

Effect of metrical primes on perceived complexity of 2:3 and 3:4 polyrhythms

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Published 16 December 2021; <https://doi.org/10.18061/FDMC.2021.0043>

Author video presentation and/or other conference material: <https://doi.org/10.17605/OSF.IO/GXM8C>

Abstract

Previous empirical studies concerning the perception of polyrhythms have isolated the rhythms from a metrical context to observe the meter associated with each rhythm. These studies show the important effect pitch and tempo have on identifying meter (Handel & Oshinsky, 1981; Handel & Lawson, 1983). For example, listeners tend to tap the 3-pulse layer in a 2:3 polyrhythm except at fast tempos where the 2-pulse layer is preferred. (Handel & Oshinsky, 1981). This study extends prior research on polyrhythms by focusing on the metrical context in which they are presented, emulating realistic musical environments. The current methodology has participants rating the complexity of the pattern and how well the polyrhythm fits with the metrical prime. My hypothesis is that a metrical prime will overwhelm any previous preference for meter, and patterns placed in simple meters will be perceived as less complex than in compound meters. Results indicate listeners do have a preference of meter in both 2:3 and 3:4 polyrhythms. Listeners also rated the complexity of the stimuli lower in simple meters for 2:3, but this relationship is not clear in 3:4. Discussion considers the implication of the results on music pedagogy and performance of polyrhythms.

KEYWORDS: *polyrhythm, meter, perception, complexity, performance strategies*

Introduction

The existing music cognition literature on polyrhythms has illuminated the complexity and variability involved in a person's ability to interpret or replicate multiple rhythmic streams. Previous experiments vary in their methodology; some require participants to replicate polyrhythmic patterns to observe performance and attentional strategies, while others explore beat perception and meter entrainment by having subjects tap a steady beat to various polyrhythms. I will review a variety of literature exploring both polyrhythm performance and perception to identify some general trends that have formed the present understanding of this research area, but I will also identify some gaps in the literature that this experiment hopes to answer.

Handel and colleagues (Handel & Oshinsky, 1981; Handel & Lawson, 1983) conducted multiple studies observing meter perception in various polyrhythms. Since a stream of two rhythms may suggest two meters, these studies examined which meter a listener might hear for specific polyrhythms. They asked participants to tap a steady beat along with the rhythmic stimuli at a variety of tempos. Many participants tapped along with a single pulse stream, but some tapped a replication of the stimuli, and others tapped hypermetrically. Often, their metrical preference was influenced by the construction of the polyrhythm, the tempo, the pitch of each stream, and the patterns of accents added to the rhythm, demonstrating the number of variables affecting our perception of meter in polyrhythms. Other researchers have used similar methodologies and agree that there are many factors influencing beat perception in polyrhythms (Beauvillain, 1983; Moelants & Noorden, 2005).

A later study by Jones et. al. (1995) suggests two attentional strategies when listening to two rhythmic streams: integrative or streaming. They found integrating both streams into one coherent pattern was only useful with a small pitch interval between the rhythmic streams, while larger pitch intervals resulted in streaming, and the listener would track one of the two streams. Fidali, Poudrier, and Repp (2013) expanded this study to include more complex polyrhythms to see if integrative attending can handle the cognitive load created by the complex stimuli. They found integrating a polyrhythmic pattern typically results in a more acute attention, although this strategy was not able to handle the memory demands created by complex polyrhythms.

In contrast to these perceptual and attentional studies, other researchers have focused on replication and performance accuracy of polyrhythms. Pressing, Summers, and Magill (1996) demonstrate one strategy available to musicians performing polyrhythms, figure-ground separation. "For a polyrhythm consisting of two separate rhythmic streams, the elements of one stream act as a ground, whereas the elements of the other stream



act as figural elements perceived in relation to the ground” (pg. 1127). They had participants perform a 4:3 polyrhythm using different combinations of the figure-ground model and found that subjects were most accurate in their performance of the ground figure.

Similarly, a study by Peters and Schwartz (1989) had participants tap a 2:3 polyrhythm with both hands while counting aloud to one of the two streams. They found that polyrhythmic performance was most accurate when attending to and counting the 3-stream. They also considered the method by which participants determined the placement of each onset. Their results suggested that the timing of each onset of the figure hand was dependent upon the placement of the previous onset from the ground hand. Peters and Schwartz conclude that “subjects do not perform the two sequences independently; the initiation of movement in one hand is more clearly depended on the preceding movement in the other hand than on the preceding movements by the same hand” (pg. 215). Krampe et. al. (2000) elaborates on this approach and suggests two models: integrated timing and parallel timing. Integrated timing allows performers to find the placement of one note on one hand in relation to the previous note, regardless of which stream it is in. In the parallel timing model, each hand tracks the intervals of its own streams, both at the same time.

