

## Connections between Music and Spatial Behaviors: Focusing on Embodied Cognitive Perspectives

Wooyong Yi<sup>1</sup>, Dongnyeok Jeong<sup>1</sup>, Jun-dong Cho<sup>1</sup>

<sup>1</sup> Department of Interaction Science, International Hall, Sungkyunkwan University,  
25-2, Sungkyunkwan-ro, Jongno-gu, Seoul, Korea  
{skeptor, nyeok, jdcho}@skku.edu

**Abstract.** This study investigated the connection between music cognition and spatial cognition based on embodied cognitive perspectives. Based on several empirical and theoretical evidences, this study conducted an experiment to find connection between pitch difference (ascending/descending melodies) and vertical and horizontal difference in behaviors of participants. As results, a statistically significant result and few marginal significant results were found. Also, the limitation and future works are discussed.

**Keywords:** Music, Embodied cognition, Spatial Cognition, Metaphor

### 1 Introduction

The purpose of the study is that investigating relationships between music and spatial cognition on the basis of embodied cognitive perspectives. The existing studies of cognitive musicology and psychology of music mainly concerned that how human perceives music, and cognitive effect of music in music practice and learning, and what is the cognitive model of music perception [1]. The common ground of these themes is that they saw human cognition as information processing system, which is influenced by traditional cognitive science.

However, an arising paradigm, embodied cognition, has affected research on music cognition, and main research areas are embodied music cognition (EMC) and enactive cognitive approach to music (ECA). EMC explains that, in music perception, there is no need to process via representations [2]. And ECA, similar to other behaviors such as hand shake, music perception is established on the interaction between the body (sensory motors) and the environment (music) [3]. In this study, based on these theoretical backgrounds, effects of music perception on spatial behaviors are investigated.

## **2 Literature Review**

### **2.1 Embodied Cognition and Music**

There are several studies that showed possible analysis of music in terms of embodied cognitive paradigm, based on theoretical developments and empirical evidences. Krueger and colleagues are representatives of investigating embodied cognitive aspects of music and music cognition [4]. Musical affordance and enactive properties of musical experience are both point out that music and body (sensory organs and structure of body) are mutually interacting in the manners of the constructivism, which is based on the hypothesis of enactive cognition.

Also, in EMC of Leman and fellow researchers, the main claim is that music is highly dependent on body that is mediator between the mind and the environment. Furthermore, some claims developed that music itself and the structure of it are perceived via our body, so that structural characteristic of our body may affect musical representations.

These embodied cognitive perspectives on music are similar to the conceptualization hypothesis among three hypotheses in embodied cognition research [5]. Among other hypotheses, the proponents of the conceptualization hypothesis assume that there is a connection between the body of an organism and the concepts that the organism can acquire.

Most renowned scholars in the conceptualization hypothesis are Lakoff and Johnson [6]. The bottom line of their claims is that linguistic metaphors may play key role in our cognition in various areas. According to this rather progressive assertion, some assumptions related to the music and the body can arise.

### **2.2 Music and Spatial Cognition**

The most interesting phenomenon in scholastic areas concerning music cognition is that various kinds of studies showed that there is certain connection between music and spatial cognition.

First of all, in traditional research, how fast the rhythm of music and mode of music is related to the spatial cognition ability, arousal and mood. Specifically, faster (higher Beats per Minute, BPM) rhythm and major mode is positively correlated to the spatial perception tasks [7]. Also, longitudinal study showed that creative ability in music such as composition and improvisation is related to the visuo-spatial ability [8].

Moreover, embodied cognition studies showed few evidences support the link between music and spatial cognition. Nelson and colleagues conducted experiment based on metaphoric similarity of music and spatial perception in terms of the space, and the results may suggest significant embodied cognitive analysis [9]. Also, Lidji tried to suggest the high/low in pitch of musical notes can be represented in high/low on vertical axis [10].

### 3 Research Questions and Hypotheses

Based on variety of literatures, we had questioned relationship of the body and musical pitch, with respect to the vertical metaphor.

*Research Question: Can our spatial cognition affected by music, with respect to the change in pitch*

According to previously reviewed studies, we could hypothesize that certain metaphors related to the music and spatial cognitive aspects might be lead to experimental hypotheses. That is, in terms of musical pitch, musical note that has higher frequency can be affect spatial cognitive behavior, mainly changing in vertical movements.

