Tempo Perception Abilities and Their Differences in Musical Experts and Musical Novices

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Keywords: Tempo Perception, Music Perception, Expert Novice Effects

Abstract

This research sought to test for differences in perception of tempo changes between musical novices and musical experts. It was hypothesized that this study would support previous research that experts hear music in greater detail than novices (Smith et al, 1996). 18 Tufts University students were assigned to a group based on whether they had more or less than 2 years of formal music education. Participants listened to 70 audio clips produced in logic express and judged whether they increased in tempo, decreased in tempo, or did not change. Participants judged which type of tempo change had occurred after each clip and their judgments were later scored and analyzed. Data showed better overall performance for experts, better ability to detect tempo decreases than increases, and better performance toward the end of the study than at the beginning. Participants in both groups performed better in conditions with a drum track than those without a drum track.

It is no mystery that experience in any given discipline will improve performance. The nature of how experts accomplish tasks differently than novices has long been a topic of research. Blessing and Anderson (1996) showed that when people solve the same problem multiple times, the processes used to solve that problem undergo reorganization and allow for some procedural steps to be skipped. This enables the given task to be performed more quickly. In the above study the researchers had participants solve algebraic analogues using ambiguous symbols. Each problem could have anywhere from 1 to 5 steps that needed to be solved. Over the course of 200 presented problems, participants showed a decrease in average solving time. This decrease became larger as the number of steps needed for a problem increased. In addition, the participants were asked to think aloud while solving the problems to allow the researchers to monitor the number of steps they required to solve each problem. The data showed that the majority of participants learned to skip steps, and that when a step was skipped once, it was nearly always skipped again for the rest of the experiment. This study also demonstrated evidence of reorganization in the solving process as participants became experts at a given task. In many situations, however, this process takes too long to analyze in a conventional lab setting.

In music, the difference between experts and novices is complex and performance on specific tasks may take years to improve in a quantifiable way. However, some past research has been successful in demonstrating expert novice effects in the musical realm. Smith et al (1994) sought to test the perception of different tonal intervals among musical experts and musical novices. In this study, participants were asked to identify the intervals of a major third, minor third, and a perfect fourth after hearing them played on a keyboard. To ensure that results would not be due to the novice's improper orientation to the musical vocabulary, a "folk-tune" condition was also added. In this condition, the researchers chose three popular folk songs (*Kumbahyah, Greensleeves*, and *Here Comes the Bride*), each beginning with one of the tested intervals. Participants in this condition needed only to indentify to which folk song the interval belonged. The data showed that, although experts were able to better identify the interval in both conditions, novices in the folk song condition showed more competence in interval detection than those in the standard group. The researchers theorized that novices do not hear music in as much detail as experts. Instead of specific changes in tonal space, they might hear a melody as a contoured shape. Inherent knowledge makes it possible to distinguish changes in frequency but not the relative distances of many such changes. This introduces a problem with expert / novice effects in music: that is how much of novices demonstrated deficits are due to lack of knowledge or orientation, rather than lack of experience. The present research sought to test for expert / novice effects in an area of music that did not require such orientation to understand, the perception of tempo.

Dichotomous comparisons of higher or lower, louder or softer, longer or shorter, and faster or slower are fundamental discriminations in music, regardless of expertise (Duke, 1994). While research on expert / novice effects in tempo perception has not been extensive, previous research has made interesting discoveries about the way individuals hear and understand tempo. Kuhn (1974) showed that professional musicians were able to indentify decreases in the tempo of a metronome beat faster than increases. Participants also correctly identified more decreases in tempo than increases, but this result was not significant. In a later study however, Kuhn and Gates (1975) found that participants of six age groups had a tendency to speed up when asked to clap a rhythm previously presented with a metronome.

The present study aimed to apply the techniques of previous research to study contrasts between musical experts and novices, as well as increase the external validity of the results. Using a metronome to study tempo perception is useful, but music that people actually listen to is more complicated than a simple beat without instrumental accompaniment. Stimuli were composed and recorded by the researcher to avoid any frequency effects. This study expected to find that musical experts both detect tempo changes with higher accuracy than musical novices, and that they would be responsive to more minute changes in tempo. It was also predicted that participants within both groups would perceive decreases in tempo with a higher accuracy than increases. The last prediction was that both groups would perform better on trials with a drum track than on those without a drum track, and that novices would be more affected than experts.

Method

Participants

The participants in this study were 18 Tufts University students from 19 to 21 years of age. The students were recruited on a volunteer basis by email, text messaging, and were approached in the Tufts' Granoff Music Building. Participants were assigned to either the musical expert group or the musical novice group based on their completed years of musical education or study of an instrument. Participants with more than two years experience with either of these were classified as experts. There were 9 experts and 9 novices. The mean age of the participants was 20.22 years.

