In Which Direction is Music Heading?

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Cultural and Cognitive Studies in Turkey

Edited by

Firat Kutluk and Ugur Turkmen

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PREFACE

How should a 30 year-old handle a mid-life crisis? Mine was not difficult to overcome, but it left me with new habits of making and listening to music. My changing musical preferences were actually reflecting my changing identity. I was shocked when I played Richard Marx's "Now and Forever". I told my friends about this experience and realized that they don't have such problems. It was becoming hard to listen to Mozart or the masters of the Romantic era, and I was drifting far away from Queen, but I couldn't explain myself.

This was the first time I found myself so close to the problem of cultural elitism. When I met people, including academicians, who classify musical genres by their values, I thought of doing a study using some kind of lie detector that can identify music genres which are liked. Of course, I still haven't succeeded because there is no software that can measure musical tastes! Nevertheless I discussed these issues with people in other fields, asking what is going on in our brains when we listen to music, what brain regions become active when we listen to music we do or don't like? We have tried to answer these questions from a multidisciplinary perspective using various fMRI and EEG studies, but I have to say that after about seven years we're still at the beginning in this regard, and not just us: the same is true all over the world.

This book contains four chapters and eight articles. Asli Galioglu and friends focus on tonality, investigating differences in the brains of musicians and non-musicians by analysing EEG signals while participants listen to tonal and atonal chords. They employ a cognitive scientific and ethnographic approach in their research on brain responsiveness to look at how positive or negative feelings are evoked by music.

Alev Sezer and friends assess the psychometric properties of the Turkish version of the Music Performance Anxiety Inventory for Adolescents (MPAI-A). Their results indicate that this kind of psychometric instrument can be of great use in surveying performance anxiety and determining its severity in adolescent musicians.

In the late 1990s, Turkey witnessed a spate of shocking murders and suicides involving young people. Society and the media described these events in terms of "Satanism". Yasemin Ata and Firat Kutluk investigate the social period in question, with the help of theories about moral panic, questioning the perceptions of Turkish society regarding metal music and determining the stereotypes held about its audience.

Another study of metal by Aykut Baris Cerezcioglu examines gender codes within the global extreme metal scene and discusses the practices of Izmir's metal scene in the context of gender roles.

Okan Murat Ozturk takes a critical approach to the conception of "contemporizing music" in the founding ideology of Early Republican Turkey. He questions the "sacred narrative" of the Republic, which was established around the figures of Ataturk and Ziya Gokalp, and explores the intellectual and ideological background of the Second Constitutional and Early Republican eras. In this way, he illustrates the process in terms of a project to change civilization, drawing attention to the hegemonic rhetoric of contemporization found in Westernist and Turkist ideology.

In his paper entitled "A Change of Perception: The Rapprochement of the State with the Cultural Colours of Anatolia through Traditional Musics", Cenk Guray discusses why the Turkish state's attitude towards the multicultural structure of Anatolia has changed during the last decade, coming to consider it a cultural treasure rather than a source of anxiety as before.

Suat Vergili and friends examine the changes and activations that reverberation time differences generate in the human brain, focusing on the auditory cortex. It has been observed that there are significant activation differences in the auditory cortex in both hemispheres with reverberation time changes.

Barbaros Bozkir focuses on how Turkish musicians identify the meaning of the term "sound". Beyond the physical meaning of sound, the terms relating to sound given by musicians determine the course of this study.

All the authors in this book are my friends, and I apologise unreservedly for terrorizing them, especially over issues relating to timing, guidelines and editing. I want to thank them all for accepting my call and sharing their radical works. I am honoured participate with them in this study.

Firat KUTLUK
Izmir, December 2014

CHAPTER ONE:

COGNITIVE STUDIES

Brain Responsiveness to Tonal and Atonal Chords: An EEG Study

Asli Galioglu, Cagdas Guducu,
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Cognitive musicology studies: an interdisciplinary approach

In the current literature, cognitive musicology studies have been based on the structural and functional responsiveness of the brain to affective states of joy, sadness, happiness, excitement, hate, likes, expectations, etc. The design of these studies has frequently involved various perception combinations related to tonality, tempo, rhythm, timbre, pitch and interval (consonance-dissonance, preference-expectancy, etc.) together with the subjects and aims specified above. In studies carried out on healthy individuals, participant reactions in terms of musical perception, memory, attention and performance are interpreted in relation to structural, emotional and expectation-based responses.

