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Response procedure, memory, and dichotic emotion recognition

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ABSTRACT

Three experiments investigated the role of memory and rehearsal in a dichotic emotion recognition task by manipulating the response procedure as well as the interval between encoding and retrieval while taking into account order of report. For all experiments, right-handed undergraduates were presented with dichotic pairs of the words bower, dower, power, and tower pronounced in a sad, angry, happy, or neutral tone of voice. Participants were asked to report the two emotions presented on each trial by clicking on the corresponding drawings or words on a computer screen, either following no delay or a five second delay. Experiment 1 applied the delay conditions as a between-subjects factor whereas it was a within-subject factor in Experiment 2. In Experiments 1 and 2, more correct responses occurred for the left than the right ear, reflecting a left ear advantage (LEA) that was slightly larger with a nonverbal than a verbal response. The LEA was also found to be larger with no delay than with the 5 s delay. In addition, participants typically responded first to the left ear stimulus. In fact, the first response produced a LEA whereas the second response produced a right ear advantage. Experiment 3 involved a concurrent task during the delay to prevent rehearsal. In Experiment 3, the pattern of results supported the claim that rehearsal could account for the findings of the first two experiments. The findings are interpreted in the context of the role of rehearsal and memory in models of dichotic listening.

1. Introduction

It is generally accepted in the neuroimaging and behavioral literature that both cerebral hemispheres have a role to play in the processing of linguistic and non-linguistic information (Voyer, Bowes, & Techentin, 2008). However, it is also quite common to find that verbal material produces more activity in the left cerebral hemisphere, whereas non-verbal material engages the right hemisphere (Hugdahl, 2000). In fact, behavioral examination of this cerebral specialization still relies heavily on dichotic listening (Voyer, 2011), possibly because it is considered a reliable and valid approach that is also cost effective and non-invasive (see Hugdahl, 2000; Hiscock, Coles, Benthall, Carlson, & Ricketts, 2000; Voyer, 1998, among others).

1.1. Dichotic listening

Dichotic listening involves the concurrent presentation of two sound stimuli, one to each ear. This technique was initially proposed by Broadbent (1954) as a way to study attention in terms of the type of information that can be gathered both from attended and unattended messages. One crucial feature of dichotic listening relevant to its use in neuropsychology is the notion that the concurrent presentation of information to each ear is presumed to result in competition between the sounds. However, when viewed as an attention task, it has been shown that much switching occurs between the attended and unattended message so that a fair amount of information can be gathered from both channels (see Lambert, 1985 for a review). In this context, one would not necessarily view dichotic listening as a valid measure of attentional competition. However, in the context of perceptual asymmetries, two processes work together to bias the results of this alleged competition toward one ear or the other.

First, dichotic presentation is presumed to activate the contralateral auditory pathways and inhibit the ipsilateral pathways from each ear to each hemisphere (Kimura, 1967). Therefore, a stimulus presented to a specific ear is processed first contralaterally. When considered together with the notion that one hemisphere is more proficient than the other at dealing with certain types of material (for example, the left hemisphere for verbal information; Kimura, 1967), it follows that, for example, a verbal stimulus would have privileged access to the left hemisphere when presented to the right ear. This would account in part for the right ear advantage (REA) reflected in more accurate responses and faster response time for the right ear with verbal material (interpreted as reflecting a left hemisphere advantage in processing), and the left ear advantage (LEA) for nonverbal material (presumed to reflect right hemisphere superiority in such tasks). Essentially, this view refers to the structural or bottom-up component of perceptual asymmetries (Hugdahl, 2000) and it suggests that the type of material contributes to confining processing to a specific hemisphere.

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The second process links the type of material presented to attention and it has direct implication for introducing an attentional bias into dichotic competition. Specifically, in Kinsbourne's (1970) view, presentation of, for example, verbal material primes the left cerebral hemisphere and biases attention to the right ear. A similar process occurs with non-verbal material, except that it primes the right hemisphere. This is the attentional component of perceptual asymmetries and it means that, in addition to the superior processing of a specific type of material by each hemisphere, attention is automatically biased to the contralateral ear by this specific material. However, as attention can be manipulated endogenously, it is also seen as top-down in nature (Hugdahl, 2000). Working in conjunction, the bottom-up and top-down components typically bias attention to the contralateral ear, resulting in the LEA and REA observed with non-verbal and verbal material, respectively. In fact, this finding is so consistent that a meta-analysis of dichotic listening studies including 246 effects sizes reported only one finding that went counter to this pattern (Voyer, 2011).

1.2. Hugdahl's model of dichotic listening and memory

As just implied, Hugdahl's (2000) model of dichotic listening is based on the notion that a combination of bottom-up and top-down factors can explain laterality effects obtained in this task (Hugdahl, 2000). In this model, bottom-up factors reflect the hard-wired specialization of each hemisphere to process specific stimuli, whereas the top-down component takes into account the modulation of stimulus effects through attention or arousal. This model provides an excellent account of why laterality effects are affected by the characteristics of the stimuli (bottom-up) as well as by manipulations of attention or instructions (top-down; Hugdahl, 1995).

