

1. Introduction

In individuals with aphasia, it has long been observed that though the ability to produce fluent strings of speech may be impaired, the ability to sing is sometimes preserved (Gerstman, 1964). In response to such observations, Albert, Sparks and Helm (1973) developed what is known as Melodic Intonation Therapy (MIT) with the suggestion that right hemisphere mechanisms believed to be involved in music processing may be able to compensate for damage to the language zone in the left hemisphere. Because music and speech share similar compositions (e.g., rhythm, pitch, duration and often linguistic content) and are thought to reign dominant in opposite hemispheres, it is understandable that such claims be made. However, collective findings in the areas of melodic and prosodic processing and the neural substrates that are involved in these processes suggest that the basis for the effectiveness of MIT must be more complicated than originally described. Although MIT has been shown to be a successful remediation tool for the partial restoration of language function in some individuals with aphasia (Sparks, Helm & Albert, 1974; Goldfarb & Bader, 1979; Schlaug, Marchina, & Norton, 2008, 2009) little evidence has been gathered as to what exactly makes this therapy effective. Consequently, a lack of evidence has been provided as to how MIT can be individualized to maximize the efficiency and efficacy of the treatment it provides.

Included in the procedure of MIT are a wide array of features involved in the processing and production of music and speech information, encompassing linguistic, motor, melodic and visual modalities. Schlaug et al. (2008) have highlighted two elements of MIT as having the largest impact: hand tapping and melodic contour. Melodic contour in itself can be broken down into the rudimentary components of rhythm and pitch for examination. Interestingly, these components are believed to be processed in separate hemispheres, the right hemisphere being responsible for spectral (pitch) information and the left hemisphere being responsible for temporal (rhythmic) information (Pell, 1998; Zatorre & Belin, 2001). In addition to more general evidence that the right hemisphere plays an integral role in the recovery of language function in aphasia (Crosson et al., 2007; Schlaug et al., 2008; 2009), it has also been suggested that patients with left hemisphere lesions may have impoverished temporal processing (Alcock, Wade, Anslow, & Passingham, 2000; Shah, Baum, & Dwivedi, 2005) and relatively intact pitch processing abilities (Alcock et al., 2000). Because melodic as well as prosodic processing are thought to overlap in usage of neural mechanisms (Patel, Peretz, Tramo, & Labreque, 1998), and are therefore both products of combined left and right hemisphere processes, the shared feature of melodic contour processing in both speech and music can be assumed to be an important aspect of MIT, and the components of melodic contour should be further examined.

2. Methods

In the present study, pitch and rhythm were contrasted using an auditory discrimination task, with the purpose of determining whether the encoding and processing of one of these types of information prevails over the other for individuals with aphasia. Participants included 11 individuals with aphasia and 16 healthy age-

matched controls. They were asked to listen to pairs of auditory stimulus strings and to determine whether the two strings were the same or different (Figure 1). Auditory strings presented in each trial were composed of either discontinuous pure tones (tone condition) or highly frequent, highly imageable, spoken single-syllable CVC words (speech condition). Strings were comprised of either monotonous tones/words that varied by beat-interval duration (rhythm condition), or beat-to-beat changes in pitch (pitch condition), where interval duration remained consistent between beats. The comparison string in each pair consisted of either a repetition of the original string (same) or changes in beat-interval duration or pitch (different).

A total of 92 pairs of auditory stimuli were presented to each subject, 12 of which were used as practice trials. Items in the auditory discrimination task were presented in a within-subjects block design consisting of the following conditions: Pitch-Tone, Pitch-Speech, Rhythm-Tone, and Rhythm-Speech. Participants were instructed to make same/different judgments immediately following presentation of the second stimulus item in each set. Participants with aphasia were given the option to express their responses verbally or using gesture (i.e., thumbs up/down, pointing to visual depictions of “same” and “different”).

3. Results

Accuracy on the auditory discrimination task was calculated using d' . A 2x2x2 mixed-model analysis of variance (ANOVA) was conducted in order to evaluate the effects of group, pitch vs. rhythm and tone vs. speech variables. The same vs. different variable was collapsed prior to analysis in calculating d' for each condition (Pitch-Tone, Pitch-Speech, Rhythm-Tone, Rhythm-Speech). For within subjects factors, a main effect of tone vs. speech was detected (Wilks' Lambda = .728, $F(1,25) = 9.319$, $p = .005$), with greater accuracy for discriminating tone stimuli overall. No effects of group or pitch vs. rhythm were found, suggesting that pitch and rhythm stimuli were balanced in level of difficulty for participants overall.

