The Effects of Movement Preparation on The Experience of Beat and Meter

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Throughout the world's various cultures and societies, the majority of music can be broken down into organizational components. Rhythm is one such component, which consists of groupings and metrical structure (Jackendoff & Lerdahl, 2006). The basic unit of metrical structure is known as the beat, and it is what comprises the metrical grids that all metered music depends on. Beat perception is the ability to perceive temporal structure within music. It is a property that is common to nearly all humans across different cultures, with at least some aspects suggested to be innate (Winkler et al., 2009; Phillips-Silver & Trainor, 2005). Over the past few decades music cognition has become an increasingly popular field of study, and improvements in imaging techniques have allowed for more thorough exploration of cognitive theories of music and the neural mechanisms that accompany them (Levitin & Tirovolas, 2009). Beat and rhythm are no exception, as there have been many efforts to understand the capabilities and mechanisms of the human brain for working with temporal mental events (Vuust & Witek, 2014; Povel & Essens, 1985; Fitch & Rosenfeld, 2007). The induction of beat is thought to have many contributing factors within the physical properties of sound that give rise to differing subjective experiences, such as melodic contour and articulations (Hannon et al., 2004; Drake, Penel, & Bigand, 2000). In addition, mental processes independent from physical properties can also affect the perception of beat; for example, isochronous ticks that have the same acoustic properties often have a perceived difference in salience (Abecasis et al., 2005). Many attempts to explain beat perception use a hierarchical model of rhythm and meter, in which salient metrical values are applied to levels of subdivisions of meter, and experienced through beat based timing, in which time intervals are relative to an overall temporal framework (Vuust & Witek, 2014). These metrical groupings are consistent with human behaviors in which people will naturally find the underlying pulse to the music and move their body to higher order metrical events, with these points on the grid being called the tacus (Levitin & Tirovolas, 2009). Much like any other property of music, there is not a conclusive explanation as to why nearly all humans can do this. There are several evolutionary theories attempting to explain why music itself exists, and the "motor skill development" theory has been of particular interest for its proposed link between music and motor function (Huron, 2001). Imaging studies have contributed to supporting this idea, as there is a growing body of literature investigating the sensorimotor factors of music providing evidence that both rhythm perception and production involves areas responsible for motor function such as the cerebellum, basal ganglia, premotor cortex, and supplementary motor cortex (Ivry & Keele, 1989; Halsband et al., 1993). In addition, there is evidence to suggest that moving to the beat can influence and improve rhythmic perception (Phillips-Silver & Trainor, 2007; Manning & Schutz, 2013). What still is unclear is the role of movement preparation in contrast with movement in such benefits. To explore this idea, the differences and similarities between movement and movement preparation must first be established. One model suggests the existence and use of an internal model that relates sensory information with motor feedback to create motor plans that control movement (Wolpert, Ghahramani & Jordan, 1995). The feedback component of this model suggests that the efficacy of motor planning is influenced by the preceding motor event, emphasizing the importance of movement in tandem with pre-movement brain functions. Imaging studies have provided evidence that areas involved in movement such as the motor cortex and premotor cortex exhibit activity when preparing for movement in stillness (Kaufman et al., 2014). Within these areas, movement promoting activity exists, but is being canceled out at a population level, allowing for the region to prepare for movement without initiating it. This begs the question of whether the activity seen in motor areas during preparation alone is sufficient to elicit the improvements in beat perception seen with movement. In this study, we look to explore how the preparation of movement itself influences the ability to maintain a steady beat. Recent research has suggested that when beat is induced, a strong beat percept can be sustained for up to 30 seconds and influence how ambiguous stimuli is heard (Nave et al., 2022). Under a modified version of the paradigm used by Nave et al. (2022), participants have to maintain a beat percept under two possible conditions, in which one requires the preparation of movement, while the other does not. We hypothesize when participants have areas associated with pre-movement engaged, they will better be able to maintain the beat percept, signifying the role of pre-movement brain activity in beat perception.

Methods

Participants

25 individuals participated in this study (mean age 19.0; SD 2.06; 9 males; 2 left handed, 1 ambidextrous), all with regular hearing. All participants were students at the University of Western Ontario, with 21 being recruited through the university ’s online participant pool (SONA). No participants reported the use of neuropsychiatric medication, and all but one participant reported not having a diagnosed neurological or psychiatric disorder. All participants signed an informed consent form prior to the experiment. One participant was excluded due to the reported use of body movement to keep time through the ambiguous phase. Six participants were excluded due to low yield of valid trials in the production task.

