Music 251 Final Project Report

Mengfan Zhang

Title: *The comparison between musicians' and non-musicians' sensitivity to note changes*

Abstract

Although pianists may change one or several notes from the score when they are performing, whether these changes are noticeable to the audience still needs to be explored. Previous studies showed that non-diatonic changes can be easier to detect by adults than diatonic changes. In this study, we extended this topic to musicians and non-musicians by comparing their note change detection abilities under several conditions. We performed melody discrimination tests which contain the melodies with a strong tonal center and a weak tonal center, where each type of the melody contains a chord note change or a non-chord note change. We hypothesize that for both musicians and non-musicians, the note changes in a melody with a strong tonal center would be easier to detect than the melody with a weak tonal center, and the non-chord related change is easier to detect than chord related change. Results show that the musicians have a better performance in all the note change detection tasks than the non-musicians. However, there are no significant performance differences between the tasks using melodies with a strong tonal center and the tasks using melodies with a weak tonal center. Moreover, musicians can easily detect non-chord note changes than chord note changes, while non-musicians show no significant detection differences between the two types of changes overall.

Introduction

Many studies have investigated people's sensitivity to melody changes. In previous studies, infants' and adults' sensitivity to changes in musical structure was compared by changing one note in a melody in two ways: a 4-semitone change remained within the key and implied dominant harmony, which is a diatonic change; or a 1-semitone change that went outside the key, which is a non-diatonic change (Trainor & Trehub, 1992). Each melody presented differed from the preceding melody in terms of key. Results indicated that adults can more easily detect non-diatonic changes than diatonic changes; however, infants have equal difficulty in detecting those two types of changes. Thus, there are qualitative differences in the ways adults and infants process musical information.

Researchers further explored the perception differences between infants and adults by studying the context effects. In Trainor & Trehub's (1993) study, the interaction between global context and local processing in infants' and adults' perception of melodic patterns was investigated. They performed tests using two types of melodies: a prototypical Western melody that was based on the major triad and non-prototypical Western melody that was based on the augmented triad. Just as in Trainor & Trehub's (1992) study, the melodies in Trainor & Trehub's (1993) study were transposed repeatedly. The transposition was either to related keys (standing in a 2:3 frequency ratio) or to unrelated keys (more complex frequency ratios). Results showed that both infants and adults could more easily detect melody changes in the context of related keys for the prototypical melody, while for the non-prototypical melody, infants showed better performance detecting changes in the context of related keys but adults showed better performance detecting changes in the context of unrelated keys. Therefore, the global context of auditory patterns influences the processing of pattern details for both infants and adults (Trainor & Trehub, 1993).

There are also many studies focused on the comparison of music detection abilities between musicians and non-musicians. Chiappe & Schmuckler (1997) studied musicians' and non-musicians' recognition memory for short, naturalistic melodies varying in their phrase structure. Results showed that musicians' recognition memory for melodies was influenced by phrasing echoes, memory for information preceding or subsequent to a phrase boundary was either disrupted or enhanced relative to memory in similar temporal locations but not containing a phrase boundary; while non-musicians, in contrast, showed no differences as a function of the phrasing of the melody. Micheyl et al. (2006) demonstrated pitch discrimination thresholds of the musicians were significantly smaller than those of the non-musicians. Rostami & Moossavi (2017) provided a physiological explanation for musicians having enhanced comodulation masking release and stream segregation than non-musicians. These comparison studies have revealed many cognitive differences between musicians and non-musicians, and many topics still need to explore more in the future.

Trainor & Trehub's (1992) study only focused on how people detect note changes in melodies with a strong tonal center, and only one kind of melody was used. It would be interesting to test how people detect note changes in different types of melodies. What's more, the difference between musicians and non-musicians is worth exploring. Thus, we decided to test musicians and non-musicians using melodies not only with a strong tonal center but also with a weak tonal center. For each type of melody, we designed three different kinds of melodies to test musicians' and non-musicians' performances. This comparison study will give us more insight into how musicians and non-musicians perceive note changes differently in various context conditions.

