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Valence-specific laterality effects in vocal emotion: Interactions with stimulus type, blocking and sex

Astrid Schepman *, Paul Rodway, Pauline Geddes [1]

Department of Psychology, University of Chester, Parkgate Road, Chester, Cheshire CH1 4BJ, UK

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ABSTRACT

Valence-specific laterality effects have been frequently obtained in facial emotion perception but not in vocal emotion perception. We report a dichotic listening study further examining whether valence-specific laterality effects generalise to vocal emotions. Based on previous literature, we tested whether valence-specific laterality effects were dependent on blocked presentation of the emotion conditions, on the naturalness of the emotional stimuli, or on listener sex. We presented happy and sad sentences, paired with neutral counterparts, dichotically in an emotion localisation task, with vocal stimuli being preceded by verbal labels indicating target emotions. The measure was accuracy. When stimuli of the same emotion were presented as a block, a valence-specific laterality effect was demonstrated, but only in original stimuli and not morphed stimuli. There was a separate interaction with listener sex. We interpret our findings as suggesting that the valence-specific laterality hypothesis is supported only in certain circumstances. We discuss modulating factors, and we consider whether the mechanisms underlying those factors may be attentional or experiential in nature.

1. Introduction

Extensive research has been conducted to examine how the two hemispheres of the brain are involved in the perception of emotions. This research has generated competing theories, with the right hemisphere (RH) hypothesis suggesting that the perception of all emotions is carried out by regions of the right hemisphere (Borod, Andelman, Obler, Tweedy, & Welkowitz, 1992; Borod, Zgaljardic, Tabert, & Koff, 2001; Bourne, 2010; Christman & Hackworth, 1993; Ross, 1981) and the valence-specific laterality hypothesis suggesting that the involvement of each hemisphere depends on the valence (positive/negative) of the emotion (Ahern & Schwartz, 1985; Davidson & Hugdahl, 1995). Other evidence indicates that the role of each hemisphere in processing emotion may depend on the complexity of the emotion (Shamay-Tsoory, Lavidor, & Aharon-Peretz, 2008) or on each hemisphere's role in approach and withdrawal behaviour (Davidson, 2004; Harmon-Jones, 2004).

The majority of evidence supports the RH hypothesis and suggests that the perception of facial emotion (Alves, Aznar-Casanova, & Fukusima, 2009; Borod et al., 2001; Bourne, 2010; Christman & Hackworth, 1993) and vocal emotion is completed by the right hemisphere of the brain (Grimshaw, 1998; Grimshaw, Kwasny, Covell, & Johnson, 2003; Ley & Bryden, 1979, 1982; Mitchell, Elliott, Barry, Cruttenden, & Woodruff, 2003; Safer & Levanthal, 1977; Scott et al., 1997; Wildgruber, Pihan, Ackermann, Erb, & Grodd, 2002). Despite this, a number of other studies have obtained valence-specific laterality effects in facial emotion perception, with the LH being superior at perceiving positive emotions and the RH superior at perceiving negative emotions (e.g. Burton & Levy, 1989; Jansari, Tranel, & Adolphs, 2000; McLaren & Bryson, 1987; Natale, Gur, & Gur, 1983; Reuter-Lorenz & Davidson, 1981; Rodway, Wright, & Hardie, 2003; Stafford & Brandaro, 2010; van Strien & van Beek, 2000; for reviews see Borod et al., 2001). It therefore remains unclear why some studies have obtained valence-specific effects, rather than a RH advantage for the perception of all emotions.

Several theories have been proposed to explain valence-specific laterality effects in emotion perception (Borod, 1993; Bourne, 2010; Davidson, 1984; Killgore & Yurgelun-Todd, 2007; Rodway & Schepman, 2007). Originally, Silberman and Weingartner (1986) suggested that valence effects were caused by the perception of positive and negative emotions by the left and right hemispheres, respectively. However, this explanation does not fit with the large body of evidence from behavioural studies (see Borod et al., 2001; Bryden, Ley, & Sugarman, 1982; Grimshaw et al., 2003; Ley & Bryden, 1982) and brain imaging studies (e.g. Mitchell et al., 2003; Wildgruber et al., 2002) pointing to a RH specialisation of emotion perception.