Materials

The materials used in this study were a PC with the programs SPSS and Quick Basic, the digital audio workstation Logic Express (Apple), and a MIDI/USB keyboard controller (Behringer UMX49). Also used in the study were the program iTunes and a set of Bose home computer speakers. The stimuli used for this experiment were 70 audio clips consisting of 2 or 3 tracks depending on the condition. In the drums condition, the clips consisted of a background piano or synth track playing simple triad chords, a lead piano or synth track playing mostly eighth notes, and a drum track. The drum track consisted of a bass drum playing quarter notes on all four beats, a snare drum playing quarter notes on beats two and four, and a high hat playing eighth notes.

Procedure

The 70 audio clips used as stimuli were recorded by the researcher in Logic. The five different MIDI sequences were recorded with the keyboard controller one track at a time. The tempo for each sequence was set to 100 bpm and the files were bounced into 10 m4a files (five files with the drum track and five files with the drum track deleted). Next, using the tempo event list and automation window, the tempo was manipulated to change in a linear fashion from the end of measure four to the end of measure eight. The ending tempo of each file depended on the condition the stimulus was made for. The three speed up conditions ended at either 104, 108, or 112 bpm. The three slow down conditions ended at either 96, 92, or 88 bpm. These files were then bounced to m4a files as well to provide the other 60 audio clips. The 70 files were placed in iTunes and made into a playlist with a random order (although this order was the same for each of the 18 participants). Once recruited, the participants signed the informed consent and were given instructions. They were instructed to listen to each clip and record (either on paper or using the PC via Quick Basic) the number one if the clip increased in tempo, two if it decreased, and three if there was no tempo change. The researcher allowed a short pause in between each clip to ensure the response had been recorded. After judging all 70 clips, the data was processed and analyzed using SPSS.

Results

Participants were able to correctly identify the change in tempo 70.79% of the time (M=49.56 sd=.076). As predicted, the expert group (M=53.67 sd=.034) performed significantly better than the novice group (M=45.44 sd=.057), $t(17)=5.32$, $p<.05$.

To measure for an overall difference in variance between groups across the seven conditions, two one-way ANOVAs were completed on the data. For the expert group, there was shown to be a significant effect of condition on amount of correct responses, $f(6,56)=31.04$, $p<.001$. For the novice group, the type of tempo change also has a significant effect on the ability to correctly identify the nature of the change, $f(6,56)=31.29$, $p<.001$

Similar to the data generated by Kuhn (1975), participants in both groups performed better on clips that decreased in tempo (M=22.77 sd=.094) than clips that increased in tempo (M=19.17 sd=.108), $t(16)=34.28$, $p< .001$. This effect was also observed within both groups. Within the expert group, t(8)=2.36, p<.05, the effect was present but was slightly stronger within the novice group, t(8)=2.98, p<.01.

In accordance with the hypothesis, experts were able to detect more minute changes in tempo than their less experienced counterparts. In the condition where the tempo increased by four beats per minute, experts (*M*=3.33 *sd*=.166) scored significantly higher than novices (*M*=1.44 *sd*=.113), t(8)=2.71, p<.05. The condition in which the tempo decreased by four beats per minute also saw a significant difference between the expert group (*M*=6.22 *sd*=.148) and the novice group (*M*=4.11 *sd*=226), t(8)=3.46, p<.01.

The position of an audio clip in the play list also affected accuracy. For both groups performance was better at the end of the study than at the beginning. Overall performance on the first 20 trials (*M*=12.93 *sd*=.073) was significantly lower than the overall performance on the final 20 trials (*M*=15.47 *sd*=.091), t(17)=, p<.001. This effect was present both within the expert group, t(8)= 5.62, p<.001, and within the novice group, t(8)=2.91, p<.01. For additional condition means and standard deviations, refer to figure 1.

The data also show a significant effect from the presence of a drum track. Participants were better able to detect tempo changes in trials that included a drum track (*M*=26.06 *sd*=.080) than in trials that did not include a drum track (*M*=23.54 *sd*=.086), t(17)= 4.44, p<.001. This effect was also significant within both the musical expert group, t(8)= 2.873, p<.05 and the musical novice group, t(8)=14.48, p<.001.

Discussion

As hypothesized, there was a difference between experts' and novices' abilities to correctly identify tempo changes. Musical experts showed evidence that some processes had undergone reorganization as Blessing & Anderson (1996) theorized. However, the results of this study show more than a simple difference between groups. Experts could identify more subtle changes in the stimuli. This heightened detection can help with error correction in musicians and allows avid listeners to notice subtle rhythmic expressivity that the untrained ear would fail to appreciate.

