested. We found that psychological masculinity was associated with stronger patterns of lateralisation for the processing of a range of emotional expressions. We also found an interaction between biological sex and psychological gender identity, with a positive relationship between psychological masculinity and lateralisation found for males, but a negative relationship found for females. The possible role of hormonal exposure in this relationship is discussed.

1. Introduction

The issue of whether there are sex differences in lateralisation for cognitive processes is currently a hotly debated topic. While evidence in support of a difference tends to show that males are more strongly lateralised than females (e.g., Bourne, 2005, 2008), a large amount of evidence has shown no sex difference (e.g., Sommer, Aleman, Bouma, & Kahn, 2004; Sommer, Aleman, Somers, Boks, & Kahn, 2008) and some research has even shown the opposite sex difference with females being more strongly lateralised than males (e.g., Obleser, Eulitz, Lahiri, & Elbert, 2001). In this paper we revisit this issue by examining strength of lateralisation for processing facial emotion across all six of the basic emotional expressions. Specifically, we consider sex differences both in terms of a person's biologically determined biological sex, and their psychological gender identity, in terms of their more psychological masculinity and femininity.

Probably the most extensively examined lateralised cognitive process, certainly in terms of the sex differences literature, is language processing. Additionally, this is also the area in which there are the most conflicting sources of evidence. Studies using varying methodologies have supported the idea that males are more strongly lateralised to the left hemisphere than females for language processing. Divided visual field studies have found that males are more strongly lateralised on a phoneme detection task (Cousin, Perrone, & Baciu, 2009) and a lexical decision task with semantic priming (Van Dyke et al., 2009). This has also been shown in an event related potential (ERP) study of word reading (Hill, Ott, Herbert, & Weisbrod, 2006) and in functional magnetic neuroimaging (fMRI) studies (e.g., Kansaku, Yamaura, & Kitazawa, 2000).

The opposite pattern of sex differences has also been reported, with females being more strongly lateralised than males. This was found in a magnetoencephelography (MEG) study of vowel processing (Obleser et al., 2001). However, a divided visual field study of both phonological and semantic processing skills found that females were only more strongly lateralised within left handed participants (Tremblay, Ansado, Walter, & Joanette, 2007). In spite of this evidence for sex differences in lateralisation for language processing, a great number of studies have failed to find such differences. Chiarello et al. (2009) found no sex differences in the anatomical size of the regions of the brain involved in language and only very little evidence for small behavioural laterality effects. Meta-analyses have also failed to find sex differences in both fMRI (Sommer et al., 2004, 2008) and dichotic listening studies (Sommer et al., 2008).

Clements et al. (2006) conducted an fMRI study of both phonological and visuospatial processing to consider whether possible sex differences in lateralisation might be consistent across different cognitive abilities. For the phonological processing task they found that males were more strongly lateralised to the left hemisphere than females, supporting the typical sex difference in lateralisation. However, for visuospatial processing the opposite pattern

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was found with females being more strongly lateralised to the right hemisphere than males. Njemanze (2007) also found that the sex difference in lateralisation varies across different cognitive functions. In a study measuring cerebral blood flow using functional transcranial Doppler spectroscopy (fTCDS) they found that males were lateralised to the right hemisphere for face processing, whereas females were lateralised to the left hemisphere. When processing objects, men were lateralised to the right hemisphere, but there was no hemispheric bias for the women. Again though, not all studies have found sex differences. In an fMRI study of both language and face processing, Haut and Barch (2006) found no sex differences. Boles (2005) examined a wide range of cognitive functions using the divided visual field methodology and found little evidence for sex differences in lateralisation. On average Boles found that sex could only account for 0.09% of the variability in lateralisation and that at best it was able to account for 0.9% of variability.

Studies of sex differences in cognitive functions lateralised to the right hemisphere, such as visuospatial and face processing have tended to provide somewhat more convincing evidence. Rilea, Roskos-Ewoldsen, and Boles (2004) and Rilea (2008b) found that males were more strongly lateralised than females on a mental rotation task. However in another study Rilea (2008a) showed that females were more strongly lateralised for mental rotation of alphanumeric stimuli. Georgopoulos et al. (2001) also found opposite patterns of lateralisation in an fMRI study using an object construction task with males having more activation in the right hemisphere and females having more activation in the left hemisphere. The same pattern was found for activation in the amygdala during both emotional memory (Cahill, Uncapher, Kilpatrick, Alkire, & Turner, 2004) spatial memory (Frings et al., 2006) tasks. Frings et al. attributed this difference to women using more verbal, left hemisphere, strategies to help them achieve the task. This suggestion fits well with previous work also suggesting that sex differences in lateralisation may be explained in terms of sex differences in cognitive strategies (Welsh & Elliott, 2001).