Experimental Design

The paradigm consists of two tasks, the beat perception task and the beat production task (see Fig. 1 & 2 for a visual depiction). Roughly half of the participants were assigned to do either task first in order to counterbalance, with 13 assigned to do the perception task first. After excluding participants that did not have enough successful trials, 18 participants remained, with 10 of them doing the perception task first. Both tasks involve trails that each consist of three continuous phases. The first two phases of each trial, the music context phase and the ambiguous phase, were identical for both tasks. In the musical context phase, participants are prompted to listen to a musical excerpt. Each excerpt is designed to induce either duple or triple meter in either a fast or slow tempo. The second phase, the ambiguous phase, participants listen to a stimulus with an ambiguous rhythm. Where the two tasks differ is in the final phase. The final phase of the perception task is the probe phase. Here, the ambiguous stimulus from the ambiguous phase continues to play, and in addition, a drum pattern is overlaid. When the stimuli stops, the participant is prompted to identify whether the drum is consistent or inconsistent with the meter established in the context phase, in other words, matching or not matching the beat. A total of 16 trials are done in the perception task, along with practice trials prior to testing. Practice trials followed the same process as test trials, but had a feedback component in which the participant was notified whether they correctly identified if the beat was matching. There were four practice trials in total to account for the four possible types of context stimuli. The final phase of the production task is the tapping phase. Similarly to the probe phase, the stimulus from the ambiguous phase continues to play throughout, however there is no drum pattern overlaid. The participant is instead instructed to tap the beat of the stimulus. To prepare the participant, a message informing them to prepare for the start of the tapping phase is presented prior to the start of this phase. Like the perception task, there is also a training period before testing. Two examples which use an overlaid drum pattern to represent taps are first given to show the participant when they are expected to start tapping, as well as what would be considered tapping on the beat. The practice trials followed the same process as the test trials, and like the perception task, included all possible context conditions. The difference was in how feedback was given, as there was no coded feedback. The researcher was required to observe and ensure that the participant understood to tap regular beat intervals. For the first 10 participants, the researcher was not able to listen to what the participant was hearing, and thus could only determine whether the participants understood the task by looking for isochronous tapping. To help provide more accurate feedback, the use of a headphone jack splitter was introduced to allow the researcher to hear the stimuli as the subsequent participants tapped.

Stimuli

The stimuli used for both tasks are modified versions of the ones used by Nave et al. (2022). All context and ambiguous excerpts included piano parts created using a MIDI Steinway grand piano in Logic Pro X, with the ones having the overlaid drum patterns also making use of a MIDI snare drum. for each trial can be broken down into three parts which match which phase they are used in.

Both the perception and production tasks started with the music context phase followed by the ambiguous phase, thus the stimuli for both phases have the same beginnings. There were a total of 16 different musical excerpts that could have been used in the music context phase. Half of the excerpts were in duple meter (3/4), with the other half being in triple meter (6/8). This property of the excerpts is dependent on the temporal position of strong and weak events. In both conditions, a measure of music consists of six possible positions of eighth-notes, and the first note of each bar is always a strong event. In a duple meter, each eighth-note alternates between being a strong or weak event, such that the first, third, and fifth beats are strong beats (SW-SW-SW). For triple meter, strong beats are separated by two weak beats in between, such that the first and fourth beats are strong beats (SWW-SWW). Through the use of compositional principles such as melodic contours and rhythmic patterns to support the strong beats, composers proficient in western counterpoint created excerpts that were able to elicit the perception of duple or triple meter, consistent with well-known theories (Povel & Essens, 1985). Aside from meter, the stimuli also differed in tempo. All 16 excerpts had two different variations, one in a fast tempo (200ms per beat) and another in a slow tempo (300ms per beat). In the fast tempo, excerpts in duple meter have strong beats at every 400ms, while those in triple meter have them at every 600ms. Comparing this to the slow tempo condition, excerpts in duple meter have strong beats at every 600ms, while those in triple meter have them at 900ms. This is done to ensure that there is no cognitive bias between different frequencies of strong beats, which is why fast excerpts in triple and slow excerpts in duple have the same number of strong beats per second. In addition to the 16 excerpts used in testing, four additional excerpts were created for practice in both tasks, as well as two more for the examples in the production task. These additional excerpts follow the same principles of those in the testing stimuli, with the four practice excerpts covering all the combinations of tempo and meter. The context excerpt lasts eight measures and instantly continues into the ambiguous stimulus.