Recently, Voyer, Bowes, and Soraggi (2009) emphasized the role of memory in dichotic listening as another component to consider in terms of its influence on bottom-up and top-down processes. Specifically, these authors argued that, in a typical dichotic listening task, we present a pair of stimuli and participants have to hold them in memory for a (typically) short amount of time before responding. This means that dichotic listening requires encoding, storage in memory, and retrieval, like other tasks that involve memory. Taking this perspective a step further, Penner, Schläfli, Opwis, & Hugdahl (2009) essentially presented dichotic listening as a working memory task and they placed their view in the context of Hugdahl's (2000) model by arguing that, as memory load increases, the capacity to exert top-down processes is exceeded and bottom-up processes are emphasized. Based on this reasoning, they predicted an increase in the REA for recall accuracy as a function of memory load. To test this prediction, Penner et al. (2009) manipulated memory load in what was a modification of Kimura's (1961) experiment. Specifically, Penner et al. varied the number of letter pairs presented dichotically to participants on a given trial. As predicted, they found that the accuracy for recall was always better for the right ear, but this REA increased in magnitude from 3 to 4 pairs and leveled off at 5 pairs. This was mostly accounted for by a slower decline in performance for the right ear as memory load increased from 3 to 4 letters.

Penner et al. (2009) elected to manipulate memory in dichotic listening by means of an increase of the number of stimuli that have to be retained. However, it is also possible to examine memory in this task by allowing the memory trace to decay during a delay between encoding and retrieval while preventing rehearsal. In this case, researchers typically find a decrease in the magnitude of the dichotic ear effect with a delay of 5–10 s for verbal stimuli (Belmore, 1981; Yeni-Komshian & Gordon, 1974) and 5–12 s for musical stimuli (Spellacy, 1970; Spreen, Spellacy, & Reid, 1970). In general, the decrease in the magnitude of the ear effect can be accounted for by a more pronounced decrease in performance for the dominant ear (i.e., the right ear for verbal stimuli) than for the nondominant ear (i.e., the left ear for verbal stimuli). Therefore, delay manipulations tend to produce results opposite to what Penner et al. (2009) obtained with list length manipulations.

Although the above conclusion might be conceived as a contradiction that requires explanation, memory load and delay cannot be viewed as similar ways to examine the influence of memory in dichotic listening. Specifically, there is evidence that these two manipulations likely have different effects both on behavioral performance (Podd, 1990; Stone, Dismukes, & Remington, 2001) and on cerebral activation (Jha & McCarthy, 2000; Rypma & D'Esposito, 1999). In fact, increasing the memory load would have its effect by increasing the number of memory traces maintained in memory (Penner et al. (2009)), whereas a delay between encoding and retrieval would promote decay of these memory traces, especially if an intervening task takes attention from the to-be-remembered information (Portrat, Barrouillet, & Camos, 2008). From this perspective, it is likely inappropriate to compare results obtained using these two disparate approaches. Accordingly, as the present study relied on a manipulation of delay between encoding and retrieval (see below), results will generally be interpreted in the context of such manipulations with dichotic listening.

1.3. Other factors in dichotic listening as a memory task

So far, we have examined ways that memory can be manipulated experimentally and how this might affect performance and magnitude of the ear advantage. However, two processes relevant to the role of memory in dichotic listening have received little attention in the recent literature. Specifically, when participants are asked to report more than one stimulus, order of report becomes quite important (Bryden, 1978). In particular, if a participant usually reports right ear stimuli first in a dichotic task, memory for left ear stimuli is likely to suffer and this presumably increases the magnitude of the ear advantage in favor of the first ear of report. Studies that examined order of report all typically produce similar results: Stimuli reported first are better remembered and there is a tendency to report verbal stimuli from a specific ear first (typically the right ear for verbal material) on a majority of trials for a given participant (Birkett & Terry, 1982; Bryden, 1962; Freides, 1977). For example, in one experiment, Freides had participants report dichotic pairs of numbers in a constant list length of six pairs and the order of report across ears was coded into different patterns. Aside from the aforementioned finding that stimuli presented to the right ear were typically reported first under free recall, Freides also concluded from a second experiment that instructions to report first from one ear favored accuracy of recall for that ear. Essentially, a right ear advantage was observed for "right ear first" and a non-significant left ear advantage occurred for "left ear first". Such findings have led authors such as Voyer (2003) as well as Wexler and Halwes (1983) to argue that dichotic tasks requiring only one response might be more valid to isolate the structural component of dichotic laterality effects as they control for order of report. An examination of order of report is therefore central to the present study. However, in order to simplify data analysis in terms of which ear was reported first on a given trial, a single pair of stimuli was presented on each trial.

Consideration of the retrieval format that is implemented might also have some influence on memory processes in dichotic listening and affect the magnitude of the observed ear advantage. Essentially, manipulating the format of material required at retrieval (verbal or nonverbal) is likely to affect how participants store the information for retrieval. For example, in their verbal task, Penner et al. (2009) argued that increased memory demands require a