Besides the different methods used, research on music yields various results related to the responses and contexts studied (Brattico et al., 2010; Amemiya et al., 2014; Bidelman and Grall, 2014; Li et al., 2014; Virtala et al., 2014; Schaefer et al., 2011; Vuust et al., 2012; Varlamov et al., 2011; Pantev et al., 2001). Studies investigating structural and functional differences in the brains of musicians and non-musicians by analysing various topographic maps that develop in the brain during the process of listening to or performing music are still in progress (Schlaug et al., 1995; Zatorre et al., 1998; Keenan et al., 2001; Amunts et al., 1997).

The functional processes evoked in the brain by music can, to an extent, be determined by various brain imaging techniques such as functional magnetic resonance imaging (fMRI), positron emission tomography (PET), electroencephalography (EEG) and magneto-encephalography (MEG).

The steps involved in researching and analysing results obtained in the field of neuromusicology necessitate the collaboration of various disciplines. In neurological and psychological studies on music preference or the effect of music on individuals, feelings have a more dominant role than cultural effects. Most of the studies focus on the positive or negative feelings evoked by music. The problem with these studies is that in the classification of stimuli presented to participants, tonal music is defined as a pleasant stimulus and atonal music as an unpleasant one. While stimuli that individuals are presumed to like are chosen from among well known favourite pieces of classical music, those that are presumed to be disliked are purposely manipulated and played in a deliberately polytonal style.

In studies carried out by Calli and Tezel in 2011, the effects of tonal and atonal music at the level of both chord and sections of music were investigated by fMRI. Although individuals were not regular listeners of classical music, they reacted negatively to atonal music and preferred tonal music. This finding supports the theories that individuals internalize tonal rules through passive exposure to classical tonal music (Bigand, 1997; McDermott and Hauser, 2005; Peretz, 2001) and that listeners familiar with classical tonal music typically show an immediate reaction to dissonance even if they have not received any education in music (Blood et al., 1999). Another theory related to the inclination of a typical person to prefer tonal music is that it has to do with overtones. Considering the general results of these two studies (Calli, 2011; Tezel 2011) a greater activation in the left hemisphere of the brain is observed in reaction to atonal music. In a right-handed individual, atonal music is observed to cause greater activation in the dominant hemisphere.

Theoretical base

An examination of the literature shows that a common aspect of studies on tonality in healthy individuals is that they have a basic theoretical foundation. In 1957 Meyer defined a single tone—the tonic—as the central reference point of the diatonic scale. He claimed that all the other pitches related to the tonic pitch, and no matter how much they may be melodically transformed, they return to the tonic. Although the secondary significance of the third (mediant) and fifth (dominant) degrees was expressed, diatonically and chromatically all tones remain oriented towards the tonic (Krumhansl and Keil, 1982; Meyer, 1957).

As a result of debates carried out in the 1980s by academics such as Bharucha, Krumhansl and Kessler, the **single tone dominance** principle posited by Meyer was replaced by the principle of **degrees of tonal**

stability. During that period, the concept of a "hierarchy of stability" was prioritized (Bigand, 1997; Krumhansl and Keil, 1982; Krumhansl and Cuddy, 2010). The chord degrees and key generated by the musical structure constitute the hierarchy. According to this musical context, the tonic is the strongest stable pitch among the 12 chromatic pitches, but is not the only one. The fifth degree (dominant) represents the second stable pitch, followed by the third degree (mediant). Next in the sequence come the less stable members of the diatonic scale, which are finally followed by tones which are non-diatonic.

In 1982, Krumhansl carried out a memory-based study on adults and children investigating the reality of tonal stability (Krumhansl and Keil, 1982). In the study, short melodies were presented, including diatonic and chromatic tones, and participants were asked to rate these on a seven-point scale from good to bad. The noticeable variance in the stable hierarchy at the end of each musical piece revealed that young children were unable to differentiate between diatonic and non-diatonic structures, and that perception of this hierarchical structure in melody was primarily present only in adults. Based on this, the author proposed that the hierarchical "tonal tradition" of music is implicit information which is derived through experience. Children and many adults are unable to define this information. A "hierarchy of stability" develops through unconscious awareness, just as with syntax in linguistics. The results of the study support the stable and organized structure of music. They suggest that the hierarchy between pitches is a learnt skill, acquired with age. Studies investigating associations between auditory processing, musical education received at an early age and neurophysiological development also reveal the effect of age (Shahin et al., 2004; Hyde, et al., 2009; Strait et al., 2012).