The ambiguous stimulus was presented in the ambiguous, probe, and tapping phases, and remained constant in structure between both conditions and all trials. The rhythm was designed such that it could be perceived as having strong beats consistent with either duple or triple meter. Each sequence of the stimulus consists of two measures of a repeating rhythmic pattern: one quarter note followed by four eighth notes. The positions that house strong beats in either meter condition all have events, thus it is impossible to temporally classify this rhythm as definitively one meter or the other based on the rhythm alone. Other contributing elements such as melodic contour also had no presence. The ambiguous sequence had one monophonic line that had no variance in pitch within each measure. The only difference between the first and second measure of the sequence is that the second measure is a major third (four semitones) higher than the first, in order to indicate the start of measures. The tempo of the ambiguous stimulus depended on the context phase, such that the entire stimulus in one trial always had a consistent tempo. Previous research suggests that listeners are able to sustain a subjective perception of the beat once it is established through the context phase, such that the strong beats of the context excerpt are maintained and applied to the ambiguous rhythm (Nave et al., 2022). The ambiguous phase itself lasts for eight measures, however, the ambiguous stimulus itself continues to play into the final phase of either task. In the production task, the last two measures of the ambiguous phase include a prompt that notifies participants of the upcoming tapping phase, in which the ambiguous stimulus plays for another four bars. The drum pattern that is played in tandem with the ambiguous stimulus in the probe phase of the perception task can have two possible rhythms, one in which just the strong beats in duple meter are played, and another playing just strong beats in triple meter. This means that depending on which is used, it can either be matching, or not matching the beat established in the context phase.

Statistical Analysis

All statistical calculations were done in Excel, Python, and JASP. We expected differences within subjects in the ability to maintain a beat percept through the ambiguous phase for the production and perception tasks. To compare performance in both tasks, a percentage score of matching trials was created for both. Quantifying the number of matching trials was relatively easier for the perception task, as participants directly chose whether the probing stimuli was matching or non matching. The number of correct responses are divided by the number of total trials for each of the four conditions: triple-fast, triple-slow, duple-fast, and duple-slow.

Statistically quantifying the number of matching trials took a few more steps for the production task. The data collected included the timestamps at which the participants tapped relative to the start of each trial. By organizing the data using Excel, we were able to employ a Python script to analyze the time in between each tap, known as the inter-tap intervals (ITI). By finding the average ITI, an estimate as to which meter participants are tapping for a given trial. The expected ITIs would be the same time values as the time intervals between each beat as described in the prior section. Our parameters were set such that for trials in a fast tempo, an average ITI that falls within 50ms before or after the expected ITI would count as a correct response. For a slow tempo, that window would be within 75ms before or after the expected ITI, making it an even ratio in respect to tempo. Using a trial with duple meter and the fast tempo as an example, the expected ITI would be 400ms. An ITI that falls between 350ms to 450 would indicate that the participant was indeed tapping in a duple meter. To account for whether they tapped in the other meter option (duple in a triple condition or vice versa), the same parameters are applied on the unexpected ITI. In this example, if the average ITI falls between the unexpected range of 550ms to 650ms, that would indicate that the participant tapped in triple time. There are two ways in which a trial can be invalid, if the ITI is either a clear outlier, or indicates tapping to the rhythm rather than the beat. Tapping the rhythm would result in an ITI around 240ms under a fast tempo and 260ms under a slow tempo, thus an average ITI in the established ranges around these values would result an invalid trial. Clear outliers refer to average ITIs that indicate the participant was not attempting to tap one of the two meter options. Most cases of this seemed to happen when the participant tapped only to the first beat of each bar, which would be around 1200ms for the faster tempo and 1800ms for the slower one. For the trails that did not indicate tapping to the rhythm or only the first beat, we decided to exclude the ones in which the average ITI was a full beat greater than the interval for triple meter, as this indicated tapping in a meter in a different metric grid, and thus would be invalid. The cut off interval would then be 50ms before the 800ms mark for the fast tempo, and 75ms before the 1200ms mark for the slow tempo. If the ITI lies outside of all the ranges mentioned above, then they are classified as neither meter condition, but are still valid, and thus count as an incorrect trial. The number of correct valid trials are divided by the number of total valid trials to determine the percentage score for the same four conditions as the perception scores. Some participants exhibited a high degree of invalid trials (greater than 25% of trials) and were subsequently excluded from analysis. To ensure the efficacy of our method of ITI analysis, we calculated the mean and standard deviation for asynchrony between taps and nearest expected taps based on which meter participants appeared to be most likely tapping in a given trial.

For both tasks, we expected participants to be able to keep a beat percept in their mind after inducing a beat from the context stimuli. The measures of the two tasks differed, though we were able to standardize them into percentage of correct trials for both, which became our dependent measure for analysis. To compare the performance between tasks, we ran a 2 × 2 × 2 repeated measures ANOVA accounting for three factors: perception task vs production task, duple meter vs triple meter, and slow tempo vs fast tempo (see Tables 1 & 2).

At the end of every testing session, participants were asked to fill out a demographics survey in which they provided information about their music and dance background, sex, age, and other information. A Spearman’s correlation was used to establish any effects of demographics on performance in both tasks.