Univariate ANOVAs were also conducted to detect between-group differences in each condition (Figure 2). Significant differences were found for rhythm-tone ($F(1,25) = 6.571$, $p = .017$) and rhythm-speech ($F(1,25) = 4.748$, $p = .039$) conditions. A trend towards significance was found in the pitch-speech ($F(1,25) = 4.080$, $p = .054$) condition. Persons with aphasia were generally poorer at discriminating both tone ($M = 2.70$, $SD = 1.64$) and speech ($M = 2.23$, $SD = 2.28$) stimuli in the rhythm conditions as compared to controls (rhythm-tone: $M = 4.30$, $SD = 1.55$; rhythm-speech: $M = 3.84$, $SD = 1.57$). No differences were found between groups for the pitch-tone condition ($F(1,25) = .682$, $p = .417$), though persons with aphasia were generally worse at discriminating in this condition as well ($M = 3.6$, $SD = 1.76$) as compared to controls ($M = 4.09$, $SD = 1.32$).

4. Discussion

The results of this study provide further evidence in support of the hypothesis that individuals with left hemisphere damage may have impoverished temporal processing, and in turn, poor rhythmic processing abilities, regardless of whether rhythmicity is based

in speech or purely tonal information. However, the finding that aphasic participants perform more poorly in the rhythm-speech condition than the rhythm-tone condition suggests that dissociation exists for the processing of rhythmic information beyond the level of acoustic processing.

Despite evidence of impaired temporal processing abilities, several individuals with aphasia have been known to demonstrate success in language recovery through participation in Melodic Intonation Therapy. Intact pitch processing, as evidenced by the results of this study, could be considered an area of strength for these individuals, suggesting that pitch information may be encoded more easily than rhythmic information in the process of MIT.

In terms of clinical application of these data, modifications to music-based therapy approaches, such as MIT, should be considered. Given that rhythm and timing might be difficult for individuals with aphasia, working on this explicitly and/or directing attention to pitch cues may increase the effectiveness of treatments in which melodic contour is utilized.

