Is There Sensory Prototype? : Focusing on Musical 
Cue effect on Behaviors related to Size 

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Abstract

In this dissertation, musical cue effects were investigated based on embodied cognition, specifically with metaphoric cognitive perspectives. Also related embodied cognitive concept of sensory prototype was discussed. As a low hierarchical concept under embodied metaphor, and a link between metaphoric cognition and other embodied cognitive hypotheses, sensory prototype was suggested. Based on previous studies and former study on similar subject, individual variables and dependent variable were selected; direction of melody and interval of octave as independent variables, and size of behavior as dependent variable. To reveal embodied effect of direction of melody and interval of octave musical stimuli were designed and presented in the experiment as outer-contextual manner. To measure size of behavior, drawing tasks on tablet were performed by participants, and the area of the drawings was analyzed by computer program. With statistical analysis via two-way within-subjects ANOVA and subsequent simple effects tests, results showed that there are embodied effects of direction of melody on size of behavior and height of behavior. Also the interval of octave was found to be effective to width of behavior. The meaning of the results and possible theoretical reasons were explained. Also, practical and theoretical implications, along with limitations of the dissertation, and direction of future research were discussed.

Keywords: embodied cognition, musical cue effect, embodied metaphor, music cognition, sensory prototype
Contents

I. Introduction

1. Background

2. State of the Problem

II. Literature Review

1. Standard Cognitive Science

2. Limitations of standard cognitive science and appearance of embodied cognition

3. Previous Studies in Metaphor
   A. Effect of metaphor in Cognition

   A. Embodied Cognition and Music
   B. Metaphoric Correlation between Music and Spatial Cognition
   C. Former Study

III. Research Questions and Hypothesis
IV. Methods

1. Design
2. Participants
3. Material
   A. Auditory Stimuli
   B. Visual Stimuli
   C. Complex Stimuli for Questionnaire
4. Apparatus and Environment
5. Procedure

V. Results

1. Picture 1
2. Picture 2
3. Subsequent Data Analysis
   A. Additional Variables
   B. Correlation Analysis
4. Analysis for Height and Width
   A. Width of Picture 2
   B. Height of Picture 2
VI. Discussion

1. Summary of Findings
   A. Analysis on Result of Picture 1
   B. Analysis on Result of Picture 2
   C. Interval of Octave

2. Implications
   A. Theoretical Implications
   B. Practical Implications

3. Limitations
   A. Theoretical Limitations
   B. Practical Limitations

4. Future Study and Research Program

5. Conclusion

VII. References
I. Introduction

1. Background

It has been several decades since the embodied cognitive paradigm started, along with many studies and founding of many empirical evidences under this paradigm. Now, embodied cognition (EC) is not only a paradigm which is a group of scientist proponents its existence, but also is a research program (Shapiro, 2011). Even though a lot of researchers have been devoted to establish the paradigm as a mainstream of cognitive science, compare to standard cognitive scientific studies, results are not sufficient to build a rigid ground of an academic standard or theoretical guidelines. In this circumstance, this study is another research for supporting the insights in the view of EC, and an effort to make difference from conventional research trends in this field. Specifically, the purpose of the study is exploring relationship between spatial cognition and music perception based on embodied cognitive perspectives.

<table>
<thead>
<tr>
<th>First-generation cognitive science</th>
<th>Second-generation cognitive science</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Mind is symbolic and cognitive processes are algorithmic.</td>
<td>1. Mind is “biological and neural, not a matter of symbols”</td>
</tr>
<tr>
<td>2. Thought is disembodied and abstract.</td>
<td>2. Thought is embodied: “physical in nature, with concepts precisely and exquisitely sculpted by neural circuitry that evolved to run a body ... The peculiar structure of our concepts reflect the peculiarities of our bodies”</td>
</tr>
<tr>
<td>3. Mind is limited to conscious awareness.</td>
<td>3. Approximately 95% of the mind is unconscious.</td>
</tr>
</tbody>
</table>
4. Though is literal and consistent, and thus suitable for modeling with logic.

4. Abstract thought "is largely metaphorical, making use of the same sensory-motor system that runs the body."

Table 1. Difference between first- and second-generation cognitive science

The birth of embodied cognition is a result of the limitations of standard cognitive science, which models cognition based on representation and computation. Lakoff (2003) claimed similar proposal. He separated cognitive science into two (first and second) generations to show the difference between EC and standard cognitive science (table 1). Perhaps these claims seem rather provocative, but also debatable. However, this dissertation is not about whether cognition is algorithmic or biological, and thoughts are embodied or not. In this study, I will more focus on the investigating phenomena in rather non-common area in embodied cognition that hopefully shed some lights on how our cognition embodied.

Perhaps most of the studies in embodied cognitive paradigm were focusing on how the bodily states affect human cognition. One of the well-known studies such as Williams and Bargh (2008) is a good example. In this research, they found that participants of experiment tended to estimate other people’s personality as ‘warm (kind)’ when they touched a hot beverage before the estimation. The result in opposite condition was consistence that haptic sensation of coldness made people saw other people as ‘cold’ ones. The evidence implies that even a social perception, which is acknowledged as a high level cognition, can be affected by situated bodily status whether a person may know or not.

For another example, evidence that certain postures can affect mind is empirically revealed. In an experiment of Carney, Cuddy and Yap (2010), participants were told to express power and openness via their postures. Interestingly, not only they felt increased powerfulness and tolerance for risk, but also hormones such as testosterone and cortisol was also changed along with participants’ mood change. This may be understandable as cognitive process is a spontaneous and complex process which is based on the interaction among mind, body and environment.

Two studies above are small fractions of perhaps prevailing research trends EC fields. It is well displayed that bodily effects on cognition is a majority in the fields. Even though there is a claim that embodied cognitive paradigm may not be able to apply to every cognitive
phenomenon (Maglio and Trope, 2012) such as abstract thinking, it appears to be clear for various types of cognition is embodied.

Along with these trends, study of music also embraced embodied cognitive perspectives. Embodied music cognition (EMC) is 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 view assumed based on conventional cognitive science (Deutsch, 2012).

Also, in EMC’s main assertions, similar to common behaviors such as handshake, music perception occurs in the process of interaction among environments (music) and the body (Leman, 2008). Based on these backgrounds, this dissertation pursued the effect of music perception and cognition on bodily behavior. The approach of the dissertation is not alike to those majority studies investigating role of bodily status and environments on how we think. Instead, I followed how our daily behaviors, not thoughts, can be affected by environment, involuntarily.

2. Statement of the Problem

As seen in the backgrounds, embodied cognition research has certain trends. However, it may not be enough to know that many cognitive process or activity is embodied. The question for next moves in field of embodied cognition might starts here: How the cognition is embodied? Lakoff and Johnson’s series of studies showed possible answer for this question (Lakoff and Johnson, 1999), which can be understood linked to symbol grounding problem.

Symbol grounding problem was firstly suggested by John Searle (1980). It is consisted of the questions about what is symbols and how human to handle them. Imagine a room with no doors or windows but two separate holes on the wall. The man in the room (‘A’) is an English user who doesn’t know Chinese and Chinese letter.

The problem is described as following; When a Chinese word come into the room through a hole, ‘A’ starts to find a matching symbol in the manuals and print the symbol through the other hole. The matching mechanisms of symbols and Chinese letters are arbitrary and massive, so ‘A’
cannot understand both Chinese letters and symbols. As time passes, ‘A’ has been working on the job and getting used to it. Therefore, from the outside of the room, ‘the room seems to understand Chinese letters.

Clearly, ‘A’ has no chance to learn Chinese or the matching symbolic language. And therefore, there is no representation of Chinese letters in mind of ‘A’. As the arbitrary symbols mean to ‘A’, Chinese letters are certain types of symbols too. This indicates that ‘A’ does not calculate when he does the job. Here is the problem. If we assume the room, can we be assured that human being is representation handling information processing system? Moreover, if human cognition is same as Chinese room, there is no difference between computer and human.

To resolve this problem, Glenberg and Robertson (2000) suggested an explanation. According to them, in order to have meanings, these symbols of Chinese room should have realistic foundations rather than arbitrary or abstract relationships. If human cognition is enough to have those relationships among symbols, ‘A’ might understand relationships between Chinese letters and the symbols. However ‘A’ can’t.

The ‘realistic foundations’ that Glenberg and Robertson suggested is embodied cognition and metaphor based on Lakoff and Johnson’s claims. Interestingly, the Chinese room itself is a strong metaphor of human cognition. We can find a formal language metaphor in the manual ‘A’ uses, and also find symbol manipulation in interactive tasks of ‘A’ in Chinese room. To understand their approach to cognition via metaphor, similar studies are discussed as followings.

Theory of Lakoff and Johnson is similar to Boroditsky’s claim, which is called ‘linguistic determinism’; “that experience with a language can shape the way one thinks (2001)” In her experiment, English users and Mandarin users responded differently based on time-spatial metaphor in their language respectively. In English, time metaphor in spatial term is displayed as forward and backward direction. On the other hands, in Mandarin, the direction is downward and upward. The results showed that participants of both groups (Mandarin and English) reacted faster when primed stimuli suggested in a direction that their language’s metaphoric usage.

Recent bilingual study also showed similar empirical evidence related to this concept. Athanasopolulos and his colleagues showed that the language we use to perceive certain events drive how we understand the events in bilingual study (Athanasopoulos et al, 2015). In this research, classifying event into categories is based on how the languages we use display them as
grammatical constraints were demonstrated. When participants exposed to a video that a person walking to a car, English users saw it as ‘person walking’ scene, whereas German users saw it as ‘person walking towards a car’ scene. Interestingly, bilinguals’ results were shifted as the language they used when they use to answer.

Also, Lakoff’s claim is sharing a common ground with Whorf’s assertion; “language shapes the way we think, and determines what we can think about” (1956). Moreover, Lakoff said “abstract thought is largely metaphorical, making use of the same sensory-motor system that runs the body.” These similar assertions emphasized the importance of metaphoric language use in our cognition. It is more clear of their claims when analyze learning process.

From the beginning of our life, learning is one of the most essential processes in our life. Not to mention of education, from walking, talking, making friends, eating, running, studying, and everything are learning. Because learning process (language and other behaviors) is interaction between pre-existed knowledge and new information, according to constructivism, metaphor may be a key to understand human cognition (including learning).

Finding similarity and imitating are key things in learning, which also essential to use metaphoric expression. Therefore, if metaphor is the essence of learning and expanding our knowledge, metaphor might be a key to understand human cognition in general. It is well shown in Lakoff and Johnson’s statement; “The essence of metaphor is understanding and experiencing one kind of thing or experience in terms of another”, which means, we expand our understanding through metaphors (Lakoff and Johnson, 1980).

Also, Gibbs and Steen showed that our understanding of conceptual metaphors is closely related to the cultural world and our embodied behavior. Also, the conceptual metaphor based on cultural world is crucial part of our language us and everyday cognitive functions, helping to loosen the burden of mental process (Gibbs and Steen, 1999). It seems that proponents of metaphoric embodied cognition conceptualizing cognition as hierarchical process.

At the bottom of the process, there are patterns of embodied experience from bodily sensation and world (Johnson 1987; Lakoff 1987; Lakoff 1990). On top of these patterns, there is metaphoric thinking, and it is linked to our abstract or non-abstract concepts. However, other hypotheses in embodied cognition describe cognitive process as dynamic, interactive, concurrent, and based on feedback (Sharpiro, 2011). I suggest that by combining these hypotheses, the
metaphor in cognitive process could be understood in extended concept that including not only conceptual metaphors, but also sensory prototypes.

The sensory prototype can be defined as non-linguistic patterns that coined by sensations from various sources such as environment, musculoskeletal aspects of body, limitations of bodily structure, movements, and so on. These patterns might not be conceptualized yet, because the level of cluster of the patterns are not sophisticated enough to be verbally represented. Thus, the detection of the prototype might not be easy.