Results

Participants did not statistically perform differently in the perception task compared to the production task, $F(1,17) = .038$, $p = .849$, $\eta^2_p < .01$, signifying that the preparation of movement had no effect on maintaining a beat percept. A significant difference was found for meter effects, $F(1,17) = 7.68$, $p = .013$, $\eta^2_p = .31$ (Fig. 3). Post hoc analyses using the Bonferroni post hoc criterion for significance indicated that the mean scores were significantly greater in the triple condition (perception: M = 0.88, SD = 2.39; production: M = 0.88, SD = 2.29) compared to the duple condition (perception: M = 0.67, SD = 1.96; production: M = 0.68, SD = 2.56), *MD* = -0.21, $t = -2.77$, $p_{\text{bonf}} = 0.013$, signifying that participants performed better in trials that had a triple meter context phase compared to those with a duple meter context phase (see Table 2). There was no significant effect of tempo, $F(1,17) = 3.49$, $p = .079$, $\eta^2_p = .17$, signifying that there likely was no bias for any certain rate of beat. No significant interactions were found between any of the factors.

A significant correlation was found between years of musical training and performance on the production task, r(16) = .56, p = .015, but not the perception task, r(16) = .32, p = .201 (Fig. 4). No significant correlation was found for years of dance experience and performance on the production task, r(16) = -0.01, p = .961, or performance on the perception task, r(16) = .25, p = .319. A significant correlation was found between performance on the perception task and performance on the production task, r(16) = .47, p = .050, (see Table 3).

Discussion

In this study, we used musical stimuli designed to induce a beat percept, and tested participants' ability to identify and maintain the percept. This was done in two conditions, a perception task that did not involve the preparation of movement, and a production task did require the preparation of movement. The paradigm used was a modified version of the one used by Nave et al. (2022), in which the researchers established its efficacy in the maintenance of beat percepts. The production task introduced a novel mechanism to the paradigm which involved exploratory methods of coding information.

Preparation of Movement

Prior research has been done to explore the relation between movement and beat perception, however the preparation of movement has not been thoroughly explored. The perception and production tasks were used to isolate the preparation of movement, and the performance between the tasks did not have significant differences. Our results suggest that the preparation of movement does not aid in the maintenance of a beat percept. There is one thing to keep in mind when examining this data, and that is the significant effect of meter. Our results indicate that participants perform better to stimuli in triple meter compared to duple across both tasks. This effect is not seen in prior research that uses this paradigm, in which no significant effects of tempo and meter were seen (Nave et al., 2022). It is interesting that our results show a bias towards triple meter, as much of the current literature suggests an inherent duple bias for tasks requiring the perception of meter (Bergeson & Trehub, 2006; Drake, 1993). This may signify the need to revisit the current paradigm or stimuli to determine the musical context or ambiguous stimulus is not skewing the data by having a more salient option. Using different measures of determining metric complexity and models of rhythm and meter could offer more insight into the perception of this stimuli (Vuust & Witek, 2014; Fitch & Rosenfeld, 2017)

Differences with Musicians and Non-Musicians

Our data suggests a significant correlation between years of musical training and performance on the production task, but not the perception task (see Table 3). This was interesting to see as past research has suggested that musicians are better at beat perception and synchronization tasks compared to non-musicians (Grahn & Rowe, 2009; Nguyen et al., 2022). No significant correlations were seen with years of dance experience. One thing to note is that there may not have been enough data on participants' musical and dance experience for an accurate representation. Out of the six participants excluded for a high degree of invalid production trials, two had six to eight years of musical training, and three had five to seven years of dance training. Of the remaining 18 participants, 13 have had musical training, with eight of them having seven years of experience or more. This is quite a lot more compared to the six participants that had dance training, with none having more than four years of experience. To fully capture the potential effects of music or dance experience, a more representative sample may be needed.

