

Embodiment and Interaction as Common Ground for Emotional Experience in Music

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Abstract. Physical activities and social interaction play crucial roles in the experience of musical emotion. This paper first discusses the physiological functions and social aspects related to music. Upon the observations we introduce the network structure underlying the emotional experience in traditional music, and extend the framework to contemporary computer music, in which computer-aided embodiment, interaction, and collaboration provide emotional experiences to the players.

Keywords: Musical emotion, interaction, embodiment, participation.

1 Introduction

Physical movements and communication are inseparable from music, coexisting in our musical experience in everyday life. These are both seen when a baby is cuddled and sung a lullaby, when children sing while playing together, when adults perform music in an ensemble, and when a community of people share music during a festive occasion. The most vivid musical emotions that we experience exist within the context of physical movement and communication.

Computer music works in embodied, interactive, and collaborative forms are often experienced emotionally. Compared to works composed as purely auditory expressions, embodied and interactive computer music seems to add another dimension of fascination to players and audiences. This paper discusses such social and physiological elements in music as a foundation for musical emotion.

Classic studies in musical emotion often employ the viewpoint that musical emotion is considered personal responses to “music as auditory stimuli” or “organization or structure of sounds in music.” Psychological experiments on music emotion strictly control the listener’s bodily actions and the external listening environment to ensure the reproducibility and reliability required for sound scientific research. These studies provide much information on the perception and cognition of music on an individual basis, which is fundamental to understanding musical emotion. However, they do not directly explain the dynamic and lively musical emotion that we experience daily. According to Johnson [1], “*the experience of sitting quietly in a chair and listening to music is almost unnatural, for our bodies want to move with the music.*” Another often neglected issue is the social aspect in music; DeNora vividly illustrates how human relationships influence everyday musical experience [2]. This paper aims to provide some theoretical thoughts on the real and non-measurable experience of musical emotion in our actual life.

This paper attempts to describe that (1) musical emotion becomes more precise and enriched with physical and social elements in music, (2) physical and social aspects of

musical emotion can be described in the form of network structure, and (3) emotional experience in embodied, interactive, and collaborative computer music pertains to the same framework.

Before starting our discussion of shared musical emotion, we need to define music, emotion, and musical emotion. Answers to the question “what is music?” are dependent on the cultural and social background of individuals, and many individuals have very strong opinions and images about music [3]. In this discourse, we focus on the embodied and interactive aspects of musical experiences, which is shared by both musicians and non-musicians; therefore, it is appropriate to refine the definitions from standard language dictionaries, assuming that they reflect the ideas and images of music of ordinary people, not just artists or philosophers:

Music is artistic creation, sonic production (not necessarily considered to be artistic), and cultural and social behavior that combines the sounds produced by humans using the elements and styles including (but not limited to) rhythm, melody, harmony, chanting, etc., which are distinct from speech.

Emotion can have diverse definitions; however, this paper followed the definition from the “Handbook of Music and Emotion” by Sloboda and Juslin [4]:

Emotions are relatively brief, intense, and rapidly changing responses to potentially important events (subjective challenges or opportunities) in the external or internal environment. They are usually of a social nature, which involves a number of subcomponents (cognitive changes, subjective feelings, expressive behavior, and action tendencies) that are more or less “synchronized.”

Musical emotion is then defined as “emotions that were somehow induced by music” [4]. Along with the above definition of emotion, when we experience musical emotion, “the potentially important events (subjective challenges or opportunities)” are music. When considering musical emotion, music should be regarded not only as stimuli from the “external environment” but also as agency in the internal environment (physiological and psychological conditions) and as a social medium.

2 Emotional information in musical activities

2.1 Embodiment: The Physiological and Physical Ground of Musical Emotion

The physiological and physical elements related to musical emotion vary from unconscious and unintentional physiological functions to conscious and intentional actions of musical performance. According to the James-Lange theory of emotion (i.e., the physiological condition of the human body determines the experience of emotion) [5], we can presume that the physiological and physical aspects of music determine the experience of musical emotion.

Studies on physiological reactions related to music include dopamine release matching the highest arousal of musical emotion [6], presence of mirror neurons [7], mirror system synchronized with musical performance gestures [8], rhythmic synchronization [9], rhythmic prediction processes in brain waves [10], and chills [11]. Physiological studies related with music are currently conducted in many institutions, and more outcomes are expected to appear. These basic motor functions and physiological responses to music are unconsciously produced and hard to control. Therefore, it is difficult to estimate how much they contribute to the physical context of our musical experience. However, since they are unavoidable and unconscious, it is reasonable to assume that they always exist and form the foundation of conscious, active motions in musical experiences.