However, it is possible that other factors could have accounted for some of this effect. While recording the MIDI sequences, the velocity at which each note was struck was not held constant. Musical experts may have recognized these contours of velocity as common techniques, but musical novices may have been distracted by these changes and performance may have suffered. Conversely, a positive effect of varying velocity is an increase in external validity. Static key velocity would ensure participants were listening solely to changes in tempo, but musicians rarely hear or play music that behaves in such a way.

Another interesting finding in this study is the effect of the direction of the tempo change. Although this effect was demonstrated in previous research with musical experts (Kuhn, 1974), the present study provides evidence that this is present in musical novices as well. Experts' experience with rushing may account for the slightly larger effect in novices. Another unintended factor that may account for part of this effect is the order of stimuli. The order was chosen randomly before the first participants were run, but a large number of conditions that increased in tempo occurred consecutively. This may have caused participants to question their judgments, leading to fewer correct answers on trials with increasing tempo. Future research on this topic may involve presenting stimuli in several different orders to minimize this effect.

The presentation order in this study brought about an interesting effect. Participants within both groups improved performance significantly from the beginning of their sessions to the end. This could be attributable to increased familiarity with the task. If this were the case, the data would show the effect of increased experience within each group over the course of each session. However, this effect may have been attributable to something other than the treatment. For example, the occurrence of more clips that increased in tempo at the beginning could have accounted for this effect. Also, the lack of a model presented before the study began may have left some participants confused about the task they were to complete. Future research should include a model trial to be presented before the study to ensure participants are aware, that they should be listening for differences within clips and not between clips.

The last effect identified in the present study was the impact of percussion on tempo detection. Participants in both groups exhibited significantly better performance in trials that included a drum track than those that did not. This is understandable considering previous research has shown the reliance on a perceived beat in recognizing tempo (Kuhn & Booth, 1988). The drums in this study were held constant across conditions and different MIDI sequences. It may be interesting in future research to examine the effects of other meters and rhythms on both perceived beat and tempo perception.

In addition to varying the percussion track in future research, it would also be beneficial to examine tempo perception in other modes, such as vision. Similar results in such a study could yield evidence of a domain general construct that is responsible for all tempo and rhythm functions. If data from the visual conditions don’t show the same effects, this could indicate that distinguishing tempo in vision and hearing is governed by separate brain functions. This may also explain the helpfulness of a conductor’s baton movements in orchestral music, especially during pieces with variable tempos.

References

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Figure 1

Means (Percent Correct) and Standard Deviations

Condition	Overall		Experts		Novices	
	M	*sd*	*M*	*sd*	*M*	*sd*
Overall	.707	.076	.767	.034	.649	.057
Tempo Increase	.639	.108	.711	.087	.567	.075
Tempo Decrease	.759	.094	.804	.059	.715	.104
No Change	.761	.197	.822	.172	.700	.212
First 20 Trials	.646	.079	.687	.065	.605	.073
Last 20 trials	.774	.091	.825	.043	.722	.099
Drums	.744	.080	.797	.036	.692	.079
No Drums	.673	.086	.737	.055	.608	.057

Figure 2

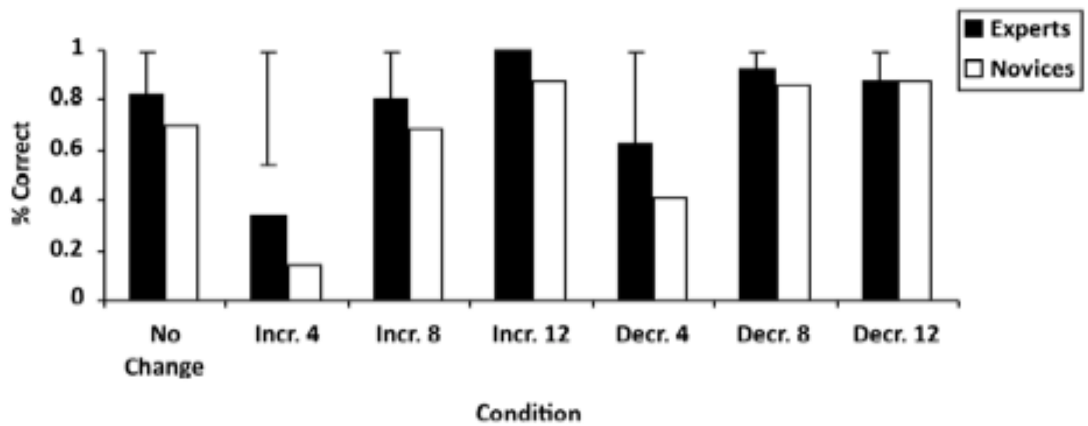

Figure 3

ANOVA

Experts

Score

	Sum of Squares	df	Mean Square	F	Sig.
Between Conditions	2.734	6	.456	31.038	.000
Within Conditions	.822	56	.015		
Total	3.557	62			

