Comparative analysis for category goodness - rating vs. discrimination sensitivity of musical rhythm patterns using Signal Detection Theory

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introduction

1 A basic concept within signal detection theory (Green & Swets, 1966; Macmillan & Creelman, 1991) is the metaphor of using discrimination statistic measures as a form of "perceptual distance" metrics. That approach has been broadly applied to the categorical perception research of various sensory continua, especially to those related to speech and phoneme perception (Harnad, Stevan, 1987). The majority of experimental works to the perception of musical - rhythm related continua, which have been concentrated to the problem of the categorical vs. non-categorical nature of perceiving musical rhythm patterns, have adopted the classical experimental approach of correlating identification and discrimination performance in terms of percent correct responses. In addition, a few of them have further been concentrated to a more elaborate description of the structural aspects for certain types of rhythm categories, using various kinds of analyses and data transformations to map the corresponding "rhythm spaces" at a perceptual level (Clarke 1987, Schulze 1989, Windsor 1993, Desain & Honing 2003, Papadelis & Papanikolaou 2004, ten Hoopen, et al. 2005).

The study described here is a part of an ongoing research which aims at an improvement of "perceptual distance" metrics for rhythm related continua at the tactus level or higher, both in terms of category goodness ratings and discrimination sensitivity.

4 PARTICIPANTS: Twenty one undergraduate students of a University Music Department participated to the experimental procedure.

EXPERIMENTAL DESIGN: Within-subjects design which consisted of the following tasks:

IDENTIFICATION TASK: Identification of the metrical interpretation (meter) that fits the best to every experimental condition.

GOODNESS RATING TASK: A six step scale was used to rate the perceived goodness-of-fit for each pattern to any metrical structure previously associated to that pattern through the identification task.

DISCRIMINATION TASK: AB same-different forced - choice procedure using pairs of adjacent variations, as well as an equal number of "placebo" pairs.

results & discussion

5 TWO GROUPS OF PARTICIPANTS: After an initial introductory session, where participants required to identify the meter of accurate metronomic - timing variations for each combination of tempo and meter category - presented in a random order -, two performance groups were formed: High scorers (GROUP A) and low scorers (GROUP B).

IDENTIFICATION & GOODNESS RATING: All analyses of identification and goodness rating data were performed separately for each group of performers.

A transformation of the initial performance space (FIG. 2) at a perceptual representation level (meter space), where the majority of variations is -more or less- associated to a certain metric structure (category), has been traditionally described in terms of category identification frequency curves within the rhythm/meter perception domain.

In Papadelis & Papanikolaou (2004) we stressed the importance of using a combination of goodness rating data and category identification ones to provide a more detailed description of the resulting "meter space" (FIGs 4 & 5). As an extension to that work, an analysis of discrimination data was further employed to map a corresponding "discrimination sensitivity space" through an elaboration of both HIT and FALSE ALARM rates which collected from the AB same-different forced - choice procedure (FIG. 7). According to Signal Detection Theory "discrimination sensitivity index" (d') for the specific design is defined in terms of z, the inverse of the normal distribution function:

d'=z(H)-z(F), where z(H)=P("different"/different) and z(F)=P("different"/placebo pair) (Macmillan & Creelman, 1991)

Even though, the majority of z(H) values reveal a trend for increased hit rate near category boundary regions (A7/8, A15/16, B8/9, C7/8, C12/13 - FIG. 6) and decreased in the regions of prototypes within each category (A4/5, A11/12, B4/5, B12/13, C4/5, C11/12), there is no such an apparent correlation between clustering of points in the "discrimination sensitivity space" (FIG. 7) in respect to category formation provided by the combination of identification plus goodness rating data of FIG. 5.

method

2 STIMULI: Three stimulus sets were constructed at the fast (MM 168), medium (MM 112) and slow (MM 72) range of musical tempi (FIG. 2), through the use of a generative rhythm pattern (FIG. 1).

That pattern consists of five successive clave - like sounds and its temporal structure is based on an a/a/b/b/b inter-onset interval sequence.

All temporal patterns (rhythm variations) within each tempo range, illustrated in FIG. 2, were produced after increasing "b" by a fixed step, at the level of JND for duration, as follows: ⇨ 3