As our task is to compare the note change detection abilities between musicians and non-musicians, we hypothesize that the musicians are easier to detect note changes in melodies than non-musicians, so musicians will have a better performance in the note change detection task than non-musicians. Using two types of melodies - a melody with a strong tonal center and a melody with a weak tonal center - we suppose that note changes in melody with a strong tonal center are easier to detect than those in melodies with a weak tonal center for both musicians and non-musicians. Based on the findings in Trainor & Trehub's (1992) study, we assume that a chord related change in melody is harder to detect than a non-chord related change for both musicians and non-musicians.

Methods

Participants

We tested 12 subjects (4 male, 8 female) for our study. All of them are Stanford graduate students. Musicians' ages ranged from 22 to 24, with a mean of 23.17 (SD = 0.75). Non-musicians' ages ranged from 23 to 31, with a mean of 25.67 (SD = 3.01). Six subjects were non-musicians, specifically, people who have no music training experience (vocal, instruments, music theory, etc). Six subjects were musicians who have at least seven years of music training experience.

At the beginning, we tested 16 subjects in total. However, 4 of them were excluded from the final analysis. Some of them made too many mistakes due to the interruption of environment noise or being absent-minded during the test, and one non-musician was excluded because she has several month's guitar training recently.

Stimulus

Two types of melodies were used in this study: the 10-note melody exemplifying the rules of Western tonal music with a strong tonal center; the 10-note melody not following Western tonality rules with a weak tonal center. There were three different melodies for the first type. The first one consisted of the notes: C4 E4 G4 F4 D4 G3 C4 E4 D4 C4, where the subscripts represent the octave from which a note is drawn (C4 is middle C); The second one consisted of the notes: C4 C4 E4 G4 A4 E4 C4 D4 E4 C4;

The third one consisted of the notes: C4 A3 C4 E4 G4 G3 C4 B3 D4 C4. There were also three different melodies for the second type. The first one consisted of the notes: D4 A4 B4 G4 D4 G4 C4 A4 F4 A4; The second one consisted of the notes: E4 G3 B4 G3 D4 G3 C3 F3 E4 E4; The third one consisted of the notes: B4 D4 G4 F4 F4 G3 C4 A4 G4 E4. Each melody has a standard condition and change-typed conditions. Standard condition is the melodies described above. Change-types conditions include chord related changes, where the sixth note of the melody is changed to another pitch which goes inside the chord group of the original note, and non-chord related changes, where the sixth note is changed to the pitch which goes outside the chord group of the original note. Each melody under each condition is transposed to E Major key and Ab Major key with the original C Major key. Figure 1 shows examples of three conditions for a melody with a strong tonal center and a melody with a weak tonal center. The key of the melodies is C Major.

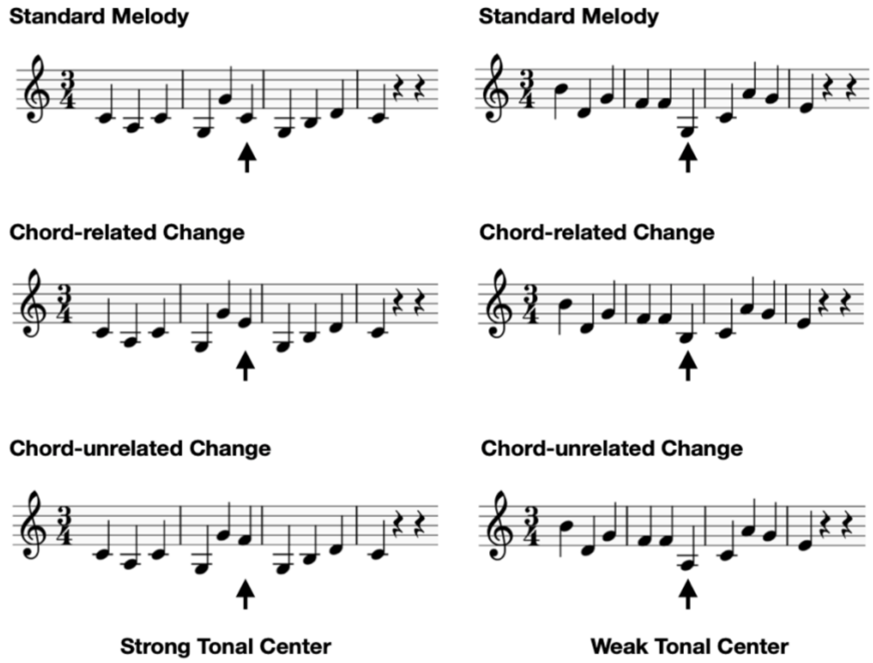

Figure 1. Standard and changed (chord related change and non-chord related change to the sixth note) melodies in C Major.