An emerging consensus is that valence-specific laterality effects are not directly caused by the perception of positive and negative

* Corresponding author. Present address: Department of Psychology, University of Chester, Parkgate Road, Chester, Cheshire CH1 4BJ, UK. Fax: +44 1244 511303.

E-mail addresses: a.schepman@chester.ac.uk (A. Schepman), p.rodway@chester.ac.uk (P. Rodway).

[1] Present address: Division of Psychology, University of Abertay Dundee, Bell Street, Dundee DD1 1HG, UK.

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emotions, but by other non-perceptual processes that are differently lateralised in the two hemispheres (Borod, 1993; Davidson, 1984; Jansari, Rodway, & Goncalves, 2011; Jansari et al., 2000; Killgore & Yurgelun-Todd, 2007; Rodway & Schepman, 2007; Stafford & Brandaro, 2010; van Strien & van Beek, 2000). For example, the modified valence hypothesis (Borod, 1993; Davidson, 1984) proposes that posterior regions of the RH are specialised for the perception of all emotions, whereas bilateral pre-frontal regions are integral to emotional experience, with the left pre-frontal region involved in positive emotional experiences and the right pre-frontal region in negative emotional experiences. According to this account, valence-specific laterality effects in perception are caused by the activation of valence-specific pre-frontal regions involved in emotional experience, so that emotions presented to the LH are viewed as more positive and those to the RH are viewed as more negative. This theory is consistent with evidence showing that emotion perception is an active, dynamic process, with faces being explored and an emotional experience being generated (see Adolphs, 2006). It is also consistent with evidence that the ventromedial frontal lobe is involved in emotional experience, and it might be via a process of emotion simulation and experience that the ventromedial frontal lobe facilitates the recognition of an emotion (see Heberlein, Padon, Gillihan, Farah, & Fellows, 2008). Killgore and Yurgelun-Todd (2007) have proposed an account similar to the modified valence-specific laterality hypothesis, which suggests that posterior regions of the RH are specialised for perceiving all emotions, but these regions are more specialised for negative emotions than positive emotions. Valence-specific laterality effects are believed to emerge indirectly due to the recruitment of frontal brain regions, which are required for elaborative processing of stimuli to enable their discrimination.

There are also theorists that have proposed a role for attentional processes that interact with dynamic emotion perception processes (Bryden & MacRae, 1989; see Hiscock and Kinsbourne (2011), for a recent review of such mechanisms in relation to the right-ear advantage for language processing). Is it possible that such factors modulate valence-specific laterality effects, possibly contributing to the varying patterns in the literature. There are multiple strands of evidence showing modulating effects on lateralisation patterns by factors that are attentional in nature. For example, van Strien and Morpurgo (1992) showed that a Right Visual Field advantage for the detection of letters was reversed by priming the trials with threat stimuli, indicating that priming the right hemisphere led to a left visual field bias. Similarly, Asbjörnsen, Hugdahl, and Bryden (1992) found that the Right Ear Advantage for Consonant–Vowel stimuli was modulated by the presence of threat stimuli. Thus, valence-specific laterality effects may be modulated by attentional effects.

An important aspect of theories of valence-specific effects is that they should not depend on the modality of the perception task, but there is no clear evidence that valence-specific laterality effects occur in vocal emotion perception. However, in three studies the effects showed asymmetries, with a suggestion that some negative emotions show a stronger LEA than positive emotions (Bryden & MacRae, 1989; Erhan, Borod, Tenke, & Bruder, 1998; Herrero & Hillix, 1990), which is not straightforwardly explained by the RH hypothesis. All other studies involving vocal emotion have reported a RH advantage (e.g. Grimshaw, 1998; Grimshaw et al., 2003; Ley & Bryden, 1982; Rodway & Schepman, 2007). A major aim of the present experiment was to examine whether valence-specific laterality effects generalise to vocal emotion.

