Proceedings of the 7th Triennial Conference of European Society for the Cognitive Sciences of Music (ESCOM 2009) Jyväskylä, Finland
Jukka Louhivuori, Tuomas Eerola, Suvi Saarikallio, Tommi Himberg, Päivi-Sisko Eerola (Editors)

A New Method of Tonality Perception Research

Cong Jiang,*[1]

*Institute for Music, Martin-Luther-University Halle-Wittenberg, Germany
[1]conger108@yahoo.com

ABSTRACT

The methods used in tonality perception research are various, like counting the appearance rate of tonic, accumulating the duration of tones in a scale, the "probe-tone" technique, etc. However, the purpose of different methods is the same that is to try to build a model of tonality perception. The profiles of tones drawn from the above mentioned methods are quite similar. Theoretically, the cone model and tone hierarchy, the rare-intervals theory and the intervallic rivalry theory provide explanation for tonality perception processing. This study with a new method tries to explain the tonality perception from the priming effect view and tries to solve the conflicts between different theories. The results partially support the tonal hierarchy, and show that grade feature in the scale is important for tonal perception, but no rare interval effect is found; music background influences tonality perception.

I. Background

A. The Definition of Tonality

Tonality exists from the very early music till nowadays pop-music. It has passed through a long process from unconsciously usage to clear awareness for composition. From time to time (medieval, renaissance, baroque, classic, romantic, impressionism, and music in the twentieth century – based on the development of western music), from one culture to another (Western, Russian, Chinese, Japanese, Arabic, Indian, etc.), from one genre or style to another (Church or spiritual music, secular music, and nowadays Jazz, etc.), and even from the view of one musicologist or music theorist to another, it is an abstract concept to make a consistent definition.

The theory of tonality dates back to Jean-Philippe Rameau's(1722) Treatise on Harmony, in which he mentioned the chord progressions, cadences and structure. However, he did not use the term "tonality". And Friedrich Wilhelm Marpurg (1757), who was affected by Rameau a lot, also described the relationship between the notes and the tonic note.

Nearly a century later after Rameau, the terminology "tonalité" was first used by Castil-Blaze (1821), who named it as the "cordes tonales" (primary triads) including the tonic, the fourth (subdominant), and the fifth (dominant); and other tones were called "cordes melodiques". He did not make any clear description of the term "tonalité", however, he had separated besides tonic the fourth tone and fifth tone (which are the three important tones reflecting circle of Fifths from view of the modern music theory) apart from other tones in a scale, which was a progression from the time of Rameau and Marpurg.

The tonality was first defined by Fétis (1844) as " a set of relationships, simultaneous or successive, among the tones of the scale". This definition seems too general, but it presents the common essence of the so-called "tonality", and it can cover nearly "all types of tonalities". So this definition can be seen as the broadest sense of the term "tonality".

About thirty years later, Hugo Riemann (1872) raised a contrary view to Fétis's definition. He made his definition of tonality that tonal relationships established by means of the chordal functions of the tonic, the dominant and subdominant. This definition is similar to the view of Blaze, and its limitation is that it is not applicable for all kinds of music, only for the western music from the seventeenth century to nineteenth century or early twentieth century.

As the chord vocabulary enlarged and more variety of harmonic progressions emerged, tonality played more important role in music, and the knowledge of tonality was further developed. Till two music theorists Arnold Schoenberg and Heinrich Schenker, the theory of tonality was well elaborated. The two theorists were of different opinions, that Schoenberg emphasized "structural function", which is the tonal distance; while Schenker stressed expansion of horizontal relationships and graphical analysis, which is the cadence.

The tonal theory or tonality has been much clearer since atonal music appears. Many theorists deemed and agreed that tonality includes pitch classes, pitch sets, graphical analysis, which seems they combined the views of Schoenberg and Schenker together.

Therefore, in the theories of tonality we can see that the relationships between tones and the function of tonic play an important role to indicate the tonality. But how does the tonality present in a real music? It can be perceived by the appearance rates of tonic, dominant and subdominant, or rare intervals, or tonal closure.

In addition to the variety of tonality definitions, there are also confusions with other terms, like "scale", "key", and "mode". "Scale" is "an alphabetic succession of sounds ascending or descending from a starting note" (Associated Board of the Royal Schools of Music, 1958); "key" is "the set of notes on which a piece of music is built, each note having a definite relation to a note known as the key-note or tonic"; "mode" encompasses the usual diatonic scale but with a different tonic or tonal center, which is partly like "key". Scale focuses on the sequence, while the key or mode stresses on the relationships of tonic and other notes. In conventional music theory, tonality rests on the idea of scales and keys (Cross, West, Howell, 1991).

