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MUSIC PERCEPTION AS A TOPIC OF COGNITIVE PSYCHOLOGY

BİLİŞSEL PSİKOLOJİNİN BİR KONUSU OLARAK MÜZİK ALGISI

Aslı ASLAN
Mersin Üniversitesi, Fen Edebiyat Fakültesi, Psikoloji Bölümü

ABSTRACT: Music perception has a long and distinguished history as a topic of psychological research because music requires a mental activity in humans. As a complex human activity, music perception is naturally an area of interest especially to cognitive psychology. Cognitive studies suggest that listener's experience of a particular musical sequence is driven and at the same time constrained by the sounds registered by auditory mechanisms but also processed by available mental resources. This assumption indicates that researchers must take into account certain inherent limitations and capabilities of the listener. The main purpose of this paper is to discuss possible cognitive processes underlying music perception. The steps taken towards this purpose will be describing the structure of music and discussing the way that this structure is perceived by human cognition.

Keywords*:* Music Perception, Musical Elements, Cognitive Psychology.

ÖZET*: Müzik insanda zihinsel bir aktivite gerektirdiği için psikolojik araştırmaların bir konusu olarak uzun ve ayrıcalıklı bir tarihe sahiptir. Karmaşık bir insan aktivitesi olarak müzik algısı doğal olarak özellikle bilişsel psikoloji için bir ilgi alanı olmuştur. Bilişsel çalışmalar gösteriyor ki bir dinleyicide oluşan belli bir müzik parçasından edindiği deneyim duyusal mekanizmalar tarafından kaydedilen sesler tarafından yürütülür ve aynı zamanda o sesler tarafından da sınırlandırılır fakat aynı zamanda da dinleyicinin mevcut zihinsel mekanizmaları tarafından işlenir. Bu varsayım gösterir ki araştırmacılar dinleyicinin yetenekleri ve yetersizliklerini göz önüne almalıdırlar. Bu makalenin temel amacı müzik algısının altında yatan bilişsel süreçleri tartışmaktır. Bu amaca yönelik adımlar müziğin yapısını tarif etmek ve bu yapının insan bilişsel yapısı tarafından algılanma yolunu tartışmak olacaktır.*

Anahtar kelimeler*: Müzik Algısı, Müziğin Elemanları, Bilişsel Psikoloji.*

1. Introduction

Music is a participatory art form (Cross, 1985). Participation demands structure in order to be communicated. Then it is not wrong to say that music requires rules for it to be carried out. Defining the structure of music is not an easy task, considering the vast number of sets of sounds and activities, which different cultures consider to be music. Even when we limit ourselves to defining only the western tonal music, a success is scarcely possible. Therefore, the focus on this paper will be the traditional western tonal music, specifically, the multilevel relations among elements of western tonal music. Chords, tones, major and minor keys, pitch, rhythm are some of these elements. They are essential to understanding the complex set of relationships between musical events. First of all, western tonal system could be studied as a combination of two different but related systems. A

system that involves pitch related structures such as tones, tonality, harmony and scales and the other is temporal pattern, which naturally involves rhythm, meter and accents. Basically, combination of these two elements defines musical events that have structural information much like letter combinations in natural and artificial grammars.

2. Structure of Music

2.1. Music as a Complex Structure of Sound and Tones

Pierce (1999) argues that the regularity of sound frequencies produced by strings of proportional lengths must have been noticed in ancient times by people of different cultures. It is quite likely that these independent discoveries led to the integer ratios that dominated the music scales developed by those cultures. In the last few centuries, mathematicians and music experts found that musical sounds as well as arbitrary sound events could be replicated by combining different intensities of periodic frequencies. As Pierce explains, the frequency components (called "overtones") produced by music instruments are all multiples of some fundamental frequency. The variations in relative intensities of the overtones define the "timbre" associated with the particular instrument producing the musical sound. Pierce describes the intensity variations of frequency components over time as "the general spectral shape" and he emphasizes that it is "crucial to timbre quality." In summary, both frequency combinations and intensity variations carries information that helps identify the physical source of sound. This is especially true for music.

Of course, the above discussion relates to perception of sound in general, rather than perception of music in particular. However, the almost-universal acceptance of music scales implies that there is more to perception of music than the ability to distinguish frequency combinations. In his discussion on intervals and scales, Burns (1999) describes the standard Western music scale as a "12-tone chromatic scale of equal temperament." He argues that other cultures' scales are equivalent to Western scale in practice, even if they contain more than 12 intervals in theory. A detailed discussion on the comparison of music scales is beyond the scope of this paper, so it will suffice to say that music scales are based on the perceived equivalence of tones differing by a certain frequency interval called an "octave." Music scales generally divide each octave into frequency intervals that have identical widths in a logarithmic scale.