Because the birth of sensory prototype is based on our sensation from our body, the characteristics of the sensory prototype might be different from the ones of conceptual metaphors. In hierarchical understanding of metaphoric embodied cognition, the patterns of embodied experience itself are becoming sensory-prototypes. Although the term ‘prototype’ in this context is quite different from metaphors, the use and role of sensory metaphors in our cognitive behavior is similar to conceptual metaphors. Because it was assumed to be derived from environment, culture and body.

I suggest that an investigation of non-linguistic metaphor, the sensory prototype in the context of embodied cognition may light an opportunity to see embodied cognitive study more expanded and thorough. After abundant research will have done, the understanding of embodied metaphoric cognition and cognition itself might be enriched. At the starting line of investigation to sensory prototype, music (auditory sense) was chosen to be tested in this dissertation.

The first reason why music was chosen is that, music looks very similar to metaphoric cognition based on the importance of format. Besides genres that intentionally break existing musical format such as free jazz, most of music follows certain format, as seen in language. Tone, mode, construct, codes, and etc. are kinds of format that a song follows. When these formats are violated slightly, we sense the difference quite easily according to the level of musical experience.

Secondly, music is very familiar medium. We are living in the ear that listening music is not hard anymore. In fact listening music was not easier than the present. Along with development of internet, smartphone, and wireless technology, music is not a thing we listen to, but now flow behind daily life for many people. Therefore, for people who listening music via smartphones or MP3 players, music is almost familiar as much as their daily language use.
Lastly, particularly in Korea, music is educated throughout elementary, middle, and high school. In other words, the fundamentals of music such as how to listen, how to read a score, history of music, how to sing, etc. were exposed to almost every person who have experienced public education gradually. That means, if exists, the effect of musical sensory prototype might be detectable easier than any other sensory-based metaphors.

In that sense, in this dissertation, as a form of sensory prototype, a part of musical (auditory) embodied cognition was investigated, linking evidences in the former study (Yi et al., 2014). The purpose of this dissertation is that offering empirical evidence to support embodied metaphoric cognition, as revealing sensory prototype, via performing an experiment concerning auditory cue effect on bodily behaviors. Specifically, among numerous auditory phenomena, musical environment was selected to be tested as sensory metaphoric cognition medium.

II. Literature Review

1. Standard Cognitive Science

“How the mind works?” is the question that human continuously asking ourselves. In 18th century, medieval times, affected by religions like Christianity, god’s intervention is believed as the force that moves our mind. Soon experimental/scientific methodology, empiric philosophy, and natural science made many attempts to break out of this mystical approach to mind.

Then J. F. Herbart’s application of mathematic formulation on mind, psychophysics of scholars such as Mark Bevir, Gustav Fechner, Herman von Helmholtz, and Wilhelm Wundt’s first psychology lab were the serious scientific approach to mind, and these were the backbones of cognitive science based on information processing paradigm (Lee, 2008).

Information processing paradigm (IPP) is rather new change of paradigm in the middle of 20th century. IPP assumes that the human mind is a collection of activities of processing information like computer. It is called computationalism. Also, IPP’s another important
characteristic is representationalism. Influenced by representationalism, IPP assumes that information is saved in human mind as a form of representation. A schematic view of IPP is displayed in figure 1 (Lee, 2008)

\[
I \rightarrow M \rightarrow O
\]

I: physical, psychological input of stimuli

M: Mind

O: intrinsic and extrinsic output of reaction

\[ f [(I) \times (M)] = O \]

Inferred \( M' \) = \( f [(I') \times (O')] \)

* apostrophe(\') is marks of inferred or tagged characteristics

Figure 1. Schematic of IPP’s model of mind

In a viewpoint of a man as information processing system, environment should be understood as gathered sensory information through our body to the brain. This viewpoint is linked Cartesian viewpoint, which is fundamental ground of brain/body dichotomy. Then limitations of this viewpoint are revealed by various empirical and theoretical evidences.

2. Limitations of standard cognitive science and appearance of embodied cognition

Some of limitations of traditional cognitive science are partially displayed in Shapiro’s study (2011). In the study, Shapiro pointed out that several hypotheses that standard cognitivism have are shrinking human mind into computational process in the brain. The hypotheses are followings; hypothesis of stimuli on psychological process, psychological process is based on inference that are established in incomplete information, these inferences are mostly well-accepted when occurred as symbolized representation, and the purpose of psychology is to
describe the algorithms rising in the brain.

Also, Lakoff (2003) stated that concepts, strong dependency of mind on the body, psychological space, metaphor, imagery, and metonymy are the evidences that neutralize traditional cognitive science's computational and representational hypotheses.

Based on these assertions, EC is raised by many scholars in cognitive science, philosophy and various academic fields. Shapiro (2011) organized and categorized many proponents and assertions in three categories. In fact, because EC is not well established theory in general, most of assertions are recognized as hypotheses.

First hypothesis is conceptualization. Conceptualization hypothesis is mostly about there is a connection between the body of certain organization (or life) and concepts that the body can acquire. This connection is similar to shape of the acquiring process is mainly limited by the body. This conceptualization predicts that different structures of bodies make difference in gathering information, and moreover perception of the world. As mentioned before, to emphasize this conceptualization hypothesis, Lakoff said that “the peculiar structure of our concepts reflect the peculiarities of our bodies.”

Second hypothesis is replacement. This hypothesis, which is mainly represented by dynamical approach, accepts the exaggerated role of the brain and argues that there is continuous interaction among body, brain and environment at the foundation of the mind. In other words, not like the conventional cognitive science, mind is not serial process of information, yet a dynamic interaction phenomenon. Van Gelder (1995) showed centrifugal governor (figure 2), which is delicate device that controls the output of steam engine, as an example of dynamic system and claimed that human mind is better in ‘thinking’ than computer because of the mind id dynamic system.
Also, Brooks (1991) invented the concept of subsumption architecture, which affected real-time artificial intelligence and autonomous robotics, based on the insight via robot research. On the contrary to GOFAI (good old-fashioned artificial intelligence), behave according to the computation in the central processing device, subsumption architecture is developed for behavioral-base technology of robot. In other words, robots made of subsumption architecture are behave based on the interaction between the robot and environment and react in sub-behaviors as a result, which is called bottom-up method, while conventional robots behave based on the top-down method. This reestablishing approach of making the robot fundamentally linked to the body of the robot and environment has affected EC research also.

Last hypothesis is constitution. While IPP sees the computational process of mind is all in the brain, constitution hypothesis assumed that cognitive process is more than just a brain process, but being further into the body and environment. The body is also a part of the mind, in constitution hypothesis. Even more provocative assertion in constitution hypotheses mind is not confined in the brain or body and the environment around the body is a part of the mind. It is called extended cognition. Clark (2008) suggested ‘parity principle’ that when our certain part of the cognitive process is activated outside of our body, it is actually our cognitive process too, according to the constitution hypothesis. Interestingly, examples in the extended mind of Clark’s might resemble modular programming method also. In the view of extended cognition, however,
our mind process various cognition in, on, and out of our body unlike computers.

In many EC related hypotheses, Lakoff and Johnson’s approach to metaphoric mind is recognized somewhat provocative. They insisted that physical form of our body gives us distinctive characteristics. And these characteristics affect conceptualization and categorization. In ‘Metaphors we live by’, they suggested conceptual metaphors are mappings that construct our thoughts, experience, daily language use, which can be seen in the example of ‘abundant = up (direction) / little = down’.

In ‘Philosophy in the flesh’ (1999), Lakoff and Johnson explained perceived world and the process of building the world as following; Perceived world ins established on senses and sensory organs and determined by interaction among culture, environment and the brain. Our perception in certain situation is dependent on our embodied experience, and interactions among brain, body, environment and culture form the experience. It is called embodied comprehension. In addition, construct of a concept via embodied comprehension is called concept embodiment.

In Grady’s research (1998), some of the examples of metaphoric thinking and expressions are displayed (table 2), which is categorized as primary metaphor in his theory. In the theory, subjective experience and judgment linked to sensory movement in daily life, and sometimes become a foundation to higher (more complex) metaphors.

<table>
<thead>
<tr>
<th>Primary metaphor</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘importance = big’</td>
<td>This opportunity is huge for us.</td>
</tr>
<tr>
<td>‘intimacy = close’</td>
<td>Jane and Conan are closer than I thought.</td>
</tr>
<tr>
<td>‘abundant = up(direction)’</td>
<td>The risk of doing so is higher than ever.</td>
</tr>
<tr>
<td>‘similarity = close’</td>
<td>These newly found artifacts are close to one another.</td>
</tr>
<tr>
<td>‘help = support’</td>
<td>I can use of your generous support on my new bill.</td>
</tr>
<tr>
<td>‘change = movement’</td>
<td>The pasta I made yesterday is gone bad.</td>
</tr>
<tr>
<td>‘time = movement’</td>
<td>Time has passed us rapidly.</td>
</tr>
</tbody>
</table>
Table 2. examples of Grady’s primary metaphor

As shown in Grady’s work, studies investigated the process of embodiment of primary metaphors establish their theoretical foundation over neuro-scientific analysis or point of view. Therefore it implies that acquisition of metaphors is automatic and subconscious process, and there are no other options because it is based on embodied experience. If a species share common body and organic system, there is a chance that primary metaphors may be a global phenomenon.

3. Previous studies in metaphors

Many studies investigated embodied cognitive fields via metaphoric assumption. Landau et al. (2010) categorized and summarized these findings. And some of the Landau’s works were adopted and modified in this review.

A. Effect of metaphor in cognition

Previously reviewed study of Williams and Bargh (2008) is also an example of metaphoric social cognition. In this case, haptic sensation of temperature is linked to the metaphor use (‘kindness = warm’).

Another evidence of relationship between haptic sensation and social cognition via metaphor investigated touching rough or soft object may affect perception of others’ hospitality (Ackerman et al. 2010). Participants tend to evaluate others more hostile when they touched a rough surface such as sand paper, and friendlier when they touched an even surface. (‘hostile = rough, friendly = even, soft’)

A different experiment was performed in same study. In this experiment, participants were asked to touch soft or hard objects while estimate other person. When they touched hard object, participants tended to evaluate others as rigid and inflexible. On the other hands, when they touched soft objects, participants evaluate others more flexible and soft. (‘rigid = hard, ‘flexible = soft’)
In additional experiment of Ackermann et al. (2010), participants were tested to choose which issue should be funded by government. The suggested issues were differed in seriousness. Participants chose to give more government fund to serious issues than less widely important issues when they held heavier clipboard. According to the interaction effect, the results were limited in case of male participants. The correlation between cognitive activity and metaphor in this research is also ‘importance = heavy’.

Also many other studies investigated effect of relevant metaphor and social cognition; Interpersonal intimacy and spatial distance (Williams & Bargh, 2008), direction of divinity is upward (Meier et al., 2007; Chasteen et al., 2009), Attracted by vertical position (Meier and Dionne, 2009).

Maricchiolo and colleagues (2008) found interesting evidence that there is a difference of comprehensibility in persuasion process depending on whether there were gestures in persuasion or not. Most effective gestures were related metaphoric meaning. In other words, when gestures and metaphoric language use are corresponding, understanding of participants were higher than other conditions. In this study, time metaphor (‘future = front, past = back’) was found.

Jostmann et al. (2009) empirically displayed connection between weight and importance. Participants of experiment were told to hold a book and instructed the book’s importance in a two condition (main text book / sub material). When they told the book is important, people tended to estimate the weight heavier than when they told the book is not so important. The link between behavior (perception) and metaphor is ‘importance = heavy’.

