Discrimination of Overlapping Rhythmic Patterns

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INTRODUCTION

Background:

- When presented with polyrhythms, or overlapping rhythmic patterns with different musical meter, listeners show difficulty tracking whether or not a probe tone falls on the beat in either rhythm without relying on selective attention [1]
- Syncopations on the third beat of a measure result in lower stability than syncopations on the fourth beat of a measure, and musicians show greater stability regardless of location [2]
- Musicians show decreased ability to detect changes in polyrhythms when ratios become more complex [3]
- Listeners show more difficulty detecting changes in synchronous tones than non-synchronous tones [4]
- Pianists show greater onset asynchrony when playing music at a round than in unison [5]

These studies support the idea that increased complexity decreases listeners' ability to follow and synchronize with rhythms. However, it is not clear if this extends to rhythmic discrimination or if the same tracking difficulties remain in overlapping rhythms of the same meter.

OBJECTIVES

Current Study:

This study used a simple discrimination task to test whether or not listeners could determine if two overlapping rhythms were the same or different.

- **Hypothesis 1 (Offset):** Overlapping patterns played at an offset would result in lower hit rates than patterns playing in unison, with patterns played at a 3-beat delay resulting in the worst performance.
- **Hypothesis 2 (Noise):** Overlapping patterns with white noise will result in lower hit rates than overlapping patterns in silence.
- **Hypothesis 3 (Interaction):** Offsets and white noise combined will result in significantly lower hit rates, beyond the effects of either one alone.

In addition to these hypotheses, participants were asked for their years of musical experience to control for the effects of training on discrimination in the task. No specific hypotheses were proposed for musical training.

MATERIALS AND METHODS

Participants:

- N = 195 undergraduate students (149 women, M_{age} = 21.34 yrs, *SD* = 3.47 yrs) at the University of Texas at Dallas
- 75 participants were categorized as musicians (over 5 years of musical training)
- Average of 5.10 yrs (*SD* = 6.218) of musical training
- Recruited from psychology classes to participate in an online Qualtrics study
- Compensated with 1/2 research exposure credit

MATERIALS AND METHODS (CONTINUED)

Stimuli:

- 24 rhythmic patterns + 3 unlabeled practice stimuli (6600 – 8740 ms) created with mechanical drumming patterns
- 1/2 of patterns had the same drumming pattern in both ears, and 1/2 had a different pattern in each ear. Same/different patterns were evenly distributed across conditions:
    - **Delay:** 1/3 of patterns were in unison (0 ms IOI), 1/3 of patterns were at a 2-beat delay (860 ms IOI), and 1/3 were at a 3-beat delay (1300 ms IOI). In delay patterns, the pattern in the right ear started after the pattern in the left ear.
    - **Noise:** 1/2 of patterns included white noise (played equally in both ears)

Procedure:

- Short demographics and music experience questionnaire
- Sound check with headphones followed by instructions to listen to each pattern once and identify whether same or different
    - 3 unlabeled practice stimuli in fixed order (not included in hit rates)
    - 24 test stimuli in randomized order
- After completion, participants were thanked for their time and automatically granted research exposure credit

Analysis: An *A*' transformation was used for hit rates. Scores were used in a mixed 3 (Rhythmic offset) X 2 (White Noise) X 2 (Musical training) ANOVA using a Greenhouse-Geisser correction, with musical training serving as a between-groups control variable. A one-sample students' T-test was also used to compare results to chance.

