

Interaction between melodic expectation and syntactical/semantic processes on evoked and oscillatory neural responses

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ABSTRACT

Background

Electrophysiological studies have shown support for a neural overlap between music and language in the resources used for processing of structural information (Patel, 1998; Koelsch et al, 2005; Carrus et al, 2011). The presence of violations in music and language elicit similar responses. For example, Patel et al (1998) showed that both music and language violations elicit a P600. Also, music and language violations both elicit early components in response to a syntactic violation, the ERAN and the LAN respectively. Finally, harmonic violations have been shown to affect ERP and oscillatory responses following the presentation of linguistic violations. For example, Koelsch et al (2005) showed that the LAN amplitude decreases when a harmonic violation is presented simultaneously with syntactic violations.

Aims

This study aimed at investigating the neural interaction between processing of music and language by adding two novel components: the use of melodic stimuli and the use of combined syntactic-semantic violations. Previous studies investigating interactions between music and language have used harmonic but not melodic stimuli. Studying the effect of melodic expectation is fundamental for an understanding of the extent to which music and language share neural resources. Further, double violations have never been used in studies of music-language interactions. This type of violation would provide further information regarding the modulation of syntax-semantic interactions by melodic expectation.

Method

Melodic stimuli were aurally presented in synch with visually presented sentences. Five-note melodies were presented simultaneously with five-word sentences. A computational model of musical stimuli was used to create melodies (Pearce, 2005). The model allows to distinguish between high-probability (expected) and low-probability (unexpected) notes. Melodies ended with either a low-probability note or a high-probability note. Sentences ended with one of the following types of words: a correct word, a semantically incongruent word, a syntactically incorrect word, a word with a combined syntactic-semantic violation. Participants were required to attend to the language, and occasionally respond to the acceptability of sentences. The

EEG was recorded and the analysis consisted in the study of event-related potentials and time-frequency representations.

Results

Syntactic violations elicited a LAN and a P600, while semantic violations elicited an N400. Double violations elicited a component resembling both the LAN and the N400, and a later component resembling the P600. Melodically unexpected note elicited a decrease in the N1 component at around 100 ms. The amplitude of the LAN decreased when syntactically incorrect sentences were presented with a low-probability note. The same effect was not observed for the N400. Low-frequency oscillatory power increased soon after presentation of all language violations and melodically unexpected notes. The simultaneous presence of violations in music and language elicited a decrease in low frequency oscillatory power elicited after single syntactic and single semantic violations, but not after double violations.

Conclusions

This study provides the first evidence to show neural interactions between melodic processing and language processing. The ERP analysis shows that melodic expectation interacts with syntactic but not semantic violations. The time-frequency analysis suggests neural interactions are occurring at low frequencies (1-7 Hz).

Keywords

music, language, ERP, EEG, oscillations.