Thesis studies empirically showed how linguistic metaphors affect human perception of given situation, phenomena, and other person. Every metaphor investigated in the experiments was based on the language we use. It seems that, based on embodied cognitive perspectives, metaphoric cognition might be present.

The direction of Front and back is used to describe future and past as seen in the example of ‘look forward to/look back’. Miles et al. measured the angle between a chair and participants back who is seated to the chair (Miles et al., 2010). The result showed that when instructor told them to imagine a future event, the angle tended to be enlarged. Also, when they were told to go back in time in their imagination, the angle tended to decreased.

Cognitive musicology has developed since 1970 based on the theoretical advancement and methodological enhancement in cognitive science, as a relatively new area in cognitive science (Laske, 1988). From the beginning, two distinguishing findings drove scientists into the cognitive musicology field; the ‘Mozart’ effect and connections between music and other cognitive phenomena such as spatial cognitive behavior. The Mozart effect refers to the effects of music on enhancement of various kinds of cognitive function. At first, the effect was limited to the spatial reasoning, but it had been spreading out to other areas (Rauscher, 1994).

One of the conventional proponents of Mozart effect is Mammarella, Fairfield, and Cornoldi’s study. In this study (2007), participants were exposed to the Four Seasons of Vivaldi or white noise while having two different working memory tasks. They reported the effect of exposure to music enhanced the result of working memory tasks unlike the white noise condition. However, most of these studies were criticized that they were not methodologically thorough, and impact of mood and arousal were neglected, which is odd because most of music are closely related to the arousal and mood shift (Schellenberg, 2005).

On the other hands, effect of early education of music had been focused in this field. In long-term education (36 weeks), children showed enhancement of broad range of cognitive functions such as IQ test, verbal comprehension, perceptual organization, freedom from distractibility, and processing speed (Schellenberg, 2004). Also how much one trained on music was tested whether the music training has positive effect on working memory or not. As a result, experts showed significant higher score in working memory task, digit span (Hansen et al., 2013).

A. Embodied Cognition and Music

Moving in different direction, embodied music cognition and the scholars of the field have investigated musical behaviors and perception based on embodied cognitive perspectives. One of the leading researchers is Krueger, who insisted the constructivism principles can be adapted to the music perception, based on interaction between music and body. In this argument, he proposed that experiencing music is not ‘passive’ phenomenon, rather this is independent, and
inter-correlated phenomenon (Krueger, 2009; Krueger, 2014). Therefore, music perception can be differing to every individual according to excitement, preference, and memory. This is called enactive cognition.

On the other hand, one of the biggest parts of this field is embodied music cognition. In this view, body acts as a mediator between music and perception-self, so that affect most of aspects in music perception (leman et al., 2010). Also, they suggested that our musical representation is affected by our bodily structure, because musical structure and music itself are unable to be perceived except traveling through the body. These proponents of embodied music cognition and enactive cognition might show disagreement in the existence of music representation, though both theories stressed important role of music while perceiving music.

B. Metaphoric Correlation between music and spatial cognition

Several studies investigated spatial correlation of music, on the basis of embodied cognition. In the experiment of Eitan and Granot (2006), participants were asked to categorize imagined motions related presented musical stimuli. The stimuli were manipulated in dynamics, pitch contour, pitch intervals, attack rate, and articulation. The results showed that tested musical parameters were significantly correlated to certain dimensions of the movement. They also found that musical-spatial metaphors were tends to be asymmetrical, along with a parameter change in one direction induces spatial metaphor rather than its counterpart.

Some scholars tried to witness real-time collaboration of music and whole-bodily movement based on the emotional aspects of music. Berger and colleagues (2013) conducted experiment on how we move along with the music. The researchers recorded participants ‘music-induced’ movement and derive common motions with computation. The music was assessed which kind of emotion is belong to it. The correlational results were found between emotional features of music and movement of professional musicians and dancers. For example, emotional value of arousal and valence were correlated with movements based on polar coordination, including movement complexity, area of movement, and hand distance (from torso).

Küssner et al. (2014) tried to map real-time cross-modal relationship in their study. Listening to continuously changing and sound varied in pitch, tempo and loudness, musically trained or not-trained participants were asked to perform gestures raised by the sound. The result showed that hand movement was consisted with previous research; vertical representation of pitch
related to vertical spatial movement positively, higher tempo related to speedier movement of hands. Also they found musical training was associated with varying results in interaction. For example, the correlation coefficient for pitch-height of musically trained participants was larger than not-trained participants.

These findings were similar to the study of Walker (1987). In the experiment, he tried to visual metaphors of music in forced selection, testing four parameters of music including frequency, waveform, amplitude, and duration. Participants were asked to choose the most appropriated set among varied visually represented patterns based on the 4 different auditory stimuli for each four parameters, which was generated by an electronic synthesizer. The results showed that the frequency (pitch) was positively correlated with vertical placement, the amplitude was positively correlated with size, waveform was related to pattern, and duration was positively correlated to horizontal length. Also, the results were differentiated between musically trained and not-trained participants. For example, musically trained participants showed significantly higher means in frequency-vertical representation selection.

Another study investigated conformity between sound and motion (Nymoen et al., 2012). They tried to show empirical correlation between sound and motion features based on hand movement. 3 auditory features including pitch contours, timbre contours, and dynamic contours of sound were manipulated into 3 seconds sound. Among several timbre aspects, brightness of sound was chosen to be manipulated. Also speed of sound war manipulated as slowly increasing or decreasing in dynamic contours. As a result, vertical position, which is associated positively with pitch change, was the most apparent discovery. The authors this result might be caused by ‘learned metaphor’, because pitch is represented in vertical dimension in (classical) musical score.

C. The Former study

Based on the literatures on metaphoric embodied cognition, an exploratory study was performed (Yi et al., 2014). Although reviewed studies displayed consistent evidence that pitch and vertical motion is positively correlated, they seems to be lacking in methodological approaches based on embodied cognitive perspectives, which might fail to reveal involuntary effect of sound. In that point, the former study tried to show embodied effect of auditory cue based on pitch change.

The independent variables of the former study were pitch interval, which was
manipulated as continuous melody of two notes, differentiated as two levels by pitch, and direction of melody, which was manipulated as continuous melody of three notes, differentiated as two levels by descending or ascending melody. Participants were asked to draw given pictures (arrow-shaped, house-shaped, and lightning-shaped; figure 3) on a paper with pens. Other musical features such as tempo, tone, timber, were controlled.

![Figure 3. Pictures for Experiments](image)

It was hypothesized that with greater interval in pitch between two notes, participants might draw pictures higher in vertical direction. This hypothesis was derived from many studies investigated relationship between pitch and movement. Also, another hypothesis expected that if direction of melody was towards ascending direction, participants drew pictures vertically higher than descending direction of melody. This hypothesis was expected because drawing is continuous process. In other words, an interaction between drawing process and melodic direction was anticipated.

The result showed no significant effect was found in relationship between pitch and vertical movement during drawing. All results on vertical movement and pitch were marginally significant or not significant at all. However, significant main effect of direction of melody was found in width of the drawing. The result was partly expected in Nymoen’s study (2012). However the direction of melody and the movement direction were not specified in their study. In results, it was interesting that unlike many studies on the relationship between pitch and vertical movement, the melodic direction and width, not height, were found to be positively correlated.

It seems that, in embodied cognitive perspective, a metaphoric relation between pitch and motion (higher pitch = higher movement) was not actually ‘embodied’, but learned phenomenon. In literature review, many studies reported that the correlation or significance were more obvious with participants who studied or trained music. Therefore, it can be assumed results of former studies might be based on metaphor, which is derived from learning process of music, which is using the exact metaphor.
Additionally, with the result of the former study, there might be size-wise relationship between music and motion. The results were consisted of several marginal effects of designed hypotheses, and significant effect of direction of melody and width. The formula of basic area (size) calculation in math is width multiplied by height. As several studies already showed, (Núñez and Matos, 1999; Núñez and Matos, 1999) mathematical concepts might also be embodied. Thus it was expected that the size of our behavior was expected to be related to pitch in auditory stimuli.

### III. Research Questions and Hypotheses

In the perspective of metaphoric embodied cognition, the results of former study cannot be fully understood. The obvious metaphor (higher pitch = higher movement) was not significantly proved, and somewhat unconventional results about width was significantly effective. However, because the experiment was designed based on embodied cognitive perspective, that stimuli of Independent variables were not displayed in front of the participants, the results might not be able to be negligible. Instead, it might be a step to understand sensory prototype, which cannot be fully explained in metaphorically, but found in our bodily patterns.

Therefore, in this dissertation, the presence of sensory prototype in auditory environment was investigated with more detailed experimental condition. As expected in former study, behavioral motion might be expected to be related to pitch, it was hypothesized that direction of melody will affect bodily motion that size of our behavior will differ. But the direction of the effect on size was debatable. There are few evidences that can be witnessed in sound effect of games. For example, in one of the most famous and loved platformer game, Super Mario Bros., when the character eats mushrooms, it gets bigger with ascending melody. The sound effect in the game also includes another direction of melody (descending melody with becoming smaller). In the perspective of sensory prototype, the prototype of melody affects cultural aspects of music, so that it became used in a way of metaphor.

Also, if there is effect of direction of melody, the interval of melody might assist the effect of auditory stimuli. The interval, which is difference between starting note and ending note,
might be seemed horizontal features in metaphoric cognition based on the representation in a score. However, it actually associated higher pitch, which affects the vertical end of the melody also. Therefore it is possible that if musical stimuli were not attended by participants, the score metaphor might not be affecting the results, so that reveal the effect of interval with respect to the vertical features of sound. It is expected that with appropriate methodological manipulation, the effect of interval was expected to affect the size of behavior too. Based on the former study and literature review, hypotheses were designed as below.

Hypothesis 1
Ascending melody would affect the size of bodily behavior POSITIVELY, which result in relatively more pixels within the picture than the descending case.

Hypothesis 2
Extended interval of melody up to two octaves would show stronger effect on bodily behavior, which result in relatively larger change in pixels within the picture than the one octave case.

Hypothesis 3 (interaction effect)
When the pitch interval of music is two octaves, the difference of pixels between ascending and descending melody conditions would be relatively bigger than when the pitch interval is one octave.

Therefore independent variables were designed in two sets; direction of melody, and interval of octave. And the dependent variable was selected as area of drawing. In the study of Küssner and Leech-Wilkinson, the authors tested effect of musical training on cross-modal correspondences in the drawing situation. The drawing was designated to reveal real-time representation of concurrently played audio stimuli. The result showed that participants represented pitch as height, loudness as thickness. Also trained participants’ results were more consistent than less trained group (Küssner and Leech-Wilkinson, 2013).

Setting aside the results, the methodology was novel, but it is also effective to show variance of drawing with respect to the size of behavior without attention on their behavior in
Without grid and reference points on tablet screen, the vast paper-like screen was considered to measure the behavior related to size. Also the tablet was chosen because of the consistency between the former study and present dissertation: drawing situation. The results would be comparable when the variable is measured in the same context.

The area of the drawing was measured computationally, because, in the former study, the measurement reliability was not effective. If the dependent variable will be measured in tablet with digitizer, it was assumed that reliability of measurement would be enhanced. Also, unlike the height and width, area cannot be measure by ruler, because the drawing, which is drawn in hands, will not be precise enough to be calculated by ruler.

**IV. Method**

1. **Design**

Experimental methods and environments were used to test the effect of musical cue on behavioral size-wise change. The design was following a 2 (direction of the melody: upward vs. downward melody) X 2 (interval of the melody: one octave vs. two octaves) within-subjects, which is designated to be analyzed as two-way repeated analysis of variance (ANOVA).