This brief survey demonstrates several key principles, including the variability and complexity of mental and motor processes involved with polyrhythms. I have observed however, that with the exception of a few studies (Keller & Burnham, 2005; Poudrier, 2017) most experiments used polyrhythmic stimuli in isolation, rather than in a musical context. To address this gap in the experimental literature, this study focuses on polyrhythmic patterns presented in metrical contexts to determine how ecological validity affects polyrhythmic perception. Ultimately, I hope to inform musicians in their musical practice. The conclusions from this study may not only serve as a glimpse into the process of hearing and performing polyrhythms, but also encourage different strategies of approaching polyrhythms when learning and performing them.

Method

Participants

Forty subjects were recruited through multiple institutions and streams of social media (22F, 17M, 1 unreported). The participants’ average age was 21.6 years ($SD = 3.57$). Six participants did not provide their

age. Most participants had some musical training; the average number of years of private music lessons was 9 ($SD = 6.13$) and the average number of semesters of music theory coursework was 3.6 semesters ($SD = 4.65$).

Stimuli

Rhythmic stimuli were created using a TR-808 virtual drum machine from onemotion.com (n.d.). The stimuli were comprised of a single rhythmic stream consisting of the composite rhythm of 2:3 or 3:4 polyrhythms. These composite rhythms were created using the snare drum sound.

The composite rhythm, which is a result of two unequal isochronous streams, can be perceived in one of two metrical contexts. Metrical primes were given in two of the three conditions which suggested one of the two possible meters in order to observe which metrical framework was preferred by the subject. The metrical prime used the hi-tom sound which was distinct in pitch and timbre from the snare drum. In the A condition, no metrical prime was used and the polyrhythms were repeated eight times. In the B and C conditions different metrical primes preceded the polyrhythms for four measures of the suggested meter and continued throughout the eight repetitions of the polyrhythm. The B condition received a prime of the faster of the two streams. The C condition received a prime of the slower of the two streams. The B prime for 2:3 implies a simple triple meter, $3/4$, while the C prime implies compound duple meter, $6/8$. The B prime for 3:4 implies a compound quadruple meter, $12/8$, and the C prime implies a simple triple meter, $3/4$. Musical notation of the stimuli are shown in Figure 1. Stimuli were presented at three different rates and are described in BPM of the slower of the two streams. The 2:3 polyrhythm was presented with the 2-stream = 50, 80, and 120 BPM. The 3:4 polyrhythm was presented with the 3-stream = 60, 90, and 136 BPM.

Procedure

Participants completed the experiment on their own devices through a Qualtrics survey and were encouraged to use headphones and locate themselves in a quiet place. They completed a short demographic survey that included questions about musical expertise. Subjects then proceeded through two blocks of stimuli and questions. The first block had 2:3 and 3:4 polyrhythms without a metrical prime, or condition A, at all three tempos. The order of stimuli was randomized. Participants were asked to listen to the stimuli and rate how complex the rhythm is. They were told to think how complicated it would be to replicate the rhythm and

were encouraged to tap a steady beat with the rhythm. The six-point complexity scale was labeled with descriptors of very simple – simple – somewhat simple – somewhat complex – complex – very complex.

In the second block, 2:3 and 3:4 polyrhythms were played with either of the metrical primes, B or C, at three tempos, again presented in a random order. Participants were asked to tap along with the metrical prime, rate how well the rhythm fits with the provided steady beat, and rate the complexity of the rhythm. The fit of the rhythm with the prime was on a six-point numerical scale with 1 described as “does not fit” and 6 described as “fits extremely well.”

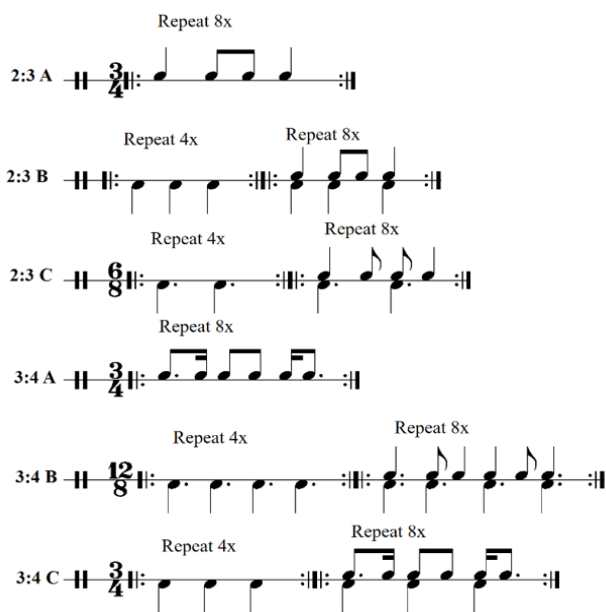


Figure 1: Notated stimuli. Composite polyrhythm is above the line, metrical prime is below.

