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Music Perception as Embodied Cognition:

Behavioral Evidence of Auditory Cue Effect

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Abstract

In this study, embodied effects of music perception were investigated and tested. Throughout the history of music cognition, recent emerging of embodied music cognition has showed significant implications. We had focused on the effect of music perception to changes in behavior matter, based on embodied cognitive perspectives. According to the experiments, significant and marginally significant results supported that there is certain effect of music on human involuntary behavior, especially pitch of the music. Also limitations, possible future studies and potential cause of the results were discussed.

Keywords: Embodied music cognition, Metaphor, Auditory perception, Behavior

1 Introduction

The purpose of the study is exploring relationship between spatial cognition and music perception based on embodied cognitive perspectives. Studies in the psychology of music and cognitive musicology mostly concerned how human

acquire and analyze music and what is the effects of learning and practicing music on human cognition in various ways [1]. These studies are mainly based on the view that sees cognition as Information Processing System (IPS).

Recently, the embodied cognition has risen against the view of conventional cognitive science. Embodied music cognition (EMC) and Enactive Cognitive approach to Music (ECA) are a part of the embodied cognition related to the music cognition. Scholars in EMC proposed that representation is not needed in music perception and cognition, unlike conventional cognitive scientists assumed [2]. Also, in ECA's main assertions, similar to the behaviors such as handshake, music perception occurs in the process of interaction among environments (music) and the body [3]. In this study, based on these backgrounds, the effects of music perception and cognition on bodily behavior are investigated.

2 Literature Review

Cognitive Science and Music

Studies on cognitive musicology are mainly divided into two parts; investigating positive/negative effects of music (the 'Mozart Effect'), and the connections among music and other specific cognitions (e.g. spatial cognition). First of all, rather well-known phenomena that can be summarized as Mozart effect are effects of music to spatial reasoning, at the beginning [4]. Then it had changed into broad assertions that listening music cause various cognitive enhancement.

In recent research, Mammarella, Fairfield and Cornoldi introduce a study that classical music has positive effect on cognitive performance [5]. Also a study on the psychology of music showed that songs of Mozart have various effects on cognitive ability to adults and young children [6]. However these studies on Mozart effect have been continuously reproduced and refuted [7].

On the other hands, other studies of cognitive musicology concerned effects of early education of music (absorbed vocabulary, visuo-motor coordination, insert picture tasks and puzzles), the effect of existence of musical expertise on working memory, and comparison research on temporary effect of music listening and long-term music education [8 -10].

Embodied Cognition and Music

Unlike conventional cognitive musicology studies, there was a stream that investigating music behaviors based on embodied cognition. Krueger is one of the scholars of proponent to embodied cognitive musicology [11-12]. His assertions were music and the body (sensors and structure) are interacting based on the principles of the constructivism. These assertions are derived from the enactive cognition, which sees experience of music is not passive, but interdependent. Moreover, music experience could be different for each individual, and make difference in excitement, preference, and memory.

On the other hand, embodied music cognition (EMC) is one of the major parts of the recent research. The proponents of EMC insist that the body acts as mediator in music perception, so music cognition depends on the body [13]. Moreover, the insistence covers bodily structure affects musical representation because music and structure of music are perceived through our body [13].

These studies on EMC and ECA are related to the conceptualization hypothesis among three hypotheses in embodied cognition research [14]. The conceptualization hypothesis assumes that there is a link between the body and bodily structure and the concepts that an organism can acquire. That is, many information acquired by mind depend on our body acquires.

Music and Spatial Cognition

These background shows that there might be strong connection between music and spatial cognition. Husain and colleagues investigated the effect of rhythm and mode of music on cognitive ability, arousal, and mood [15]. The results indicated that faster and major mode music made participants to show higher score on spatial cognition tasks. Also, earlier stage Mozart effect studies were mainly focused on spatial reasoning ability while listening music [16].

There were several long-term studies. Hassler and fellow scholars empirically showed that creative musical abilities, such as improvisation and composing ability, are positively related to visuo-spatial ability [17]. Also, in the study of 1997, Raucher indicated that children who had piano lessons showed higher points on spatial reasoning test than children who hadn't [18].

