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Review paper

POLYPHONIC MUSIC AND ASPECTS OF ITS PERCEPTION

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Abstract. *This paper presents several different studies which suggest that music in more musical voices (voice multiplicity) tends to be perceived more positively. These empirical studies emphasize the importance of horizontal organiztion on music perception. According to the author Vinoo Alluri (Alluri, 2012) the polyphonic timbre has been found to be a significant perceptual component of music, especially in studies that involve tasks such as genre identification, categorization, or emotional affect attribution.*

Key words: *polyphony, horizontal motion, voice multiplicity, perception, emotional sensations*

1. INTRODUCTION

1.1. Polyphony as an auditory stimulus

There is a very important study by Rudolf Alexander Rasch (Rasch 1981) which includes some aspects of the perception and performance of polyphonic music. According to this author, experience and observation tell us that the human ears is often capable of separately perceiving two simultaneous sounds from different sources. Examples are the ability to understand speech against a background of noise and also to follow individual parts or voices in polyphonic music (in the widest sense of the word). This ability cannot be taken for granted. The various simultaneous signals are superimposed on each other on their way to our ears. Our hearing system obviously performs some kind of analysis to make possible the perception of the original sound stimuli. The issue is particularly evident in music where there is more than one melodic line. That is the case with music that is traditionally called polyphonic (mostly composed before 1750), but often also with symphonic music and ensemble chamber music (mostly composed after 1750).

The harmonies of single tones fuse into a single perceptual image as does the doubling of melodic lines by the same or other instruments, either in unison or in octaves.

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The simultaneous use of organ stops results in a single sound impression. To a lesser extent this is also true in homophonic music such as harmonized melodies. There is only one melodic line which is clearly perceived.

In polyphonic music, however, the simultaneous components of the auditory stimulus do not fuse into one single melodic line but retain their own musical significance. Until now, most research in musical acoustics and perception has been devoted to problems concerning single tones and single lines of melody. Polyphonic music poses a great number of questions concerning performance and perception. These questions cannot be answered by ways of research on single lines and tones but need to be investigated separately. The perception of polyphonic music derives from several fields of Science (Rasch 1981).

Author Diana Deutsch believes that when it comes to perceptual fusion and separation of various components of music “We first enquire into the relationships between the components of a sound spectrum that cause us to fuse them perceptually so as to form unitary sound images, and those that cause us to separate them perceptually so as to form multiple sound images. In particular, we focus on two types of relationship: harmonicity of the spectral components, and temporal relationships between the spectral components. For example, in polyphonic music it is desirable that simultaneously sounded tones should stand out clearly from each other, and Bach, in his polyphonic works, avoided intervals that promote tonal fusion” (Deutsch 2007, 1).

According to Chagas (2005), one of the most fascinating things about listening is our ability to perceive a multitude of sounds occurring at same time in the environment. His formulation of this ability is “simultaneous auditory perception”.

“From a musical point of view, the concept of “simultaneity” is related to “polyphony”, a term used to designate different kinds of music and conveying two important notions: *multiplicity*, and *individuality*. Polyphonic music consists of *several* and *independent* parts generally subordinated to a unifying principle of organization but also presenting a diversity of elements which generate variety. In Western music the distinctions polyphony/monody and polyphony/melody express the predominance of the notion of “voice” and the generative function of “pitch” in musical organization. The typical architecture of Western polyphony is built on a system of voices organizing pitch in two compositional space domains: the domain of horizontality – the linear or temporal succession of sounds – and the domain of verticality – the simultaneity of sounds. These domains can be represented as vectors in 3D space: horizontality and verticality are associated respectively with the functional categories of “melody” and “harmony”, which do not represent internal differences in the system, but rather different points of view for observing the temporal and spatial relationships between the pitches” (Chagas 2005, 2-3).

1.2. Horizontal Motion

“The horizontal aspects of music are those that proceed with time such as melody, counterpoint (or the interweaving of simultaneous melodies), and rhythm. The vertical aspect comprises the sum total of what is happening at any given moment: the result either of notes that sound against each other in counterpoint, or, as in the case of a melody and accompaniment, of the underpinning of chords that the composer gives the principal notes of the melody” (https://www.britannica.com/art/harmony-music).