Results

Table 1 shows the average fit and complexity ratings in all conditions. See Figures 2-5 for visual representations of the data.

Metrical Preference

For the 2:3 polyrhythm, participants rated the stimuli as fitting with the 3-layer prime significantly better than the 2-layer prime in the slow and medium tempo conditions, with $p < .05$ for both tempo conditions. However, for the 2:3 polyrhythm at the fast tempo, participants did not show any preference for metrical prime, $p = 1$. Additionally, there was a significant effect of tempo on fit ratings with the 3-layer prime, which at

the fast tempo is significantly lower than at the medium and slow tempos, ($p < .05$ for both).

For the 3:4 polyrhythm participants rated the rhythm as fitting better with the 3-layer than the 2-layer in all tempo conditions, with $p < .05$ for all tempo conditions. There was no significant effect of tempo on the fit ratings for 3:4 polyrhythms, $p > .05$.

Table 1: Average fit and complexity ratings for 2:3 and 3:4 stimuli in all context and tempo conditions.

			Complexity		Fit	
			M	SD	M	SD
2:3	Slow	No Prime	1.38	0.70	---	---
		2-Layer	2.48	1.26	3.95	1.74
		3-Layer	1.53	0.72	5.58	0.71
	Medium	No Prime	1.98	0.95	---	---
		2-Layer	2.85	1.14	4.15	1.59
		3-Layer	1.98	0.77	5.60	0.74
	Fast	No Prime	2.48	0.99	---	---
		2-Layer	3.23	1.07	4.05	1.52
		3-Layer	2.48	1.06	4.10	1.28
3:4	Slow	No Prime	2.33	1.10	---	---
		3-Layer	2.73	1.06	5.10	1.06
		4-Layer	2.95	0.72	3.88	1.79
	Medium	No Prime	2.73	1.06	---	---
		3-Layer	2.83	1.06	5.25	0.87
		4-Layer	3.38	0.77	4.03	1.59
	Fast	No Prime	2.18	1.08	---	---
		3-Layer	3.35	1.29	5.08	1.00
		4-Layer	3.80	1.06	3.45	1.69

Complexity

Complexity ratings were converted to a 6-point numerical scale for analysis. For the 2:3 polyrhythm participants rated the stimuli with the 2-layer prime as significantly more complex than with no prime and with the 3-layer prime at the slow and medium tempo conditions, with $p < .05$ for all comparisons. However, for the 2:3 polyrhythm at the fast tempo, the stimuli with the 2-layer prime was rated as significantly more complex than with no prime, $p < .05$, and approaching but not significantly more complex than with the 3-layer, ($p = .062$).

For the 3:4 polyrhythm, the complexity ratings in only one condition are significantly different from the others. The complexity rating of the stimuli with the 4-layer prime at the medium tempo is significantly higher than with the 3-layer, ($p < .05$).

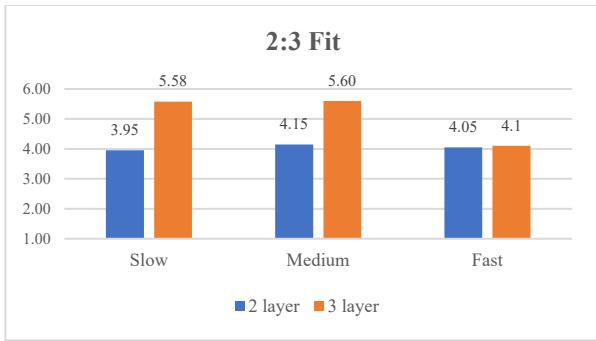


Figure 2: Average metrical fit ratings for 2:3.

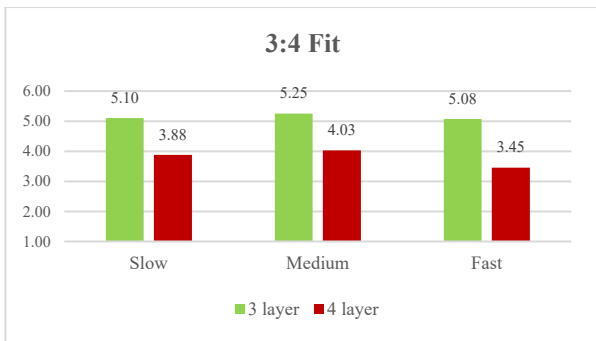


Figure 3: Average metrical fit ratings for 3:4.