Limitations

There are a few limitations within this study to consider. Because the production task was a novel addition to the design of this paradigm, the implementation of it had minute changes from the first to the last participant. Based on researcher observation, those who were given the production task first seemed to have more issues with understanding the task. Because the perception task involves a drum pattern to indicate the beat, it is possible that it could have served as more instruction for those who were given the perception task first. Because the production task seemed to be less intuitive, participants often required greater instruction or practice before starting the task. This could have introduced variance as the researcher would have to find examples and explanations to explain the concept of beat, which was not an issue with the perception task. With an increasing number of participants, the explanations became more standard over time to try to reduce variance and possible demand characteristics, but this came from reflecting on what worked best for earlier trials. One explanation that seemed to work and limited influence was to use an example that was not in either 3/4 or 6/8, such as “Beat It” by Michael Jackson, which is in 4/4. It is also possible that misunderstanding the production task could have led to an increase of invalid trials and thus exclusion of the participant. Of the participants that were not excluded, two had noted issues with understanding the production task, both being assigned to do it first. One of them scored exactly the same in the production task compared to perception task, in which both had a 50% better performance in triple meter, which could possibly be attributed to a noted lackluster explanation on the researcher’s part that could have potentially skewed the trials towards a triple bias. The other participant had a better performance in the perception task (.625) compared to the production task (.5625), and displayed a clear duple bias, which could also be a result of a biased practice session, as explaining the task using a 4/4 example did not suffice, and the researcher had to tap along with one of the duple practices for the participant to understand. This essentially served as an extra example trial, in which there was supposed to be an equal amount for both meter contexts. What is interesting is when investigating performance based on order, there is no significant effect of order on production task performance, however those who were assigned production first performed significantly better in the perception task (see Tables 4 & 5). This finding does not seem to be consistent with the possible limitations proposed above, which may suggest that they may not have that great of an influence. The difference in the perception task scores could possibly be explained as the after effects of having to do a task involving movement right before. It is possible that having to do a similar task that does engage movement control could induce some sort of habit in which the instruction to not use movement to aid the maintenance of a beat percept is more easily subconsciously disregarded, or the underlying cognitive strategy for appraising the probe stimulus could have been altered.

Another limitation comes with our parameters for coding the scores for production task performance. We decided to count average ITIs that were within 50 ms before or after the expected ITI for fast tempo trials and within 75ms before or after for slow tempo trials as correct. Though this range does seem to work, it did start out as an arbitrary estimate, and ended up being the only range we tried. We attempted to verify the efficacy of our parameters by examining asynchrony relative to suspected meters, and found that trials that had an average ITI within the ranges we set had a much smaller standard deviation of asynchrony for both tempo conditions, while the means did not differ in the fast tempo and was considerably out of range for those out of range in the slow tempo (see Table 6). This suggests that in trials that were classified as tapping one of the two expected meter options, participants were tapping much more in line with the expected beat positions compared to trials classified as invalid or neither of the two expected meters. This shows that our parameters are definitely within the right ballpark, however, it is possible that trials with average ITIs that are on the fringe due to an outlier ITI by missing a beat could still imply a steady meter, and thus be misclassified. More examination of our current analysis method needs to be done to ensure the efficacy of classification.

Our sample size also proved to be a potential issue. In an ideal situation, we would have 30 participants after exclusions. Due to time constraints, we were only able to get 25 total participants, with only 18 of them yielding sufficient data. This means that our results could potentially be influenced by being underpowered.

Future Directions

One possible addition to this study would be to investigate this research question using neuroimaging techniques. Nave et al. (2022) used EEG to investigate beat-related SSEPs which were shown to be indicative of performance in a similar task. Investigating brain activity could not only offer insight into the mechanisms of maintaining a beat perception with and without the preparation of movement, but could also potentially explain why our results differed from previous studies and further evaluate our methods of data analysis.

Another possible future direction would be to investigate the effect of including stimuli with different rhythmic complexities. Previous research suggests that simple integer ratios within rhythms result in better reproduction (Grahn & Brett, 2007). Using neuroimaging techniques in tandem with employing context stimuli of differing rhythmic complexities proposed in previous literature (Fitch & Rosenfeld, 2007; Toussaint et al., 2002; Povel & Essens, 1985) could offer insight into how the maintenance of a beat percept could be incorporated into previously proposed mechanisms.

Conclusion

The current study did not support our hypothesis that the preparation of movement would aid in the maintenance of a beat percept. Participants were tasked with either identifying or producing a beat consistent with an induced context after listening to a rhythmically ambiguous stimulus. They did not perform differently between tasks, signifying that preparing to move did not affect performance. An effect of meter was present, which is not consistent with previous research, and should be further investigated. Exploratory methods of analysis were used to assess the novel production task, in which measures of validity point towards them being adequate.

However, future research should attempt to verify our parameters with a larger sample size, in addition to further exploring the effects of movement preparation on musical experiences.