Every participant experienced all 4 conditions, according the experimental design, due to eliminate personal characteristics in behaviors related to the dependent measure and to observe change of behaviors in person-by-person. Also, to rule out order effect of treatments, stimuli were displayed in counter-balanced sets (Williams, 1949).

2. **Participants**

The experiment was conducted as a session of experiment, which was informed as ‘a test
for designing complex cultural contents’. This information was given not only to camouflage the real objective of the experiment, but also not to confuse them in the ‘strange’ environment of the experiment. The venue was International hall at the Sungkyunkwan University, located in Seoul, Korea.

Most of participants were recruited voluntarily via online notice bulletin of Sungkyunkwan University’s website, including the simplified objective of the experiment, the link of enrollment page, and the reward. Based on given time table in the enrollment page, participants chose when to participate, and informed their basic information to identify at the experiment site. Few participants were recruited near the venue of experiment, because of cancellations.

Most of the participants were undergraduate students of Sungkyunkwan University, which was predicted because of the recruiting method. Very few participants were graduate students. Recruited participants were total 53, consisted of 26 males and 27 females. After an outlier elimination, analyzable group of participants were shorten to 47, including 21 males and 26 females, meaning 1 female and 5 males were eliminated from total register. As a result, analyzed participants were total 47 students (age mean = 23.13, age SD = 2.39, minimum age = 19, maximum age = 33).

Outlier detection and elimination was performed as follow. Two experimenter agreed criteria for behavior characteristics of possible outlier;

1) Motivational Behavior: Participants should be self-motivated through the experiment. For example, he one whose act was seen only motivated by quick reward can be selected as an outlier.

2) Consistent Behavior: The results of the experiment should be stable. An abrupt result can be considered as outlying behavior.

3) Concentrated Behavior: Participants should be concentrated in the process of experiment. A participant who was distracted other than experiment can be an outlier.

4) Comprehension and Acceptance of Instruction: Participants should understand given instruction and reasonably follow the instruction.

These criteria were rated in the scale of 10 points (1 to 10), and the average point was used
for identifying outliers. Those whom were rated as relatively low points were checked as outliers. Also, if the score of certain criterion was relatively too low, even the average was not under the threshold, elimination from the register was considered. The percentage of threshold was supposed to be more than 0.80 based on (Shrout and Fleiss, 1979).

There was no participant who has disability or discomfort in any kinds of senses including hearing, seeing, or touching. Also, even though there were few participants who need time to be used to the task, every participant who are not eliminated from data show reasonable adjustment before, during and after the task. For reward, a gift certificate valued 5000 won (cultural voucher) after the entire experiment was over.

3. Material

Though, in this dissertation, all information is presented in English, every stimulus was displayed in Korean, which is the first language of every participant, except one participant who was from China. However, even the participant was able to speak, read, and listen Korean properly, which were checked before the experiment began. There were three types of materials were given: auditory stimuli for making experimental conditions, visual stimuli for drawing guide, examples, and instruction, and complex stimuli (audio, pictorial, and textual) for questionnaire.

A. Auditory Stimuli

Music is one of the most important parts in the experiment. The music used in this experiment was composed by mac application named Garage band, which can make music based on time-line sequence, being able to use many instruments.

In the former study, stimuli had both rhythm and melody parts. However, to rule out effects possibly originated from other than escalading pitch (melody), rhythm part was eliminated in this dissertation. Also, in the former study, some participants reported that instruments used was bizarre, therefore it was hard to be concentrated on the tasks. In turn, the stimuli were set to piano, unlike many studies in these subjects (Eitan and Granot, 2006; Berger et al., 2013; Walker,
1987), which is one of the most familiar to Korean students based on the music education they had across the compulsory education period (elementary, middle, and high school). Also, previous research used piano in the experiment (Lidji et al., 2007) in order to show spatial association of musical stimuli. However in the study, piano and violin were compared to show effect of timber.

Additionally, to test the effect of the melody only, the BPM (beat per minute, tempo of the music) were controlled throughout the conditions at 120 BPM. The speed of BPM was selected based on the result and report from pilot and former study. The participants of those experiments reported that the speed of the music was ‘comfortable’ or ‘not irritating’.

The baseline (starting note of the melody) was set to middle C, also marked as C₄, which is first note that is learned in piano (or other instrument) education (figure 4). In one octave ascending condition, a loop was played C₄ to C₅, note by note, and turn by turn. In one octave descending condition, a loop was played C₅ to C₄ as well. In this case, to rule out the effect of pitch depth, baseline note was not started from C₄. Therefore, the interval of both condition were within same octave.

![Figure 4. Middle C in a score](image)

In two octave ascending condition, a loop was played C₄ to C₆, note by note, and in turn. In contrast, in two octave descending condition, a loop was played to C₅ to C₃ as well. The interval of the melodies was not completely match. The reason is that if two octave conditions’ intervals are perfectly matched, when all music stimuli are looked together in the score, there will be a growing tendency of pitch. Then the manipulation can be biased by the tendency. Thus, in two octave condition’s baseline notes of the stimuli were differed from one octave condition. The design of stimuli is presented in table 3 and figure 5.
There were 4 sets of auditory stimuli, which are provided to the participants along with counter-balanced order based on balanced Latin-square methods (Williams, 1949).
B. Visual Stimuli

Visual stimuli were given to participants in Microsoft PowerPoint slides, which are controlled by experimenter in the room via wireless mouse/presenter. The main purposes of the visual stimuli were to give instruction of the experiment, guide the procedure, and show the picture to draw according to the preset order.

At first, the name of the experiment (complex cultural contents design) was presented, and then the purpose of the experiment and privacy protocol was instructed. After that, cautionary instruction, which is important during the drawing, was informed, such as they should following the very instruction and they should notify if there were any discomfort or irritation.

The most important point in the early part of the slides was letting participants know how to draw. Because given drawing device (tablet) was unfamiliar to most participants, it was essential to inform how to use and draw using the tablet step by step. Also, in order to prevent using too much time for drawing each picture, participants were informed the goal was to draw given pictures within limited time, which was not specifically notified due to rule out interpersonal difference of drawing skills.

One other important information was what not to do during drawing. Due to the measurement (Image J; figure 6) and the dependent variable, the results of drawings should not be a ‘messy’ picture. In other words, the drawings could not be drawn in dessin (rough sketch). Therefore, participants were informed that they should draw a line in one stroke, or they can erase or undo the drawing. Also, Image J is able to measure the area just out of a closed curve, so that participants were asked to ‘finish’ the drawing by connect the lines as a closed curve.

![Image J](image.png)

Figure 6. Image J

To ensure this instruction was well transferred, an example was given as figure 7. In the example slide, a good example and bad example drawings were displayed and labeled as well.
However, even after this instruction and examples were given, several participants did not follow, or made mistakes. Therefore, adjustment processes of the drawing were performed during coding session by a function of Image J.

![Figure 7. The example of how to draw a picture](image)

Accordingly, it was provided that how to use undo with given keyboard and how to erase with designated digitizer. It was also noted that they could undo and erase as much as they can as long as the limitation of time was allowed. Moreover, because participants’ hands possibly were not ready for drawing in their full capacity, hand massage by themselves and hand shaking was suggested. Lastly, for preparing musical cue and saving pictures, participants were asked to raise their hand after finishing a drawing.

![Figure 8. Pictures used in tutorial session](image)

After the instruction, tutorial was started for preparing participants series of drawing session. In order to enhance uniformity of the results, seven different pictures including dependent measure materials were given in tutorial (figure 8). It was anticipated that, by doing
this tutorial session, participants could get used to the new apparatus and the drawing process including environment, instruction, procedure, and experimenter as well. However, in pilot test, participants’ results were change abruptly after two drawings in actual measure session (two drawings after tutorial session). Therefore, in actual experiment, first two drawings after tutorials, were attached to the end of the experiment, so that participants showed uniform behaviors, which might be a consequence of learning process.

There were two dependent measures for drawing. The shape of the two were based on the basic figures, such as triangle, rectangle, circle, trapezoid, and etc. in order to make the drawing tasks familiar, which is considered to be needed because using digitizer might be already make the tasks unfamiliar enough. To make the task not too easy, the basic figures were not used to be measured by themselves. Instead, the combinations of the basic figures were used. Among many combinations of basic figures, those two pictures displayed in figure 9 were selected. The reasons of selection were various; drawing difficulty, not reminding of familiar shape, reports from pilot tests, direction of expansion of the shapes, and symmetry. The first picture was combination of rectangle and circle. And the second picture was combination of trapezoid and triangle.

According to 4 conditions, each picture supposed to be drawn 4 times. However, in consideration of the learning curve, hand skill adjustment, and familiarity of the shape, these pictures were included in tutorial session, which is in advance of actual measure among basic figures and control stimuli. As a result, a participant drew each picture 7 times, including one trial in the tutorial, and first two trials were neglected in the analysis.

![Figure 9. Picture 1 and 2 of dependent measures](image-url)
The order of the pictures was alternatively changed turn by turn during the drawing session, in order to eliminate learning effect and fatigue. The experimental sequences of all four sets were displayed in the table 4.

<table>
<thead>
<tr>
<th>Set</th>
<th>Music</th>
<th>Order →</th>
<th>Music</th>
<th>Order →</th>
<th>Music</th>
<th>Order →</th>
<th>Music</th>
<th>Order →</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Music</td>
<td>M 1</td>
<td>M 2</td>
<td>M 4</td>
<td>M 3</td>
<td>C</td>
<td>M 3</td>
<td>M 4</td>
</tr>
<tr>
<td></td>
<td>Picture</td>
<td>P 1</td>
<td>P 2</td>
<td>P 1</td>
<td>P 2</td>
<td>C</td>
<td>P 1</td>
<td>P 2</td>
</tr>
<tr>
<td>B</td>
<td>Music</td>
<td>M 2</td>
<td>M 3</td>
<td>M 1</td>
<td>M 4</td>
<td>C</td>
<td>M 1</td>
<td>M 4</td>
</tr>
<tr>
<td></td>
<td>Picture</td>
<td>P 1</td>
<td>P 2</td>
<td>P 1</td>
<td>P 2</td>
<td>C</td>
<td>P 1</td>
<td>P 2</td>
</tr>
<tr>
<td>C</td>
<td>Music</td>
<td>M 3</td>
<td>M 4</td>
<td>M 2</td>
<td>M 1</td>
<td>C</td>
<td>M 2</td>
<td>M 1</td>
</tr>
<tr>
<td></td>
<td>Picture</td>
<td>P 1</td>
<td>P 2</td>
<td>P 1</td>
<td>P 2</td>
<td>C</td>
<td>P 1</td>
<td>P 2</td>
</tr>
<tr>
<td>D</td>
<td>Music</td>
<td>M 4</td>
<td>M 1</td>
<td>M 3</td>
<td>M 2</td>
<td>C</td>
<td>M 3</td>
<td>M 2</td>
</tr>
<tr>
<td></td>
<td>Picture</td>
<td>P 1</td>
<td>P 2</td>
<td>P 1</td>
<td>P 2</td>
<td>C</td>
<td>P 1</td>
<td>P 2</td>
</tr>
</tbody>
</table>

Table 4. Experiment sequence based on Latin-square counter-balancing

There were controls in the sequences. Because to make the sequences counter-balanced, participants who experience set B, C, and D would draw same picture consecutively. We worried that it might make participants more tired of the task. Therefore, control, or break, tasks were embedded between concerned parts of the sequence. For set A, to make every set equivalent regarding the amount of the task, difficulty, and order of stimuli, two control stimuli were added.

C. Complex Stimuli for Questionnaire

To gather participants’ information and to measure control variables, complex stimuli via...
A google form was used. In advance to the drawing part of the experiment, participants were called into the separate room for fill questionnaire on PC. After they got in the room, a brief instruction of the experiment and procedure were provided. Then personal information such as name, age, gender, and handedness were asked for participants in order to use in experiment, label experimental condition, and document characteristics of participants.