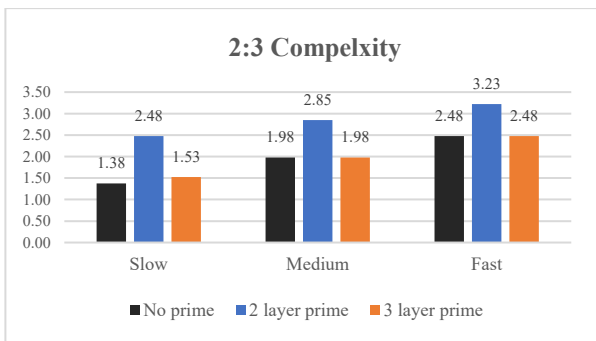


Figure 4: Average complexity ratings for 2:3.

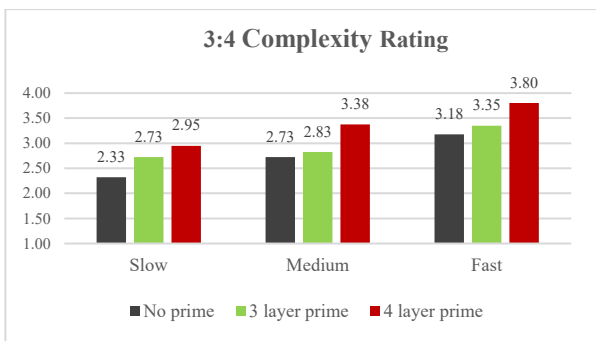


Figure 5: Average complexity ratings for 3:4.

Discussion

Preferred Meter

I predicted that any inherent preference for meter in 2:3 and 3:4 polyrhythms would be ignored when the rhythms are played in the context of a clear meter. Having provided two metrical primes that elicit the two possible meters of each polyrhythm, I expected no preference to be given to the fit of the polyrhythms in either of the contexts. However, results show a preference for the 3-layer (3/4 meter) with 2:3 polyrhythms at slow and medium tempos, and a preference for the 3-layer (3/4 meter) with 3:4 polyrhythms at all tempos. These results do bear some similarity to the tapping patterns of the subjects in Handel and Oshinsky’s (1981) study. They found most participants tapped the 3-layer in the 2:3 polyrhythm except at faster tempos, where some began tapping the 2-layer. This is mirrored by the metrical fit ratings in the present study with the 2:3 polyrhythm rated as fitting the best with the 3-layer except at the fast tempo.

Results from the 3:4 polyrhythm are less similar to Handel and Oshinsky (1981). Their participants preferred tapping the 3-layer at slow tempos, but tapped the 4-layer at the equivalent of this study’s medium tempo. No clear preference was shown at fast tempos. However, the results of the fit ratings show participants preferred the 3:4 polyrhythm in the context of the 3-layer at all three tempos. While there are some similarities between these perceptual ratings and previous tapping studies, metrical fit ratings may not be able to replace or replicate tapping behaviour.

Complexity

The two metrical primes used in this study are suggestive of either a simple or a compound meter. Since compound meters require more subdivisions than duple meter, I predicted polyrhythms placed in the context of a compound meter would be rated as more complex than the simple meter. This was true for the 2:3 polyrhythm with the 2-layer prime (with the implication of a compound meter of 6/8) since it was rated as significantly more complex than the 3-layer prime (3/4 simple meter) and no prime. However, this relationship is not observed in the 3:4 polyrhythm, except at the medium tempo where the 4-layer prime suggesting a compound meter of 12/8 was rated as significantly more complex than the 3-layer prime (3/4 simple meter).

The insignificant differentiation of complexity ratings in the 3:4 polyrhythm could be a result of the higher note per second density compared to the 2:3

polyrhythm. A greater number of onsets in the pattern means the listener must process more information. Note density has been shown to correlate with complexity ratings by (Eerola et. al., 2006). This correlation can also be observed in the different tempo conditions. As the tempo increases, so does the note density and complexity ratings. For the 2:3 polyrhythm, there was a moderate positive correlation between tempo and complexity rating ($r = .338, p < .05$) and for the 3:4 polyrhythm there was a weak positive correlation between tempo and complexity rating ($r = .262, p < .05$).

Conclusion

This study further demonstrates the complex metrical structures of polyrhythms, but suggests there might be conditions in which listeners can more easily interpret these rhythms. This can serve to better inform musicians and music educators when studying and performing polyrhythms. For example, since the data here suggests 2:3 polyrhythms are perceived to fit best with the 3-layer, musicians might try practicing this polyrhythm in a 3/4 metrical context where the 3-layer is the main pulse and the 2-layer is subdivided from the ground layer, similar to the ground-figure model in Peters and Schwartz (1989) and Pressing, Summers and Magill (1996).

Future directions of this study might be to investigate the figure-ground model further and include subdivisions in the metrical prime to reinforce the intervals between onsets of the polyrhythm. This could be used to develop a model of polyrhythmic subdivision that would advance our understanding of the perception of these challenging rhythmic patterns and help musicians better understand how to perform polyrhythmic patterns accurately.

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