B. Current Theories of Tonality Perception

The theories on the perception of tonality are mainly tonal hierarchy theory and perceptual theory, including rare-intervals hypothesis and the intervallic rivalry theory.

1) Tonal hierarchy theory

The series studies with probe-tone technique, done by Carol L. Krumhansl and her colleges, set off a new upsurge of researching on perception of tonality. The tonal hierarchy theory describes the perceived stability of the hierarchical in the diatonic set. That is, in the major diatonic set, the most stable and consonant perceived tone is the tonic, then follows the fifth note of the ascending scale – the dominant, after that is the third – the mediant, the other diatonic notes follow behind, and the chromatic notes (not in the diatonic set) are the least stable and inconsonant ones. This forms a cone model to present the tonal hierarchy. It is always questioned about its static explanation.

2) Other two theories

The perceptual theory, proposed by Butler (1980), is based on the recognition of critical intervallic relationships – the "leading - tone" or "tendency - tone" successions within tonal music.

There are another two similar theories, one is rare-intervals hypothesis, and the other is the intervallic rivalry theory.

a. Rare-intervals hypothesis

The rare-intervals hypothesis, raised by Brown (1981), deals with the relationships between the tones in diatonic pitch set. Browne analyzed the characteristics of the diatonic pitch set – the appearances rate of different intervals. According to the appearances rate of intervals, the order from the unique one to the common one is as follows: tritone – once, minor second – twice, major third – three times, minor third – four times, major second – five times, and fine fourth – six times. So in the diatonic pitch set, tritone and minor second are considered as the rare intervals. These two rare intervals can be the distinctive features of a diatonic set. They can not only guide us to find out the location of the tonal center, but also tell us it is major-mode from other modes. However, the tonality perception is usually formed before "rare interval" appears.

b. The intervallic rivalry theory (a perceptual theory)

The intervallic rivalry theory (Butler, 1989) comes to solve the question above. It contains two levels of tonal context, one is non-temporal intervallic context within pitch sets, and the other is temporal relations of tones. The two levels consider both special and temporal aspects. The special aspect refers to the tone-relationships of pitch set, which is also mentioned in tonal hierarchy theory and rare-interval hypothesis; while the temporal aspect refers to the sequence of the tones (not only bound to scale sequence) in the music context. So this theory can explain the process of perception in actual music. Butler (1989) gave a precise interpretation of the progress of tonality perception, which is also called "position finding". It is a step-by-step way to find out the tonic, considering the relationship of successive tones and comparing with the rare-interval characters of major-mode.

C. The Research Methods of Tonality Perception

The studies on the perception of tonality explore the process of the perception. The purposes of these studies are to verify the musical theory, or to establish models of perception process, but less for the purpose of aesthetics. The methods used in tonality perception research are various, like counting the appearance rate of tonic, accumulating the duration of tones in a piece of music, the "probe-tone" technique, and also borrowing the methods from other relative researches, for instance the research of tonal closure

1) Probe tone technique

a. Probe tone technique with evaluation

The probe tone technique is the method for the tonal hierarchy theory. The process of probe tone technique is that listeners are given a music context first, either a scale or major triads, and then follows a test tone or chord, listeners are asked to evaluate how the tone or chord presented later fit with the former music context. The evaluation scale has 7 grades. Then the data analysis is based on the values of evaluation.

b. Probe tone technique with response-time measures

Nearly all the process is the same as the method described above, except the task for listeners. Listeners are asked to response as quickly and accurately as they can to judge whether the test tone or chord is in the same key of the given scales or chords. The response-time is collected to analyze.

No matter the task for subject is evaluation or "quick-accurate" response, the recency effect may exist in the procedure. Because some argued that the last a few tones work on the primary memory, which influences the tonality judgement; but others verified that a sequence with no expectation has little recency effect.

2) Durational weighting of tones / a tally of note durations (Hughes, 1977)

The tone profile was drawn according to a tally of note durations. The method of durational weighting of tones is as simply as counting the duration of tones in some piece of music. Hughes has done the job, and concluded that tonic lasts longer than any other tones in the diatonic set, the second-longest is fifth, and the third is subdominant.