Erhan et al. (1998) presented six nonsense syllables dichotically with each nonsense syllable expressed in a different emotional tone. In agreement with the RH hypothesis they found a LEA for the perception of all vocal emotion. However, in an additional analysis they separated participants into those demonstrating a left ear advantage (LEA) for emotion detection and those who showed no ear advantage. They found that the LEA group had a significantly stronger LEA for negative emotions than for positive emotions. Erhan et al. suggested that this could provide partial support for the valence hypothesis, with the RH having a larger role in the perception of negative, than positive, emotions. Bryden and MacRae (1989) presented emotionally intoned words dichotically and obtained a left ear advantage (LEA) when the task was the detection of target emotions, while a right ear advantage (REA) was found for the detection of word targets in the same stimuli. In addition, there was a trend ($p < .06$) for a greater LEA for negative emotional words than positive emotional words. This might indicate a greater role for the RH in negative emotion. Herrero and Hillix (1990) found a stronger LEA for stimuli with sad intonation than for those with "glad" or "mad" intonation, though, unfortunately, they provide no detailed statistical analysis of separate ear advantages by emotion.

Examination of prior work on the valence-specific laterality effect in vocal emotion suggests a possible modulating factor, namely stimulus blocking. The experiments by Bryden and MacRae (1989) and by Erhan et al. (1998) used stimulus blocking, with all emotional targets or emotional stimuli, respectively, belonging to a particular category (e.g. happy, angry, sad etc.) presented in the same block of trials. It is possible that stimulus blocking plays a role in the production of asymmetrical ear advantages for different emotions. To examine the effect of blocking, we manipulated this with blocked conditions presenting single emotions, and a mixed condition presenting multiple emotions in a block of trials. A potential effect of this blocked design is that it may promote sustained top-down effects. These may be experiential in nature, and may enhance the activation of brain areas involved in emotional experience (Erhan et al., 1998). Alternatively, long-term attentional mechanisms may be engaged by this manipulation (Bryden & MacRae, 1989; Kinsbourne, 1970). We return to this issue in the Discussion.

A further potential modulating factor of the valence-specific effect is the nature of the stimuli used. Rodway and Schepman (2007) used morphed stimuli, which blended pitch from emotional stimuli with the other prosodic cues from neutral stimuli through resynthesis. In the present study, these stimuli were deployed to examine the role of bottom-up information in the valence-specific laterality effect. It has also been suggested that difficult perceptual discrimination, as for example present in weakly expressed emotions, encourages the utilisation of valence-specific prefrontal regions (Killgore & Yurgelun-Todd, 2007) during the perceptual discrimination task. If, in line with Killgore and Yurgelun-Todd, weaker stimuli lead to greater frontal involvement in perceptual discrimination, then one might expect valence-specific laterality effects to emerge with morphed stimuli. In contrast, stimuli carrying strong emotions may lead to a stronger likelihood that brain regions associated with emotional experience are activated (see also Rodway & Schepman, 2007). There are studies which suggest that emotional stimuli have the property of leading to attentional capture (e.g. Bannerman, Milders & Sahraie, 2010; Hodsoll, Viding, & Lavie, 2011), as well as rapidly triggering central (Sauter & Eimer, 2010) and peripheral physiological responses (Aue, Cuny, Sander, & Grandjean, 2011). Thus, stimuli with emotional content may have an effect because they mobilise mechanisms for emotion-specific processing and create an emotional experience. Thus, in an alternative to the prediction based on Killgore and Yurgelun-Todd, valence-specific laterality effects may only emerge with original stimuli that carry genuine emotional information.

A final factor of interest follows from the observation that the majority of studies have obtained valence-specific laterality effects in females but not males (e.g. Burton & Levy, 1989; Rodway et al., 2003; van Strien & van Beek, 2000) whereas Jansari et al. (2000,