In 1987, Bharucha published a study emphasizing the importance of key variation in musical stability. Bharucha favoured the tonal hierarchy model related to 12 chromatic tones, major-minor chords and their interconnections. He revealed that it is not enough to know the hierarchies within tonality itself, but that it is necessary to consider their association with the degrees of other tonalities. Based on this, he redefined the principle of single tone/single pitch consistency and stability as variability-reversibility.

All these efforts were carried out with the aim of defining music according to its meaning and functional features. What is the use of music? Which feelings are evoked by which music? Does it have a therapeutic effect? Questions such as these led to the investigation of music through the use of verbal, observational and questionnaire-based methods in pioneering studies in the fields of psychiatry and psychology.

Approaches designed to determine the affective, perceptual and psychological effects of music on humans shared a common basis in terms of using components of classical music such as such as harmony, melody, pitch and chord. Imaging techniques employing high temporal resolution and electrophysiological methods play an important role in the investigation of the effect of these components on the brain. Assessing the effects on the brain (brain responsiveness) of stimuli related to the five senses (auditory, visual, tactile, gustative and olfactory) remains an important issue today. There are many methods of assessment used in brain research, especially to investigate the structural and functional properties of the brain (from cell to tissue). The most frequently employed ones are imaging techniques, primarily Computed Tomography (CT), Magnetic Resonance Imaging (MRI), functional Magnetic Resonance Imaging (fMRI), functional Near Infrared Spectroscopy (fNIRS) and electroencephalography (EEG). Among these, EEG possesses the advantages of being non-invasive, low in cost and high in temporal resolution, and has therefore been employed in this study.

An EEG approach to cognitive musicology

Decades after Caton first recorded electrical activity in the cerebral cortex of a monkey, Hans Berger made the first recording of electrical activity in the human brain from outside the skull in 1924. Though initially EEG waves were assumed by most to be the noise of the brain, after almost a century of studies, EEG is now understood as a marker of cognitive functions and has taken its place in clinical usage. EEG can show brain activity during coma, sleep and wakefulness and can also be used to diagnose and track the progress of certain pathological conditions. Examining published investigations of brain responsiveness to external stimuli via EEG, terms such as evoked potentials (EP), event-related potentials (ERP) and event-related oscillations emerge.

Evoked potentials are generally described as the brain’s response to an external stimulus during spontaneous activity. Event-related potentials are associated with cognitive functions, decision-making and perception-related activities. In ERP-based studies, the oddball paradigm is one of the most widely-used designs. In this methodology, there are two types of stimuli: target and non-target stimuli. Participants are asked to direct their attention to target stimuli and count them or press the button when they appear.

Observed oscillatory brain activity may be explained by oscillative neural population theory (Basar and Karakas, 2000). This theory describes how the brain has different oscillations in different frequency ranges. Five of these frequency bands have been widely studied for some years, namely delta (0.5–4 Hz), theta (4–7 Hz), alpha (8–13 Hz), beta (15–30 Hz) and gamma (28–70 Hz). Brain responsiveness to external stimuli differs between the frequency bands. Most studies have underlined that some of the frequency bands are correlated with specific cognitive functions (Basar et al., 2007; Schack et al., 2005; Ozgoren et al., 2005). Brain oscillations can be also seen during spontaneous activity without any external stimuli. Given this, features such as occurrence frequency, latency of the oscillations and modality of stimuli are important in describing the brain's electrical activity.

The first EEG studies on music involved the interpretation of delta, theta, alpha, beta and gamma waves (defined as the classic wavebands of EEG). In 1975, Michael J. Wagner used EEG on 30 musicians and 30 non-musicians, introducing a novel approach to operant and behavioural psychology studies based on electrophysiological data, taking into account heart rate, perspiration and saliva secretion, muscular tonus, and skin conductance. Classical music was played for two-minute intervals. Data from temporal and central electrodes suggested central nervous system activation in the cortical region. More alpha rhythms were observed among musicians than non-musicians when listening to music (Wagner, 1975).