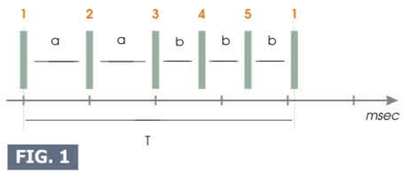


FIG. 1

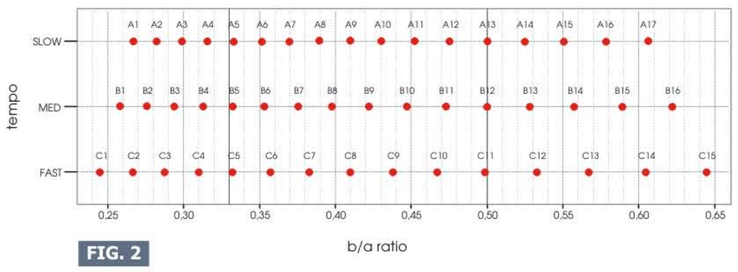


FIG. 2

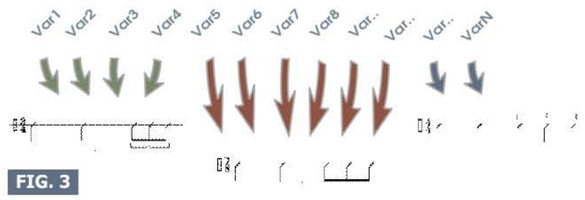


FIG. 3

3 A_n: $2a_n+3b_n=T_{slow}$ A_{n+1}: $2a_{n+1}+3(b_n+JND_{slow})=T_{slow}$

JND_{slow}=9,92 msec T_{slow}=2500 msec

B_n: $2a_n+3b_n=T_{med}$ B_{n+1}: $2a_{n+1}+3(b_n+JND_{med})=T_{med}$

JND_{med}=7,28 msec T_{med}=1607 msec

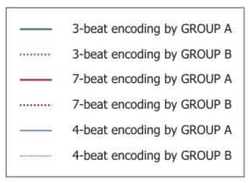
C_n: $2a_n+3b_n=T_{fast}$ C_{n+1}: $2a_{n+1}+3(b_n+JND_{fast})=T_{fast}$

JND_{fast}=5,66 msec T_{fast}=1071 msec

The above systematic interpolation of durations a and b defines a hypothetical performance space of rhythm microvariations (Desain & Honing, 2003), which is represented graphically in FIG. 3 using as a reference the continuum of durational relations b/a.

A potential categorization at a mental representation level, of any series of the produced micro variations, in terms of a goodness-of-fit to a musical metrical structure is illustrated schematically in FIG. 3.

FIG. 4



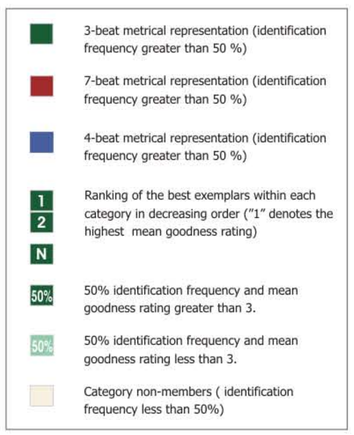
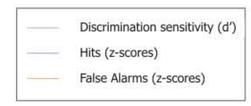


FIG. 6



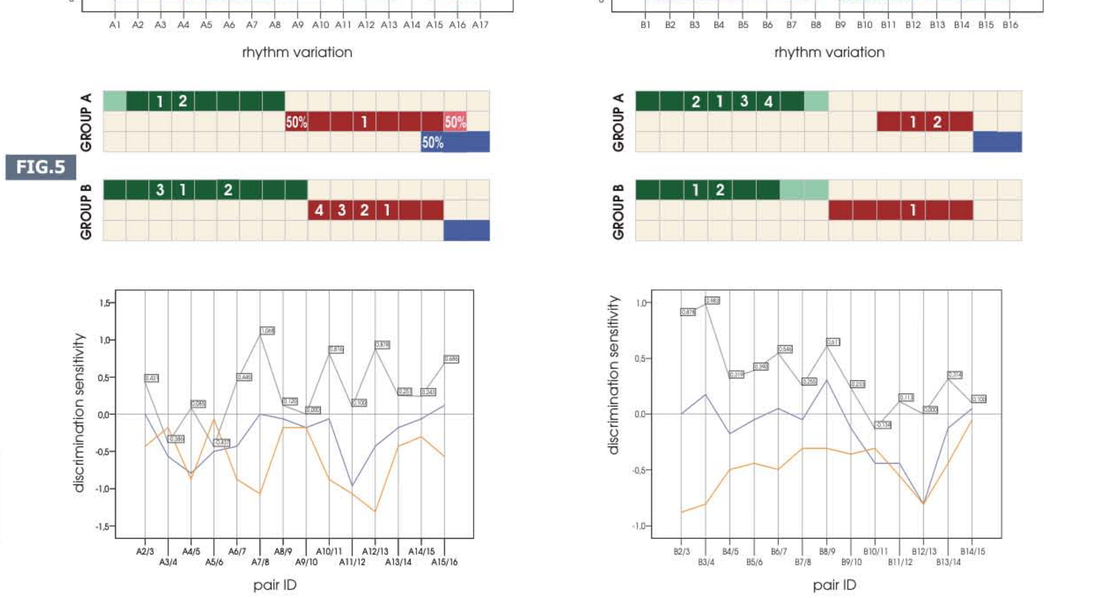


FIG.5

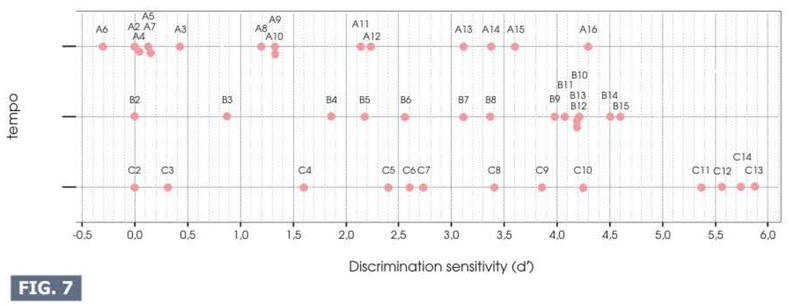


FIG. 7

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further research

An extension of that work aims at two basic objectives:

a) on the development of a more sophisticated experimental design for estimating discrimination thresholds based on adaptive rather than constant stimuli techniques.

b) the effect of acculturation on the perception of symmetric vs. non-symmetric structure of rhythm at the tactus level. Investigation is going to be conducted, both within the context of a specific cultural environment, as well as, cross-culturally through a comparative approach.

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