Novices

Score

	Sum of Squares	df	Mean Square	F	Sig.
Between Conditions	4.157	6	.693	31.293	.000
Within Conditions	1.240	56	.022		
Total	5.397	62			

Figure 4

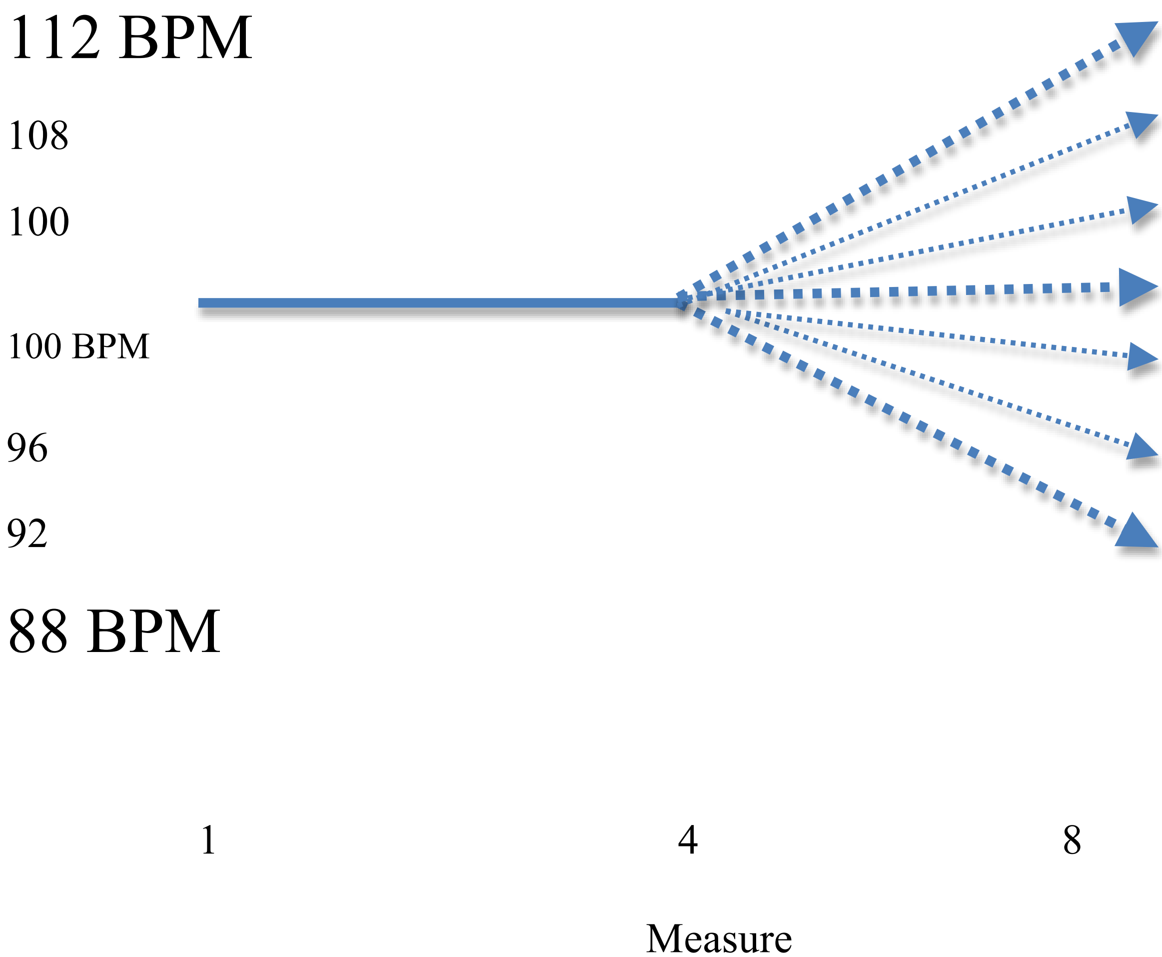

Figure 1. Table of means and standard deviations showing the average percentage of correct responses for each group over the examined conditions

Figure 2. Clustered bar graph of the data for each of the seven different tempo change conditions

Figure 3. ANOVAs tables representing the statistics associated with both the expert group and novice group

Figure 4. Graphical representation of the seven different tempo changes that occurred in the second four measures of each audio clip