In a study carried out by psychologists in 2008 in Mexico, the consistency of alpha oscillations between genders (7 female, 7 male) was investigated in individuals with no musical education (Flores, Gutierrez et al., 2009). Three pieces of classical music were picked and pre-labelled according to affective states such as happiness and fear, based on the results of a survey. Brain responses related to musical affective states and participants' ratings on a five-point scale were examined. Pleasant music was observed to evoke activation in both genders in the left anterior and posterior regions, while with unpleasant music, activation was observed in the posterior midline region in the right hemisphere in males and bilaterally in females.

The processing mechanisms for dealing with auditory stimuli of various characteristics have yet to be uncovered. In this context, there are studies involving the use of music as an auditory stimulus in various paradigms. One such study, conducted in 1983 by Bharucha and Krumhansl and based on the abovementioned hierarchy of harmonic stability, investigates the brain's response to tonal music within the context of European classical music's rules of tonality and major-minor patterns (Bharucha and Krumhansl, 1983).

In another study, Koelsch and Mulder model a surprise ending to the final chords of a piano sonata (2002). Koelsch, Schroger and Gunter present results which suggest that Neapolitan chords create dissonance in ongoing harmony (2002). Koelsch and Frederici, in various experiments, refer to the role of selective attention in cognitive response (2003). The authors suggest that there are electrophysiological responses related to knowing the rules of harmony and the process of education. Likewise Shahin et al. (2003) propose that components of auditory evoked potentials such as N1 and P2 develop in relation to past musical experience in musicians. Brattico et al. observed that in neurophysiological studies involving chords determined according to the harmonic rules of European classical music, the brain responds differently when defining and when making an aesthetic judgement, suggesting that the left hemisphere (F3) is more active in defining and the right hemisphere is more active in liking (Brattico et al., 2003)

Differences in pitch and instrumental timbre, defined as consonant or dissonant, result in greater auditory sensitivity and greater ERAN (early right anterior negativity) in musicians compared to non-musicians (Koelsch et al., 2007; Koelsch and Schmidt et al., 2002; Villarreal et al., 2011). Leino et al. (2007) studied cadence among non-musicians. Besides consonant or dissonant chords (as studied by Park et al., 2011 and Passynkova et al., 2004), those comprised of tones accepted to be in tune or mistuned were used; thus the importance of pitch within musical structure was addressed, and brain responses related to variances in cadential sequences on the level of tonality were determined (Leino et al., 2007). In regard to the consonant and dissonant tone groups in harmony rules, the concept of attention became more prominent than memory and mood theory (Passynkova et al., 2007). Based on ERP studies, Virtala et al. (2011) claimed that the categorization of major and minor tonal combinations occurs in the auditory cortex of the human brain via enculturation.

Studies conducted in the last twenty years by music psychologist Koelsch, and more recently by Brattico and Tervaniemi (2001) mostly employ a series of five chords. Comparison of brain responsiveness data involves brain responsiveness components such as ERAN, N2b-P3b and N5. These oscillational responses have been described as reactions of electrical activity in the brain to states of consonance-dissonance in a series of chords. In contrast to the literature on ERAN responses, Passynkova's studies address the interhemispheric relationship of affective perception and non-affective definition. It is suggested that the hearing of chords is based on information transfer and that in various states of perception interhemispheric responses yield different results.

Materials and Methods

Brain responsiveness

In the present study, the brain responsiveness of musicians and non-musicians was evaluated using EEG. Latencies of brain responses to tonal and atonal chord stimuli were compared within and between groups.

Subjects

Subjects with any neurological, psychiatric or chronic diseases were not accepted as participants in the study. All of the subjects attended audiometry tests to determine whether or not they had less than a 15dB difference in perception between their ears. Three subjects who failed this test were excluded from study. 20 musicians (10 male, 10 female, mean age 29.0 years) and 20 non-musicians (10 male, 10 female, mean age 28.4 years) participated in the study. The Edinburgh handedness scale was used to determine the laterality index (LQ) of both groups. Musicians' mean LQ was 91.6 and non-musicians' mean LQ was 91.7. Both groups filled in STAI-TX I and SCL-90R forms in order to define their current psychological state.

Selection of the chords

A preliminary study was conducted on tonal and atonal chords to determine which chords were to be used. Triads with M3-m3 (major third-minor third) pitch intervals were created on 12 pitches taking into account the rules of European classical harmony. A total of 40 tonal chords—20 major, 20 minor—were obtained in the root position, 1st inversion and 2nd inversion. Following an evaluation by researchers from the Department of Music Technologies at Dokuz Eylul University, the tonal chord number was reduced to 40.