After the drawing, participants were guided to the separate room again, and asked to finish the questionnaire, which was about control variables. There were three main control variables. First variable was to rule out effect of attention on the music played during the experiment. Because this dissertation is based on the embodied effect of music, which bypass attention or center of consciousness, the music were not supposed to be big part of participants' attention. The questions were followings:

1. Was the music consisted of one song or many songs?
2. Did Music disturb you while you were drawing?

These questions were rated in 7-point scale, which had different state at each side of the scale. For the first question, 1 referred to changing to smaller volume and 7 referred to changing to bigger volume. For the second question, 1 referred to one song was repeated constantly, and 7 referred to many songs were played in turn constantly. For the last question, 1 referred to no disturbance at all, and 7 referred to highly disturbed.

The second variable was for testing emotional effect. Because music generally related to the emotional shifting, the outcome of the experiment cannot be justified as embodied effect without examining whether there were emotional factors affected the results. Thus, to measure emotional shifting based on the music, two stages of treatment were performed. In the middle of the questionnaire, participants were asked to stop and rest. While resting, wet tissue was given to the participants in order to make them washing their hands with it. This particular treatment was used after study of Lee and Schwarz (2010; 2010), for the purpose of resetting participants’ mind by reducing effect of treatment before washing hands. To do so, we expected participants’ emotional state were back to initial state, which is the state before the experiment.

Then, participants were asked to check visual questionnaire based on subjective assessment mannequin (SAM) (Bradley and Lang, 1994). After the SAM measure, participants were asked to
wear headphones and listen to the music. The music was similar to the music used in the drawing session, but slightly different. The tempo and instrument were same. However the music was consisted of two repeated ascending notes in different keys (Do-Mi-Sol-Do-Mi-Sol-Do + Si-Re-Sol-Si-Re-Sol-Si). By doing this, experimenter aimed to mix different emotional base based on different codes, so that shows sheer effect of ascending pitch notes.

Participants were exposed to the music approximately 45 seconds. The time of exposure was adjusted ±5 seconds based on the concentration and readiness of the participants. 45 seconds of time were determined through the pilot test. In the interview after pilot test, participants were asked about how much time did they needed to be immersive enough to the music. While listening, each participant was asked to be comfortable posture, and close their eyes, in order to rule out other environmental factors. After the listening, another set of SAM was showed.

The reason why was SAM used was that, first, whole process of experiment was already text-heavy due to detailed instructions. Also, participants experienced rather exhausting series of drawing. Thus participants were likely tired of reading text already before emotional assessment, and it might cause negative skew of emotion.

Second, common measures used in emotional assessment were usually consisted of various kinds of different emotions (Caicedo and van Beuzekom, 2006; Sloan and Kring, 2007). Among many emotions, it was hard to choose a part of emotions to measure, because each participant might had different background, personality, character, and situation. Therefore particular emotional state could not be measured for generalize effect of emotion.

Lastly, a music-induced emotion might be volatile, especially the music used in this experiment. Music can cause huge emotional change, based on many factors. However, the music of experiment was simplified form according to the conditions, so that if there were emotional shifting, it might not be easy to capture the shifting. Therefore, the measurement of emotion should not be take long time. Considering these factors, SAM was relatively adequate measurement.

The third variable was experience and history of music listening and tablet use. For music listening, it was possible that how much music people listening could be linked to the results of the experiment (Küssner et al., 2014). Therefore, how much time participants listen to music should be measure to see whether there is effect of listening habit. Also, as stated earlier, tablet
and digitizer could be bizarre tool for some participants. Therefore experience of tablet should be measured to rule out the effect of how much participants were familiar to the devices.

4. Apparatus and Environment

The dependent measure was the size of drawings. To have precise measurement, the way used in former study, pen and paper, cannot be used. Thus, digitalized tablet for drawing, which has flat monitor for role of papers and digitizer for pen, was used. The product was made from Wacom. The size of the tablet was large enough to draw freely (based on the interview of pilot test), and no participant reported performance issue and the size problems. The environment for dependent measurement is displayed in figure 10.

![Image of drawing session environment](image)

Figure 10. Environment of drawing session
(chairs were changed and camera was relocated in practice)

For sound stimuli Bluetooth speaker JAMBOX of JAWBONE was used. Because the experiment was held in mirror-split room, ordinary speaker cannot ensure the volume that loud enough to listen from the other side of the room. The very product was showed no issue on this
matter, which is renowned for powerful volume. However, the volume was little at first, and became loud enough to hear step by step, to make participants concentrated in the instruction and their drawing. Even though the volume was loud, the terminal volume was manipulated not to disturb participants based on pilot test and several practices.

An additional monitor was used for displaying instruction and visual stimuli. The arrangement of the monitor and the tablet was concerned because of the eye-hand coordination. Therefore the monitor was placed right in front of the participants, so that position of the participants, tablet, and the monitor to be in line. The information displayed from the monitor was manipulated by instructor with wireless mouse, so that participants were not interrupted by process of the experiment.

The monitor, tablet, computer, and digitizer were placed on a wood-finished table, enough to place them all and little margin. Because a chair could be modified in height and posture, therefore participants could have comfortable position during experiment. Also based on the handedness, the position of digitizer was modified before the drawing session.

Also the whole drawing session of the experiment was recorded in HD video with sound in order to observe the behavior, check time consumed, and detect outliers. To ensure participants to be concentrated in the experiment, the camera was installed backside of the participants, so that the face of them was not recorded. There were no participants reported any disturbance of using video camera.

The key aspect of this experiment was to ensure that participants weren’t focused on the music. To make sure that, several experimental setting was used. Firstly, specially designed mirror room is used. The room is designed to observe experiments on the other side of the mirror, which is installed on the wall of the experiment site. In practice, participants were guided to the room with mirror, where there was no sound-making device. However, on the other side of the wall (mirror), a speaker was installed, which was manipulated by an observer in the same room. By setting as this, most of the participants could not aware that the played music was part of the experiment. Also some participants, who asked about the music and its role, were informed that there was another experiment was on-going, so that they could focus on the drawing. A view behind the mirror is displayed in figure 11.

Secondly, additional questionnaire were provided to rule out possibilities of music-
awareness. Even though experiment was performed in mirror room, there might be some participants still kept listening to auditory stimuli and had attention to the music. To rule out this case, questionnaire designated to spot on these participants. The set of questionnaire was consisted of three questions, asking whether there was volume-shifting of played music; the music is consisted of one theme or several; was the music played irritated. The results of these questions also used to detect outliers.

Figure 11. The view of experimental room from the behind of the mirror (chairs were changed and camera was relocated in practice)

Lastly, displaying method of music was designed. Because four different stimuli, according to the experiment design, should be played in turn as participants finishing and starting a new drawing, the change of the music related to their task could be revealed. Therefore, the music were not played right after finish of the drawing, randomized duration (2 to 5 seconds) was inserted in advance of the change of music. While doing that, to guarantee equal exposure time for listening, saving time (of the digitalized drawing) was used. The instructor was trained to manipulate consumed time for saving files according to the type of stimuli.

5. Procedure
The experiment of the dissertation was held in several rooms in international hall, Sungkyunkwan University (figure 12). Total number of experimenter was two, including an instructor and an experiment guide. The experimental process was started from participants’ on-time arriving. It was specified on the flier introduction that participants should come to the site at least 5 minutes in advance to the scheduled time. After greeting, which was performed as warm as possible by the instructor due to difficulty of the experiment, participants were guided to room 1. The role of instructor was giving information of general aspects of the experiment, supervising questionnaire process in room 1 and manipulating music stimuli in room 2. The role of the experiment guide was giving information about drawing session and supervising drawing process in room 3. Schematic of procedure is displayed in figure 13.

![Figure 12. Schematic of Experiment Rooms](image)

In the room 1, participants were asked to take their outer wear off for easy arm movement, and put their luggage and phone down. After giving brief instruction on what this experiment is about and how this experiment goes, participants answered series of information on computer for personal identification and measuring handedness. Then, experimenter guided participants to the room 3, where the drawing session was set.

In room 3, the guide greeted participants, and asked them to sit. When they sat on the chair, they were informed that the chair can be modified for them in order to find the most comfortable posture. Also, based on their handedness, the digitizer was moved to designated place (left or right).
The drawing session was started from there, by noticing general information about the session to participants. The guide told that what is the purpose of the experiment, what they were about to do, how to use the tablet and the digitizer, what rules they should follow, what they should not do, and how to end each drawing. All information was displayed on the monitor in front of participants, and was read by the guide as well for effective deliberation. Also, when information that is important and hard to understand quickly came up, pictorial examples were ready for comprehensive instruction.

Participants started actual drawing, using digitizer, in the tutorial session. The tutorial was consisted of 7 pictures including circle, triangle, rectangle, trapezoid, dependent measure 1, 2, and ‘T’-shaped picture. These pictures were given in designated order, same for all participants. Including main dependent measuring session, all pictures were suggested to be drawn in limited time, in order to make drawing simple to rule out unexpected variables and noise. After tutorial session was over, participants were reminded that though some pictures already saw will be displayed again, they should be concentrated and draw the picture as they first see them. At this point, the actual dependent measuring was started, with preset order of auditory stimuli were played whereas, in tutorial, the auditory stimuli were played in random order.

In the dependent measuring session, two dependent measuring pictures were displayed alternatively with modified Latin-square counter balancing order. Among preset order, house-
shaped picture was given to eliminate learning effect. Total 10 dependent measuring pictures, 5 pictures each, were drawn in this session, which was 1 for each picture in consideration of learning curve. Stimuli were manipulated as depicted in figure 14. After the tutorial session, participants started to be exposed to the auditory stimuli in preset order, during the instruction of the actual measure session displayed. In general, participants were asked to raise their hand to show their drawing is finished. That was the signal for the instructor in the room 2 to change the auditory stimulus. To be cautious enough not to be noticed, the timing of changing was slightly delayed from the hand raising.

While the instructor changing the music, the guide saved the result of drawing with concentrating on auditory stimuli. Because every stimulus should be played same amount of frequency in advance of the drawing due to the adaptation to stimulus, the guide tried to have enough time to make participants to be exposed to the music at least two repetitions. To accomplish that, spent time to saving files was controlled by the guide. After the change, the stimulus was kept playing until the next hand raising. After finishing drawing session, all participants were asked to wash their hands with wet-tissue in order to prepare them for questionnaire. The detailed procedure

Figure 14. Detailed Procedure of Drawing and Stimuli Manipulation

Participants were guided to room 1 by instructor, who was not sighted by participants
while getting out of room 2. Instructor notified them to sit comfortably in front of the computer they used to fill out the information in advance, and the questionnaire session began. Most of instructions were given by computer, designed in Google Form. The questionnaire was consisted of mainly two parts. First part was questionnaire designated for ruling out extrinsic variables. Second part was sensory-complex questionnaire including music that is designed for observing reactions to the music. After all questionnaires were done, participants were notified that the whole experiment was over and given stated reward.

V. Results

Before stating results, a summary of variables and hypothesis are presented as followings.

- IV 1 (two levels): Direction of melody, within-subjects variable; the direction of the melody, which changing in pitch ascending OR descending

- IV 2 (two levels): Interval of octave, within-subjects variable; the pitch difference between first and the last notes (one octave OR two octaves)

- DV: Number of pixels within the drawing

- Hypothesis 1

  Ascending melody would affect the size of bodily behavior POSITIVELY, which result in relatively more pixels within the picture than the descending case.

- Hypothesis 2

  Extended interval of melody up to two octaves would show stronger effect on bodily behavior, which result in relatively larger change in pixels within the picture than the one octave case.

