THE INTERACTION BETWEEN MELODIC PITCH CONTENT AND RHYTHMIC PERCEPTION

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1. BACKGROUND AND AIMS [Leah Latterner]

1.1 Introduction

Music perception is a complex process that requires the individual to simultaneously interpret dozens of different aspects of musical sound, ranging from simple properties like volume and intensity to more complex ones like harmony and meter. Of these, perhaps the two most important and salient properties of musical sound are melody (that is, pitch content) and rhythm (that is, temporal or durational content). Music theorists and researchers have long regarded these as separable entities, often discussing or considering them in separate discussions, paragraphs, or papers; this mindset is also evidenced by the overwhelming disparity between the amount of research that has been directed at pitch perception and the amount directed at rhythmic perception. However, in the actual experience of listening to music, these elements seem at times to be interwoven and often interdependent. This raises the question: to what extent are melody and rhythm separate entities? Are they processed independently from one another entirely, or does one influence how the other is processed? The present study hopes to begin to address these questions by focusing on one way in which melody and rhythm might interact.

1.2 Previous Research

Surprisingly little research has been conducted on the relationship between rhythm and melody to date. Several studies do exist, however, each of which compares melody and rhythm processing in its own way. One such study, carried out by Peretz & Kolinsky (1993), investigated a brain lesion patient C.N. with amusia (an inability to correctly perceive and/or process music) that, interestingly, seemed to preserve rhythmic processing ability but not pitch processing ability. By using a comparison paradigm, the authors found that C.N.'s performance on rhythmic tasks was comparable to control subjects, but that C.N. was markedly impaired in melodic perception tasks. In addition, though control subjects showed an incongruence effect (a decrease in performance accuracy as a result of only one element changing between stimuli in the comparison task) suggesting a cognitive interaction between melody and rhythm in those subjects, C.N. did not show such an effect. The authors concluded that melody and rhythm processing can be dissociated (as in C.N.), but that they are integrated later in processing in typical individuals.

Focusing on the factors of melody that influence rhythmic perception, Hannon et al. (2004) asked subjects to match a metrically ambiguous musical stimulus (i.e. a short melody that could be perceived in triple or duple meter) to the accompaniment that suited it best (a series of isochronous accented beats in either triple or duple meter) and then analyzed the ability of several types of musical and temporal accents to predict the perceived meter. The study found that though temporal/durational accents were most important in predicting perceived meter, melodic accents like contour change and melodic repetition also predicted metrical perception, showing that melody can in some ways influence rhythmic processing.

Finally, a study carried out by Mackenzie et al. (1986) investigated whether tonality had an effect on rhythmic performance in concert pianists. In this experiment, subjects were asked to sightread short segments of music that were either tonal or atonal while their performance was recorded. Later, the pianists' timing was analyzed as a measure of rhythmic precision. Interestingly, results indicated that atonal music was played with more rhythmic consistency than tonal music, suggesting perhaps that the set of pitches from which a melody is taken and/or the pattern of progression of those pitches might influence rhythmic perception and performance capabilities.

1.3 Present Research

In order to further investigate how rhythm and pitch processing interact, the present study chose to focus more deeply on the issues of tonality raised by Mackenzie et al. (1986). In atonal music, melodies are often non-diatonic; branching off of this, the present study seeks to examine whether the pitch set from which the pitches of a melody are taken influences the listener's rhythmic processing ability (i.e. his ability to accurately compare the rhythm of one melody to another).

2. METHOD [Kevin Sherwin]

2.1 Participants

The participants in our study included both males and females, with slightly more males than females. Ages ranged from 18 to 49, with most participants in the 20's age-range. All except for three participants had at least some musical training, which ranged from 1 to 20 years of experience learning a musical instrument. Consequently, our findings generalize to both males and females in the 20's age-range with musical training.