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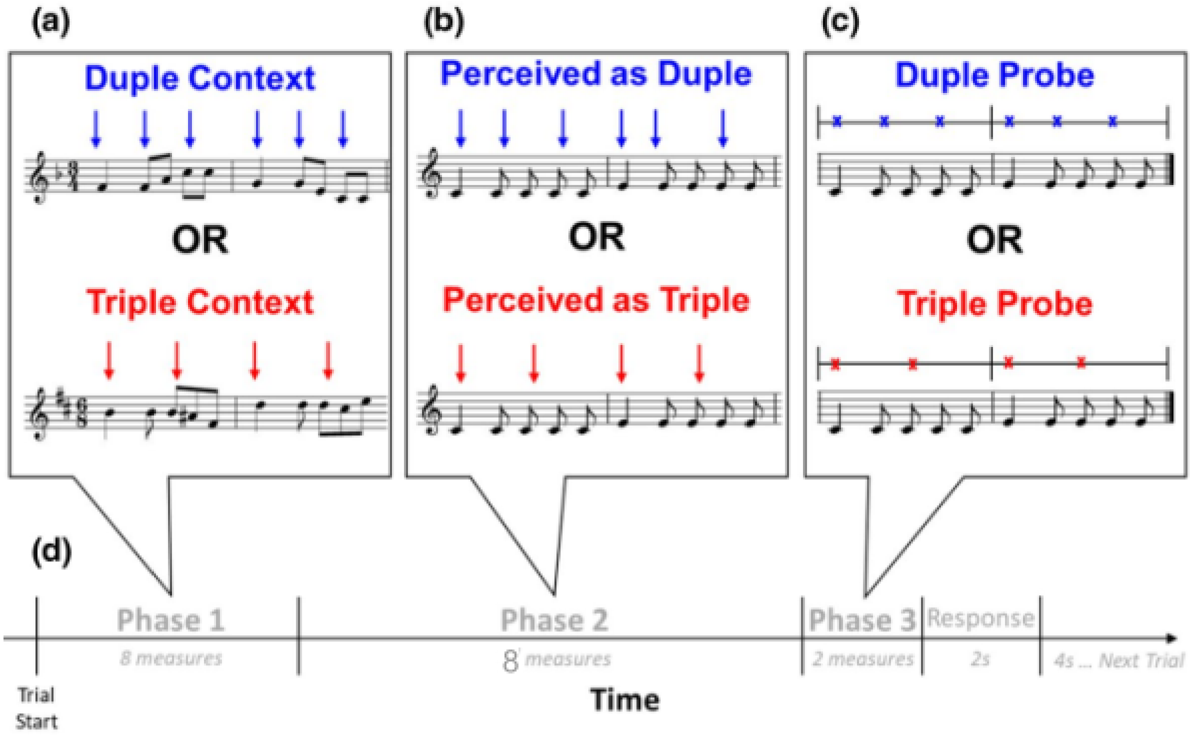
Figures