Collecting the duration of tones is an interesting idea, and the coincidence of the result from such method with music theory can not be accidental, there might be more or less relationship between the function of tones and durations. However, when music is heard, can man calculate the duration of tones and compare the length of tones with each other? Or the longer duration would effect us more? The question here not only refers to the duration of tones, but may also refers to the rhythm.

3) Order of pitch selected from an excerpt

This method was used by Brown (1988) in his study. He used the tones that emerged in an excerpt of Schubert's Sonata, and reordered these pitches in three orders. Listeners were asked to judge the tonality of the three reordered notes. The result came out that the order of notes does influence the judgement.

4) From tonal closure view - indirect methods

The studies of tonal closure, although they do not focus on the perception of tonality, deal with the tonality coherence in a piece of work (Cook 1987, Thompson & Cuddy 1992, Karno &Konecni 1992, Tillman & Bigand 1996, etc.), like the cadence of phrases and movements, which are also the clues to separate music structures. The experiments were indirectly or directly designed for testing the tonal closure perception.The indirect way usually was asking subjects to rate a scale of feelings, like pleasure, melancholy or happy, passionate or calm, etc. Cook (1987), Karno &Konecni (1992), Tillman & Bigand (1996). The direct way was asking subjects to report the distance between the beginning key and ending key (Thompson & Cuddy, 1992), or between the tonality of original version and the one of transposed version, or asking subjects to rearrange the segments as a coherent music (Deliège, Mélen, Stammers and Cross, 1996). These methods can serve for musical structure studies, and also useful for tonality perception research.

II. Aims

Although the research on tonality perception lasts for years, there is no satisfied theory that can clearly explain the process of tonality perception. This study tries to follow the former researchers to keep studying with a new method considering priming effect, and tries to explain the process of tonality perception more dynamically, and at the same time tries to solve the conflicts between the early theories and to compare the difference of listeners from different music background.

The hypothesizes are follows:

1) because of the stronger tonal function of tonic and dominant in comparison to other tones, these tones should arouse relevant keys faster than tones of other functions;

2) according to rare-interval theory, rare intervals should arouse relevant keys faster than other common intervals;

3) tones or intervals that are common to many keys should arouse relevant keys faster than those common to only a few keys;

4) intervals would get faster response than single tone because they can provide more precise information of tonality;

5) subjects learning western instruments would have better performance than ones learning traditional Chinese instruments.

III. Experiments

A. Participants

Participants were 4 undergraduate students, 9 graduate students from College of Music, Capital Normal University, and a doctor student from Beijing Normal University, China. All of them now are majoring in musicology and have studied instruments for at least 7 years, five among them have studied for more than 15 years. Five of them play traditional Chinese instruments, who are considered as non-western music background learning non-western music in non-western country; others play western instruments, including piano, clarinet, guitar and percussion, who are considered as quasi-western music background learning western music in non-western country. Futhermore, all of them studied western music theory at classes.

B. Materials

The materials used in the experiments can be divided into two forms: one is MIDI file of test tones and scales made by Sibelius 5. The length of the tones (500ms) and the tempo of the scales sequence (120bpm with sixteenth notes) were set. The other is a track from CDs (see the references, only piano works were involved). Both forms were transferred into wav file for the experiments programming by software Presentation.

C. Design

This is a with-in subject design, which means all the participants take all the trials.

The test stimuli are divided into three categories: single tone, interval and chord. In this paper only the already-done experiment of single tone and interval is going to be reported.

The given context includes two conditions: color-square with a tone as tonic (orange for major, purple for minor, taking the accompanied tone as tonic) and music. The color-square was used to try to let participants imagine the mode freely, but not exactly followed the scale. The relationship between the color-square and mode was learned before the test.

The task was to make judgement whether the test single tone belongs to the context or not, and there were three possible answers: Yes, No and Not Sure.

Unlike the former experiment, in each trial the test tone(s) came first, then followed by the context, the respond should be made after the context. As for test stimuli - single tone, each tone was presented for 250 ms, then followed with a color-square with a tone, which worked as a trigger to lead participants to imagine relative tonality, or an excerpt of piano music. For example, the test single tone is C, the following context is orange square with G, then the subjects should imagine G major; or the following is a music in G major. C belongs to G major, so the response should be Yes. However, when the following context is purple square with B, then the subjects should imagine b minor. C doesn't belong to b minor, so the response should be No. (Sequence of each trial see Figure 1) The tonality could be imagined quite freely as participants like, but not based on the scale.

