



Music Influences the Processing of Syntax

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INTRODUCTION

•Language and music are both rule-governed systems for combining discrete units (words and pitches) into longer, hierarchically-structured sequences

•In language, these rules are known as *syntax*. Music can also be described as having syntax, which is implicitly learned and constrains a listener's expectations for future musical events¹

•The processing of syntactic incongruities in music has been shown to evoke ERP responses that are statistically indistinguishable from those evoked by linguistic syntactic incongruities²

•Broca's areas and its right hemisphere homologue have been implicated in the processing of both linguistic syntax³ and musical syntax⁴

•Patel⁵ has offered a "shared syntactic integration resource hypothesis", proposing that these frontal areas may support the syntactic computations common to language and music

HYPOTHESIS

•If syntactic computations across both domains utilize the same cortical areas, the simultaneous processing of language and music may result in interactions between the domain-specific syntactic computations

•Garden path sentences offer an opportunity to test the influence of musical parsing on linguistic parsing

•Initial parsing of the syntactic structure places "the cake" as the direct object of "ate", until "baked" indicates the need for syntactic reinterpretation

As the child ate the cake **baked** in the oven.

As the child ate the cake baked in the oven.

•The word that indicates the need for syntactic revision (**baked**) evokes a late positive ERP component, known as the P600⁶

•If each word of the garden path sentence is presented simultaneously with a chord that is part of a hierarchically-structured chord sequence, the structure of the chord sequence may influence the parsing of the garden path sentence, potentially reducing the P600 effect

I IV V I I IV IV V V I Chord Phrases
As the child ate the cake baked in the oven.

STIMULI

VISUAL STIMULI: SENTENCES

•148 Grammatical Sentences

•50% Garden path (10 words)

"As the child ate the cake **baked** in the oven."

•50% Control (12 words)

"As the child ate the cookie cake **baked** in the oven."

•100 Ungrammatical Sentences

•50% Mock garden path (10 words)

"As the actress became the character exceeded her acting skills."

•50% Mock control (12 words)

"As the dinner arrived the waiter the busboy cleared away the bread."

AUDITORY STIMULI: MUSIC

•124 Chord Sequences, 1 musical phrase



•124 Chord Sequences, 2 musical phrases

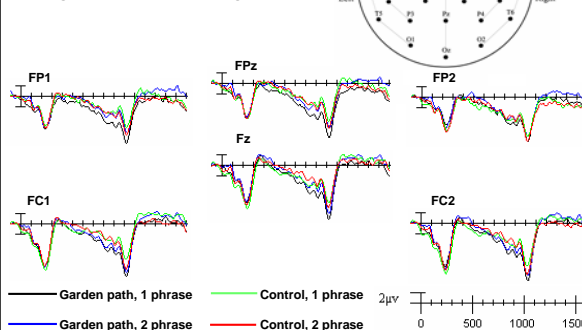


PARTICIPANTS

Fourteen individuals were recruited from the Tufts University community

DATA ACQUISITION

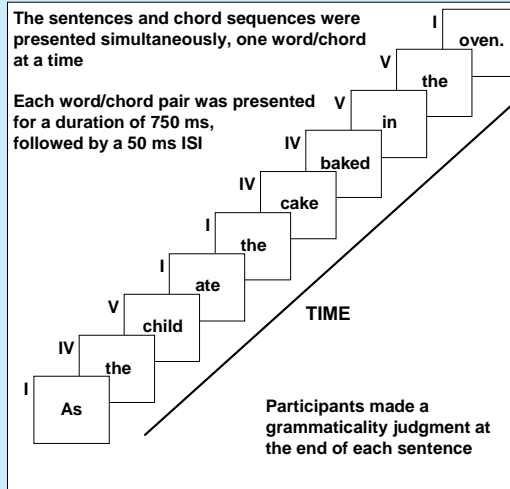
EEGs were recorded using a 32 channel montage, as illustrated to the right



TRIAL PARAMETERS

The sentences and chord sequences were presented simultaneously, one word/chord at a time

Each word/chord pair was presented for a duration of 750 ms, followed by a 50 ms ISI



Participants made a grammaticality judgment at the end of each sentence

RESULTS

BEHAVIORAL DATA: GRAMMATICALITY JUDGMENTS

	Chord Sequence Type		% Correct
	1 Phrase	2 Phrase	
Garden Path Sentence	67.2%	72%	
Control Sentence	92.6%	93.1%	

Sentence type: $F(1,13)=19.81, p=.001$
Chord sequence type: $F(1,13)=4.41, p=.056$ (approaching significance)

Interaction: $F(1,13)=2.03, p=.178$ (n.s.)
T-test, garden path 2-phrase > garden path 1-phrase: $t(13)=-1.916, p<.05$, one tailed

ERP DATA

Average amplitudes were calculated for the critical word in the garden path sentence and the corresponding word in the control condition (indicated in red in the stimulus section). The average amplitude for each electrode was used in separate ANOVAs (sentence X music X electrode X hemisphere) for 3 time ranges: 300-700 ms, 700-1100 ms, and 1100-1500 ms. No significant effects were found for the 2 earlier time ranges.

Significant Effects, 1100-1500 ms (using Greenhouse-Geisser correction)

Midline electrodes (Fpz, Fz, Cz, Pz, Oz)

Sentence X Music X Electrode: $F(2,089, 27,153)=3.654, p=.038$

Linear contrast: $F(1,13)=6.013, p=.029$ (Strongest in anterior electrodes)

Perimeter electrodes (FP1&2, F7&8, T3&4, T5&6, O1&2)

Sentence X Music X Electrode: $F(2,079, 27,028)=3.983, p=.029$

Linear contrast: $F(1,13)=4.218, p=.06$ (Strongest in anterior electrodes)

Lateral electrodes (FC1&2, C3&4, CP1&2)

Sentence X Music X Electrode: $F(1,439, 18,706)=6.512, p=.012$

Linear contrast: $F(1,13)=7.642, p=.016$ (Strongest in anterior electrodes)

CONCLUSIONS

•Music influences the processing of syntax

•The two-phase chord sequence reduced the amplitude of the response to garden path sentences (relative to the one-phase sequence), indicating that the parsing of the music influenced the parsing of the sentence, which led to increased behavioral accuracy

•The interaction is strongest in the frontal electrodes, which is consistent with the cortical regions that have been implicated in syntactic processing in both language and music

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