Figure 1

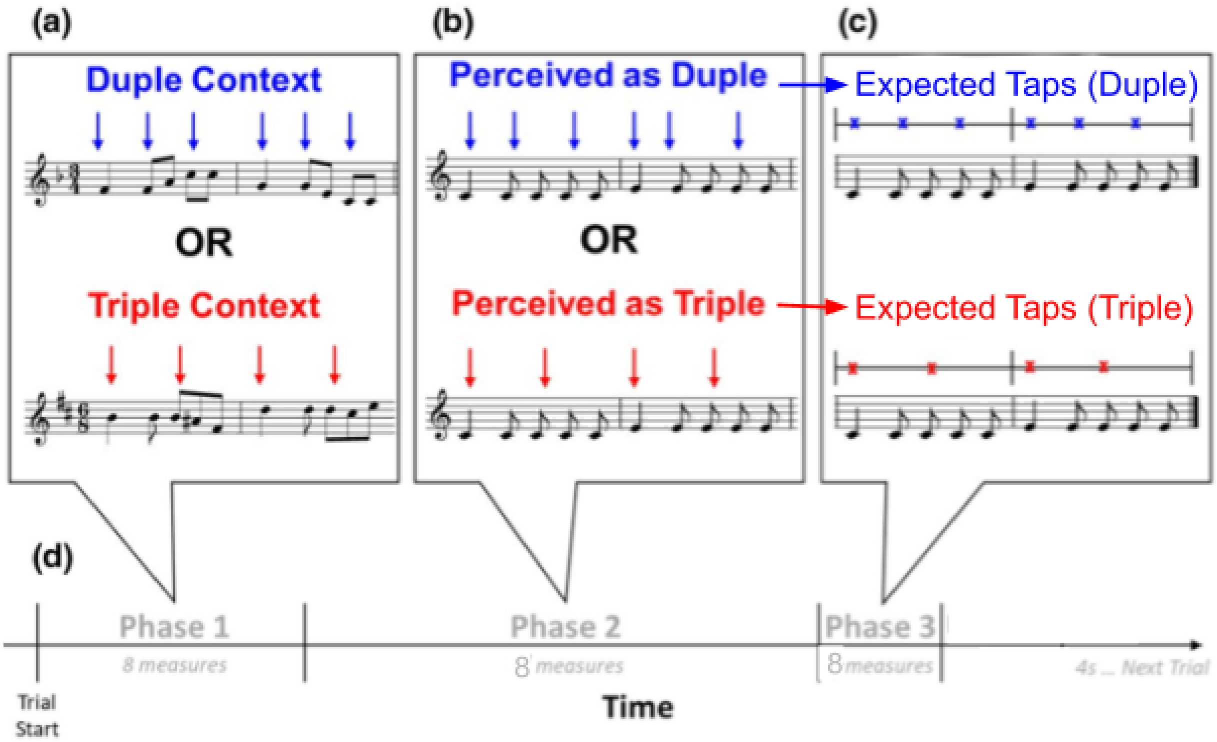
Perception Task



Note. Displays the events of the trials in the perception task. Arrows represent strong beat positions. (a) Context phase: example of an excerpt in duple meter (blue) or triple meter (red). (b) Ambiguous phase: example of where strong beats are depending on which meter is perceived. (c) Probe phase: example of drum patterns in either meter condition, “x” represents drum events at strong beat positions. Fig. 1 is a modified version of Fig. 1 of Nave et al. (2022)

Figure 2

Production Task



Note. Displays the events of the trials in the production task. Vertical arrows represent strong beat positions. (a) Context phase: same as Fig.1a. (b) Ambiguous phase: same as Fig.1b. (c) Tapping phase: example of where participant taps are expected. Horizontal arrows show which condition in the ambiguous phase is expected to result in each tapping pattern, “x” represents potential participant taps. Fig. 2 is a modified version of Fig. 1 of Nave et al. (2022)

Figure 3

Mean Scores of Task Performance by Stimuli Condition

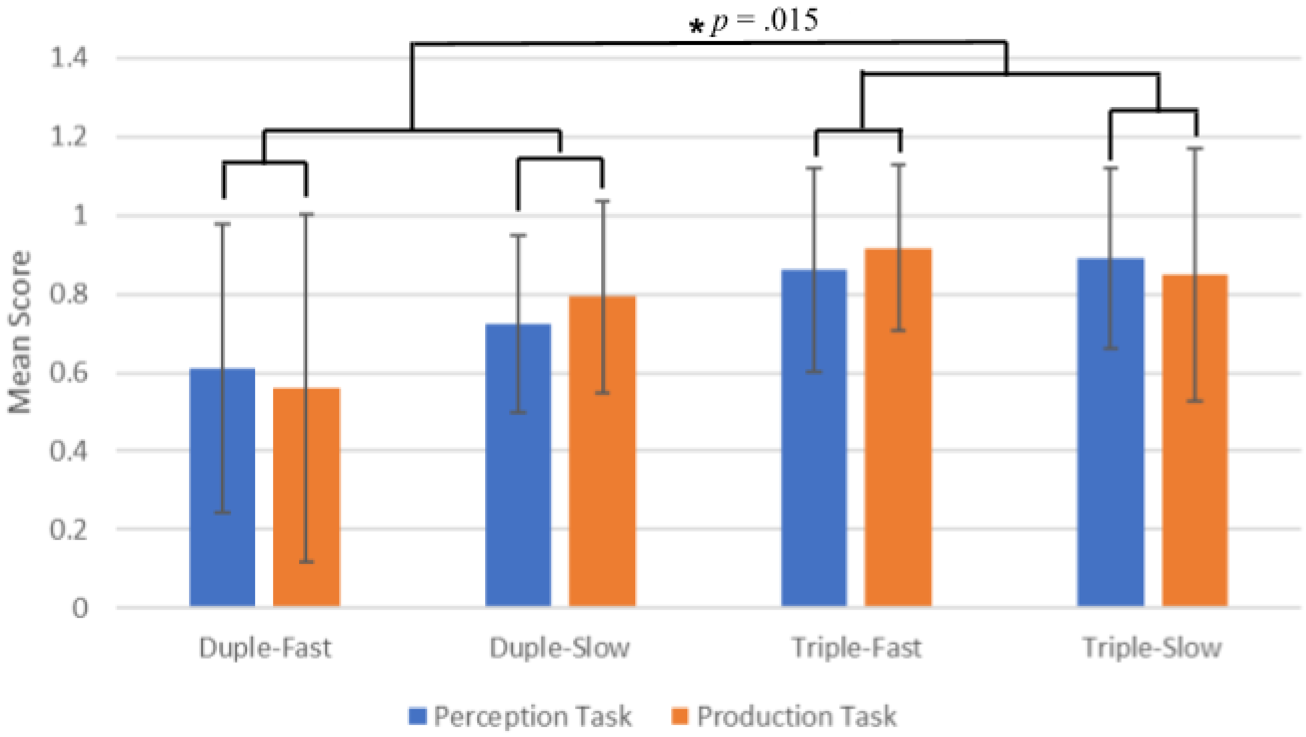
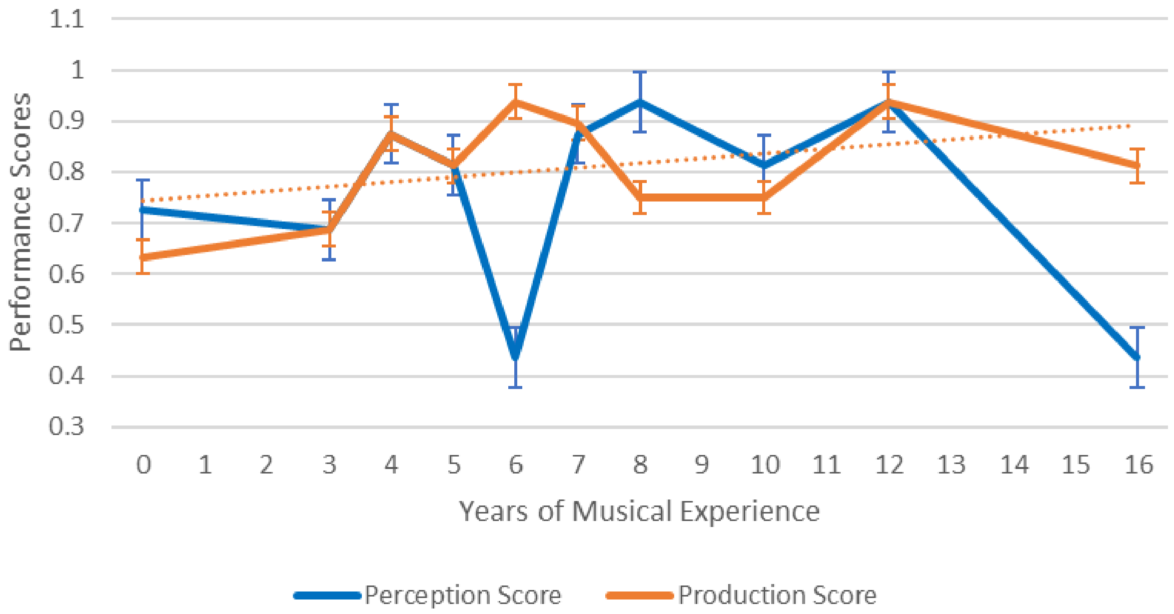


