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Between- and within-ear congruency and laterality effects in an auditory semantic/emotional prosody conflict task

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ABSTRACT

The present study investigated the influence of within- and between-ear congruency on interference and laterality effects in an auditory semantic/prosodic conflict task. Participants were presented dichotically with words (e.g., mad, sad, glad) pronounced in either congruent or incongruent emotional tones (e.g., angry, happy, or sad) and identified a target word or emotion under one of two conditions. In the within-ear condition, the congruent or incongruent dimensions were bound within a single stimulus and therefore, presented to the same ear. In the between-ear condition, the two dimensions were split between two stimuli and, therefore, presented in separate ears. Findings indicated interference in both conditions. However, the expected right ear advantage (EA) for words and left EA for emotions were obtained only in the between-ear condition. Factors involved in producing interference and laterality effects in dichotic listening tasks are discussed.

1. Introduction

Tasks that require the simultaneous processing of two competing stimuli are typically referred to as conflict tasks (Dunbar & MacLeod, 1984; MacLeod, 1991; Stroop, 1935). The traditional Stroop conflict task (Stroop, 1935) presents color names in ink colors that are either congruent ("red" written in red ink), or incongruent ("red" written in green ink), and requires participants to name the ink color while ignoring the word. Results generally indicate that participants are slower and less accurate in identifying the ink color when the word and the ink color are incongruent than when they are congruent. Findings such as those in the Stroop task are generally known as interference effects in that the automatic processing of the word tends to interfere with the processing of the ink color (MacLeod, 1991). Additionally, even though the processing of the word may interfere with the processing of the color, it is also generally found that processing of the word is facilitated by the presentation of a congruent color (MacLeod).

Although conflict tasks have been shown to be a reliable indicator of executive control processes (Botvinick, Carter, Braver, Barch, & Cohen, 2001; MacLeod, 1991), most tasks tend to use visually presented stimuli. This has restricted to a single sensory modality our knowledge of the role played by specific brain regions in conflict resolution. Additionally, most conflict tasks use components that are processed by parallel systems, such as word naming and color naming used in the traditional color/word Stroop task (Swick & Jovanovic, 2002).

Over the years, a great deal of research has been conducted examining other stimuli and processes that might produce conflict effects similar to those found in the traditional Stroop (1935) task. Although many of these have, again, used stimuli presented in the visual modality, recent efforts have been made to develop an auditory Stroop-like task using emotionally valenced words or sentences pronounced in congruent and incongruent emotional prosodic tones (Grimshaw, 1998; Kitiyama, 1990; Kitiyama & Ishi, 2002; Mitchell, 2006a; Nygaard & Queen, 2008; Schirmer, Zysset, Kotz, & von Cramon, 2004). A unique aspect to the use of verbal and emotional material in a conflict task is that each dimension is processed in a specific region of the brain that is lateralized to separate hemispheres (Bryden & MacRae, 1988; Hugdahl, 2000; Ley & Bryden, 1982; Voyer, 1996). A task that produces both reliable laterality and conflict effects could provide important insight into the processes involved in resolving conflicting information, as well as how processes that occur in separate hemispheres, such as the processing of words and emotional tones, are integrated into a single percept. Furthermore, an auditory conflict task that combines semantic and emotional dimensions could have real-world implications, as we are required on a daily basis to interpret incongruent semantic-emotional prosodic cues in the form of sarcasm, irony, and humor (Nygaard & Queen, 2008; Voyer, Bowes, & Techentin, 2008).

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The lateralization of processing of verbal information to the left hemisphere has been well established in both auditory (Wexler & Halwes, 1983; Hugdahl, 2000) and visual modalities (Hellige & Sergent, 1986; Voyer, 1996). Although patient studies examining emotion recognition in the presence of right and left hemisphere brain damage provide strong evidence for right hemispheric processing of emotional prosody (Borod et al., 1998; Nicholson et al., 2003; Wunderlich, Ziegler, & Geigenberger, 2003), behavioral and neuroimaging studies have been less consistent, with some studies finding right hemisphere processing of emotional prosody and faces (Bryden & MacRae, 1988; Kavcic & Clarke, 2000), and others reporting bilateral processing (Haas, Omura, Constable, & Canjli, 2006; Kotz et al., 2003; Mitchell, 2006b). Although a number of explanations of these inconsistencies have been suggested (see Ross, Thompson, & Yenosky, 1997), one explanation put forth by Pell (2006) is most relevant to the present study. Pell suggests that, although verbal laterality effects can be studied using words without prosody, emotional prosody is usually examined in the context of words (Pell, 2006; Walker, Daigle, & Buzzard, 2002). This suggests that interpreting prosody within a semantic context would require greater left hemisphere involvement, thereby leading to findings of bilateral processing.