Some results of several studies could be linked to embodied cognitive perspectives. The purpose of Nelson's study was not appeared to be an embodied cognition study. However the experiment was conducted based on the metaphoric similarity between music perception and spatial cognition. And the result might be a significant to the embodied cognition society [19].

Lidji and fellow scholars [20] conducted an experiment to show frequency of musical notes might be represented as vertical way. As a result, music experts automatically visualized high/ low pitch as high/low spatially in their minds.

3 Research Question and Hypothesis

Based on the many reviews, we wanted to investigate whether there is direct, involuntary and implicit effect of music on our spatial behaviors. According to embodied perspectives and the role of music in spatial cognition, it was assumed that spatial behaviors might be affected by components of music closely.

Research Question: *Is our spatial cognition affected by music, in terms of the change in pitch, so that it would make changes in our behaviors?*

To examine this research question, a variable among many components of

music should be determined; pitch, rhythm, mode, harmony, melody, and etc. According to the Lidji's study [20], the pitch of music was determined as independent variable (IV) in our study to find the effect of pitch in behaviors, which could be considered as a step forward into embodied cognition research.

Then how behavioral changes can be measured? Among many possible candidates, drawing pictures is chosen to be the task for measurement. Specifically, the participants of the experiments would be asked to trace (draw) given simple pictures with their hand, and the drawing were measured by ruler in centimeter. By this method, changes in behaviors can be measured more precise and easier to be analyzed. Also, because a drawing has various dimensions, we can comprehend the results of the experiments.

Hypothesis 1: *While listening repetitive melody with pitch gap, the listener will draw given pictures larger when the gap between is wider.*
Hypothesis 2: *While listening repetitive melody with melodic direction, the listener will draw given pictures larger when the melody is ascending rather than descending.*

Hypothesis 1 is simply designed to reveal the effect of pitch gap. The reason why the gap between the notes was emphasized is the concerning that giving same note as stimulus in experiment might cause fatigue and failure to deliver the intention of the design.

Hypothesis 2 is designed to be more targeted to the behavior (drawing). Because drawing process has strokes in various directions, ascending/descending melodies were considered as focused cue. Based on these research question and hypotheses, we designed behavior-based experiments.

4 Methods

Participants

48 participants (M = 23.5, SD = 3.58) with no difficulty in viewing, listening and hand use were recruited via online announcement and fliers. The participants were consisted of 24 males and 24 females. Most of the participants were undergraduate students of Sungkyunkwan University. Other participants were office workers and graduates. Offered reward after experiment was 5,000 KRW.

Apparatus and Environments

The experiments were conducted in sound-proof room, sized in 20 m^2. The instruction and stimuli were displayed on 15 inch sized all-in-one PC on top of the table in front of the participants. The light of the experiment room was comfortable. The music stimuli was given to the participants via hided Bluetooth speaker, which is linked to iPhone 5S. For drawing, standard A4 size papers and red, blue and black colored pens were used. The red pen is used in tutorial process,

and other two colors were for measuring. The color difference in pens was for the covering reason in order to give participants a false purpose of the experiments.

Stimuli

Total 5 different music were composed by GarageBand application; A control stimulus music, 2 songs for hypothesis 1 (pitch gap; IV 1), another 2 songs for hypothesis 2 (ascending/descending melodies; IV 2).

The IV 1 is composed as repeated melody of two different notes, which were 'Do – Mi' and 'Do – Sol'. The first ('Do – Mi') displayed a narrower gap in pitch than the second. And the stimuli for IV 2 were composed as repeated and orderly put three notes; 'Do – Mi – Sol' and 'Sol – Mi – Do'. These melodies were designed to show effect of directional melody for those paintings which have vertical strokes. It was expected that the former melody (ascending condition) will make participants draw 'higher' pictures than the descending condition. Also, the control music was consisted of repeated note ('Do').

The other aspects of music such as rhythm, mode, and harmonic code were not manipulated. Also, two different IVs were not exposed to the same participant, and in one experiment, a participant was experiencing both levels of one IV (within-subjects design).