*Hypothesis: In music listening situation, when melody is composed of arising notes, the listener will draw suggested picture vertically higher than when melody is composed of descending notes.*

### 4 Methods

#### 4.1 Participants, Apparatus and Environments

Participants with no disability in the arm/hand use and auditory/visual ability were gathered by online flyers. The composition of participants was 24 males and 24 females (Age;  $M=23.4$ ,  $SD=3.58$ ). Also most of the participants were undergraduate students of Sungkyunkwan University. The experiment was conducted in sound-proof room (area  $20\text{ m}^2$ ) with table, chair and All-in-One PC. The most of the instructions, stimuli and questionnaire were offered through the PC. The music was composed by the Garage Band and played via Jawbone Jambox. Standard A4 size white papers were used to gather participants' drawing and three BIC pens with different colors (black, blue and red) were used together.

#### 4.2 Stimuli and Procedure

The music used in the experiment is the independent variable (IV). The IV has two different levels and the each level represent arising/descending melody. The two melodies were suggested to the participants as within-subjects condition. Therefore the results of the experiment were analyzed by paired samples T-test.

In the experiment, participants were exposed to the music in advance to be adjusted in the musical environments. For practice, several random pictures were offered to be drawn by participants with control auditory stimulus. The targeted pictures were simplified arrow (upper sided), house and thunder. The size of the drawn pictures was measured with rulers in the unit of millimeters for dependent variable (DV).

## 5 Results

Based on the analysis of paired-samples T-test, experimental results were analyzed. In the result of the thunder picture (not of others), participants showed a statistically significant tendency to draw a wider (in width) picture when melody arises ( $M = 57.50$ ,  $SD = 21.01$ ) than when melody descends ( $M = 52.13$ ,  $SD = 19.15$ ) ( $t(23) = -2.22$ ,  $p = 0.036$ ). Also there was a marginal significance were shown in height of the arrow ( $t(23) = 1.65$ ,  $p = 0.112$ ) and the thunder ( $t(23) = 1.57$ ,  $p = 0.13$ ).

## 6 Discussions

Based on the results, musical elements, especially pitch, may have effect on human behaviors. This result possibly shed lights on the hypotheses of EMC and ECA, and also hypothesis of this study.

However, the obvious short-coming of the study also revealed. First hypothesis, which concerns the frequency of the pitch and height of the drawing did not showed in the results. Therefore more sophisticated rationales and elaborated design of the experiment will be needed in future studies. Specifically, more IVs such as rhythm and mode of the music should be tested for supporting EMC and ECA.

**Acknowledgments.** This study was supported by Brain Korea 21 Plus project (Project No. 10Z20130000013)

## References

1. Deutsch, D.: The psychology of music. (eds.) Academic Press (2012)
2. Leman, M., Lesaffre, M., Nijs, L., & Deweppe, A.: User-oriented studies in embodied music cognition research. *Musicae Scientiae*, 14(2 suppl), pp. 203--223 (2010)
3. Matyja, J. R., & Schiavio, A.: Enactive Music Cognition: Background and Research Themes. *Constructivist Foundations*, 8(3), pp. 351--357 (2013)
4. Krueger, J.: Affordances and the musically extended mind. *Frontiers in psychology*, 4, pp. 1003--1003 (2014)
5. Shapiro, L. A.: Embodied cognition. London: Routledge (2011)
6. Lakoff, G., & Johnson, M.: The metaphorical structure of the human conceptual system. *Cognitive Science*, 4(2), pp. 195--208 (1980)
7. Husain, G., Thompson, W. F., & Schellenberg, E. G.: Effects of musical tempo and mode on arousal, mood, and spatial abilities. *Music Perception*, 20 (2), pp. 151--171 (2002)
8. Hassler, M., Birbaumer, N., & Feil, A.: Musical talent and visual-spatial abilities: A longitudinal study. *Psychology of Music*, 13(2), pp. 99--113 (1985)
9. Nelson, D. J., Barresi, A. L., & Barrett, J. R.: Musical cognition within an analogical setting: Toward a cognitive component of musical aptitude in children. *Psychology of Music*, 20(1), pp. 70--79 (1992)
10. Lidji, P., Kolinsky, R., Lochy, A., & Morais, J.: Spatial associations for musical stimuli: a piano in the head?. *Journal of Experimental Psychology: Human Perception and Performance*, 33(5) (2007)