There is a wealth of studies on how perception of music depends on the positions of tones in the music scale. Dowling (1999) summarizes certain papers that studied under what conditions changes in familiar melodies made them unrecognizable to listeners. He describes the "patterns of ups and downs" of musical tones as the "contour" of a melody and lists evidences that deviations from the contour of a melody are easily caught by listeners. In other words, the contour is the most identifying aspect of music. According to Dowling, even infants recognize melodies on the basis of contour, but as one enters adulthood, one learns to recognize melodies on the basis of tonal structure. The perception of tonal structure is a significant advance; it enables listeners to distinguish melodies that are identical in contour but shifted in frequency. However, Dowling also quotes some evidence to show that small variations in individual tones (as much as a semitone, the smallest interval in the Western music scale) are not recognizable

to many listeners. The secret is in the recognition of the "key" that the melody is based on. Musical melodies are not constructed by using all possible tones within an octave, but they are based on certain subsets of the tones, called "keys." Dowling points out that while many listeners can recognize key changes, they are not able to detect variations in a melody that do not deviate from the key.

All this discussion indicates that listeners of music somehow perceive the rules employed by creators of music, even if they are not familiar with the structural aspects developed by musicians over ages. This may be explained as being the result of gradual diffusion of music knowledge across populations sharing the same heritage, but that would be a naïve conclusion. The theory of music has always been too complex even for many musicians to wholly learn and explain. We could conclude that there are perceptual and learned aspects of music knowledge.

2.2. Music as a Form of Language

The widespread use of discrete tones is an indication of a language-like structure embedded in music. Burns (1999) likens the practice of using a specific set of tones in music to the tendency of using a specific set of sound elements in auditory communication between animals and humans. He also points to religious and ritual sources of music as possible reasons for using a standard framework in music developed by any group of people. Moving from the analogy of music to language, researchers have often developed models to represent the music as a form of alphabet or as a grammatical structure (West et al., 1985). Although West et al. argue that "music does not exist to convey meaning" like the spoken (or written) language does, they do admit that "much music is intended to express ideas or portray events." They summarize Lerdahl and Jackendoff's works (1977, 1982) as one of the most successful models of musical structure developed using the grammar analogy. That model dealt with four kinds of structural analysis to music and applied the well-formedness rules that are the basis of grammatical structures.

Carterette and Kendall (1999) agree that music has "syntax" just as a language does. When it comes to the explaining what the meaning of music is, they list several studies suggesting that emotions invoked by music may be viewed as the meaningful content of music. Countless studies that they quote indicate that emotions intended to be conveyed by melodies sharing the same tonal structure is perceived in the same way by people of different cultures. In terms of its emotional content, music may be somewhat naively thought to be a universal language, but many critics have noted that emotional responses to music are "determined by cultural tradition rather than by the inherent qualities of music" (Gregory and Varney, 1996). The multitude of structural elements of music also makes it too ambiguous compared to a language. Aiello (1994) indicates that "the syntax of music has much more latitude than that of language."

In summary, experts agree about the existence of a grammar-like structure in music. So that perception of music can be studied like the perception of grammar.

2.3. Music as a Collection of Patterns

Gabrielson (1993) views the perception of rhythm as the perception of "grouping of the sound events," or as a pattern. Sound patterns that make up the rhythm

repeat themselves in a regular manner. Regularity of patterns is perceived through the periodic occurrences of "accented" (or, emphasized) members of patterns. As Butler (1992) noted, perceptual grouping of sound tones into patterns invoked a series of studies trying to apply Gestalt grouping principles to the perception of music. According to the results of some studies summarized by Butler, perception of grouping was not uniform from one melody to another, or even among the different performances of the same melody. As Van Noorden (1975) found, listeners grouped tones according to pitch proximity (i.e., according to how close the frequencies were), but as the tempo got slower even tones highly differing in pitch could be grouped together. Dowling (1973) found other interesting results by "interleaving" two melodies (by merging them into one melody). The listeners could easily recognize at least one of the melodies if the notes of the merged melodies sufficiently differed in pitch. There are, of course, many more studies with different results, but they cannot be discussed here in detail. In general, studies show that listeners tend to group elements of music.

