AN INITIAL EXPLORATION OF PARALLELISM IN MUSIC: EQUI-TEMPORAL THREE-TONE DIATONIC SEQUENCES

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1. INTRODUCTION

The perception of parallelism in music is considered crucial to the understanding and expression of affect in music (cf. Lerdahl and Jackendoff, 1983, p. 51-521). Yet there seem to be no quantitative models of the perception of parallelism in music. Simplistically, the perception of parallelism in two sequences can be divided into pitch-pattern parallelism (parallelism based on the pitch-height of the contour) and time-pattern parallelism (e.g., parallelism based on the timing of events such as onsets, offsets, and durations).

This work tested several models of pitch-pattern parallelism in short, three-note, musically relevant, sequences. To assess parallelism, one can focus on the corresponding changes between adjacent notes (i.e., the intervals), or one can focus on the actual pitches. Both can be rationalized, and both were explored. However, only the interval-based pitch-pattern parallelism is presented herein for reasons of space.

To quantify parallelism, sequences were encoded as intervals and then two sequences were compared interval-by-interval. The sum those comparisons over all intervals is a measure of parallelism. For the comparison, there are several approaches, each having pros and cons, but only most intuitive are cited herein. One can sum the differences between intervals (DifInt), the absolute value of differences between intervals (MADInt), or the root-mean-square of the differences between intervals (RMSInt). The second and third are analogous to the mean absolute deviation and the standard deviation commonly used in statistics. One can also sum the differences between the absolute values of the intervals (DifAInt), which is subtly different from the MADInt. The measures DifInt and DifAInt are arbitrarily affected by the order of computation (i.e., which of two sequences is called A and which is called B). To eliminate those order effects, one can take the absolute value of those measures creating ADifInt and ADifAInt.

A simpler model examines only the Up/Down pattern of the contour. Each interval is coded as increasing (1), unchanging (0) or decreasing (-1) Analogous to the above, one can sum of the differences in the Up/Down pattern (UD), the absolute value of the differences in the Up/Down pattern (MADUD), or the root-mean-square of the differences in the Up/Down Pattern (RMSUD). In addition, to remove order effects, one can take the absolute value of UD creating AUD.

Each of these models (and many not mentioned) was tested against the empirical assessment of parallelism in a total of 324 pairs of three-note equi-temporal sequences. Equi-temporal seqeunces of notes were used to avoid time-pattern parallelism.

2. METHOD

2.1 Participants

Sixty participants (40 females) with a mean age of 22.28 ± 7.31 years (range: 17 to 50), with the equivalent of an average of 13.76 ± 15.04 years of instruction at one hour per week (many studied more than one hour per week). All participants were recruited from the university community, primarily the Departments of Psychology and Music. Royal Conservatory of Music (RCM) or equivalent grades ranged from 0 to Grade 10 with mean and standard deviation 2.18 ± 3.46. One had a degree in music. Most (38) had no formal RCM grade. Participants were quasi-randomly assigned to one of three groups (n = 20 per group). Groups did not differ on age, musical experience, sex or handedness.

2.2 Apparati and Stimuli

Participants were presented with pairs of three-note sequences, selected from a set of 18 sequences. All notes of all sequences were confined to the diatonic notes of the key of C within the octave C_4 to C_5 (referenced to A_4 = 440 Hz), referred to as c, d, e, f, g, a, b, C. The 18 sequences were ccc, cec, Ceg, feg, bga, agb, ceg, CgC, egc, def, fef, dfe, Cge, cge, geC, fff, aba, dfe. The full set of all 18x18 pairs of sequences was tested, including both orders of each pair (A then B, and B then A).

Sequences were created using the acoustic piano of the internal MIDI driver (instrument 0, mode 0) of a Creative Labs Sound Blaster 16 in an IBM compatible computer. Each pair of sequences (e.g., each trial) was presented binaurally through Sony headphones connected directly to the audio output of the Sound Blaster. All notes were 240 ms (approximately 250 mm). Each trial consisted of the first sequence (720 ms), followed by a 1500 ms pause, then the second sequence (720 ms), and then a 4000 ms response window. Responses were only collected during the response window. Following the response, there was a 1500 ms inter-trial time. The same computer presented instructions on screen (throughout the experiment) and recorded responses.