Dichotic listening is one of the most reliable auditory methods of assessing the lateralization of verbal and emotional information (Hugdahl, 2000; Voyer & Flight, 2001). In this method, participants are presented with two sounds simultaneously (a different sound to each ear) and asked to identify at least one of the sounds they heard. The premise of the dichotic task is to provide more information at a given moment than the brain is capable of processing or consciously analyzing (Hugdahl, 2000; Kimura, 1961). Results of dichotic listening tasks using verbal material typically demonstrate that words that are presented to the right ear are identified more accurately and faster than words presented to the left ear, a phenomenon often referred to as the right ear advantage (REA) (Bryden, 1988). Similar findings of a left ear advantage (LEA) are typically found for emotional prosody (Bryden & MacRae, 1988; Hugdahl, 2000). However, in keeping with Pell's (2006) hypothesized left hemisphere involvement, the magnitude of the LEA for emotions is generally smaller than the REA for words.

The lateralization of semantic and emotional prosodic information to separate hemispheres should make them ideal for studying interference effects. Surprisingly, conflict studies combining semantic and emotional information seldom examine possible laterality effects. In part, this may be because wide variations in both the approach and definition of conflict in tasks using these two dimensions have led to inconsistent results of conflict effects. For example, although the semantic component typically consists of emotionally valenced words (e.g., *kill* would be a negatively charged word, and *hug* would be a positively charged word), the emotional component ranges from music intended to induce specific moods, to emotional faces, and emotional prosody (Bradley & Lang, 2000; Gerrig & Bower, 1982; Gotlib & McCann, 1984; Nygaard & Queen, 2008). Although these tasks clearly meet the criteria of a conflict task, variations in stimulus presentation, type of conflict, and task requirements have not allowed the clear emergence of a link between the processing of semantic and emotional information (Gerrig & Bower, 1982; Wurm & Vakoch, 1996, 2000). The variations in the emotional component may also account for the lack of consistent laterality effects.

Recent research has focused on developing a lateralized conflict task using stimuli that combined a semantic dimension (words) and emotional prosody (emotional tones) that exploits the conflict both between the dimensions as well as between the processes involved. Grimshaw (1998) used both a binaural task as well as a dichotic task that presented participants with the words (“mad”, “sad”, “glad”, and “fad”) pronounced in congruent or incongruent emotional tones (angry, sad, happy, or neutral). Congruency, however, was only assessed in the binaural task where, following presentation of the sounds, participants were asked to identify the word and emotional tone in separate blocks of trials. Interference was measured by comparing performance on incongruent trials to performance on the neutral trials. Results indicated that processing of the words interfered with the processing of emotion tones. Although there was a trend toward emotional tones interfering with the processing of the words, it did not reach statistical significance. In a later replication with twice as many participants and trials, the same effect size reached significance, suggesting that the earlier findings were due to a lack of power. In that later experiment, Grimshaw (1998) did find that the emotional tones significantly interfered with the identification of the words, although to a lesser degree than the interference of words with the emotional tones.

In the dichotic task, participants were presented dichotically (a different pair to each ear) with pairs of the same stimuli as used in the binaural task and were asked to identify the presence of a specific target word in one block of trials and a specific target emotion in another block. Grimshaw found the expected REA for the dichotic identification of words, and a LEA for emotions, although the magnitude of the latter was much smaller.

It can readily be seen that Grimshaw's (1998) study did not allow the assessment of laterality and interference effects in the same task. Other researchers who have attempted to assess both effects in a single task have not found significant laterality effects. However, these tasks have typically required participants to make a valence judgment of one of the dimensions (George et al., 1996; Schirmer et al., 2004). Peper and Irle (1997) suggested that making a judgment of prosody valence would involve attaching a verbal label to a specific tone, a task that would require greater left hemisphere involvement. This suggests that a task that does not require verbal labeling of emotional prosody, such as, target detection, may produce the more robust laterality effects.

This reasoning prompted Techentin and Voyer (2007) to extend Grimshaw's (1998) approach by demonstrating that interference and laterality effects could be elicited in a single dichotic listening task. Using the same stimuli as in Grimshaw's dichotic task, participants were dichotically presented with pairs of words pronounced in emotional tones and asked to identify the presence of either a target word or emotional tone. To reduce the attentional set created by having the same target for an entire block of trials, the target dimension (i.e. a word or emotional tone) was randomized across trials using a post cue. Specifically, if the target dimension was a word (e.g., “mad”), then the word (“MAD”) appeared on the computer screen immediately following the presentation of the sounds. If the target was an emotional tone (e.g. angry), then a line drawing of a face depicting the target emotional tone appeared on the screen. Using a key press, participants indicated whether the target word or emotional tone had just been presented. Results indicated that words interfere with the identification of the emotional tone, but emotional tones did not interfere with words.

An interesting finding in the Techentin and Voyer (2007) study was that, a REA for the identification of the words was found only when they were presented with the congruent emotional tones, whereas a significant LEA for emotional tones was found only when the words and emotional tones were incongruent. This finding was interpreted as showing that, for the word targets, congruent information emphasized the verbal content, whereas in the emotional tone targets, the incongruent emotional tone may have added salient context to a word, thereby emphasizing the emotional content. This would increase the involvement of the left and right hemisphere, respectively, causing a stronger laterality effect of relevance to emerge.