- Hypothesis 3 (interaction effect)

  When the pitch interval of music is two octaves, the difference of pixels between ascending and descending melody conditions would be relatively bigger than when the pitch
interval is one octave.

The results were analyzed in two-way within-subjects (repeated measure) ANOVA (analysis of variance) via SPSS program. After outlier elimination, total number of participants was 46 (female = 25, male = 21), and the gender ratio was 45.7 to 54.3 as males and females respectively. The mean of participants' age was 23.11, and standard deviation was 2.42 (min = 19, max = 33).

Because there was no between-subject factor, Levene’s homogeneity test could not be able to be assessed. Also, because the level of each variable was less than two, Mauchly’s sphericity test could not be able to be assessed, either.

The dependent variable of this dissertation was area of the drawings, which represent size of the behavior. For this condition, dependent variables were measured as the number of pixels for the area (in other words, for area, the number of pixels within the picture). To do this task, the PC program named Image J, which is frequently used by biologists in order to measure the size of the biological matters such as tumor, cell, and etc., was used. There were two drawings were drawn; picture 1 and picture 2 (figure 15 and 17, respectively)

1. Picture 1

![Figure 15. Picture 1 (Dependent Measure Task)](image-url)
A descriptive statistics of the result and analysis of variance table of picture 1 are fully summarized in table 5 and 6. As seen in table 6, there was no statistically significant result in the analysis of area of picture 1 ($p_{interval} = 0.426$, $p_{direction} = 0.486$, and $p_{interaction} = 0.713$). Therefore, no hypothesis based on the picture 1 is supported by the results.

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>Dof</th>
<th>MSe</th>
<th>F</th>
<th>P</th>
<th>$\eta^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interval of Octave</td>
<td>1.207 * 10^9</td>
<td>1</td>
<td>1.870 * 10^9</td>
<td>0.646</td>
<td>0.426</td>
<td>0.014</td>
</tr>
<tr>
<td>Direction of Melody</td>
<td>4.239 * 10^8</td>
<td>1</td>
<td>8.597 * 10^8</td>
<td>0.493</td>
<td>0.486</td>
<td>0.011</td>
</tr>
<tr>
<td>Interval * Direction</td>
<td>2.131 * 10^8</td>
<td>1</td>
<td>1.557 * 10^9</td>
<td>0.137</td>
<td>0.713</td>
<td>0.003</td>
</tr>
</tbody>
</table>

Table 6. The result of analysis of variance for Area (Pic 1)

Figure 16. Plot of interaction in ANOVA of picture 1 (Area)
2. Picture 2

Figure 17. Picture 2 (Dependent Measure Task)

<table>
<thead>
<tr>
<th>Direction of Melody</th>
<th>Interval of Octave</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>One M(SD)</td>
</tr>
<tr>
<td>Ascending</td>
<td>142307.39 (57732.96)</td>
</tr>
<tr>
<td>Descending</td>
<td>125922.65 (43365.76)</td>
</tr>
</tbody>
</table>

Table 7. Descriptive statistics of Area (Pic 2)

A descriptive statistics of the result and analysis of variance table of picture are fully summarized in table 7 and 8. A significant interaction effect was found between interval of octave and direction of melody (F(1, 45) = 4.069, p<0.05). Also, a significant main effect of interval of octave was found (F(1, 45) = 4.274, p<0.05). There was no significant main effect according to direction of melody (p_{direction} = 0.556). However, when a significant interaction effect discovered, a main effect cannot be interpreted alone (Fisher, 1936; Kirk, 1982).

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>Dof</th>
<th>MSe</th>
<th>F</th>
<th>p</th>
<th>(\eta^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interval of Octave</td>
<td>2.720 (10^9)</td>
<td>1</td>
<td>6.364 (10^8)</td>
<td>4.274</td>
<td>0.044*</td>
<td>0.087</td>
</tr>
<tr>
<td>Direction of Melody</td>
<td>2.110 (10^8)</td>
<td>1</td>
<td>6.006 (10^8)</td>
<td>0.351</td>
<td>0.556</td>
<td>0.008</td>
</tr>
<tr>
<td>Interval * Direction</td>
<td>3.477 (10^9)</td>
<td>1</td>
<td>8.547 (10^8)</td>
<td>4.069</td>
<td>0.050*</td>
<td>0.083</td>
</tr>
</tbody>
</table>

Asterisk(*) indicates p value is under 0.05

Table 8. The result of analysis of variance for Area (Pic 2)
As a result of interaction effect, ANOVA plot seems to show that in ascending condition, participants draw significantly larger at one octave condition than listening two octaves condition. It is somewhat opposite to the original hypothesis. Also, though the difference was small, drawings of descending condition in two octaves were larger than in one octave. It seems that level of octave made the relationship between area and direction of melody opposite. To examine where the significant difference among variables is, a simple effects tests were performed via SPSS syntax function. The used syntax code is displayed in a box below this paragraph.

```
GLM AreaPict2Up1 AreaPict2Down1 AreaPict2Up2 AreaPict2Down2
/WSFACTOR direction 2 simple (1) octave 2 simple (1)
/EMMEANS=table(direction*octave) compare(direction)
/EMMEANS=table(octave*direction) compare(octave)
/plot = profile(direction*octave)
/print=etasq test(mmatrix)
```

Among 4 different pair wise comparison (interval is fixed to one octave, ascending and descending conditions were compared; interval is fixed to two octaves, ascending and descending conditions were compared; direction is fixed to ascending, one and two octaves intervals were compared; direction is fixed to descending, one and two octaves intervals were compared), only one condition, which is when interval was fixed to one, showed statistically significant simple
effect: $M_{\text{one, ascending}} = 142307.40$, $M_{\text{one, descending}} = 125922.65$, $p = 0.015$.

To sum up, within the significant interaction, when the interval of octave was set to one, the mean area difference between ascending and descending melody tend to show bigger than the interval was set to two. Therefore effect of direction of melody was partially supported at one octave condition. However, in two octaves condition, the difference between ascending and descending melody were not significantly different in simple effects tests. Also, except suggested hypotheses of interaction, the main effect of interval of octave was rejected.

3. Subsequent Data Analysis

A. Additional Variables

Although research question was on the relationship between direction of melody, interval of octave, and size of behavior, it needs to explore any possibilities that might affect the results unexpectedly.

First possibility to check is the role of emotion. Perception of music could be closely linked to emotional and behavioral change, so that, in order to make clear the effect of stimuli, the effect of emotion should be controlled (Krumhansl, 2002; Burger et al., 2012). Thus, after the drawing session, the emotional change was measured as check SAM (self-assessment manikin) scale before and after listening pre-generated music. The example of SAM scale and listening procedure of actual experiment were presented in figure 19 and 20 respectively. As an analysis of paired sample t-test, All three emotional states were not showed significant difference before and after listening music (Arousal ($t(46) = 0.436$, $p = 0.665$), Dependence ($t(46) = -0.919$, $p = 0.363$), and Valence ($t(46) = 1.967$, $p = 0.055$)).

![Figure 19. Self-Assessment Manikin (Arousal)](image)

However, valence showed a marginally significant difference between pre- and post-stimulus. The valence is a scale for measuring positive/negative aspect of the emotion, based on choice among faces of Manikin with different expressions in SAM scale. In the result of t-test,
participants perceived higher valence before listening the stimulus (M = 4.75, SD = 1.04) than after the listening (M = 4.45, SD = 0.87). This is, the emotion of the participants generally turned slightly negative. There is few studies that valence could affect behaviors (movement) indirectly (Gross and Levenson, 1993; Egermann et al, 2015), there were no related studies that investigated valence's effect on the size of behavior (searched at June, 2015; among studies cited Self-Assessment Manikin; keywords: valence, posture, movement, motion, behavior, size). Therefore it was assumed that slight change in valence might not effective enough to affect the results.

Another possibility was how much the participants cared continuously on the existence of music. Although it was considered through several procedures, the possibility could not be negligible. Therefore questions were asked to figure out the attentive level to the music. The questions asked for this process were followings; ‘Was the music consisted of one song or many songs?’ ‘Did music disturb you while you were drawing?’ Asked by 7-points interval scaled questions, most of participants could not figure out the displayed pattern of music (M = 2.34, SD = 1.81, Median = 2, Mode = 1), and were not interrupted by auditory stimuli (M = 2.13, SD = 1.44, Median = 2, Mode = 1).

Even though they tended not to be affected or were not attended by musical stimuli in general, participants who were definitely affected by the attention on music can skew the results.
of the experiment. Thus, to pin-point these participants as outliers, outlier-assessment was performed based on the scores they gave in those questions. In the frequency test on the average of two questions, 96.7 per cent of participants marked below 4 in 7-points scale. Only two participants answered over 4 point, 4.5 and 6 respectively. They were considered in outlier assessment, and the participant who marked 6 was eliminated from the final analysis.

Typical time to use for listening music and familiarity for tablet device were also considered. These factors were recorded as series of 7-points ordinal scale. For listening time, the question was based on how much time they spend on listening music a day, including 7 different criteria; none, 5 minutes, 15 minutes, 30 minutes, an hour, one and a half hour, and more than one and a half hour. Most of participants spent half hour for listening music, and 63 per cent of participants use under half hour to the listening (M = 4.33, SD = 1.40).

Tablet experience were measured with three different questions, including total tablet use experience, tablet using time, and tablet use history. Total tablet use experience was measure as 7-points interval scale, asking did they have used tablet devices so far, from ‘not at all’ to ‘very much’. As a result, most of participants have no experience or very little (76.1 per cent for those who checked 1 and 2 in 7 points scale, M = 2.02, SD = 1.84, Median = 1, Mode = 1).

Tablet using time was asked as how much does they spend on tablet a day based on average time in a week, using 7-points ordinal scale. The question included 7 different criteria; none, 15 minutes, 30 minutes, an hour, 2 hours, 3 hours and more than 3 hours. Most of the participants did not experienced a tablet or 15 minutes (91.3 per cent for those who checked none and 15 minutes, M = 2.02, SD = 1.84, Median = 1, Mode = 1). Also there were no participants who answered they used 3 hour and more.

Tablet use history were assessed based on the question that asking how long have you used tablet continuously. The question included 7 different criteria as ordinal scales; none, 3 months or less, 6 months, a year, 2 years, 3 years and more than 3 years. The result showed relatively radical (M = 1.2, Median = 1, SD = 0.453, Max = 3). To merge three questions into one variable, reliability test was performed. The result of Cronbach’s alpha was 0.746, which is bigger than 0.7. Based on Cortina (1993), three questions on tablet experience were merged as tablet experience variable.

B. Correlation Analysis
In order to investigate relationship among these variables, correlation analysis was performed. All values in the table below are Pearson’s R.