When describing different textures, musicians often refer to relationships between musical parts, or voices. In this context, a ‘musical voice’ does not necessarily need to be sung, but instead can refer generically to any horizontal musical line. A monophonic texture could arise both from a single person chanting or from several instrumentalists performing in unison. Similarly, polyphonic music with multiple musical voices could be performed by a single musician using a polyphonic instrument. While polyphony in the broadest sense can refer to any music with more than one simultaneous note, it also can be used in a more specific sense to designate contrapuntal textures with a high degree of independent linear motion (such as occurs in canons, fugues, and Renaissance motets) (Broze, Paul, Allen & Guarna 2014).

The cognitive and sensory approaches emphasize the effect of harmony-the vertical arrangement of the tones-on musical tension. The effect of the melodic arrangement between the tones of successive chords is neglected by these models. Horizontal organization is an equally important factor influencing the structure of chord progressions. Good horizontal organization is produced by adhering to a number of more or less strict rules, referred to as counterpoint rules in pedagogical treatises. Several empirical studies have supported the importance of horizontal organization on music perception (Bigand, Parncutt & Lerdahl 1996).

1.3. Music and emotions

Experiments that will be presented in the next section of this paper imply that music with more musical voices tends to be perceived more positively and causes emotional sensations with listeners. Positively valenced emotions are recognized by participants who were included in these empirical studies. Therefore, some aspects of how music can affect our emotions are given in the text to follow.

“The link between *music and emotions* is more of an issue than ever before, and music research is increasingly focusing on understanding the complex characteristics of this interaction. After all, for a long time the fact that music has an emotional impact upon us was one of the greatest of enigmas, since fundamentally it only consists of inanimate frequencies” (Willimek 2011, 1).

Music has the ability to induce emotional and cognitive process in humans. Music also encourages creative thinking and improves mental engagement (Bodnar 2017). Emotional reactions to a different stimulus enable measurement of emulation in examenee. Some changes as heart beat, blood pressure, body temperature, inhale and exhale speed, can differ when preparing to listen to the music and while listening to it.

Emotions (when listening to music) can be caused by the structural characteristics of music (e.g. tempo or dynamics) as well as subjective associations to the music piece. However, the importance of differentiating the feelings that are perceived and those that are evoked is emphasized. First of all, the mechanisms responsible for evoking emotions and for perceiving emotions can be completely different. Then, the evoked emotions are much harder to detect and measure in relation to the emotions that are perceived. Finally, perceived emotions can be completely different from evoked emotions (Juslin & Laukka 2004).

The Theory of Musical Equilibration (known in the original German version as the *Strebetendenz-Theorie*) is the first to create a psychological paradigm which explains the emotional effects of music. It breaks down musical sequences into one of their most essential components — harmony — and directly uses this material as the basis of its argumentation.

Bernd Willimek's Theory of Musical Equilibration, the *Strebetendenz-Theorie,* has its roots in the music-psychology teachings of Ernst Kurth. It is the first international compilation which lists the emotional character of musical harmonies, and at the same time it is also the first general description of their emotional impact. It explains the psychology aspects underlying the musical character of these structures as the consequence of processes in which the listener identifies with musically-encoded processes of will (Willimek 2011).

Furthermore, researcher Imre Lahdelma (Lahdelma 2017) underlines six mechanisms to account for music's ability to induce emotions in listeners, and these are of interest also in the current context of emotion perception, as emotion induction and perception can sometimes be closely intertwined:

"1) *Brain stem reflex* refers to a process whereby an emotion is induced by music because fundamental acoustical characteristics of the music are taken by the brain stem to signal a potentially important and urgent event (e.g. loudness, speed).

2) *Evaluative conditioning* refers to a process whereby an emotion is induced by a piece of music because this stimulus has been repeatedly paired with other positive or negative stimuli.

3) *Emotional contagion* refers to a process whereby an emotion is induced by a piece of music because the listener perceives the emotional expression of the music, thereby "mimicking" this expression internally.

4) *Visual imagery* refers to a process whereby an emotion is induced because the listener conjures up visual images while listening to the music.

5) *Episodic memory* refers to a process whereby an emotion is induced to and in a listener because the music evokes a memory of a particular event in the listener's life.

6) *Musical expectancy* refers to a process whereby an emotion is induced to and in a listener because specific features of the music violate, delay, or confirm the listener's expectations about the continuation of the music; this mechanism was first proposed by Meyer (1956).

7) *Cognitive appraisal* is related to an evaluation of music on various dimensions in relation to current goals/plans of the listener" (Lahdelma 2017, 19-20).