Figure 4

Task Performance vs Musical Experience



Note. Musical experience yielded a significant correlation with production scores but not perception scores. See Table 3 for values.

Tables

Table 1

2 × 2 × 2 ANOVA for effects between task, tempo, and meter

Cases	$F(1,17)$	p	η^2_p
Task	.04	.849	< .01
Meter	7.68	.013*	.31
Tempo	3.49	.079	.17
Task * Meter	< .01	.966	< .01
Task * Tempo	.03	.875	< .01
Meter * Tempo	3.59	.075	.17
Task * Meter * Tempo	1.27	.275	.07

*$p \leq 0.05$

Table 2

Descriptives for effects between task, tempo, and meter

Task	Meter	Tempo	Mean	SD
Perception	Duple	Fast	.61	.37
		Slow	.72	.23
		Total	.67	.20
	Triple	Fast	.86	.26
		Slow	.90	.23
		Total	.88	.24
Production	Duple	Fast	.56	.44
		Slow	.79	.25
		Total	.68	.26
	Triple	Fast	.92	.21
		Slow	.85	.32
		Total	.88	.23

Table 3

Spearman's Correlations for demographics and task performance

Variable		Music Experience	Dance Experience	Perception Task Performance	Production Task Performance
Music Experience	Spearman's rho	-			
	p-value	-			
Dance Experience	Spearman's rho	0.36	-		
	p-value	0.148	-		
Perception Task Performance	Spearman's rho	0.32	-0.01	-	
	p-value	0.201	0.961	-	
Production Task Performance	Spearman's rho	0.56*	-0.24	0.47*	-
	p-value	0.015	0.319	0.050	-

*$p \leq 0.05$

Table 4

Independent Samples T-Test for performance by order of tasks

	t	df	p
Perception Task Performance	-2.50*	16	0.024
Production Task Performance	-1.06	16	0.304

*$p \leq 0.05$

Table 5

Descriptives for performance by order of tasks

	Order	N	Mean	SD
Perception Task Performance	Perception first	10	0.69	0.18
	Production first	8	0.87	0.10
Production Task Performance	Perception first	10	0.75	0.18
	Production first	8	0.82	0.10

Table 6

Mean and SD of asynchrony

		Mean	SD
Fast Tempo	In range	0.16	0.03
	Out of range	0.16	0.12
Slow Tempo	In range	0.14	0.05
	Out of range	0.28	0.39