Deutsch (1999) argues that auditory system relies on grouping to reconstruct the original sound events from the mixture of auditory stimuli that it receives from different sources. As the above mentioned studies imply, the auditory system has the ability to reconstruct not only the original sound elements, but also the structure of musical melodies, even if they are intertwined with other melodies. However, as Deutsch notes, all those different characteristics of music cannot be perceived by employing a single grouping mechanism. She suggests that more than one grouping mechanism at work and they employ different dimensions such as frequency, amplitude, timbre, etc. However, some of those dimensions may be more dominant than others. Jones (1993) presents evidence that average listeners compares the "dynamic shapes" while trying to detect a similarity between two melodies. However, she emphasizes that dynamic shape is not simply pitch contour, i.e., it is not only dependent on ups and downs of frequencies of tones. The timing of the accented tones and the rhythm complements the contour in defining the dynamic shape. This last point is an important one, because it implies that shifts in individual tones of a melody may escape detection if the overall shape of the melody is preserved.

3. Empirical Investigations of Music Perception

3.1. The Place of Music Perception in Cognitive Psychology

The majority of music perception studies in cognitive psychology are directed at describing mental capacities that are exhibited quite generally. For that reason, most of the studies do not employ participants with extraordinary musical talent or extreme deficits. In fact most of the studies have involved only ordinary people, non musicians or amateur musicians. The music perception studies usually focus on the questions such as how musical knowledge is acquired, what kind of strategies employed, and how the musical materials processed. There are different approaches to study of music psychology. One of them is the developmental approach. Developmental approach has interest in finding answers to how musical knowledge is acquired. This approach in music research is also concerned with knowledge that seems to come by nature during infancy or childhood. However, cognitive psychology makes most of the contributions to music psychology. It will not be wrong to say that cognitive psychology concentrates on the studies which emphasize the influence of knowledge on perception (Krumhansl, 2000).

Cognitive psychology also encourages the study of how musical knowledge is acquired. In other words, cognitive psychology is concerned with how listeners process musical information. In psychology, studies describing the human cognitive system for processing musical materials seem to receive more attention than those trying to explain how musical knowledge is acquired.

3.2. Pattern Recognition Studies in Music Perception

Objects that are visually close to each other and objects that are similar in shape or color tend to be perceived as a group. Moreover, the perceiving mind seeks the simplest available grouping. It also looks for repetition and symmetry within a continuous whole. The closure effect will complete the shape automatically in mind. In music, tones following the tonal hierarchy and chords following the harmony of an existing melody serve as completing agents of the musical shape that will form the complete melody. Thus, studies on music can give useful insights into the way we perceive auditory patterns. In fact, early Gestalt psychologists used music as a reference point to their theory, because a melody as a whole has a shape, which can be heard without recognizing the individual notes. We can also add to that conclusion another phrase like "without recognizing the tonal-hierarchic and harmonic relationships of individual chords." Independency of melodic identities from a definite order of specific notes had fascinated most of the Gestalt psychologists.

In this respect, one of the most significant contributions to music analysis was that of Leonard B. Meyer. Meyer (1956) was using the Gestalt concepts of fundamentals of information theory in his arguments and applied them to his definition of meaning in music. The concept of stability played a central rote in Meyer's idea of musical structure. Meyer also generalized the Gestalt theory to principles of tonal organization. His tonal hierarchy analysis gave very specific predictions about the ordering expected for Western tonal music. Thus his tonal system was hierarchical. He suggests that, in Western music, the tonic tone is the tone of ultimate rest toward which all other tones tend to move. Meyer also suggests that on the next higher level the third and fifth of the scale, though active melodic tones relative the tonic, join the tonic as structural tones.

However, it was Hirsh who started the most basic and direct study in the field of pattern recognition in music in 1959. Perception of acoustic sequences had long been a topic of major interest in psychoacoustics. Hirsh's (1959) studies first involved threshold measurements of pairs of items consisting of tones and clicks. His procedure basically involved a pair of qualitatively different sounds; listeners were required to identify in which order the two sounds appeared. Hirsh reported that the threshold for identification of order, regardless of quality of music elements, was about 20 ms. However, Broadbent and Ladefoged (1959) claimed that identification of order in the study by Hirsh (1959) was inferred and not perceived. They reported that untrained listeners were unable to discriminate the order of pairs when the threshold was 150 ms, but with practice the threshold decreased to 30ms. After these debates, a distinction was made between the ability to discriminate between the order of the two sounds and the ability to identify their order.