1.4. Aims of the polyphonic timbre perception

In his study: *Acoustic, Neural and Perceptual Correlates of Polyphonic Timbre*, author Vinoo Alluri (2012) presents the main aims of this kind of research. The central focus of his thesis is to investigate timbre perception in a polyphonic context using an interdisciplinary approach. The main idea of this paper is also to make a connection between polyphonic timbre and how it affects human listeners in emotional and acoustical context. Moreover, presenting several researches on this topic may inspire other researchers to conduct more experiments either on this, or on similar topics.

Specifically, the study aims at filling existing gaps in the field of monophonic timbre and extends timbre perception investigations to polyphony in an interdisciplinary setting. The studies are divided based on the following sub-topics, according to the Vinoo Alluri. In this paper some of the most important points are underlined.

1. Link between polyphonic timbre and emotions,
2. Polyphonic timbre semantics,
3. Acoustic features of polyphonic timbre,
4. Perceptual dimensions of polyphonic timbre,
5. Perceptual validation of acoustic features of polyphonic timbre.

2. Perception of Polyphonic Music

2.1. Multiple sound source effect

When multiple sound sources emit at the same time, it is possible to experience several special auditory phenomena. The distinction of each individual tone (when several of them are received at the same time) depends on the nature (similarity) of those tones and their number, but above all on the discriminative ability of the listener. The merging of tones is usually achieved in a harmonious harmony: some tones are "friendly" to each other, and the chords merge. Masking is the phenomenon that one tone covers another, and that is not heard. There are two general rules of masking: a stronger tone masks a weaker one, and a deeper tone masks a higher one. A sound shock is a phenomenon that instead of two tones (from two sources) only one is heard, which becomes stronger now, weaker now. This phenomenon applies to tones that differ from each other by a small frequency - from 1 to 16 hertz. Differential tone occurs if two tones (from two sources) differ from each other by a frequency greater than 16 Hz. Then each of these tones is heard separately, but next to them a third tone equal to their difference in frequency is heard, and it is the product of their interference, called the differential tone. The summation tone (discovered by Helmholtz) is also the product of mixing two basic tones, but the pitch corresponds to the sum of their frequencies. While the differential tone is a consequence of physical stimulus, the summation tone is a consequence of nerve summation (Ognjenović 2011).

“Experience and observation tell us that human listeners are often capable of separately perceiving two simultaneous sounds from different sources. Examples are the ability to understand speech against a background of noise and also to follow individual parts or voices in polyphonic music (in the widest sense of the word). This ability cannot be taken for granted. The various simultaneous signals are superimposed on each other on their way to our ears. Our hearing system obviously performs some kind of analysis to make possible the perception of the original sound stimuli. The issue is particularly evident in music where there is more than one melody line. This is the case in music that is traditionally called polyphonic (mostly composed before 1750), but often also in symphonic music and ensemble chamber music (mostly composed after 1750)” (Rasch 1981, 9).

2.2. Perceptual component of polyphonic music

There are number of studies which suggest that music with more musical voices tends to be perceived more positively. Polyphonic composers explicitly construct multiple concurrent musical parts or streams whose perceptual independence is deemed important. Thus, one might assume that there exists in polyphonic music a compositional intent to preserve stream segregation between the voices - an intention that may not be present in other types of music (Huron 1991).

Polyphonic timbre has been found to be a significant perceptual component of music, especially in studies that involve tasks such as genre identification, categorization, or emotional affect attribution. One study that V. Alluri (Alluri 2012) comes up with in his paper is the study carried out by Gjerdingen & Perrott in 2008. It examined the time required for people to identify or classify into genres very short music excerpts. They reported that musical extracts as short as 250 ms were sufficient for genre identification. The authors highlight the importance of the overall timbre in the perceptual process of identification and categorization. The authors describe the overall timbre as an agglomerate "of spectral and rapid time-domain variability in an acoustic signal" which is put together by the listener in a Gestalt-like manner that thereby enables listeners to identify, classify, and categorize the heard piece of music. In other words, overall timbre possesses cues that enable identification and classification (Alluri 2012).

Speaking of identification of short music excerpts, there is an interesting study by Andrew H. Gregory, conducted in 1990. Listeners heard short extracts of polyphonic music, and had to decide whether or not a subsequent melody was present in the polyphonic excerpt. For many of the excerpts accuracy of recognition was high, suggesting that the different melodic lines in polyphony can be perceived simultaneously. If one melody was on a higher pitch than another it was more easily recognised, and there were differences in the recognisability of individual melodies. When these factors were held constant, recognition was more accurate if the melodies were closely related in key, in the same pitch range, had simultaneous note onsets and were differentiated in timbre. Within the same pitch range melodies having the same tempo were better recognised, but in different pitch ranges then differences in tempo improved recognition accuracy. Three melodic lines seemed to be as easily discriminated as two in the excerpt studied (Gregory 1990).