Performance skill relies on motor skill acquisition, which affects the brain structure while training for a long time. Skilled pianists spend a long time developing and maintaining their performance skill [12, 13]. Skilled performers who started their training at an early age have a significantly larger area corresponding to their hands in the motor cortex in their brain than non-musicians do [14]; they have an enlarged genu, the signal pathway area in brain related to motor functions [15], and a stronger connection between the neural pathway for music and listening and the pathway for hand motions [16]. Overall, performance training during early childhood enlarges the functional area of the brain's motor skills, stimulates the activation of the area, and creates a neural pathway for performance. An artistic and expressive performance requires precise control of physical movements, and acquiring such controls demands rigorous training and re-wiring of neural pathways of the brain simultaneously. We could say that using our body intensively for making music transforms our brain and presumably increases the sensitivity, accuracy, and resolution in both music listening and making.

2.2 Collaboration, Participation, and Interaction: The Social Element of Musical Emotion

Social aspects of musical emotion are often anecdotal, yet I trust that many people feel that live musical experiences in groups tend to be more emotional than experiencing music in isolation.

Most Western traditional music, which is expected to have a composer, players, and listeners, is a social behavior delivering sounds from person to person, and music performances require coordination and communication among performers in a multimodal way [17]. Luck and Toiviainen studied the synchronization between conducting gestures and performing music using a motion-capture system, finding that the performers synchronized most precisely at parts with a gradually reducing or very fast tempo [18]. Other studies report that visual observations of conducting [19] or performing gestures [20] can deliver emotional expressions to participants regardless of their musical experience. These studies show that musical emotion is communicated not only in the auditory domain but also in multimodality including motions and visions.

Many cultures in the world share dynamic and strong emotions through music. In many cases, such as rituals and festivities, players and listeners are not differentiated. People play, sing, dance, and share in very strong emotions together, sometimes reaching high degrees of excitement. In these situations, active performance, listening, and physical motion occur at the same time, and music is felt as a shared dynamic experience, providing strong emotional bonding.

This kind of musical experience exists not only in traditional rituals but also in modern cultures. According to Csikszentmihalyi [21]:

“The audiences at today’s live performances, such as rock concerts, continue to partake in some degree in these ritual elements; there are few other occasions when large numbers of people witness the same event together, think and feel the same things, and process the same information. Such joint participation produces (...) the sense that one belongs to a group with a concrete, real existence.”

Performance, especially improvisation, requires strong attention and focus and tends to promote dynamic communication of musical emotion [22]. This paradigm of group improvisation in motion is employed in many multimedia sound-art installations.

Delivery and sharing of musical emotion rely not only on sonic information but also on sharing motions, gestures, and visions; musical and performance expressions can deliver emotions using sound and music. Yet, from the viewpoint of the James-Lange theory of emotion, if people move their bodies together to play music, they

share the physical condition, resulting in sharing the emotional condition. That means that sharing motion along with music accelerates emotion sharing among people. The emotion experienced may not be exactly same, yet “the dynamic contour of musical emotion” is shared by people in a synchronized manner.

3 A Network Model of Musical Emotion

This section describes a model for the communication of musical emotion. In this model, the communication of musical emotion is described as a network of human agents with an internal system and an interface of perception and expression. Maturana and Varela describe a schematic of connected agents with internal state which are affected by a surrounding environment [23]. A similar model of perception and motor function sharing is also presented in Benzon’s literature [22]. These literatures describe the physiological and psychological conditions between coupled agents (i.e., interacting people), but do not discuss the emotion-sharing mechanism in musical situations in detail. Given this context, we wish to extend the discussion on emotional communication in music in this section. This study regards musical experience as a communication of musical emotion, and music as a medium of emotion. We aim to explain that musical emotion sharing is founded upon the physical and social aspects.