2.2 Stimuli

The experimental materials included 18 distinct rhythm patterns. There were 6 original rhythms for the complex rhythm case and 6 original rhythms for the simple rhythm case. All rhythms were in the time signature of 4/4 and had 13 note onsets. Complex rhythms featured syncopation at the duration level of the note onset for over 50% of the note onsets in the metric grid representing the rhythm. Simple rhythms had no syncopations at the duration level of the note onset in the metric grid representing the rhythm. For example, a note onset of half note duration was allowed on beats 2 and 4 of the construction of the complex rhythms, but not in the simple rhythms, because beats 2 and 4 are not present on the half note duration level of the metric grid representation of the rhythm. For 3 rhythms from the 6 original simple rhythms and for 3 rhythms from the 6 original complex rhythms, local rhythmic perturbations that preserved the number of note onsets were applied. This resulted in the construction of a total of 6 new rhythms that differed from the 6 original rhythms due to the applied perturbation. Consequently there were 9 distinct complex rhythms and 9 distinct simple rhythms.

The experimental materials also included 12 distinct pitch patterns. There were 4 pitch patterns from the diatonic pitch set in C major, 4 pitch patterns from the pentatonic pitch set in C major, and 4 pitch patterns from the chromatic pitch set. The pitch patterns were constructed by random selection from the pitch patterns' respective pitch sets, except for the first and last notes of the pitch sets. The first and last notes of the pitch sets were selected to be C to control for the variability of the first and last notes of the pitch patterns across trials. The final audio samples of the pitch patterns were digitally synthesized on GarageBand. The following figure diagrams the pitch patterns, where "D" means diatonic, "P" means pentatonic, and "C" means chromatic:

Melody	Note 1	Note 2	Note 3	Note 4	Note 5	Note 6	Note 7	Note 8	Note 9	Note 10	Note 11	Note 12	Note 13
D1	C	E	C	A	B	G	B	G	A	F	A	B	C
D2	C	B	D	F	B	F	C	E	F	E	G	D	C
D3	C	B	D	E	A	B	A	F	G	C	A	D	C
D4	C	A	E	C	E	G	D	B	A	F	D	F	C
P1	C	G	C	G	E	D	A	D	A	G	E	G	C
P2	C	G	E	C	G	C	E	C	E	D	G	E	C
P3	C	D	A	E	C	D	C	G	D	E	A	E	C
P4	C	E	G	A	E	G	C	A	D	G	E	D	C
C1	C	B	E	F	G#	C#	A	D#	E	F	A	D#	C
C2	C	G	A	F	D	E	G	C	A	G	B	F#	C
C3	C	G	G#	A	A#	E	G	C#	C	G	E	E	C
C4	C	F	C#	G#	D#	B	D	F	A	B	D#	C#	C

The 4 pitch patterns from each pitch set were given 4 distinct rhythmic patterns. 2 pitch patterns of the 4 pitch patterns from each pitch set were also given the perturbed version of the pitch pattern's original rhythm. The pitch pattern with the original rhythm and the pitch pattern with the perturbed rhythm were then paired in the experiment and participants were asked whether they thought the two rhythms to be the same or different. Using this same-different paradigm for our experiment, we also paired identical pitch patterns with the same rhythmic patterns and asked participants whether they thought the two rhythms to be the same or different. Consequently, there were 12 different conditions, 6 of which presented two of the same pitch patterns with different rhythms, and 6 of which presented two of the same pitch patterns with the same rhythms. There were twelve trials and in each trial, the participant was presented one pair of pitch patterns. The variables were the pitch set from which the pitches were randomly selected (either diatonic, pentatonic, or chromatic) and the complexity of the rhythmic patterns (either simple or complex).

2.3 Task & Procedure

Using the same-different paradigm for our experiment, we paired identical pitch patterns with either the same rhythmic patterns or rhythmic patterns that were locally perturbed from one another. We then asked participants whether they thought the two rhythms to be the same or different. The 12 different conditions were presented in a randomized order so that the pitch patterns from different pitch sets, as well as the complex vs. simple rhythms, were assorted throughout the experiment 6. Each pair of pitch patterns was presented in one audio file, in which there was silence and a high-pitched signal tone in between the pitch patterns. For the pair of pitch patterns, the participant was asked to determine whether the rhythm was the same or different.