Three experimental studies suggest that music with more musical voices (higher voice multiplicity) tends to be perceived more positively. Studies were conducted by eminent researchers in this field: Yuri Broze, Brandon T. Paul, Erin T. Allen and Kathleen M. Guarna (Broze, Paul, Allen & Guarna 2014).

Experiment 1: Perception of Musical Loneliness

In the first experiment, participants heard brief extracts from polyphonic keyboard works representing conditions of one, two, three, or four concurrent musical voices. Two basic emotions (happiness and sadness) and two social emotions (pride and loneliness) were rated on a continuous scale. Listeners rated excerpts with higher voice multiplicity as sounding more happy, less sad, less lonely, and more proud.

In this experiment, fugal compositions were chosen as stimuli (recordings of J. S. Bach's Well-Tempered Clavier played by a professional harpsichordist), because they feature polyphonic textures with clearly defined voice multiplicities. Fugues typically begin with a single monophonic melody: the fugue's subject. Additional voices then accumulate, with each new entry repeating the subject melody.

The procedure was the following: Participants (twenty-eight Ohio State University School of Music undergraduates: 17 female, 11 male, aged 19–21) were asked to provide emotion ratings for musical excerpts played through free-field speakers at a comfortable level. In addition to loneliness, three other emotions were rated to disguise the target emotion, as well as to provide data for exploratory analysis. Subjects rated the prototypical negative and positive emotions of 'sadness' and 'happiness'. Participants were instructed to rate the emotions they perceived in the music.

The positively valenced emotions happiness and pride both exhibited increased ratings for higher voice multiplicity, while ratings for the negatively valenced emotions of sadness and loneliness showed the opposite effect.

Experiment 2: Generalization to Emotion Valence and Sociality

A between-groups design was used with regard to valence, and within each valence group, three social and three nonsocial emotions were chosen. All in all, three predictions were tested:

- positive emotion ratings should increase, and negative emotion ratings should decrease as voice multiplicity rises;
- social emotions should exhibit larger-magnitude voice multiplicity effects than nonsocial emotions;
- researchers hoped to reproduce the result that monophonic stimuli evoke stronger responses than any other multiplicity level.

Six positive and six negative emotions (split by sociality) were chosen such that no two emotions fell in the same subcategory. Participants were alternately assigned to the positive-emotion or the negative-emotion group in the order in which they arrived. Using identical slider interfaces as in the first study, the positive-emotion and negative emotion groups rated identical stimuli for the emotions. Because the major mode and minor-mode excerpts did not appear to elicit different response patterns, results for all 36 stimuli were analyzed together (7 minor fugues and 2 major fugues with four voice multiplicity conditions).

Emotions responded in the expected direction, with positive emotion ratings increasing with voice multiplicity and negative emotion ratings decreasing. In short, it seems that thinner polyphonic textures are associated with negative emotional valence and thicker textures with positive emotional valence. Once again, the effect appeared to taper off as multiplicity rose. Results from a second experiment indicate that this effect might extend to positive and negative emotions more generally.

Experiment 3: Emotion Rating Strength and Voice Denumerability

In a third experiment, participants were asked to count (denumerate) the number of musical voices in the same stimuli. Denumeration responses corresponded closely with ratings for both positive and negative emotions, suggesting that a single musical feature or percept might play a role in both. Possible roles for both symbolic and psychoacoustic musical features are discussed. The present study investigates the perception of musical emotion in terms of musical voice multiplicity: the number of musical parts or voices simultaneously present in a texture. Because the primary goal was to measure a purely musical effect (and not one which would actually reflect the number of musicians performing), they used stimuli performed by a single person on a polyphonic instrument. This study was divided into three parts: emotion generation, emotion rating, and denumeration. The third part is the most important part for this study. In the third part, subjects denumerated the voices in excerpts by typing a single digit into an empty text field. Listeners appeared to resort to estimation processes when denumerating voices in four-part textures, resulting in very high error rates.

Positive emotion ratings increased with voice multiplicity while negative emotion ratings decreased, replicating the emotion valence effect identified in Experiment 2.

By contrast, the third experiment requested that listeners provide their own emotion labels, prompted by musical stimuli. These emotions might have been understood as musical emotions with specific musical meanings and referents. Thus, participants in experiment three might have been making ratings based on an excerpt’s musical similarity to the one that initially evoked the emotion instead of to a more typical understanding of individually experienced emotions. Because emotion terms were generated for all four multiplicities, it is understandable why monophonic stimuli would not always evoke the strongest responses.

