Rhythmic similarity in Flamenco music: Comparing psychological and mathematical measures

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BACKGROUND IN MUSIC PSYCHOLOGY
Previous research on simple synthetic rhythmic patterns revealed the categorical structure of rhythm perception in music [1]. However, further research is needed to investigate complex rhythmic structures. This paper investigates rhythmic similarity in terms of mathematical measures and psychological measures. This study focuses on flamenco music, which is characterized by hand-clapping patterns whose underlying meter is composed of a pattern of soft and accented claps.

BACKGROUND IN COMPUTER SCIENCE
A mathematical analysis of the five 12/8 rhythmic patterns used in flamenco music was recently conducted to establish several musicological hypotheses [2], and specifically confirmed the existence of an ancestral rhythm for flamenco music. This analysis relied on the similarity between the rhythmic patterns. Such similarity was measured with two different rhythmic similarity measures: the chronotonic distance and the directed swap distance.

AIMS
Presented in this paper are the results of a listening test conducted to evaluate the perceived similarity of the rhythmic patterns used in flamenco music (5 basic patterns + ancestral rhythm). The psychological ratings of similarity are then compared with the mathematical measures proposed in [2].

MAIN CONTRIBUTION
The goal of this experiment includes to test out the validity of mathematical measures proposed in [2] from a perceptual point of view. The listening test described below aims at comparing the representations derived from the mathematical measures with representations derived from psychological ratings of rhythmic similarity for 6 patterns described below (5 basic patterns + ancestral rhythm). In a previous article, we described a similar comparison in the case of the 5 basic patterns only [4].

Fifteen participants with an average of 3.9 years of musical training were recruited from the student population at McGill University. Participants listened to the six MIDI-generated patterns and were asked to estimate the similarity of all pairs of the 6 rhythmic patterns at 2 different tempi (70 and 90 dotted quarter notes/min). Similarity ratings were made with the mouse on a scale presented on the computer screen with end points labeled "very similar" and "very different". The patterns used were the following, were an ‘x’ denotes an accented clap and a ‘.’ denotes a soft clap.

(1) Fandango [x . x . x . x . . x . .]
(2) Soleá [ . . x . . x . . . x . x]
(3) Bulería [ . . . . x . . . x . . x .]
(4) Seguiriya [x . . . x . . . x . . x .]
(5) Guajira [x . . x . . . x . . x .]
(6) Ancestral rhythm [x . . . x . . . x . x .]

A dissimilarity matrix was created for each participant based on their dissimilarity ratings. A global dissimilarity matrix was obtained by summing individual matrices across the 15 participants. Afterwards the BioNJ phylogenetic program [3] was used to construct the phylogenetic tree for each tempo.
For both tempi, 2 main clusters emerge from the analysis, the first one contains Guajira, Fandango and Ancestral, which all have onsets on the 1\textsuperscript{st} and 6\textsuperscript{th} beats, the second one contains Soleá and Bulería, which both have anacrusis. Seguiriya is isolated from the others. The perceptual measures of similarity were then compared with mathematical measures of rhythmic similarity used in [2] specifically the directed swap distance and the chronotonic distance.

**IMPLICATIONS**
The tree representations derived from the psychological ratings were found to best match with the directed swap distance tree, in terms of clusters and most distinct meters. The directed swap distance is defined as the minimum number of position interchanges of adjacent ‘x’s and ‘.’s to transform one pattern into the other.

**REFERENCES**

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