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Impaired recognition of musical emotions and facial expressions following anteromedial temporal lobe excision

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ABSTRACT

We have shown that an anteromedial temporal lobe resection can impair the recognition of scary music in a prior study (Gosselin et al., 2005). In other studies (Adolphs et al., 2001; Anderson et al., 2000), similar results have been obtained with fearful facial expressions. These findings suggest that scary music and fearful faces may be processed by common cerebral structures. To assess this possibility, we tested patients with unilateral anteromedial temporal excision and normal controls in two emotional tasks. In the task of identifying musical emotion, stimuli evoked either fear, peacefulness, happiness or sadness. Participants were asked to rate to what extent each stimulus expressed these four emotions on 10-point scales. The task of facial emotion included morphed stimuli whose expression varied from faint to more pronounced and evoked fear, happiness, sadness, surprise, anger or disgust. Participants were requested to select the appropriate label. Most patients were found to be impaired in the recognition of both scary music and fearful faces. Furthermore, the results in both tasks were correlated, suggesting a multimodal representation of fear within the amygdala. However, inspection of individual results showed that recognition of fearful faces can be preserved whereas recognition of scary music can be impaired. Such a dissociation found in two cases suggests that fear recognition in faces and in music does not necessarily involve exactly the same cerebral networks and this hypothesis is discussed in light of the current literature.

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1. Introduction

As initially proposed by Klüver and Bucy (1939), in monkeys the amygdala appears to be essential to process fearful signals. This well established finding has been recently confirmed in humans by Lanteaume et al. (2007) who were able to induce negative states, such as fear, by electrical stimulation of the amygdala. Several neuropsychological studies have provided additional support for this hypothesis by investigating patients with amygdala lesions. In these studies, patients who had undergone a unilateral medial temporal lobe excision that included the amygdala for the treatment of medically intractable epilepsy demonstrated a deficit in recognizing fearful facial expressions, although they could usually recognize happy faces (Adolphs et al., 2001; Anderson et al., 2000; Burton et al., 2003; Hlobil et al., 2008; McClelland et al., 2006; Palermo et al., 2009). The specific role of the amygdala in the recognition of fearful faces was also confirmed in patient SM who presented a selective and bilateral amygdala lesion (Adolphs et al., 1994, 1995). Further evidence for the relationship between the amygdala and the perception of threat was provided by neuroimaging data obtained in healthy participants. These studies have observed an increase of activation in the amygdala when fearful facial expressions were shown to the participants, as compared with happy faces (Breiter et al., 1996, Experiment 1; see Calder et al., 2001 for a review; Morris et al., 1998a, 1998b; Whalen et al., 1998, but see also Sergerie et al., 2008). Thus, both neuroimaging and neuropsychological studies consistently relate the processing of fearful faces to the amygdala.

However, the specific role of the amygdala in processing emotional expressions of faces has been questioned. This structure seems to be more generally involved in recognizing threat signals in facial and nonfacial stimuli, including music. Music constitutes an efficient means of inducing fear and suspense (e.g., in movies, Cohen, 2001). While the perception of scary music can be influenced by culture (e.g., by prior exposure to scary movies), it seems to be universally recognized (see Fritz et al., 2009). In this recent study, emotion recognition from western music was assessed in native African participants (Mafa) who have limited exposure to western culture. Results showed that Mafa participants recognized happy, sad, and fearful western music above chance, suggesting that the expression of these basic emotions in western music can be recognized universally, as are facial expressions (Ekman et al., 1969; Elfenbein and Ambady, 2002).

Although the capacity to identify scary music seems universal, this ability can be disturbed after brain lesion. In a previous study, we showed that patients with unilateral medial temporal lobe removal were impaired in recognizing scary music and to a lesser degree peaceful music, whereas recognition of other emotions, such as happiness was spared (Gosselin et al., 2005). These results suggest that both the right and the left anteromedial temporal lobes (including the amygdala) play a role in the recognition of threat in a musical context. To confirm the critical role of the amygdala in this ability, the same methodology was used in SM who had presented a bilateral lesion limited to the amygdala (Gosselin

et al., 2007). As predicted, SM was unable to recognize scary musical excerpts but she also demonstrated difficulties in processing sadness, whereas the recognition of the other emotional categories was not impaired. Recent neuroimaging studies provided further support to this conclusion by using visual stimuli in combination with musical backgrounds. Baumgartner et al. (2006) showed that the activation of the amygdala was higher when negative pictures (e.g., fearful pictures of the International Affective Picture System, Lang et al., 2005) were presented with scary music (congruent condition) than when these were combined and presented with positive music (incongruent condition). Similarly, an increase in amygdala responses was observed when emotionally neutral movies were combined with scary music as compared to the condition where the movies were presented without music (Eldar et al., 2007). Finally, a study by functional magnetic resonance imaging (fMRI) showed that listening to scary music is sufficient to activate the amygdala, especially when participants listened to the musical excerpts with closed eyes, as compared with opened eyes (Lerner et al., 2009). All of these neuropsychological and neuroimaging results are in agreement with the hypothesis that the amygdala is involved in processing fear as expressed by music (see Koelsch, 2010, and Peretz, 2010, for recent reviews on musical emotions).

Taken together, prior studies suggest that the amygdala might be a multimodal structure. Being anatomically connected to different associative areas, including visual and auditory areas (Aggleton and Saunders, 2000), it is not surprising that the amygdala can be involved in processing fearful signals independently of their modality. However, prior attempt to find evidence for the multimodal involvement of the amygdala in fear processing by using vocal expression stimuli (including speech prosody) have yielded inconsistent results. For instance, some neuropsychological studies found impaired fear recognition for both facial and vocal expressions in the same patients with amygdala damage (e.g., patient DR: Calder et al., 1996; Scott et al., 1997; patient NM: Sprengelmeyer et al., 1999; and patients with unilateral lesion: Dellacherie et al., 2011a). Conversely, other patients showed difficulties in recognizing fearful faces, while they were normal at recognizing fearful vocal expressions (e.g., patient SM: Adolphs et al., 1994; Adolphs and Tranel, 1999, patient SP: Anderson and Phelps, 1998a, 1998b). Neuroimaging experiments have also yielded mixed results. Dolan et al. (2001) found an enhanced activation in the amygdala when fearful faces were presented with congruent fearful voices as compared with incongruent happy voices. However, Pourtois et al. (2005), by adding single modality conditions, found activation in the amygdala when fearful faces were presented alone, but no activation when the fearful voices were presented alone. This lack of convergence in recruiting the amygdala across visual and auditory modality, more particularly with vocal expressions, is intriguing. The multimodal role of the amygdala in the recognition of fear expressed by visual and auditory modalities can also be assessed by using another powerful threatening auditory signal, namely scary music.

As mentioned before, a few neuropsychological studies supported the multimodal implication of the amygdala in

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