In the first experiment, participants rated brief musical excerpts for four emotions, including perceived loneliness. Researchers predicted that music with fewer musical voices would tend to sound lonelier than music with many musical voices. A second experiment tested whether voice multiplicity effects generalize to emotional valence and sociality. Finally, a third experiment allowed subjects to generate their own emotion labels and directly measured their ability to denumerate the voices in the specific stimuli used. To anticipate the results, listeners appear to associate increasing polyphonic voice multiplicity with increasing emotional positivity. Moreover, ratings for perceived emotion will bear strong resemblance to the perceived number of the present musical voices, suggesting that perception of both emotion and voice numerosity might rely on the same underlying cues (Broze, Paul, Allen & Guarna 2014).

There are some other interesting ideas and studies. For instance, according to the author Huron (Huron 1991), some studies have demonstrated that the perceptual tracking of auditory streams is confounded when streams cross with respect to peach. A study of part-crossing in 105 polifonic works by J.S. Bach shows a marked reluctance to have parts cross – even when the effects of peach distribution are controlled. Therefore, this analysis of works by Bach shows that Bach's compositional practice accords with the traditional voice-leading rule to avoid local part-crossing.

Furthermore, there are two interesting experiments that investigate the perception of structural stability in atonal music. The first experiment suggests that listeners may hear atonal music in terms of the relative structural importance of events and that listeners' hearing is greatly influenced by metrical and durational structure. A second experiment reveals that, even in the absence of clear rhythmic, timbral, dynamic, and motivic information, listeners infer relationships of relative structural stability between events at the musical surface. The effects of three main variables (pitch commonality, horizontal movement, and dissonance) and two salience criteria (register and parallelism) are considered. The results indicate that in the absence of a clearly differentiated surface structure, listeners' judgments of stability are influenced by the dissonance of chords and the horizontal movement of voices. The conclusion is that salience (phenomenal accents), voice-leading, and dissonance are potentially important factors in the abstraction of relationships of relative structural importance, and hence to any inference of prolongational structure in atonal music (Dibben 1999).

CONCLUSION

Multi-voice music offers listeners certain musical pleasures that monophonic music does not, and the pleasure that they experience might be misattributed to the musical stimuli. The simple perception of concordant harmony has long been described as a sensory pleasure. Additionally, there might be musical enjoyment involved with the successful parsing of a musical texture (Huron 2001). Notably, one might expect that the population of undergraduates studying aural skills would be particularly likely to enjoy resolving multiple voices, raising the strong possibility that these results might not generalize beyond trained musicians.

It is typically easier to resolve individual voices in polyphonic textures than in homophonic textures due to staggered voice entries (Huron 2001; Rasch 1981). Moreover, polyphonic textures tend to exhibit higher onset density in general, producing a more ‘active’ musical surface. Both might increase perceptual voice numerosity, and therefore lead to the perception of more positive emotions.

In the end, it is necessary to mention two exceptional books which are connected with this topic in the context of music cognition. The first one is Peter Pesic's *Polyphonic Minds: Music of the Hemispheres* (2017). Pesic defines polyphony as the interweaving of simultaneous sounds and explores the history and significance of "polyphonicity," or "many-voicedness," in relation to human experience and how we understand the mind. He searches for answers to the question of how the brain processes polyphony. Marc Leman, another researcher in the field of music cognition, also examines the impact that musical sound can have on human beings in his book *Embodied Music Cognition and Mediation Technology* (2008). He explains that "involvement assumes a relationship between a person and music. This relationship may be either direct or indirect. Research such as Leman's and Pesic's connects directly to music cognition through the study of various types and textures of sound and how they engage the mind in thinking, reasoning, interpretation and evaluation and how they evoke emotional sensations in human.

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POLIFONA MUZIKA I ASPEKTI NJENE PERCEPCIJE

Ovaj rad prikazuje nekoliko različitih studija koje ukazuju na to da se muzika sa više glasova (višeglasje) bolje percipira nego jednoglasna, pri čemu autori naglašavaju važnost horizontalne organizacije muzičke teksture na percepciju muzike. Prema Aluri (Alluri, 2012), polifoni zvuk je veoma značajna perceptivna komponenta muzike, naročito u studijama koje uključuju zadatke kao što su identifikacija muzičkog žanra, kategorizacija ili emocionalna senzacija.

Ključne reči: *polifonija, horizontalni pokret, višeglasje, percepcija, emocionalne senzacije.*