The contexts involved all the possibilities that the test single tone could belong to, which means the test tone could be I, or II, or III, ...or VII in the context's tonality. Besides, there was also incongruence between the test tone and the context, which means the test tone is out of the context's tonality. Incongruency condition was used for detecting sensitivity. The ratio of congruency and incongruency of test tone(s) and context is about 5:1.

And the trials were grouped according to the context. That is, there were three groups, one was with orange square and a tone, the other was with purple square and a tone, the third

was an excerpt of music. In each group, trails were randomly ordered.

Considered of SOAs for psychoacoustical priming or conventional and short memory, duration between the test tone and the context was controlled in 650ms. Between trials, there was 250ms white noise to avoid or reduce the impact from the former trials. The speed and accuracy of responses will be recorded.

As for test stimuli - interval, only two intervals were involved, one was pure fifth, the other was augment fourth. The context was mixed the color-square and music together, but no longer tested in a separate group. The trials were grouped according to the intervals. That is, there are two groups, one was of pure fifth, the other was of augment fourth. The intervals were presented successively either ascending or descending. The sequence of each trial was as the same as the single tone's. In the interval trials, no incongruency condition was involved.

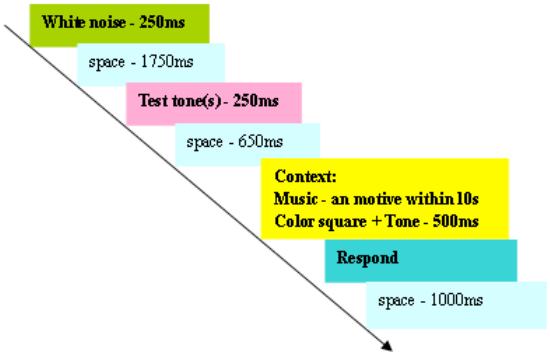

Figure 1. Sequence of each trial

The experiment is programmed by Presentation 0.71.

D. Procedure

Before the experiment, participants were asked to do some practice, from which they could learn the relationship between a color square on the screen and mode (orange - major, purple - minor). This would be used in the later experiments. In the practice, orange square accompanied with ascending or descending major scale, purple square accompanied with ascending or descending minor scale, but the keys were different from each other.

Then came to the pretest, in which the process was quite similar as the formal experiments, three context-conditions were shown. Participants were asked to read the instructions carefully, to get to know the task, and to get familiar with the responding keys for judgement (on the mouse and the keyboard). They should respond as quickly and correctly as possible after the context shown.

In the experiment, single tone with each context condition consisted of 25 trials, which were randomly presented. Major condition came first, then followed minor condition, then music condition. The two intervals with mixed context conditions. The pure fifth with mixed condition consisted of 22 trials, and the augment fourth with mixed condition consisted of 10 trials. The task was same as in the pretest, and the new trial began until the respond to the former trial was made. There was 2 minutes pause between each group. (Sequence of the experiment see Figure 2)

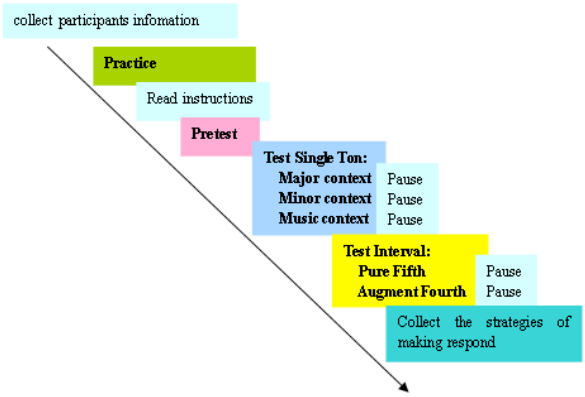

Figure 2. Sequence of the experiment

IV. Results

The results here relate to the hypothesis, mainly around these issues: 1)analyse the sensitivity index d'; 2) differences of accuracy and reaction time among grades within scales and modes; 3) differences of accuracy and reaction time between common interval and rare interval; 4) differences of accuracy and reaction time to single tone and intervals; 5)accuracy and reaction time differences between music background.

1) Signal detection Analysis

In the three conditions of single tone, the sensitivity to major condition (d'=2.07) is higher than to minor (d'=1.81) and music condition (d'=0.92). There's no significant difference among the sensitivity in the three conditions, so the sensitivity of the participants were relatively stable.