Participants were given the following general instructions in the beginning of the experiment:

> In this experiment, you will hear a series of musical clips, which will be presented in pairs. Your task is to compare the rhythm of the first pitch pattern with the rhythm of the second pitch pattern in each clip. After the first pitch pattern finishes playing there will a brief period of silence between the two pitch patterns. A high-pitched tone will indicate when the second pitch pattern is about to start. You will hear each clip only once. After listening to the two pitch patterns in the clip, you will be asked if the rhythm of the two pitch patterns were the same or different.

Participants were specifically instructed in each trial by the following directions, choosing either same or different:

Click on the play button to hear the sound. After the sound has finished playing, select a response. Press the continue button to continue to the next trial. Were the rhythms of the pitch patterns the same or different? Same/Different

2.4 Data Collection & Analysis

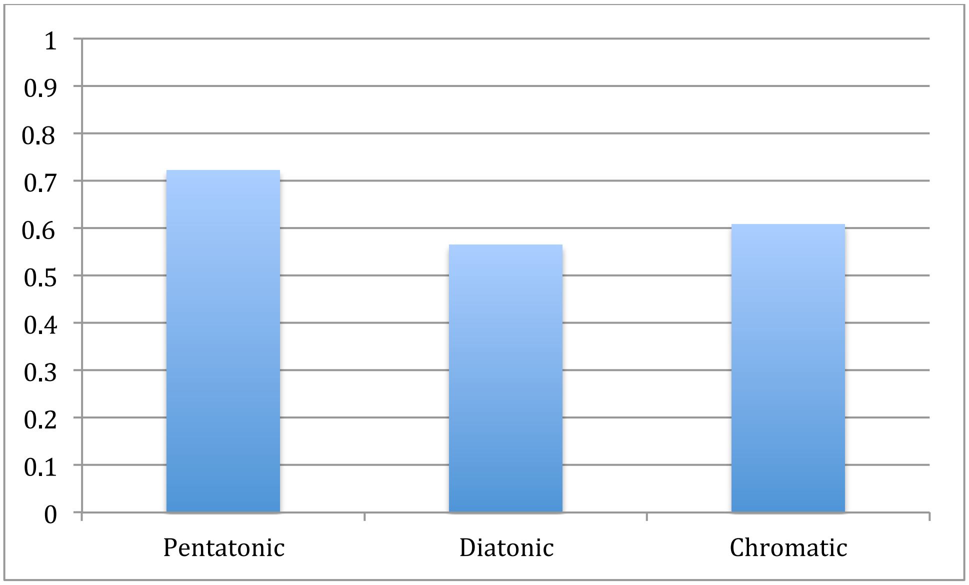
The data was collected through the NYU Music and Audio Research Laboratory and was organized in the form of an excel spreadsheet. Our measure was the accuracy of the participants' response to whether the pair of pitch patterns had the same or different rhythm. The data was transformed into percentage accuracies for each diatonic, pentatonic, and chromatic condition. Percentage accuracies were also calculated for each simple and complex rhythm condition, as well as for each simple-diatonic, simple-pentatonic, simple-chromatic, complex-diatonic, complex-pentatonic, and complex-chromatic condition. A total accuracy percentage was also calculated for all of the conditions. We conducted a p-test to statistically determine the significance of the percentage accuracy difference between conditions.

3. RESULTS [Gideon Broshy]

3.1 Responses: Percent Accuracy Across Pitch Set Condition, All Trials

Across all trials, subjects were significantly more successful at the same-different task in the pentatonic condition (72.283% accuracy) (SD = .464) than in the diatonic (56.522%) (SD = .497, p = .0135) and chromatic (60.870%)