3.1 Physiological Model for Emotional System

The human body is the fundamental agent in the communication of musical emotion. Humans relate to the external world by perception (introverted) and expression (extroverted). The external, incoming information is perceived and modifies the already existing psychological and physiological conditions. Let us name this integrated entity of psychological and physiological conditions as one’s “internal state.” Inside the body, neural responses including brain activities and hormonal secretions occur, changing the internal state dynamically. Extroverted phenomena such as physiological responses, motions and gestures, facial expressions, performance, and voice transmit the internal state to the outside world. We can assume that emotion exists in a manner that integrates the conscious and unconscious elements in the brain. The internal system should have a function to integrate the conscious and unconscious elements as a preparatory stage for emotion. A simplified model for this dynamic system is drawn in Figure 1.

.2 Bi-directional Communication of Musical Emotion

We first consider the simplest case in which two humans share emotion. This mutual sharing of musical emotion is described in Figure 2. The emotion that exists inside the internal system of performer A is expressed to the outside world with the expressive interface, and the expressed emotional information is delivered to performer B’s internal system via their perceptual interface.

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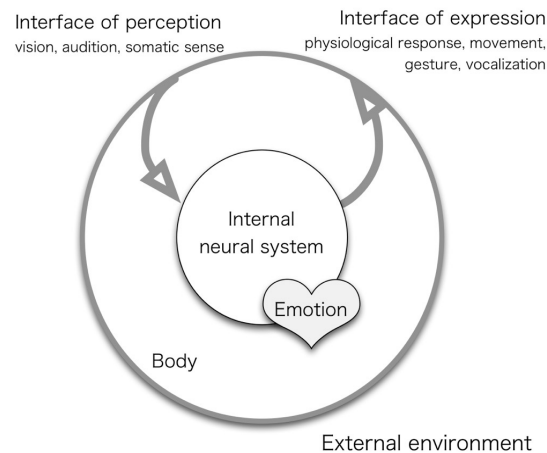


Fig. 1. The model of the emotional system. Humans are viewed as a physical system with the interface of perception/expression and the internal system that encloses emotion. The internal system consists of the central nervous system including the mirror system; the peripheral nervous system including autonomic, somatic, and motor nervous systems; and the endocrine system.

In this model, music is a medium for emotional expression and perception. However, the medium of emotional delivery is not limited to music as a sound, but other accompanying factors of music such as gestures, movements, and visual presentations. The musical information (i.e., solid lines in Fig. 2), extra-musical information (i.e., dashed lines in Fig. 2), and internal state of the perceiving person affect the emotion in a musical experience as a whole.

Bi-directional communication of musical emotion is mutual: performer B's reaction and expression also affect performer A's emotion dynamically. In this way, the feedback loop for the emotion sharing is established.

With this loop structure, emotion can dynamically travel between two people. When this transmission of emotion happens continuously and it is synchronized with music, the sharing of musical emotion described in Section 2 occurs. When musical emotion is shared, each participant understands and responds to each other's emotion, and they progressively exchange their emotion through music. This process enables the communal production and synchronized experience of the dynamic contour of musical emotion.

This structure is true whether the two people are both performers or one is a performer and the other a listener. According to Small, "*musicking*" refers to participating in a musical performance, including both of playing and listening [24]. Small emphasizes rather passive attitudes of listeners in classical music concerts in the main chapters of his book: in such situations, the arrow from the listener to the performer in this model is very thin. However, in other genres, active participation of listeners is welcomed. In such settings, performers often change their expression based on the listeners' reactions, and listeners take an active part in a musical performance, thickening the arrow from the listener to the performer in the model.

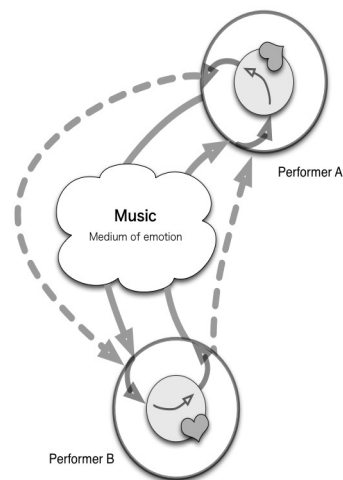


Fig. 2. Communication of musical emotion is established by the feedback at the internal system described by the arrow in the internal system. Musical emotion travels between two people via the medium of musical information (solid line) and extra-musical information (dotted line, e.g., bodily information).

3.3 Multi-directional Communication of Musical Emotion

The experience of dynamic musical emotion shared by a group of people is described in Figure 3. With “song and dance” experiences and group improvisations, participants formulate a network and intervene in musical production. In such musical performances, each person connects to everyone else’s emotion using the interface and internal system and actively participates in the music, creating the musical emotion together. This is an N:N dynamic communication system that uses musical and extra-musical information as a medium of emotion.