2) Accuracy and reaction time difference among grades within scales and modes

The results does not reflect the same hierarchy as the ones by former researchers (Krumhansl, 1986; etc.). From figure 1 we can see that, in major context, the reaction time to tonic is the shortest, followed by II, VII, V, VI, III, IV; in the minor context the result is quite same as in major, the response to tonic is the fastest, followed by II, VII, V, IV, III, VI.

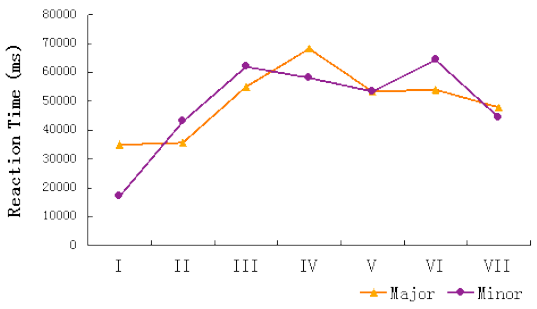

Figure 3. Reaction time to single tone in major and minor graph context

While the reaction time in the music context is longer than the major and minor context, and the profile differs too. II instead of tonic shows the fastest response, followed by V, VI, I, IV, III, VII.

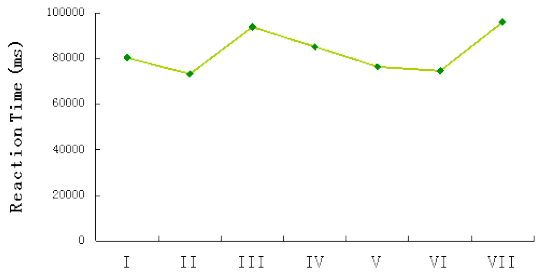

Figure 4. Reaction time to single tone in music context

As for accuracy to each grade, the profile is more similar as the profile of tonal hierarchy. In major context, the tonic gets highest responds, then follows V, IV, II, VI, VII, III; in the minor context, tonic is also easier to make correct judgement than other tones, the following tones are V, IV, II, III, VI, VII, though their accuracy is quite similar with each other. While in the music context is a little bit difference that V gets more accuracy than others, and IV, III, II, VII are even better than I and VI.

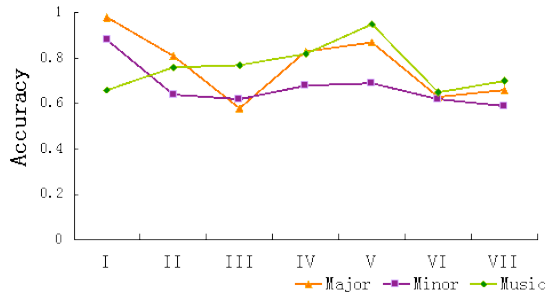

Figure 5. Respond accuracy to single tone in major, minor and music context

3) Interaction or main effect of grade and mode

Comparing the reaction time in major context and minor context, there is no interaction between grade and mode, ($F=0.818$; $p=0.556$). The main effect of mode is also not significant ($F=0.054$; $p=0.817$); while the main effect of grade is significant ($F=5.378$; $p=0.000$). In the post hoc multiple comparisons it reports that tonic has significant difference between III ($p=0.013$), IV($p=0.002$), VI($p=0.01$), but has no significant difference with V, II, VII, nor do the other grades and their between.

4) Accuracy and reaction time difference between intervals

Comparing the reaction time to pure fifth and augment fourth, in either pure fifth condition ($p=0.246$) or augment fourth condition($p=0.728$), there's no significant difference between reaction time to the two direction (successive ascending and descending) intervals. There is no significant difference between the response time to interval pure fifth and interval augment fourth ($p=0.737$).

As for the accuracy, participants did better in pure fifth with major context.

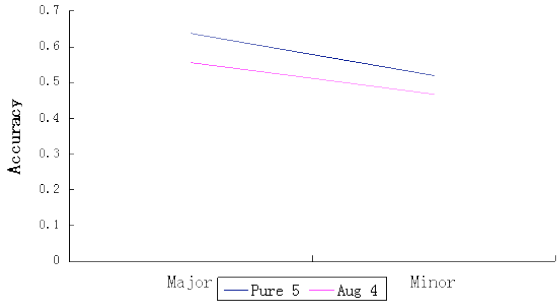

Figure 6. Respond accuracy to interval pure fifth and interval augment fourth in major and minor context

5) Difference between music background

Comparing the reaction time of students with different music background. There are only two significant differences between the student of quasi-western music background and non-western music background. One is that their reaction time to the tonic in major and minor context are different ($F=7.059$; $p=0.01$) ; the other is their reaction time to pure fifth and augment fourth are different ($p=0.000$).