Sex differences have also been examined in lateralisation for face processing. Although the evidence is weak for the processing of facial identity (e.g., Kampf, Nachson, & Babkoff, 2002; Voyer, 1996), rather more convincing evidence has been presented for the processing of facial emotion. Using the chimeric faces test, we have previously shown that males are more strongly lateralised to the right hemisphere than females for processing positive facial emotion (Bourne, 2005, 2008; Bourne & Todd, 2004). This finding has also been supported by ERP studies of the processing of facial emotion (Proverbio, Brignone, Matarazzo, Del Zotto, & Zani, 2006) and emotional stories (Gasbarri et al., 2006). However, Gasbarri et al. (2007) found that the P300 ERP response to negative emotional images was larger in the right hemisphere in men and larger in the left hemisphere in women.

While there is some convincing evidence for there being sex differences in lateralisation, particularly with males being more strongly lateralised than females, there is also equally convincing evidence against it. In this study we re-examine whether there might be sex differences in lateralisation for processing emotion and expand on our previous work in two ways. First, in our previous work we only looked at lateralisation for processing positive facial emotion (i.e., happiness). There are currently two competing theories regarding the lateralisation of emotion processing: the right hemisphere hypothesis (Borod, 1992), which proposes that the processing of all emotion is lateralised to the right hemisphere, and the valence hypothesis (Davidson, 1992), which proposes that the processing of positive emotion is lateralised to the left hemisphere and the processing of negative emotion is lateralised to the right hemisphere (see Bourne, in press). To address this limitation, in the current study we measured strength of lateralisation for the processing of all six of the basic emotions: anger, disgust, fear, happiness, sadness and surprise.

Second, in this experiment we have expanded our consideration of sex difference by examining both biological sex (i.e., male vs. female) and psychological gender identity (i.e., psychological masculinity vs. psychological femininity). Previous work looking at various cognitive processes has shown interactions between biological sex and psychological gender identity in terms of performance. For example, Ritter (2004) found that psychologically feminine men performed better than psychologically masculine men on a verbal processing task, on which women generally outperform men. In this study the Bem Sex Role Inventory (Bem, 1974) will be used to assess psychological masculinity and femininity. This is one of the most frequently used psychometric measures of psychological gender identity and has been used in a large number of psychological studies. It is possible that psychological gender identity might be a mediating factor in the biological sex difference in lateralisation for face processing. It is predicted that the biological sex difference in lateralisation will be become more apparent by taking into account psychological gender identity. Specifically, it is predicted that people who have higher psychological masculinity will be more strongly lateralised than those who are psychologically feminine.

The main aim of this paper is to understand the variability in lateralisation reported in previous work. While biological sex has been considered, the role of psychological gender identity has not. Of particular importance is to understand the relationship between these two variables. While biological sex differences have been reported in lateralisation (e.g., Bourne, 2005, 2008), there is still a fair amount of variability in lateralisation that remains to be explained. One possibility is that this additional variance may be explained, at least to some extent, in terms of psychological gender identity. Alternatively, the biological sex difference itself might be better explained in terms of psychological gender identity, the two factors might interact with each other or they may each explain variability in lateralisation in varying and distinct ways. For example, Weekes, Zaidel, and Zaidel (1995) and Weekes, Capetillo-Cunliffe, Rayman, Iacoboni, and Zaidel (1999) found different relationships with lateralisation on a dichotic listening task for biological sex and psychological gender identity. The data will be analysed using regression modelling to test for the different possible relationships between lateralisation, biological sex and psychological gender identity. Biological sex and psychological gender identity will be simultaneously entered into the model; consequently the variable which best explains the variability in lateralisation will be most significant. The interaction between biological sex and psychological gender identity will also be entered into the model.

2. Methods

2.1. Participants

There were 85 participants (39 males) with a mean age of 25 years (SD = 7.4, range 18–49). The participants were undergraduate psychology students who were recruited through a experimental participation scheme. All participants were right handed by self-report and this was confirmed with a handedness questionnaire (adapted from Dorthe, Blumenthal, Jason, & Lantz, 1995). None reported any previous neurological damage or psychiatric diagnosis. This study was given approval by the Ethics Committee of the School of Psychology, University of Dundee.

2.2. Chimeric faces test

In this study we used six versions of the chimeric faces test to test for strength of lateralisation across the basic emotions: anger, disgust, fear, happiness, sadness and surprise. There were 24 trials for each emotion. These were presented in blocks and block order was randomised across participants. The experiment was run on a computer using Superlab version 4.1. Participants were seated centrally in front of the computer monitor and a chin rest was used to ensure that the stimuli were presented in the centre of the participant's visual field and to maintain a viewing distance of 52 cm.