Each note had a duration of 0.5 seconds and there was a 0.5 second blank following the last note, so the length of each sequence was 5.5 seconds. All melody sequences were composed in MuseScore and were edited as MIDI format in Audacity. Audio files were in stereo, 16 bits, and 44100Hz sampling rate. All the experiments were performed in quiet rooms. Stimuli could be played through a loudspeaker or headphones and the loudness level could be adjusted by the subjects.

Procedures

The task was run on PsychoPy (Peirce et al., 2019), and the subjects were asked to judge whether there was a note change between two melodies in each trial. For each trial, a pair of melodies, one from the standard condition and another from standard or chord-related change or chord-unrelated change condition, were used, and the two melodies were in different keys. For each of the six different melodies (two types of melodies and each contains three different melodies), we used each melody in three conditions to make up six different pairs; thus, a total of 36 trials were performed in this experiment.

Figure 2 shows the diagram for our task timeline. The subjects could make judgements by pressing ‘left arrow’ key or ‘right arrow’ key for the different or same melodies they detected. The two melodies were in different keys, so the detection of change had to be based on relative rather than absolute pitch information. The reason we used relative pitch information was to force the subjects to make judgements based on context rather than on memory. After subject made a judgement for the present trial, the next trial automatically started.

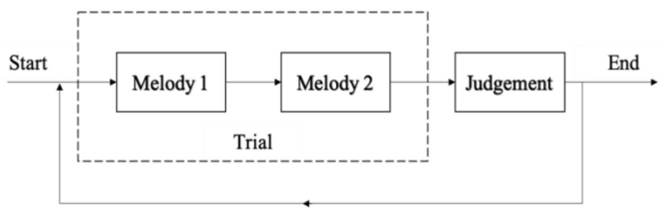

Figure 2. Diagram for the task timeline

Data collection and Analysis

Participants’ answers (yes/no) for all trials indicating whether they hear a note change between two melodies were collected during the experiments. The average precision of note change detection in all trials was calculated. ANOVA was used to compare the performance of musicians and non-musicians in all task conditions. The average precision of all subjects’ performance in melodies with a strong tonal center and melodies with a weak tonal center was also compared using ANOVA. The detection of chord related change and non-chord related change was analyzed using ANOVA and t-test.

Results

Comparison of Musicians and Non-musicians

Due to the long-term musical training experience, we expected that musicians' performance detecting note changes is better than that of non-musicians. To verify this assumption, we calculate the average precision of correct answers for note changes in all test conditions for musicians and non-musicians, and the results are shown in Figure 3. The average precision of musician group is 67.13% (SD = 6.19), and the average precision of non-musician group is 48.61% (SD = 6.52). The difference proved highly significant when tested using one-way ANOVA, $F(1, 10) = 11.94$, $p = 0.006 < 0.05$. Figure 4 illustrates the comparison of musicians' and non-musicians' average precision of correct answers for note changes in each test conditions. Musicians show a better performance than non-musicians almost in all the test conditions, except for the chord related change in melodies with weak tonal center, where musicians and non-musicians have equal average precision. Therefore, our hypothesis that musicians have a better performance in note change detection tasks than non-musicians has been supported.

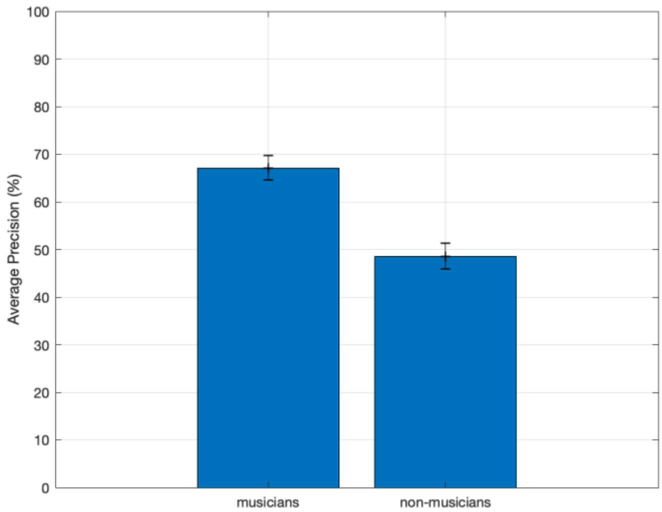

Figure 3. The average precision of correct answers for note changes in all test conditions for musicians and non-musicians