V. Discussion

A. About Methods

The obvious feature used in the experiment is the early appearance of the test tone(s). To do so is considering the process of tonality perception. From the former studies, it is known that subjects can form the tonality perception within few notes or bars. Most experiments are done with post-test tones after a context, so the result can only show the already-built tonality perception, and find the relationship between the post-test tone and the former context. Thus, this procedure is much suitable for the tonal function research of tones or interval, rather than the process of tonality perception, because it is not so directly. How about the verse sequence of the text tone and the context? That may more direct to get to the way to the tonality perceiving.

Considering the studies in priming effect, including direct priming effect and indirect priming effect, it seems that they are the possible way to solve the inversion problem mentioned above. Take the test tone(s) as a priming stimuli, which has the similar tonal information that would be presented in the later context, then it would arouse the relative tonalities. So the task could be tonality recognition. However, with the musical terminologies, the recent experiments are only done with people who have music knowledge.

The test tone can involve single note, intervals and chords, and the given context is now mainly refer to western music system (major and minor mode). However, if all the tonalities that one test stimuli could arouse and the sequence of

successive intervals and chords were considered, this study would be a huge project.

B. About Results

From the results, it concludes in following aspects:

1) The profile of accuracy to the seven grades in major, minor, and music contexts is basically congruent with the profile of tonal hierarchy, so the result of this study can be reliable.

2) Although the profile of accuracy has congruency with tonal hierarchy, the profile of reaction time is quite different. Tonic in both major and minor context shows faster responses, and has significant differences to other tones. The two notes around tonic: II and VII take the place of tonal-functional tones, like V, IV and III. It is hard to say that whether II and VII play important roles in a tonality, because this result may be influenced by the task in the experiment. In the experiment, participants were triggered to imagine the relative scale by a color square, they could sing the scale ascending or descending by heart and responded whether the former test note belonged to the triggered scale or not.

In this case, I is always sung at the beginning, no matter what the mode would be; II and VII are the nearest note to the tonic, which could be sung next to in the scale, while III and VI are a little further from tonic, IV and V are the latest to appear in the scale. This recency effect should be avoid in the further experiment.

3) In the real music context, participant did not need to compare the scale in their mind, so the "scale sequence effect" is almost disappeared, while the reaction time took longer than in scale context. The responds to V, VI, II and I are relative faster than to IV, III and VII. The rapid response to I, V, VI, II reflects that they are taking more stronger tonal function than others in the real music, so that subjects could faster recognize that they belonged to the presented tonality in music. While VI, III and VII were recognized slower, so they are considered as unstable tones in the scale and they need to resolve to the stable ones which present the tonal function. Another possible reason for the slower respond to them maybe that they are not so impressive that are less used in the musical pieces. When they are not stressed in the music, it would be hard to catch their features. However, there is no significant difference between the seven grades recognition in the music condition.

4) There is no interaction between grade and mode, mode has either no significant main effect on the response, only grade has the significant main effect, especially the tonic is superior to others. It verifies that the character of each grade takes an important role in tonality perception.

5) The two intervals involved in the experiment are the first step about the interval studies. Buttler(1989) concluded that rare intervals can be an important elements for tonality perception, if so they could arouse the tonality recognition faster than common intervals. However, this study does not verifies this conclusion. There is no significant difference between the reaction time to pure fifth and augment fourth, and even subjects did correctly in pure fifth context than augment fourth context. Faster respond to pure fifth may because of its common appearance in the scale. If subjects compare the test pure fifth, there are many reference of pure fifth in the scale, if the test one fit any of them, the respond could be confirmed, and the ratio of accuracy could be higher. While augment fourth is seldom in major and minor, subjects should fit them with exact information and then make response, the correct ratio is lower than pure fifth. Thus, augment fourth gets lower accuracy than pure fifth.

Intervals direction does not influence in reaction time.

6) As for music background, it presents significant difference of two group participants in reaction time to mode and intervals. Chinese music is featured of pentatonic, though there are also fourth and seventh in the scale, which are less functional as the ones in western music and different from them in temperament. So the students playing Chinese instruments are less "adaptive" their ears than the students playing western instruments.