2.1 Procedure

While seated comfortably in a Industrial Acoustics sound-attenuating room, each participant completed a single eight-stage experiment. The test session required about 1 hour, including the collection of background information and debriefing.

Stages 1, 3, 5, and 7 assessed the internal representation of tonality of the participant using a modified probe-tone task (cf. Frankland & Cohen, 2004), with Stage 1 as practice. These are not discussed further.

Stages 2, 4, 6, and 8 assessed the perception of parallelism, with Stage 2 as practice. Each of Stages 4, 6, and 8 presented a 6x6 grid of pairs of sequences (i.e., 36 pairs of sequences, or 36 trials). In each trial, participants heard two three-note sequences and rated the degree of parallelism using a 3-point scale. No definition of parallelism was provided. Across three stages, each participant provided ratings for 108 pairs of sequences. Hence, three groups (randomly assigned) were required to complete the entire 18x18 (324 pairs of sequences) grid. Within each stage, there were actually two blocks of trials with the same 36 trials in each block. However, there was no discernable break between blocks. Trials were presented in a unique random order for each block, and for each participant.

3. RESULTS

Preliminary analyses indicated no effect of missing values, and not interactions involving block. Hence, the two blocks were averaged. Cluster analyses indicated that, within each stage, all participants rated the pairs of sequences in much the same manner (i.e., there were minimal effects of training or experience with music). To collapse data across groups, the data of each participant was converted to deviations from the mean of that participant. Mathematically, this is equivalent to removing the subjects and groups (nested within subjects) terms of a mixed ANOVA (cf. Cohen & Cohen, 1983, p. 428-435).

The first analysis examined ratings as a function of pair of sequences using an ANOVA. Not surprisingly, there was a significant effect of pair ($F(323,6154) = 11.45$, $p < .0005$), but the important statistic is the effect size, η^2, of .375. The ANOVA captures any and all differences due to the IV (pairs). This implies that, at best, a model of parallelism can only hope to explain 37.5% of the variance. Each model was tested in a regression analysis, using rating as the DV and quantified parallelism as the IV. To capture potential non-linearities in responding, all regression analyses used a fourth-order polynomial fit. The results are presented in Table 1, which shows the increase in explained variance (R^2 and ΔR^2) due to the hierarchical inclusion of each term of the power series.

Table 1: The Analysis of the 10 Interval-Based Models of Parallelism

Model	Linear R^2	Quad ΔR^2	Cubic ΔR^2	Quart ΔR^2	All R^2
DifInt	.000	.004	.000	.006	.011
MADInt	.043	.067	.032	.010	.151
RMSInt	.044	.069	.030	.010	.152
DifAInt	.001	.067	.001	.003	.072
ADifInt	.015	.017	.008	.002	.043
ADifAInt	.088	.004	.001	.014	.115
UD	.001	.007	.000	.010	.138
MADUD	.074	.109	---[1]	---[1]	.183
RMSUD	.079	.101	.041	---[1]	.220
AUD	.014	.004	---[1]	---[1]	.017

Note: [1]Term could not be computed.

4. DISCUSSION

Generally, results indicated that participants could provide reliable within- and between-estimates of the perception of parallelism in three-note sequences, despite the lack of an a priori definition of parallelism. However, diffences in sequences only explained 37.5% of the total variance in responses. Furthermore, the best models could explain only explain 22.0%, or only 58.7% of those systematic differences.

Other models not discussed, some based on intervals and many more based on the actual pitches (rather than the intervals) fared about the same. Various combinations of various models managed to achieve a more impressive 30.0% of the variance, but this is still only 80.0% of the availalbe systematic variance. Hence, the implication is that other models of parallelism are needed, or that the perception of parallelism may depend on factors that are not truly about the pitch contour (e.g., issues of tonality). This work continues with more models and longer sequences. It is also currently being extended to time-pattern parallelism.

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