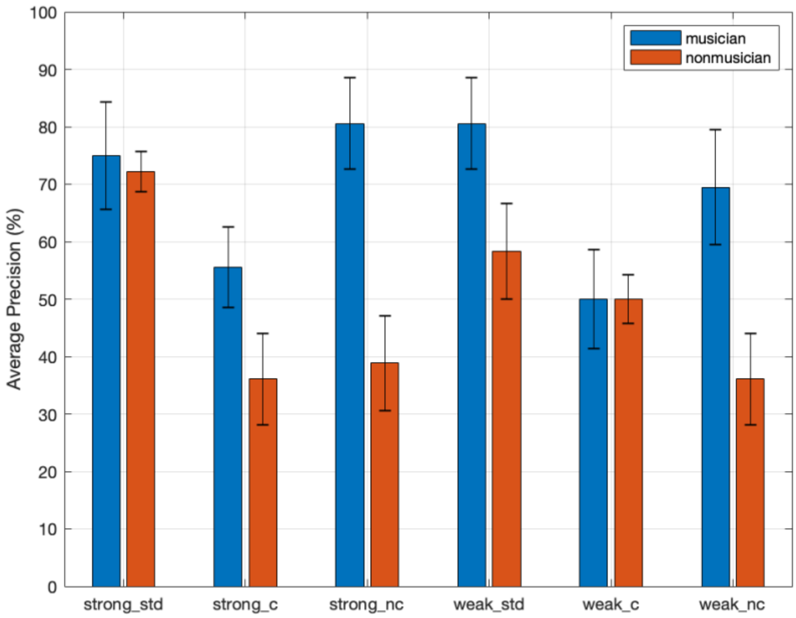

Figure 4. The average precision of correct answers for note changes in each test conditions

Comparison of Precision between Melodies with Strong Tonal Center and Weak Tonal Center

As melodies with strong tonal center exemplify the rules of Western tonal music, we hypothesized that note changes in melody with a strong tonal center are easier to detect than that in melodies with a weak tonal center. However, further inspection of Figure 4 reveals that the average precision of correct answers for melodies with a strong tonal center is similar with those with a weak tonal center for both musicians and non-musicians. This was confirmed by two-way ANOVA, with melody type (melody with a strong tonal center, melody with a weak tonal center) as a within-subject factor. The main effect of melody type is not significant, $F(1, 10) = 0.08$, $p = 0.787 > 0.05$. Additionally, the interaction between group and melody type is not significant, $F(1, 10) = 1.92$, $p = 0.196 > 0.05$. Thus, there is no significant difference between note change detection tasks using melodies with a strong tonal center and melodies with a weak tonal center for both musicians and non-musicians.

Comparison of Precision between Chord Related Change and Non-chord Related Change

Since notes in a same chord group have similar harmony effects and they are very "close" musically, a chord related change in the melody might be harder to detect than a non-chord related change. As shown in Figure 4, for musician group, the average precision of correct answers for chord related note changes is smaller than that for non-chord related changes; for non-musician group, the performance difference between the chord related note change tasks and the non-chord related note change tasks is not as large as musician group. We analyze precision of correct answers with two-way ANOVA, with change type (chord related change, non-chord related change) as a within-subject factor. The main effect of change type is marginal significant, $F(1, 10) = 3.46$, $p = 0.092 < 0.1$. The interaction between group and change type is significant, $F(1, 10) = 9.62$, $p = 0.011 < 0.05$. For musician group, precision for non-chord related change is significantly larger than chord-related change ($p = 0.016 < 0.05$); for non-musician group, the difference between chord and non-chord related change is not significant ($p = 0.418 > 0.05$).