The studies described thus far have explored identification or recognition of different orders of sound sequences. In later stages of these experiments the

number of music elements employed increased to four or five. It was after these order identification studies that the term “holistic pattern recognition” entered the scientific literature in this area. Researchers concentrated on the holistic organization of acoustic patterns. Holistic pattern recognition was basically defined as identification of organization. In the first study of this kind, Royer and his associates introduced item durations to make identification of order easier for the listeners (e.g., Royer and Gamer, 1970). In one of those studies, Royel and Robin (1986) used sequences consisting of two easily discriminated sounds (for example, tone A and tone B). The two tones were arranged in different sequences without a pause (for example, ABBBAABA). In another kind of sequence, one of the tones was replaced with silence. It was found that listeners tended to perceive such patterns as special groups with definite starting points. That was exactly in line with Gestalt psychology. However, authors were cautious to remind that the rules governing such organizations seemed to be more complex than Gestalt psychology would imply. The majority of these studies seem to focus primarily on the structure of traditional western music when trying to find answers to musical perception issues.

3.3. Expectancy Studies on Music Perception

Many researchers studying the perception of music have noted that music listeners are able to perceive the relationships between the structural elements of music such as tones and rhythm (e.g. Dowling, 1999; Butler, 1992) and develop expectations on the rhythm and tone patterns of even unfamiliar melodies (e.g. Butler, 1992). The basic question is to find out that what sort of knowledge listeners have about music and how this knowledge affects the way listeners perceive and remember music (Krumhansl, 1990; 1983). The mostly accepted view was that the experience of music goes beyond registering the acoustic parameters of tone frequency, timbre, etc. These are recorded, organized and stored in memory in a form different from sensory codes. Music was assumed to evoke enduring mental structures. The investigations primarily focused on these structures and tonality, harmonic hierarchies particularly.

A number of experiments were conducted to answer whether tonal and harmonic hierarchies would be reflected in judgments of listeners. In Krumhansl’s (1990) experiments listeners were required to judge how close a relationship there was between a pair of tones. In many of her experiments, half of the listeners had some formal training in music theory, in addition to training on an instrument. The remaining listeners had no music theory background. Later, these judgments were compared with statistical summaries of the frequency with which melodic intervals appear in tonal hierarchy. The pattern of responses of these two groups of listeners provided indication of degree of correspondence between the intuitions of listeners with or without formal knowledge of music theory. Krumhansl, (1990) showed that both groups of listeners judgments reflected tonal and harmonic hierarchies.

Cuddy, Cohen, & Mewhort (1981) also conducted a series of experiments. They employed twenty sequences that were composed to represent the factorial combination of harmonic structure, contour and repetition pattern. The sequences were composed on the basis of a priori principles of tonality that was expected to lead to the highest ratings of perceived structure. Results showed that ratings of

perceived structure and ease of recognition were influenced by harmonic progression, contour and repetition within the sequence.

The harmonic hierarchy also appeared in Rosner & Narmour's (1992) similarity judgment studies: Rosner & Narmour (1992) examined the influence of musical properties that determine the perception of harmonic closure by presenting listeners with pairs of melodies. Listeners were asked to judge which member of each pair seemed more closed. Multidimensional scaling and hierarchical clustering studies showed that harmonic hierarchy and properties of contour were important in determining the perceptions of listeners (Rosner & Meyer, 1986). This showed that harmonic hierarchies of music were reflected in judgments of listeners.

In another experiment, conducted by Halpern (1984), basically, all melodies were constructed in a way that they were similar to one another in clearly specified musical ways. To be more precise, a set of melodies was constructed by combining two levels of four musical patterns such as intervals, contour, rhythm and mode in the melodies. Thus, each melody had a well defined musical relation to each other melody in the set. The basic question asked here was to find out which relationships among the tunes would be more salient to new listeners. For experiment 1, a couple of undergraduates were asked to give similarity judgments of all pair of tunes. Initially, Tune A and Tune I were composed. 16 melodies were composed using two note patterns. One of the note patterns was called "Tune A'. All tunes derived from Tune A had the same sequence of intervals. The second note pattern was called Tune I. Those derived from Tune I were called Note Pattern 2. Each tune was written with either of two rhythms. The original tune was written with pitches in back to front order but with the original rhythm maintained. This process created a forward and reverse of Tune A. Tune K was the reverse of Tune I, Tune E was the minor version of Tune A, and Tune M was the minor counterpart of Tune I. In fact, during the whole experiment one music pattern was used again and again but in different versions. Results showed that both the musicians and nonmusicians gave essentially equivalent answers. To be exact, tunes with different rhythms were rated as being very dissimilar, whereas tunes identical except for being in a major or minor mode were rated as being very similar. In addition, when questioned, no participants claimed to be aware of the factorial structure of the tune set. Halpern (1984) claims that results corresponded better for the non-musicians than for the musicians. She suggested that musicians presumably exceeded non-musicians in the ability to categorize music in multiple ways, but even non-musicians extract considerable information from newly heard music.