Some other cases may be regarded as 1:N communication: for example, a live rock or concert performance by a charismatic musician where audiences share overwhelming emotions. Musicians use music and physical actions as their medium, efficiently approaching the audience’s interface and internal system and producing very strong emotional responses among many people. However, genuine performances are not unilaterally offered; great musicians promptly sense audiences’ vocal and gestural reactions, and deliver dynamic and delicate adjustments in their musical expressions.

In this model, musical and extra-musical information are emphasized with a solid line and a dashed line. Each of the connections represented with these lines can be stronger or weaker, allowing the communication to be distributed unequally, or some functions to be used more intensively.

Overall, our musical experience is a multimodal process that integrates the auditory, visual, and somatosensory interfaces and exploits the full function of the internal system. The produced music is a fruit of this dynamically collaborative and multimodal process and reflects the dynamic trajectory of musical emotion shared by the participants.

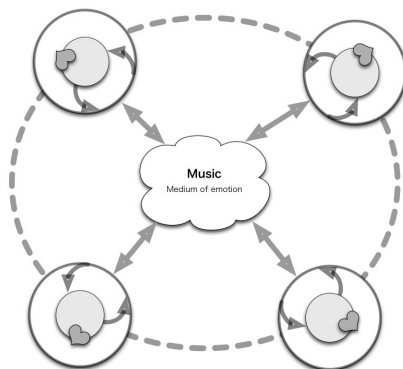


Fig. 3. Dynamic communication of musical emotion of a group of people. While the participants interactively intervene into music, they share the musical emotion with music (solid line) and extra-musical information (dotted line) as the medium. The dynamical transformation of music induces further transformation of musical emotion.

4 Embodiment and Interaction in Computer Music

Embodied and interactive works in computer music often offer emotional experiences to both audiences and performers. In this section, we attempt to relate these emerging musical styles to the network model of musical emotion.

4.1 NIMes and Computer Music

New interfaces for musical expressions (NIMes) offer physical controls for computer music performances in real time. The means of acquiring control signals vary from sensors to physiological signals (such as EMG and EEG).

One of the earliest NIMes was a radio baton invented by Max Mathews [25], an interface that allows control of the rhythm and dynamics of music. Other early sensor-based NIMes investigated the direction of computer music being “performed” with the human body [26, 27] and gave a strong impression to the audiences that NIMes are equally playable and playful as traditional musical instruments.

This direction of embodiment became even more progressive by transforming the human body into instrument. Some musicians used physiological signals such as EMG (electromyography) and motion-related signals (e.g., using accelerometer) to control music dynamically [28, 29]. Their ways to control music were more sonification-oriented, rather than being MIDI-based. The message of the “human body as an instrument” attracted audiences. Musical performances that use EEG (electroencephalography) also provide similarly emotional, often intimate experiences to audiences [30, 31].

Although we tend to focus on the technical innovations when considering NIMes, their emotional offerings cannot be ignored. Both performers, who are often inventors themselves, and audiences are focused and engaged in the musical performance with a full range of emotions.

The emotional quality experienced in NIME performances is equal to that of a classical music performance, and the same structure of musical-emotion communication can be observed. The performers communicate with audiences using

musical and extra-musical information. Both the real-time music rendering and visual presentation of the performing gestures enable the immediate delivery of musical emotion from the performer to the audiences. The audiences provide reactions to the music, and the performers can reflect that into the music. This mutual communication of musical emotion is present in NIME performances.

4.2 Laptop Orchestra

Laptop orchestras are practiced in many universities, and their courses are popular among students [32-34]. The performers of laptop orchestras have to observe, react, and participate in musical performances with other performers. Many repertoires require the performers to not only play but also improvise according to the music. This framework also allows an intensive communication of musical emotions among performers themselves and with audiences. The musical emotion is expressed in terms of musical and extra-musical information (in this case, gestures, motions, shared-codes, messages over networks, etc.) and performers have to musically respond in time with gestures, which are captured by sensors [35]; these musical action and responses form the network structure of emotional communication. This performative communication provides a strong sense of unity to the performers and audiences, making the laptop orchestra an emotional experience to both performers and audiences [36].