Procedure

We conducted two experiments for each 24 participants according to two different IVs. Fundamental procedure is following: Introduction → Instruction → Preparing hands by stretching for ease of hand use → Tutorial process with 4 different pictures and control stimulus for adapting (red pen) → Drawing 3 different pictures along with the first condition with corresponding stimulus (black or blue pen) → Drawing same 3 pictures along with the second condition with corresponding stimulus (the rest of colored pen).

In experiments, the change of the music was informed to avoid confusing of goal for participants. Also, the start of the music was put slightly in advance to the picture displaying for adaptation to the musical environments.

Manipulated conditions (pen color, order of stimuli) were counter-balanced. Also, to see the effect of the manipulation in stroke, few suggested pictures had starting points for controlling the stroke while drawing. Pictures for tutorials and experiment are suggested in figure 1 and figure 2.

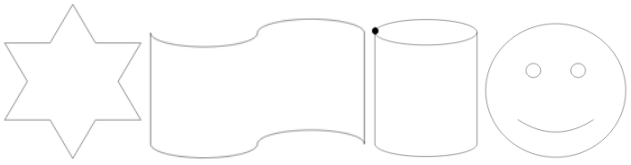

Figure 1. Pictures for Tutorials

Figure 2. Pictures for Experiments

5 Results

A paired-sample T-test was used to analyze both two different effects of IVs, which had two condition levels (within-subjects design). For IV 1 (pitch gap), none of conditions showed significant results. However in case of a picture of thunder, participants draw higher picture while listening narrower gap condition ($M = 122.33$, $SD = 39.24$) than wider gap condition ($M = 117.33$, $SD = 38.54$), which is statistically marginally significant result ($t(23) = 1.59$, $p = 0.126$).

For IV 2 (ascending/descending melody), a statistically significant result was found for the thunder picture ($t(23) = -2.22$, $p = 0.036$). In this case, while listening to the ascending melody, participants draw wider (in width) picture ($M = 57.50$, $SD = 21.01$) than listening to the descending melody ($M = 52.13$, $SD = 19.15$).

Also, marginally significant results were found in the height of the arrow picture ($t(23) = 1.65$, $p = 0.112$) and the picture of thunder ($t(23) = -1.57$, $p = 0.13$) in IV 2 similar to we hypothesized.

6 Discussions

According to the results of experiments, the hypotheses of this study are partially proved empirically. The significant result in IV 2 shows that melody with direction affected behaviors, which is independent to the music, involuntarily.

Additionally, the stimuli were designed simply as possible, so that the result might does not related to changes in moods of participants. Moreover, results with marginal significance could lead to an explanation. Marginal results in IV 2 might show that there are some relationship between melodic directions and behavior in terms of metaphor we use.

Considering the flaws of experiments (pictures for the dependent measures should have be put in the tutorial process; the order of the pictures might affect the results; not only pitch gap and melodic directions, but also monotonic pitch stimuli should have be tested also), marginal results may turn out to be significant in the revised experiments.

There were several studies that concerns music cognition and metaphors. McAdams summarized that ‘auditory image’, which is a metaphoric term, is a

type of representation of "a sound entity exhibiting coherence in its acoustic behavior" [21]. Also, Walker [22] followed embodied cognitive perspectives to explain musical knowing and moving (perception and behavior) in terms of physical metaphor. Moreover, Weber [23] exhibited conceptual metaphors in music ("Musical landscape", "Moving Music", and "Musical Force"), and analyzed how our physical movement are 'grounded'.

According to the reviewed literatures, musical metaphors seem to be related to the embodied music cognition in terms of rather radical embodied cognition, which is insisted by Johnson and Lakoff [24]. Their studies indicated that human body is the shell of our mind, and the metaphor is bridge linking cognition and behaviors. In the results of IV 2, we saw musical metaphor (going up/down in melody) might be linked to our metaphoric behavior (drawing vertically larger/smaller). Based on the idea of Lakoff and Johnson, future works may pursue the possible existence of various musical metaphoric behaviors.

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