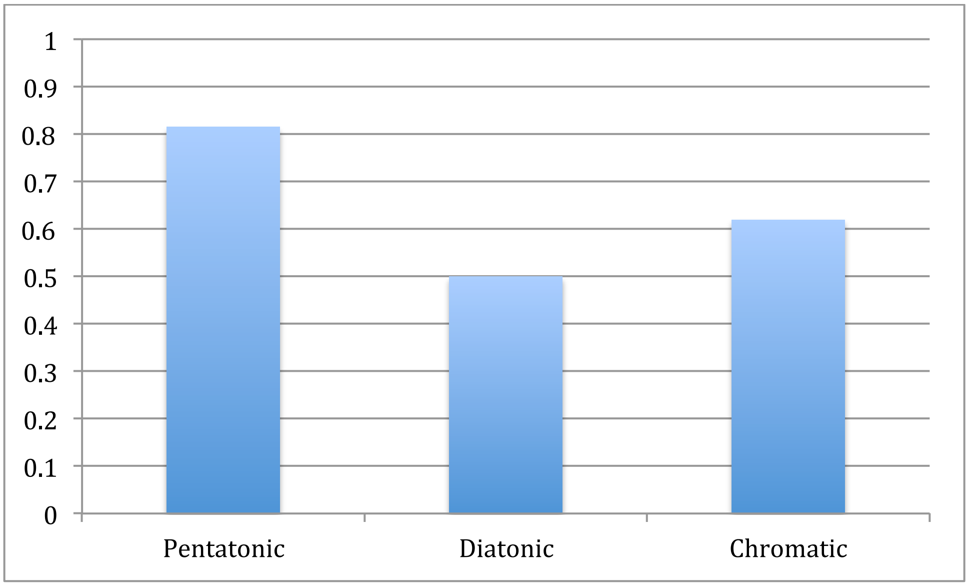
(SD = 0.494, p = .04) conditions. There was no significant difference between success in the diatonic and chromatic conditions (p = .6743).



NOTE: The x axis on all graphs denotes % correct responses in the same-different task.

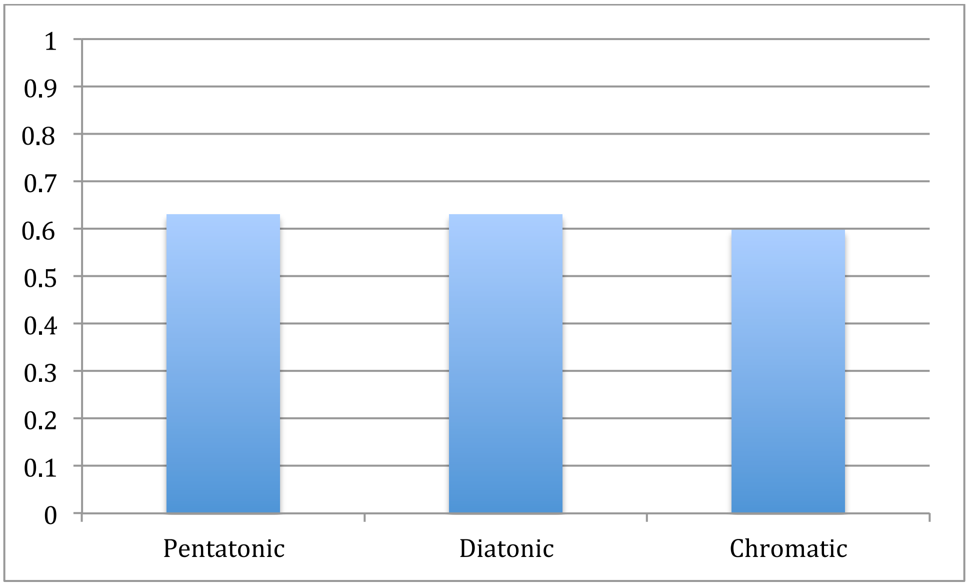
3.2 Responses: Percent Accuracy Across Pitch Set Condition, Simple Rhythm Trials

On simple-rhythm trials, subjects were significantly more successful in the pentatonic condition (81.522% accuracy) (SD = .407) than in the diatonic (50.000%) (SD = .503, p <.0001) and chromatic (61.957%) (SD = 0.488, p =.0102) conditions. There was no significant difference between success in the diatonic and chromatic conditions (p = .1052).