<table>
<thead>
<tr>
<th></th>
<th>1)</th>
<th>2)</th>
<th>3)</th>
<th>4)</th>
<th>5)</th>
<th>6)</th>
<th>7)</th>
<th>8)</th>
<th>9)</th>
<th>10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) 1X1 P1</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2) 1X2 P1</td>
<td>.845**</td>
<td>-</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3) 2X1 P1</td>
<td>.632**</td>
<td>.710**</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4) 2X2 P1</td>
<td>.795**</td>
<td>.749**</td>
<td>.688**</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5) 1X1 P2</td>
<td>.713**</td>
<td>.605**</td>
<td>.495**</td>
<td>.658**</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>6) 1X2 P2</td>
<td>.643**</td>
<td>.616**</td>
<td>.603**</td>
<td>.600**</td>
<td>.703**</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7) 2X1 P2</td>
<td>.624**</td>
<td>.695**</td>
<td>.678**</td>
<td>.637**</td>
<td>.657**</td>
<td>.747**</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8) 2X2 P2</td>
<td>.744**</td>
<td>.616**</td>
<td>.650**</td>
<td>.637**</td>
<td>.789**</td>
<td>.789**</td>
<td>.737**</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9) TabletExp</td>
<td>.348*</td>
<td>.291*</td>
<td>.256</td>
<td>.396**</td>
<td>.139</td>
<td>.145</td>
<td>.199</td>
<td>.335*</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>10) ListenTime</td>
<td>.435**</td>
<td>.338*</td>
<td>.195</td>
<td>.382**</td>
<td>.301*</td>
<td>.240</td>
<td>.198</td>
<td>.168</td>
<td>.071</td>
<td>-</td>
</tr>
</tbody>
</table>

Note. * (p < 0.05), ** (p<0.01)

Table 9. Correlation among dependent measures and tablet usage, listening time

Set aside correlation among dependent measures, several significant correlations were found related to tablet experience and listening time. Four dependent measures of picture 1 showed significant positive correlation with tablet experience and listening time except ascending melody with two octaves interval. However, in picture 2, a portion of dependent measures for each variable (listening time and tablet experience) was significant in positive correlation. The difference the results of correlation between picture 1 and 2 might affect the difference of results’ significance. But considering there were no difference of environment in experimental condition, the difference between picture 1 and 2 was the difference of drawing pattern itself. Thus the correlation’s effect on the significance of the results was considered to be unlikely.

In picture 1, two octaves ascending condition only showed statistically insignificant correlation with tablet experience and listening time. In this case, considering that the mean value of the condition was the lowest among four related conditions, the correlation might affect the result of picture 1. It could be suggested that there is certain interaction between independent variables at this point, considering that other two octaves or ascending conditions showed significant correlation. Additional analysis will be needed to investigate more.
4. Analysis for Height and Width

As stated in literature review section, the most studied musical feature was the pitch - height relationship. Also based on the results of the former study (width and height), a dependent variable was chosen. The present results shows that partial support on the pitch – area relationship, so that additional analysis for investigating whether this results will be consistent with those width and height of picture 2. The analysis method was same as the area, and analysis for picture 1 was not needed because there was no significant effect.

A. Width of Picture 2

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>Dof</th>
<th>MSe</th>
<th>F</th>
<th>P</th>
<th>η²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interval of Octave</td>
<td>23876.17</td>
<td>1</td>
<td>3992.70</td>
<td>5.98</td>
<td>0.018*</td>
<td>0.117</td>
</tr>
<tr>
<td>Direction of Melody</td>
<td>5765.76</td>
<td>1</td>
<td>3594.08</td>
<td>1.60</td>
<td>0.212</td>
<td>0.034</td>
</tr>
<tr>
<td>Interval * Direction</td>
<td>10410.09</td>
<td>1</td>
<td>5138.32</td>
<td>2.03</td>
<td>0.162</td>
<td>0.043</td>
</tr>
</tbody>
</table>

Table 10. Descriptive statistics of Width (Pic 2)

Table 11. The result of analysis of variance for Width (Pic 2)

In the analysis of two-way repeated (within-subjects) ANOVA, a main effect of interval of octave was found (F(45) = 5.98, p = 0.018). The summarization of the results is displayed in table 10 and 11. When the interval of melody was longer, the width of the drawing was wider as well. However the direction of melody and interaction between interval and direction were not statistically significant (p_direction = 0.212, p_interaction = 0.162). The result of analysis is also consistent with the former study. Therefore, it looks more obvious that the width of behavior, in this case drawing, would be affected by melodic component of music in terms of how higher the pitch
going up.

Figure 21. Plot of interaction in ANOVA of picture 2 (width)

B. Height of Picture 2

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>Dof</th>
<th>MSe</th>
<th>F</th>
<th>P</th>
<th>η²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interval of Octave</td>
<td>3871.39</td>
<td>1</td>
<td>1970.65</td>
<td>1.965</td>
<td>0.168</td>
<td>0.042</td>
</tr>
<tr>
<td>Direction of Melody</td>
<td>287.50</td>
<td>1</td>
<td>1634.02</td>
<td>0.176</td>
<td>0.677</td>
<td>0.004</td>
</tr>
<tr>
<td>Interval * Direction</td>
<td>8186.89</td>
<td>1</td>
<td>2145.39</td>
<td>3.808</td>
<td>0.057</td>
<td>0.078</td>
</tr>
</tbody>
</table>

*asterisk(*) indicates p value is under 0.05

Table 13. The result of analysis of variance for Height (Pic 2)
In the analysis of two-way repeated (within-subjects) ANOVA, a marginally significant effect of interaction between interval of octave and direction of melody was found ($F(45) = 3.81$, $p = 0.057$). The summarization of results is displayed in table 12 and 13. Even though the $p$-value was marginal, the interaction effect should be specified by simple effects tests, as done in the analysis of area.

Among 4 different pair wise comparison (interval is fixed to one octave, ascending and descending conditions were compared; interval is fixed to two octaves, ascending and descending conditions were compared; direction is fixed to ascending, one and two octaves intervals were compared; direction is fixed to descending, one and two octaves intervals were compared), only one condition, which is when interval was fixed to one, showed statistically significant simple effect: $M_{(one, ascending)} = 456.17$, $M_{(one, descending)} = 433.67$, $p = 0.031$.

To sum up, within the marginally significant interaction effect, when the interval of octave was set to one, the mean height difference between ascending and descending melody tend to show bigger than the interval was set to two. The result of height analysis was consistent with area analysis of interaction, which is based on the simple effects tests. It might indicate that the difference of area is based on the difference of heights.
VI. Discussion

1. Summary of Findings

A. Analysis on Result of Picture 1

First of all, there was no significant effect of independent variables in analysis of picture 1. If we assume that the manipulation was effective and exogenous variables were controlled, the difference might be occurred from picture itself. The picture 1 is a combination of circle and rectangle, and the picture 2 is a combination of trapezoid and triangle. Each picture was selected among other candidate combinations based on symmetry, familiarity, and response from pilot test.

At the hypothesis building, considering the results of the former study, dependent variable, which is size of the picture, was derived from the formula of area in mathematics (area = width X height). However, among principle diagrams, a circle is the only diagram that the area cannot be calculated by the formula. Thus, if the use of formula is valid in hypothesis building, it is understandable that the area of picture 1 was not affected by musical conditions. Also, if sensory prototype, which is established behavioral pattern within sensory-motor system, exists, the results might raise couple of theories about why the result of picture 1 was not significant.

1) The concept of the formula ‘area = width X height’ is embodied, but the ‘area = Pi X radius^2’ is not embodied.

2) The pattern of embodiment about size or area is based on rectangle, not circle.

Investigating first theory, there were few studies exploring the conceptual metaphor of area. In the several studies of Tall (Tall, 1991; Tall, 2003; Tall, 2006; Tall, 2009), the application of embodied method for learning calculus, specifically the concept of integral was tested. The concept of integral on this case was limited to the area below certain functions in Cartesian coordinates. There was no evidence that what kinds of metaphor were used in the application of integral, and the embodied pattern of the concept of area. Similar to many other learning materials of calculus, Tall used rectangle as a basic element of area, along with limitless number of
infinisimals. However, ‘embodiment’ in the Tall's series of work was somewhat limited that the embodied learning was referred to physical-graphical interaction-based learning.

In the literature review, an embodiment of conceptual area was not clear. As shown in the Tall's applications, the learning process of integral is consisted of representations, which are graph, Cartesian coordinates, and so on. With these representations are made of graphical images that include basic protocols of calculation area using infinite number of rectangles. We cannot say that the concept of integral is embodied. Instead, with a bold speculation, the usage of rectangle as a basic area component of understanding integral might show that a rectangle is meaningful when it comes to the conceptual metaphor of area.

The second theory could be understood easily by look around our daily life rather than mathematics itself. Our environment, which is modified by ourselves, is consisted of rectangular objects and concepts if they are related to area concepts. For example, when we think of area of a farm land or structure of apartment building, rectangular images are naturally represented along with units such as square-meter, square-inch, and so on. The meaning of square is multiply by itself, but the learning of meaning of square starts from a square. It is interesting that investigating whether these cultural environments of learning conceptual area is first of the embodied meaning of area lead us to those specific area learning concept. However, for here, the discovery of this phenomenon might indicate that the embodiment of area is closely related to rectangular shape.

Second of all, the difficulty or complexity of the picture 1 might affect the results of analysis. To assess the complexity of a diagram, Euclidian geometry cannot be used. In turn, fractal analysis should be needed to assess complexity of a diagram in mathematical context. However, using fractal is based on mathematical term ‘complexity’, which is not proved to be appropriate for analyzing complexity in the embodied perspectives. Thus suggesting easy method, structure of each picture was calculated by counting number of structural components. Picture 1 has 8 vertexes and 8 segments, while picture 2 has 7 vertexes and 7 segments. Simply put, the number of vertexes and segments of the picture 1 outnumbered those of the picture 2. Therefore, participants might perceive the picture 1 as more complex structure than the picture 2, though the method of complexity calculation was not scientifically established.

There were few reports in the assessment difficulty of drawing materials in the pilot
Some participants of pilot study reported that the picture 1 in harder to draw than the picture 2, because of circular part of the picture 1. Specifically, they told that symmetry of circle was hard to imitate. Moreover a participant reported that the difficulty of the picture 1 was frustrated, so that even music was irritated while drawing the picture 1. It is impossible to know the actual effect of difficulty of the pictures, because the difficulty was not measured during the experiment practices besides pilot test. However, considering reports of pilot test and complexity test, the picture 1 is likely to be harder to drawer than the picture 2. Also, drawing circle is generally hard compared to draw straight line. Therefore, the difficulty of drawing might be the reason why the results of the picture 1 were not significant.

**B. Analysis on Result of Picture 2**

With simple effects tests, a partial support of hypothesis on direction of melody was revealed, especially when the melody interval is within one octave. It is hard to say that the presence of sensory prototype was witnessed. However, a novel link between size-wise behavior and direction of melody was found in limited condition. There might be auditory-induced behavioral patterns that linking ascending melody with larger motion, and descending melody with smaller motion.

The previous studies on musical pitch and motion (and perception) consistently argued that pitch is correlated with vertical motion. To specify the reason of the result on area, the analysis of width and height is concerned.

In the result of width, when presented interval of melody was doubled, participants tended to draw wider pictures. It is partly consisted with the result of the former study, because the conditions compared were including two notes (pitch gap condition) melody and three notes (direction of melody condition) melody, and results showed that the direction of melody had main effect on width of the drawings. Also because these results were not expected based on the previous studies on pitch – height relationship, they might affect the result of area in general.

Based on the marginally significant result of interaction effect, simple effects tests were performed for height of picture 2. As a result, the effect and the pair-wise condition of tests were consistent with the result of area. In other words, when, and only when the interval is fixed to one
octave, the ascending melody condition showed vertically higher drawings than the descending condition. If embodied cognitive patterns of area can be derived from the mathematical formula (width X height), the result of area might be affected by height rather than width considering the analysis of both width and height.

The interesting point of these analyses is that the consistent and inconsistent results with previous metaphoric cognitive research were found. Indeed, the analysis of area is somewhat novel founding that could not been expected by previous studies. And the analysis of height, although the analysis was based on marginally significant interaction, is consistent with previous metaphoric cognition theory and the results of previous studies. However, the results of these results are interesting because the methodological approach of the experiment was based on embodied cognitive perspectives, which lead participants not to be continuously attended to the auditory stimuli. Based on the evidence that the previous studies results were not consistent in various cultural domains, which are outside of the Western culture, this analysis seems more appropriate (Ashley, 2004).

Also, the results showed that not only simple causal relationship between one-dimensional metaphors, which including linear motion and linear change in pitch, but also revealed that this metaphoric relation might be effective in two-dimensional metaphor. Moreover, the results from analysis of area are not consistent with minor metaphor of negative pitch – area relation and the evidence of Huron’s study (Nymoen et al., 2012; Huron et al., 2009).