Pollard-Gott (1983) used previously composed music in a same kind of study. Participants were asked to classify passages from Liszt's sonata by their similarity of musical theme or in other words underlying melody. But when they were exposed to the passages, they all used more of the elements musical parameters such as pitch range, loudness, etc but musicians more so than non-musicians made use of the more sophisticated thematic classification. According to Halpern (1984) because Pollard-Gott (1983) used previously composed music, the exact nature of the relationships among the passages were sometimes difficult to specify.

Another method used to quantify the hierarchy of stability is called “probe tone method” by Krumhansl (1990). Krumhansl found that when an incomplete scale was played, it created strong expectations about the tone that was to follow. In the actual experiment, both ascending and descending incomplete C major scales were used. The ascending scale was sounded in the octave below middle C and it consisted of the sequence of notes C, D, E, F, G, A, B. That order created strong expectations about the tone that is to follow. The tonic (C) itself was heard as the best completion. The descending scale began two octaves above middle C and it consisted of the notes C, B, A, G, F, E, and D. The probe tone came next, and the listener’s task was to rate it as a completion of the scale context again. This experiment suggested that hierarchy of stability appears to be a function of the musical relationship between the final tone and the tonic of a scale. Results of probe tone studies showed that tonal contexts in traditional Western music establish a perceptual hierarchy. In another study, Krumhansl (1979) found that the tones that form the tonic triad of the tonal contexts are perceived as most closely related to each other and the nondiatonic tones least closely related, and that a pair of tones is perceived as more closely related when the first tone is nondiatonic and the second diatonic than vice versa.

A number of expectancy experiments were also conducted to understand tonality and harmonic hierarchies; Schmuckler (1989) conducted an experiment to examine the factors underlying the formation of melodic and harmonic expectancies. Expectancy was first mentioned in Lerdahl and Jackendoff’s (1983) generative grammar for western tonal music in their concept of “prolongational reduction”, which captures listeners’ feelings of tension and relaxation among musical events. In Schmuckler’s study, the main concern was to understand whether or not tonal structure would be reflected in expectancy profiles. Schumuckler used previously composed musical pieces of composer Robert Schumann in his experiments. Each piece was split at certain stopping points that were selected by identifying melodic or harmonic progressions occurring at these points. Listeners who heard a fragment of a piece were asked to decide which was the melodic/harmonic fragment ending immediately before the labeled probe position. Experimental trials consisted of the context passage plus a melodic harmonic continuation. Listeners’ task was to rate how well the final event fit their expectations of what was to come next. In his classical work “Emotion and Meaning in Music” Leonard Meyer (1956) referred to expectancy measures. He suggests that generation of expectations underlies not only the comprehension of musical structure, but also the perception of musical meaning and emotion.

Bharucha (1987) studied the perceptual facilitation in harmony by developing a priming task for chords. In that study, he was aiming to measure the difference in processing time for chords as a function of their relationship to the preceding context. He adapted this task from psycholinguistic study of semantic facilitation. In a typical semantic facilitation experiment, participants are presented with a word (prime) followed by a string of letters and they are instructed to judge as fast as possible whether the letter string is a word or not. Typically, related words were processed more quickly and with fewer errors than unrelated words. Bharucha (1987) found that the chords that were harmonically more closely related to the musical prime were processed faster and with fewer errors.

4. Conclusion

The fact that everyday sounds are labeled as mere noise and judged to be different from music implies that music has a content other than mere sound waves of which it is composed. As described in this paper, musical patterns consist of several structural elements forming more than one type of hierarchy and structure in a single pattern. Thus any single musical pattern embodies more than one type of information. Studies show that listeners are indeed sensitive to underlying hierarchical organizations of musical context. Moreover, listeners appear to be sensitive to surface cues. Using information from above mentioned studies, it should be of no difficulty to attribute new meanings to multiple information loads of musical patterns. In fact, musical tones produced by various sound devices have long been used in transmitting information (See.ICAD). Morse code was an early example of condensing written words into short and long bursts of sound. In modern days of radio and TV, short jingles condense all or most of the audio-visual content of commercial advertisements. Once an association is established between a musical pattern and some non-auditory information, this association can be exploited and expanded by modifying the scale and rhythm of the pattern and new meanings can be added to existing pattern.

In addition, as Meyer (1956) once had reminded, the similarities between musical structure and psychological reference points are suggestive. These similarities indicate the possibility that principles of organization in music resemble those found in the more traditional cognitive domains. In sum, we can say that music can be a very useful tool for cognitive psychology. I suggest that music research will continue to contribute significantly to research on human auditory cognition.

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