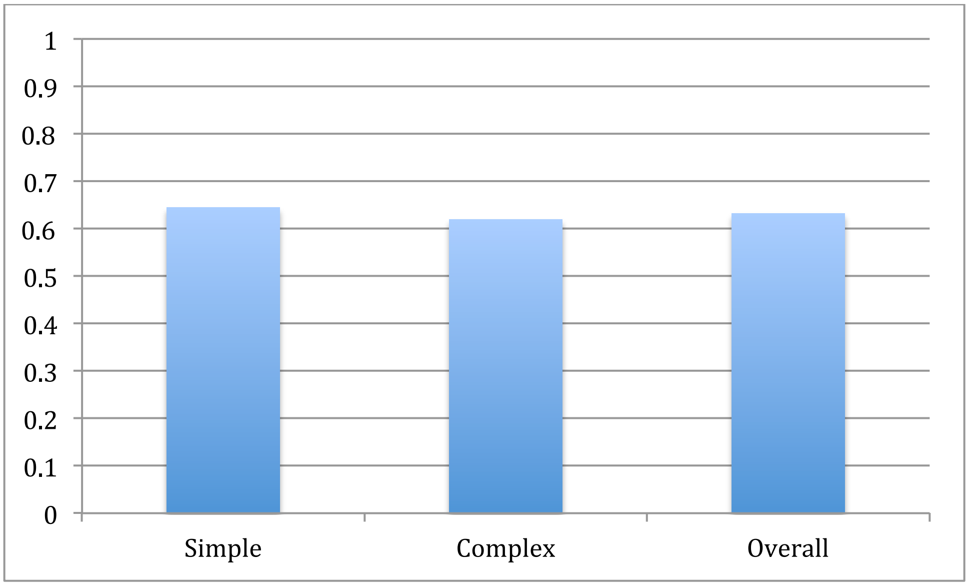
3.3 Responses: Percent Accuracy Across Pitch Set Condition, Complex Rhythm Trials

On complex-rhythm trials, there was no significant difference between success in the pentatonic (63.043% accuracy) (SD = .495) condition and the diatonic (63.043%) (SD = .485, p = .549) or chromatic (59.783%) (SD = .500, p = .658) conditions. There was no significant difference between the diatonic and chromatic conditions (p = .2976).



3.4 Responses: Percent Accuracy Across Rhythmic Complexity Condition, All Rhythms

Across all trials, there was no significant difference between success in the simple rhythm (64.493%) (SD = .482) and complex rhythm (61.957%) (SD = .493) conditions (p = .257).



4. CONCLUSIONS [Gideon Broshy]

Our results suggest that rhythmic processing is facilitated in pentatonic contexts. We predicted a progressive increase in rhythmic ability from the chromatic to the diatonic to the pentatonic condition; however, our results do not show a significant difference between rhythmic ability in diatonic and chromatic contexts.

In the rhythmic-complex trials, subjects were not significantly more successful in the pentatonic condition than in the diatonic or chromatic conditions. This suggests that there was a threshold of rhythmic complexity beyond which distinctions between pitch set were not determinant of success or failure; in other words, the complex rhythms were "too complex," and obscured the effect of pitch condition. Unfortunately, this conflicts with the fact that overall, there was no significant difference between simple-rhythmic and complex-rhythmic trials; we think this incongruity would be resolved if we ran the experiment with more subjects.

We would like to advance a few possible explanations for subjects' success in the pentatonic condition. We think pentatonic contexts might facilitate rhythmic perception because they involve fewer pitches, because they contain fewer dissonances than other pitch sets, because they feel more "stable" than other pitch sets, and/or because they are more familiar than other pitch sets.

There are significant limitations to our approach. Melodies differed in overall time length and number of measures, and within melodies, some notes were unintentionally repeated more often than others. In the "different" trials, the altered sections were sometimes placed in the middle of a melody, sometimes at the end; we did not control for the position of the alteration. We did not control for number of leaps/skips vs. steps. Finally, contour and rhythmic accents might have biased listeners towards favoring particular pitches, "unbalancing" the influence of pitch set. However, none of these seem to be particularly compelling confounds (alternate explanations for our data).

Subjects reported that the extreme length of the silence between rhythms in each trial was disorienting, and the high-pitch tone was distracting.

This experiment should be re-run with more subjects, to see if the aforementioned conflict in our data is resolved, and to see if a significant difference emerges between success in the diatonic and chromatic conditions. A further experiment might include more pitch sets (e.g., octatonic and whole tone) and a pitch-less condition, to test for the effect of pitch overall.

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