Within the same pitch range as the 40 tonal chords, 40 atonal chords not conforming to the minor/major third rule were developed, built from the pitch intervals A4 (augmented fourth), d5 (diminished fifth), m2 (minor second), M2 (major second) and 7. The chords were played in a recording studio on a digital piano set to concert grand, lid closed, room effect active, stereo tone, and recorded as MIDI data. Each chord's duration and nuance was equalized. All chord durations were set at 2000ms. The final output was in 16 bit, 44.1 kHz wave format. A total of 40 tonal and 40 atonal chords were played to the participants.

Ten tonal chords (5 minor and 5 major) were chosen from the tonal chords and presented to the participants prior to the main experiment as non-target stimuli in ERP. The tonal chords were F-II, G-II, C, C-I, E-II, Am, Am-I, Em-II, Fm-II and Cm. Five atonal chords were chosen as target stimuli.

Stimulus unit and EEG recordings

Auditory stimuli were sent to the subjects via a high quality audio mixer (Allen and Heath Zed 14, UK) and headphones (Sennheiser HD 380 Pro, Germany) set to a volume level of 60 dB. An EMISU device was used for synchronization between the EEG output and stimulus; it also recorded the responses of subjects (Ozgoren et al., 2009). Subjects were asked to press a button under certain conditions and these responses were delivered to the EMISU system via a response pad connected to the EMISU system. EEG measurements were made while auditory stimuli were applied to the subjects, using a 64 channel digital EEG amplifier (Neuroscan, Synamps 64, USA). International 10–10 electrode positioning system requirements (Jasper, 1958) were applied in the placement of the EEG cap (Neuroscan, Quik Cap, USA). Earlobes were assigned as reference electrodes. During the experiment, subjects were seated in a comfortable chair in an isolated room.

Experiment protocols and recording process

Spontaneous EEG activity during two one-and-a-half minute sessions—one with eyes open and one with eyes closed—was recorded for each subject before the main experiment began. After the spontaneous EEG reading was taken, the main experiment was conducted. The experiment protocol was as follows:

1. 120 pseudo-randomized tonal chords were played to the subjects, followed by an interview and questionnaire scaling their feelings (tonal EP).
2. 120 pseudo-randomized atonal chords were played to the subjects followed by an interview and questionnaire scaling their feelings (atonal EP).

3. ERP training (for non-musicians only).
4. 150 pseudo-randomized tonal and atonal chords were played to the subjects followed by an interview and questionnaire scaling their feelings (ERP session).

Following the four-and-a-half minute presentation of the tonal chords, participants were interviewed using semi-structured questions. These questions were based around the participant's feelings and what he/she felt and thought while listening to the chords. The participant's preference and appreciation was confirmed with ethnographic questions. Participants were obliged to rate their feelings after listening to the chords on a scale of 0 to 10, with 0 denoting the most negative, 5 neutral, and 10 the most positive. The same procedure was repeated after participants had listened to the atonal chords. In the interview after ERP session, participants rated their success and rated the sessions according to how difficult they found the atonal chords on a 0–10 scale with 0 denoting the easiest, 5 normal, and 10 the most difficult.

Table 1.1. Participants' scoring of feeling in the tonal, atonal and ERP sessions.

	Tonal	**Atonal**	**ERP1**	**ERP2**	**Sex**
Non-musicians	6.00	3.35	2.76	2.12	10F–10M
Musicians	7.06	3.94	0.94	0.72	10F–10M

Participants were asked to identify chords involving the combination of intervals m2-M2 and m2-m2. Care was taken to keep tonal and atonal chords in the same octave so as not to create any differences in tone due to frequency. The series of chords in the tonal, atonal and ERP chord sessions are presented in the appendix.

EEG analysis

Analysis of EEG recordings was based on epochs which included 1000ms pre-stimulus and 1000ms post-stimulus intervals. Several artefacts, such as eye movements and sweating, were removed from the EEG epochs before analysis. These epochs were first corrected to the baseline (x-axis) then filtered with a band-pass filter with a 0.5–48Hz cut-off point. Average files were created for each subject after filtering and these were used to create grand average files for each group, from which graphs and figures were generated.