In a supplementary analysis, the note change tasks in melodies with a strong tonal center and melodies with a weak tonal center are separated. For musician group, precision for non-chord related change is significantly larger than chord-related change in melodies with a strong tonal center ($p = 0.045 < 0.05$); precision for non-chord related change is larger than chord-related change in melodies with a weak tonal center but fails to reach statistical significance ($p = 0.201 > 0.05$). For non-musician group, the precision difference between chord and non-chord related change is not significant in melodies with a strong tonal center ($p = 0.822 > 0.05$); while the precision for chord related note changes is significantly larger than non-chord related note changes in melodies with a weak tonal center ($p = 0.042 < 0.05$).

Discussion

Our experiment shows that musicians have a better performance in note change detection tasks than non-musicians. For both musicians and non-musicians, there is no significant difference between note change detection tasks using melodies with a strong tonal center and melodies with a weak tonal center. Precision for non-chord related change is significantly larger than chord-related change for musicians, and for non-musicians, the precision difference between chord and non-chord related change is not significant. Moreover, there is an interesting finding that precision for chord related note changes is significantly larger than non-chord related note changes in melodies with a weak tonal center for non-musicians.

Musicians, who have at least seven years of music training experience in our experiment, showed a better performance in note change detection tasks than non-musicians. Just as in Micheyl et al.'s (2006) study, musicians demonstrated a significantly smaller pitch discrimination thresholds than non-musicians, our tasks measure the note change detection abilities and musicians show a significantly higher performance. Musicians, who have a long-term music training experience and involve in more musical activities than non-musicians, are more familiar with the relative pitch within the melodies. Therefore, musicians are more sensitive to the note changes than non-musicians who have no music training experience.

For both musicians and non-musicians, there is no significant difference between note change detection tasks using melodies with a strong tonal center and melodies with a weak tonal center. This demonstrates that the musical context is not an important cue when listener trying to detect note changes. Whether or not the melodies following the Western tonality rules, there is no significant enhancement or reduction to the note change detection performance.

Another finding of the present study is that precision for non-chord related change is significantly larger than chord related change for musicians, while the precision for chord and non-chord related change is not significantly different for non-musicians. The musicians have similar performance with the adults in Trainor & Trehub's (1992) study, but non-chord related changes in our task are harder to detect than the non-diatonic changes in their tasks, and this might be the reason that non-musicians show no significant difference between the chord and non-chord changes overall. Musicians having different performance in chord and non-chord related note change detection tasks may attribute to their long-term music training experience. For the changes violate Western musical structure (non-chord related note changes), musicians can easily detect them; while for the changes preserved Western musical structure (chord related note change), musicians have difficulty detecting them. Moreover, musicians show a significantly larger precision in non-chord note changes than chord note changes only in the melody with a strong tonal center but not in the melody with a weak tonal center, where they obtain a higher precision in non-chord note change condition but fail to reach statistical significant. This observation also demonstrates that the long-term music training experience makes musicians familiar with Western musical structure and easier to detect non-chord related note changes under this musical context.

One interesting result of our study is that precision for chord related note changes is significantly larger than non-chord related note changes in melodies with a weak tonal center for non-musicians. One possible explanation for this observation is that non-musicians have no music training experience, so they may make the judgement through guess. This phenomenon may be an accidental result but still need to explore more in the future.

Except some subjects did not perform well due to the environment noise or personal issues, the whole experiments went very well. For future research, studies about rhythm and pitch are related to our results (Krumhansl, 2000; Van Krevelen, 1951). Krumhansl （2000) demonstrated the relations between musical structure and perceptual and cognitive processes, which could be useful in the fundamental design of our experiments. Van Krevelen (1951) described the ability to make absolute judgments of pitch. We are really interested the performance of people who possess absolute pitch. Whether or not they will show different results in chord and non-chord related note change tasks. For future work, we will explore the note change detection abilities of musicians having absolute pitch.

Conclusion

In this study, we compare the note change detection ability between musicians and non-musicians. Results show that musicians have a better performance than non-musicians in all the test conditions. Both musicians and non-musicians show no detection difference between melodies with a strong tonal center and melodies with a weak tonal center. Moreover, musicians are easier to detect non-chord related note changes than chord related note changes, while non-musicians show no detection difference between the two types of chord changes overall. Therefore, this study makes a thorough comparison between the performance of musicians and non-musicians in note change detection tasks and will explore the performance of musicians having absolute pitch in the future.

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