In conclusion, tonal hierarchy is partly verified in accuracy aspect; the result does not support the idea of rare intervals, which can be further concluded that complex possibilities of appearance in different tonalities may not influence the tonality perception; grade functional characters is an essential elements for tonality perception; music background influences the toanlity perception.

C. About Further Studies

In this study, there are some problems that should be avoid or solved in the further studies. One is the "direct priming effect" that not only lets the subjects face to the serious and professional task, but also excludes the non-musical subjects; the other problem is the "recency effect" that may influenced the judgement a lot. So, in the further studies, indirect priming task will be taken into account and trying to do the experiment with non-musical trained subjects, and keep verifing the hypothesis raised in this study.

References

Butler, David.(1989). Describing the Perception of Tonality in Music: A Critique of the Tonal Hierarchy Theory and a Proposal for a Theory of Intervallic Rivalry. *Music Perception*, 6(3), 219-242.

Butler, David.(1990). Response to Carol Krumhansl. *Music Perception*, 7(3), 325-338.

Butler, David, & Brown Hellen.(1994). Describing the Mental Representation of Tonality in Music (pp191-212). In Aiello, Rita, & Sloboda, John (Eds.). *Musical Perceptions*. New York: Oxford Univ. Press.

Cook, N. (1987). The perception of large-scale tonal closure. *Music Perception*, 5, 197-206.

Cross, I., West, R., & Howell, P. (1991). Cognitive Correlates of Tonality (pp201-243). In Howell, Peter(Eds.). *Representing Musical Structure* . London: Academic Press.

Deliege, I., Melen, M., Stammers, D., & Cross, I. (1996). Musical schemata and real-time listening to a piece of music. *Music Perception*, 14, 117-160.

Fétis, Joseph. (1879). Traité complet de la théorie et de la pratique de l'harmonie contenant la doctrine de la science et de l'art. Paris: Brussels.

Heather McCartney (1999). The Perception of Large-Scale Tonal Closure. http://www.mus.cam.ac.uk/~ic108/PandP/McCartney99/McCartney99.html

Janata, Petr, &Reisgerg, Daniel.(1988). Response-Time Measures as a Means of Exploring Tonal Hierarchies. *Music Perception*, 6(2), 161-172.

Karno, M.,& Konecni. V.J. (1992). The Effects of structural interventions in the firstmovement of Mozart's Symphony in G Minor, K 550, on aesthetic preference. *Music Perception*, 10, 63-72.

Kölsch, Stefan. (2000). *Brain and Music: A contribution to the investigation of central auditory processing with a new electrophysiological approach.* Leipzig: Druckerei Risse.

Krumhansl, Carol L. (1990). Tonal Hierarchies and Rare Intervals in Music Cognition. *Music Perception*, 7(3), 309-324.

Krumhansl, Carol L. *Cognitive Foundations of Musical Pitch.* New York: Oxford Univ. Press, 1990.

Marvin, E.W. &Brinkman A. (1999). The Effect of Modulation and Formal Manipulation on Perception of Tonic Closure by Expert Listeners. *Music Perception,*16(4), 389-408.

Sadie, S., Tyrrell, J., & Grove, G. (2001) *New Grove Dictionary of Music and Musicians.* London: Macmillan, Vol. 25.

Tillmann, B., & Bigand, E. (1996). Does formal musical structure affect perception of musical expressiveness? *Psychology of Music,* 24, 3-17.

Thompson, W.F. & Cuddy, L.L.(1992). Perceived key movement in four-voice harmony and single voices. *Music Perception*, 9, 427-438.

Zhu Ying. (2000). *Experimental Psychology*. Beijing: Peking Uni. Press.

CD Files:
Schubert- Piano Sonata D960, D894;
- Moment musical in Fm D780-3, Op94-3;
- Impromptus, D 899 & D935
Schumann- Humoresque: Sonata in F sharp minor
- Davidsbündlertänze, Sonata No. 2, Toccata in C
Haydn- Les 11 Sonates Piano.
- Sonates Hob. XVI-34, 32, 42.
- Fantaisie Hob. XVII-4. Adagio Hob. XVII-9
Mozart- Piano Sonatas
- Piano Variations Rondos Etc
Grieg- Piano Concerto. 6 Lyric.
- Piano Works

.