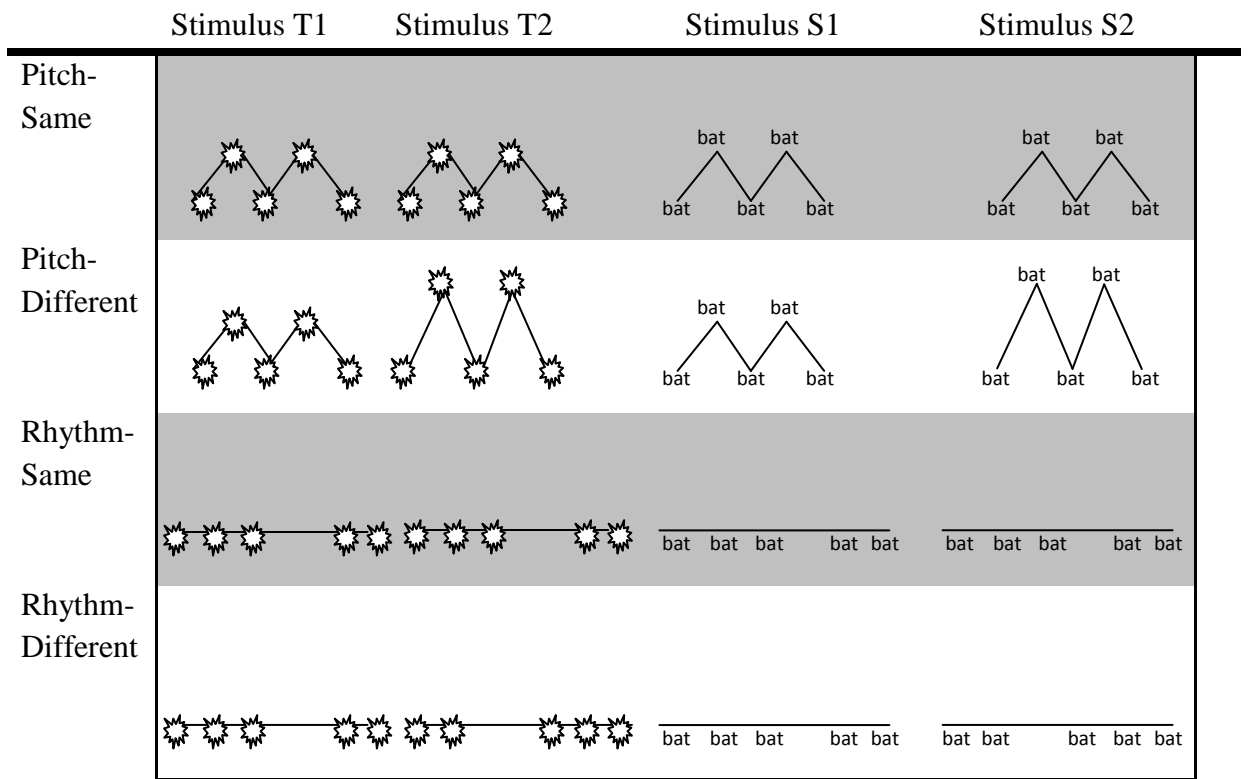


Figure 1. Stimuli design

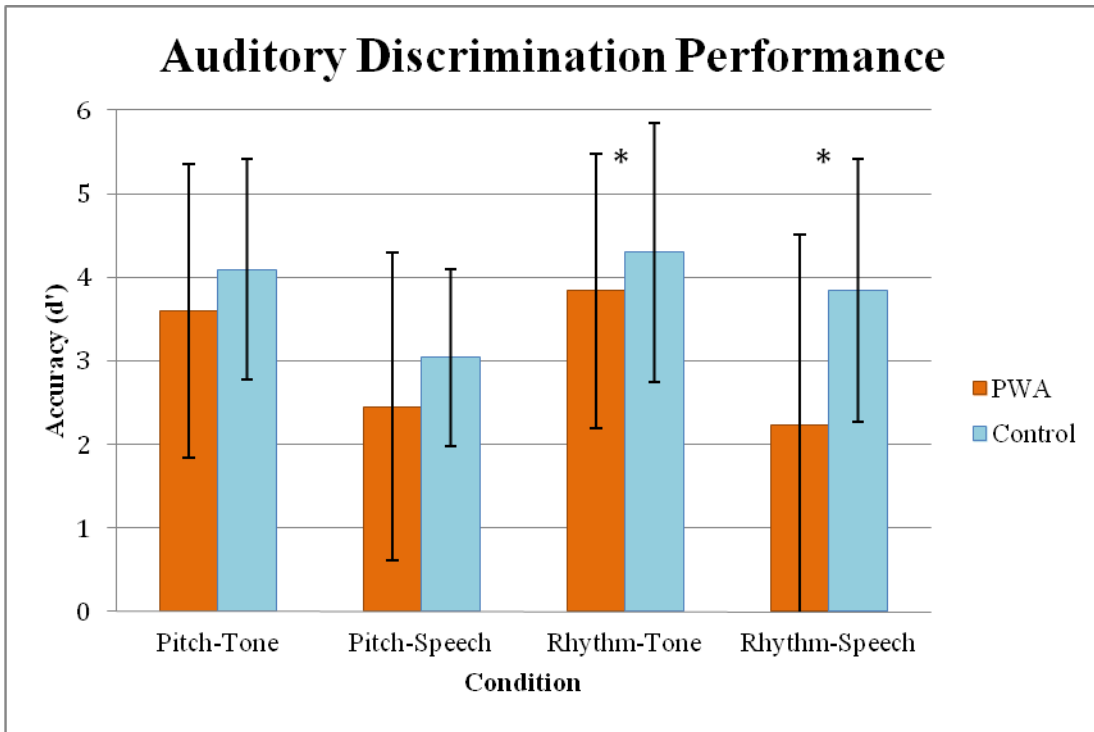


Figure 2. Between-group performance on auditory discrimination task by condition, $*p < .05$

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