4.3 Networked Performances

The idea that people perform music together from a distance is highly attractive and has fascinated many musicians. Some network-connected performances are conducted in concert form with audiences [37, 38] while others are conducted as a gig among musicians without expecting particular audiences [39]. These performances involve singing, playing traditional instruments, and performing NIMEs or mobile apps. Again, the network structure of musical emotion communication is present and musicians are having a deeply emotional experience playing music. The main difference from traditional music is that the medium and pathway for musical and extra-musical information are now on Internet. However, the emotional experience in the networked music is fundamentally similar to that in the traditional music making, or perhaps augmented with the excitement to perform music together with unexpectedly distant musicians.

4.4 Collaborative and Participatory Paradigms

Collaboration and participation have become prominent factors in computer music. Many platforms and interfaces that enable collaborative creation of music have been proposed [40-43]. Installation, sound-art, and audience-participation performances are also very popular [44-47]. These systems function as a foundation for communicating musical emotion; the systems can reflect the intentions and emotions of participants in real-time by means of sound, vision, gestures, motions, and physiological conditions. Jo et al. describe the participatory design of music based on community, where people intensively focus on the process of creating new music [48]. With these participatory frameworks, participants can exchange musical ideas and emotions forming the network structure, and their musical performances offer emotional experiences to both participants and audiences.

5 Discussion

5.1 Audio as a Fluid Medium

In this model of communication of emotional sharing, music is regarded as the medium of emotional expression. The acoustic quality of music promises immediate intersubjectivity by mixing sounds.

When multiple people express their emotion, the expressions do not easily merge if they are not in the acoustic medium. Expressions by a solid object or physical motion exist individually and do not naturally blend together. Expressions intermix when the information is represented in a “mixable” medium such as sound, light, and liquid. By choosing sound as the expressive medium, music allows people to fuse their expressive information and construct an auditory scene where people can detect auditory objects if the sound production is well controlled [49].

The mixing of the sound medium is characteristic as multiple sounds intermix in real time with very little directive influence, creating an acoustic field. Each participant in the acoustic field, even if the person produces a different sound than the other people, is exposed to the same acoustic event at the same time as the others, which is constructed of many different sounds contributed to by everyone in the field.

This mixing/fusing quality of music offers the physical basis for the immediate emotion sharing in the communication of musical emotion. Therefore, music is a physically intersubjective medium. Such a quality enables the intersubjective experience of musical emotion among multiple participants.

5.2 Discovering New Values in Music

The perspective of dynamic and collaborative communication of musical emotion enables us to consider new musical values. Interactive sound art, embodied musical instruments and NIMEs, participatory music, and collaborative computer music performances, as illustrated in Section 4, are emerging genres that progressively expanded after the 2000s with the development of computer and internet technologies. These new musical works are often presented in computer music and media art events such as ICMC, NIME, Ars Electronica, and SIGGRAPH. These repertoires do not necessarily pursue the traditional values in common Western music such as abstract musical expressions [50], but rather exploit the dynamic and embodied experiences aided by technologies and the musical emotions themselves as media of expression.

The values of traditional Western music are rooted in the traditional Western music theory. In order to focus on the value of music as an abstract art, abstract descriptions (e.g., score-based notation) are essential. Moreover, the history of music theory and music analysis based on scores formulated the values of traditional Western music.

We believe the above-mentioned new musical works should be evaluated in terms of the theory of musical emotion rather than the values of traditional Western music. Our model and theory for musical emotion enables the evaluation of contemporary works in terms of contemporary perspectives. Such a discourse will develop a new system of musical works and theory and will eventually help us discover new musical values.

Interactions and embodiment in music have not been fully considered in music theory; consequently, some musical aspects such as performance and participation have plenty of room for further theoretical development. Theorization of this research area and enfolded it into the system of musical theory is beneficial for the further development of music theory and musicology. Our discourse on musical emotion in

physical and social contexts, along with the related studies to unveil the gestural, emotional, and social circumstances of new music [51-55], hopefully contributes to the basis for a new theory for music.

6 Conclusion

In this paper, we described the common structure found in emotional communications in both traditional and new music using a network model of musical emotion. The exchange of emotion via musical (i.e., sounds) and extra-musical information (i.e., gestures, visuals, motions, messages, etc.) is the key for live music experiences and is one of the sources of focus, fascination, and excitement in live performances of new music. Embodiment and interactions are essential factors for this structure. We think this structure itself is a musical heritage that is common for the music of various styles and cultures, including computer music.

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