RESULTS

T-test results: Participants performed above chance ($A' > 0.5$) in all conditions ($p < .001$)

Main effects:

- **Main effect of delay:** Delay was significant, $F(1.971) = 15.260$, $MSE = .027$, $p < .001$, $\omega^2 = .028$. Unison condition ($M = 0.756$, $SE = 0.011$) had higher accuracy than 3-beat conditions ($M = 0.719$, $SE = 0.011$), $t(1.988) = 3.028$, $p_{Holm} = .005$, $d = .217$, and 2-beat ($M = 0.688$, $SE = 0.011$), $t(1.988) = 5.516$, $p_{Holm} < .001$, $d = .395$, levels. The 3-beat condition resulted in higher accuracy than the 2-beat condition, $t(1.988) = 2.488$, $p_{Holm} = .013$, $d = 0.178$. Hypothesis 1 was partially supported.
- **Main effect of noise**: No main effect of noise was found. Hypothesis 2 was not supported.
- **Main effect of musicianship (Control)**: Musicians ($M = 0.754$, $SE = 0.012$) performed more accurately than non musicians ($M = 0.688$, $SE = 0.012$), $F(1) = 13.625$, $MSE = .087$, $p < .001$, $\omega^2 = .032$, $d = 0.264$.

Interaction effects:

- **Interaction of delay X noise:** Delay and noise had a significant interaction, $F(1.988) = 13.254$, $MSE = .027$, $p < .001$, $\omega^2 = .023$. Participants Hypothesis 3 was partially supported, but a different pattern of results was seen than expected.
- **Interaction of delay X noise X musical training (Control):** All three variables together had a significant interaction $F(1.988) = 3.732$, $MSE = .027$, $p = .025$, $\omega^2 = .005$. Musical training did not interact significantly with either independent variable alone. Musicians (Figure 1) are charted separately from non-musicians (Figure 2) to show the different patterns of results.

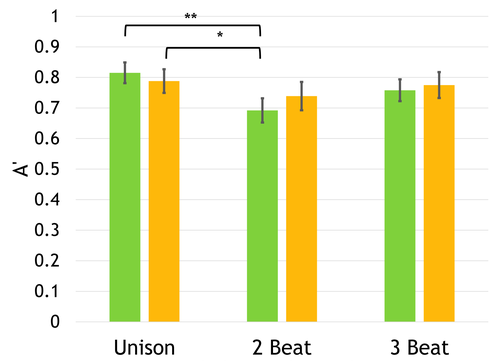

Figure 1. Musicians' *A*' scores by condition.
Note. Error bars represent 95% confidence intervals.
* $p_{Holm} < .05$, ** $p_{Holm} < .01$, *** $p_{Holm} < .001$

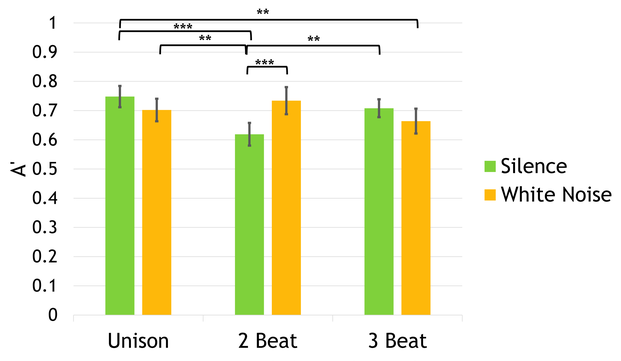

Figure 2. Non-musicians' *A*' score by condition.
Note. Error bars represent 95% confidence intervals.

CONCLUSIONS

Primary findings

- Listeners can generally discriminate different rhythms being played simultaneously.
- Rhythmic discrimination is negatively impacted by increased auditory complexity.
- Musical training may increase the ability to discriminate rhythms, even within these complex conditions.

Implications

- Complex rhythmic patterns, in the form of polyrhythms, rounds, and different patterns in the same meter, are common in music, and this study suggests that listeners can discriminate between two separate patterns instead of integrating them into one stream.
- The effects of auditory complexity might have implications for synchrony in musicians performing overlapping rhythms in a complex environment

Future directions

- The interaction needs further examination to determine if the differing beat patterns explain the differences between 2-beat and 3-beat offsets or if the longer lag time gives participants more time to alternate attention between the two patterns.
- Listeners might be able to identify same/different patterns without tracking them extensively. Future research might examine if listeners can accurately identify patterns in same/different pairs after listening.

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