Results and discussion

Brain responsiveness to tonal and atonal chords was preliminarily analysed for EP and ERP sessions in terms of latency variance. Figures 1.1 and 1.2 (see colour centrefold) show EEG signals from F_Z electrodes, demonstrating brain responsiveness to tonal and atonal chords.

As seen in Figures 1.1 and 1.2, latency differences were found between the brain responsiveness of musicians and non-musicians. These differences, picked up by the Fz electrode, were found to be statistically significant between the groups (Table 1.2); in other words, musicians' brains responded earlier, to a statistically significant degree, than those of non-musicians.

Table 1.2. Comparison of brain response latencies to tonal and atonal stimuli for musicians and non-musicians

	Tonal	Atonal
Fz	P1**, N1**, P2**, P3*	P1**, N1*, P2**

(* $p<0.05$; ** $p<0.005$)

Although there is no similar study to this focusing on tonal and atonal chords as paradigms, consonant and dissonant chords have been studied frequently. Musicians' responses to music-related stimuli have repeatedly been found to have shorter latency periods than those of non-musicians (Amemiya et al., 2014; Muller et al., 2010 and 2009). The findings of this study show that musicians on average responded faster than non-musicians, supporting the findings of previous studies mentioned above.

As seen in Figures 1.3 and 1.4 (see colour centrefold), EEG signals from the F_Z electrode demonstrated brain responsiveness to tonal and atonal chords in the ERP sessions of each group.

Analysing brain responses to target and non-target stimuli, a significant difference ($p<0.05$) was found between musicians and non-musicians in terms of response latency. Due to the advantage musicians have in terms of musical training, their responses were more accurate and earlier (Table 1.3).

Table 1. 3. Comparison of brain response latencies to target and non-target stimuli for musicians and non-musicians during the ERP session.

	Target Stimuli	Non-target Stimuli
Fz	P3**	LN*

(* $p<0.05$, ** $p<0.005$).

The differences between the groups according to the frequency distribution of brain responsiveness are shown in Figure 1.5 (see colour centrefold).

As seen in Figure 1.5, the delta frequency band shows higher activity for musicians, while non-musicians demonstrated higher theta band activity. In this regard, there are some contradictory results to be found in the literature relating separately to musical performance and listening. EEG recordings made while musicians perform have showed alpha and delta band activation (Babiloni, et al., 2011). Carrus et al. (2011) observed that delta and theta band activation increased among non-musicians in music-linguistic interaction. In studies on musical taste among non-musicians, researchers have suggested that preferences could be appropriately determined through responses in the beta and gamma frequency bands (Hadjidimitriou and Hadjileontiadis, 2012). Lin et al. (2005) found that among non-musicians, listening to different musical genres could affect alpha band activity.

Cognitive neuroscience literature indicates that the delta frequency band is mostly related to discrimination, matching and decision-making (Polich & Criado, 2006) while the theta frequency band relates to encoding and retrieving information and emotions (Passynkova et al., 2007). The alpha frequency band has been related to positive and negative emotions (Schmidt & Trainor, 2001).

Interpreting the frequency band activation in this study suggests that musicians discriminate stimuli according to their characteristics, while the non-musicians do not only discriminate stimuli according to their characteristics but also use other sources in order to encode information about the stimulus.

Conclusion

This study has applied pioneering research to objectively and subjectively evaluate the effect of music, a phenomenon which contains sensory, cognitive, cultural and emotional components. The effect of tonal and atonal chords on the brain was evaluated by means of a unique electrophysiological experimental design. This research design and approach can be used to conduct studies on topics such as culture, memory, specialty, experience and psychological effects. The effects of "priming" shown in neuroscience studies which differentiate between levels of experience (expert musicians and non-musicians) have been taken into consideration as a background to the research methodology. This study proposes that findings on brain responsiveness can also be evaluated and interpreted through objective methods.

Furthermore, various technical components such as chord sequences, the electrophysiological timing of chords, etc. might encourage future studies by using the music and cognition database proposed in this study. Various cognitive functions of the brain, such as listening to music or solving mathematical problems, may trigger a variety of responses, differing in timing, intensity and frequency band response, as a result of engaging different functions of the brain such as memory, perception, attention, etc.

In conclusion, this study has provided preliminary results that hint at widely-shared responses to tonal and atonal chords amongst listeners familiar with European classical music.