C. Interval of Octave

Then why the interval of octave didn’t affect to the area of drawings? It is possible that manipulation of independent variable was not clear to the participants. There are two presumptions of the reasons; the interval of octave could be perceived as ‘going further away’ metaphor maintaining melodic pattern, rather than ‘going up further’, and another metaphor might dilute the effect of interval, which is ‘interval as time going’ metaphor.

First of all, considering interval as ‘going away’ metaphor, which is horizontal linear metaphor, not vertical, this can be understood easily by imagining a score. To go up in the melody with same code and tempo, the notes represented in score as gradually going up, and
going horizontally going further. Therefore, if there are metaphors sharing same context as this ‘score’, and the pitch – vertical motion metaphor is one of those shared metaphor, then increased interval might not only be limited to the pitch – vertical relation, but also affected as additional metaphor. In turn, if additional metaphor of interval was activated, the results might not be based on the sensory prototype, but based on the metaphoric cognition. However, there were no direct evidences were found in literatures. Only study of Eitan and Granot (2006) reported a distance – loudness metaphor.

Additionally, Lidji et al. (2007) empirically displayed that both one note and two notes (interval) melodic conditions were related to horizontal spatial representation. One note sound condition is basically an absolute pitch condition. However, the result of this study was different from others. Also, even though two notes interval was too short to be in comparison with this dissertation, when it comes to the trend of results, those two conditions in Lidji’s study can be matched to the result of analysis of width in picture 2. However, this study could be based on association by learned metaphor, because the results were only showed in musically trained group. If those trained group participants recall the image of a musical score, the result could be proved in both horizontal and vertical relation with interval regardless of the specific metaphor.

Another possible metaphor is time – interval metaphor. Previously discussed interval – distance metaphor could be comprehensible as visually induced metaphor based on the musical score. That is someone who knows score can easily imagine. However, time metaphor does not need visual representation because if we observe ascending melodic change, time passing should be followed. It may imply that there is time – interval metaphor. Even though the exposure time of each stimulus and auditory exposing duration before starting a drawing were controlled throughout the one octave and two octaves conditions, the repeated pattern of two octaves condition cannot have same duration to the one octave condition under consistent tempo. Related to this phenomenon, a Scheffé analysis of a group of participants of Walker (1987) showed there might be correlation between duration and horizontal metaphor. Additionally, in Lidji’s study (2007), the results might be affected by duration, which were varied between one repeated note condition and repeated two notes condition.

2. Implications
A. Theoretical Implications

For analysis from the area, the result of this dissertation contributes to the part that previous studies did not expected. Especially, when it comes to the result that cannot be derived from known metaphors, the existence of sensory prototype was partly supported. That is, new possibility of cognitive and behavioral patterns that underlies metaphoric cognition’s hierarchical position was found, which cannot be represented metaphorically, and linguistically. Thus, the most positive interpretation of the dissertation is that the results can link conceptual gap of conceptualization hypothesis, replacement hypothesis, and constitution hypothesis.

Additionally, the finding of conceptual metaphor, established from mathematical metaphor, which is the formula of area, is another interesting theoretical implication. Conventional metaphoric cognitive research tended to prove simple relation between this concept and that concept linearly. However, the result showed that there is possibility that complex metaphors, consisted of composition of several one-dimensional metaphor. That is, different metaphoric cognitive functions can be linked together as a single complex metaphoric relation. Thus, from now on, studies within embodied cognitive perspectives, especially those who are considering metaphoric cognition, would approach the conceptual metaphor as linked bridge from a metaphor to other metaphors.

Also, embodied cognitive methodology was performed as an alternative to conventional embodied music cognition experiments. Musical and auditory stimuli are inherently hard to block, and are very easily blended with other auditory stimuli. Moreover, to prove embodied cognitive effects, participants should be exposed to the stimuli while not listening to them, which is an oxymoron. To accomplish this mission, in this dissertation, several methodological procedures were applied such as using mirror room, instructing that there is another experiment in the other room, and gradually turning the volume up. Although there are already several methods in music cognitive experiments such as playing music while performing tasks, or playing music before the task and getting the reactions, the condition I tried to apply was not able to fit in those methods because participants should be exposed to several stimuli continuously while performing tasks.

B. Practical Implications
The sum of the results is that melodic direction affects behavioral aspects linked to both area and height. Additionally, interval of octave affects behavioral aspects linked to width. Focusing on behaviors, tendency to act bigger or smaller can be induced by music, and tendency to act wider or taller can be induced too. Although further research should be accompanied with practical applications of these phenomena, some speculations can be followed for future directions.

First implication is applications in marketing. Although the result of this dissertation is based on two-dimensional space, if we assume this behavioral tendency can be expanded to three-dimensional size, volume, we can speculate that the 'bigger' choice can be affected by music in purchasing context. Also because online shopping is based on two-dimensional space, screen, so that the context might be more suitable for the discovery of this dissertation. Of course, study for investigating link between 'bigger' behaviors and 'bigger' choices should be established in advance.

Also, in marketing context, placement of merchandises can be affected by musical embodiment. Tendency to behave bigger, higher, and wider is linked to look bigger, higher and wider naturally. For example, in the experiment, participants had to look wider and higher, in order to draw a picture bigger without knowing. The sight modification should follow our behavioral change. Therefore, we might induce customers to look around more by playing designated musical stimuli for browsing many products or discover target brands. This can be applied to any circumstances which need discovering sights. To prove this issue, additional study should be performed by observing eyesight using eye-tracker.

Moreover, this sight-inducing paradigm can be much more useful when emergent actions are needed. For example, when a fire is started inside of a building, fast action such as finding fire extinguishers and navigating fire escapes as soon as possible, are crucial for saving lives. Then, if music induces a modified field of vision or even directional cue, it might be useful especially when sight is not perfect because of fog or heat. Also, for another example, appropriate auditory cues can be useful to drivers who needs guidance to figure out it is OK to go or not to go. However these applications should be tested thoroughly in advance of practice for better understanding of relationship among audio – motion – vision cognition.

Additionally behavioral guidance can be another implication. When we learn something
with our body, we are usually guided by teachers or practice ourselves with mirror. For example, practicing golf swing and dancing cannot be practiced well without appropriate visual feedback. If additional auditory cue is accompanied, visual feedback and guide experience can be more effective. For example, an additional auditory feedback device can help novice golfers to swing bigger or smaller to impact the ball effectively by ascending or descending melody.

Some studies tried to realize these applications. Nirjon (2012) developed a device called MusicalHeart, that giving heart-rate feedback through audio channel, in order to maintain appropriate heart rate while exercising. Tajadura-Jimenez (2015) also developed analyzer of footsteps and gait using Arduino. The device analyzes the gait pattern, and make auditory signal, which varied in pitch, in order to generate a body-weight model. By modifying body weight model, users can perceive their body healthier and focus on the exercise.

3. Limitations

A. Theoretical Limitations

First theoretical limitation is less consideration on selecting auditory stimuli in general. In generating stimuli, many criteria such as tempo, instrument, and levels of IV manipulation were considered. However, those criteria were not sufficient in theoretical aspects. The selection process of stimuli was held mostly based on pilot test, interview and considering practical issues. Thus, it could be not easy to generalize this dissertation as a whole. However, embodied cognitive theory is still developing paradigm, and previous studies in this field did not offer proper criteria in general also.

Second theoretical limitation on visual stimuli is similar to the auditory stimuli. By selecting picture 1 and 2 for measuring size, many logical procedures were considered, but lacked in theoretical basis. Especially in picture 1, adding circular feature into dependent measure was not thoroughly investigated. However, this choice leads the discussion into discovering new possibility of metaphoric cognition. Therefore, to enhance theoretical implication, future works should cover this issue on stimuli generation.
Accordingly, complexity and difficulty of drawing was not perfectly balanced. Composition of basic diagrams, symmetry, and familiarity were considered to choose dependent materials. However it was not perfect for acknowledging the idea that perceiving different pictures might generate different perceptions in various criteria. It seems crucial when it comes to fatigue and motivation of participants, which is important to design future studies.

Lastly, even though the results are linked to spatial cognition, related abilities such as spatial reasoning were not measured. Indeed, though using within-subjects design for ruling out personal characteristics in behavior and inserting appropriate amount of tutorials for diminishing difference in performance, an additional analyzing about spatial abilities cannot be done.

B. Practical Limitations

First of all, gathering process of participants revealed practical limitations. In the process of outlier elimination, male outliers outnumbered female outliers. Therefore gender ratio was skewed a little. However, this skew was not included in the results, so that this issue was not presented in result section. Also most of the participants were young generation attending in University. Thus this dissertation lacks in representative in various age groups for generalizing the results. Future studies should consider these issues by gathering participants with additional manipulations and more wide range of ages.

Also, listening time and tablet experience was not perfectly controlled. These factors could not be controlled during and after the experiment. To control these factors, gathering process of participants should be stricter. To minimize effect of these factors subsequent correlational analysis was performed.

Another issue in gathering participants is the on-site gathering. Although the enrollment of participants was handled in detail, some applicants did not show with or without reason at the scheduled time. To speed up whole experiment plan, additional gathering was tried near experiment site. However, these participants were not planned to be attended in an experiment, so that their motivation and concentration might varied. This issue was minimized by using this information in outlier elimination.

Additionally, giving reward might be an issue. Because the reward was specified in the
application flier, participants knew that they will be given designated reward. This might be an issue considering motivation in the experiment. Participants might perform the task quicker if they know the condition for reward is just finishing the experiment. This partial failure to control motivation for engagement could lead more outliers and contaminate the results of the experiment. Therefore, when it comes to motivation, participants gathering should be carefully executed in future works.

4. Future Study and Research Program

Many possible future direction of research were found. The direction is mainly differentiated by two possibilities. First one is for theoretical advancement. As stated, we could observe possibility of existence of sensory prototype. Thus new studies should focus on full revealing of sensory prototype and discovering various prototypes. Because sensory prototype is not obvious as embodied metaphor by its definition, which is not manifested by linguistic metaphors, series of exploratory, but methodologically strict experiments must be needed to explore sensory prototype. Therefore, time and resources are crucial.

Another direction in theoretical advancement was found based on metaphoric cognition. The auditory-affected behavior can be analyzed as cause and effect based on a metaphor mathematical function. At the same time, this composite relation could exist as a metaphor. That is, two conceptual metaphors (pitch – height, previous studies; pitch – width, former study) were connected as one behavioral embodied pattern (pitch – area = height X width). Therefore future studies can find complex metaphor in various fields including mathematics, test them in strict experiments, and try applications of complex embodied metaphors.

Second direction is practical use of embodied patterns including both embodied metaphors and sensory prototypes. Embodied cognition studies are already used in various fields. For example, correlation of the uniform color of sports team and winning ratio, and number of given violence on team and uniform color are well studied and considered (Hill and Barton, 2005; Attril, et al., 2008; Elliot and Aarts, 2011). Thus a development of actual working device and testing should be followed for application examples that mentioned early. Especially, not only linear movement, but also higher dimensional movement was proved to be affected by auditory cues, so that the areas of application would be vast.
5. Conclusion

The presence of effect of musical cue on behavioral change was tested. Specifically, ascending and descending melody affected the size and height of behavior, and interval of melody affected width of behavior. These results were tested by relatively strictly designed on the basis of embodied cognitive paradigm compared to similar studies in this subject. Also new embodied cognitive concept within hierarchical structure of embodied cognition, sensory prototype, was suggested and discussed to link gap between metaphoric cognition and other embodied perspectives. Finally, various directions for future studies were suggested and new applications of the revealed facts were considered.

VII. References


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