Applications of Auditory Cues for Spatial Cognitive Behaviors Based on Embodied Music Cognition

Dongnyeok Jeong
Department of Interaction Science, Sungkyunkwan Univ.
Seoul, South Korea
nyeok@skku.edu

Wooyong Yi
Department of Interaction Science, Sungkyunkwan Univ.
Seoul, South Korea
skeptor@skku.edu

Jun-dong Cho
Department of Interaction Science, Sungkyunkwan Univ.
Seoul, South Korea
jdcho@skku.edu

ABSTRACT
Music has been studied as a cognitive activity that has variety of possibilities. For example, many cases showed that music affects spatial cognitive process and cognitive performances.

In recent emerge of embodied cognition, in addition to the former research, music's connection to various bodily aspects are investigated. Especially, stepping aside from the boundary of information processing systemic or emotional perspectives, several studies found that there is a link between music and spatial cognition based on embodied cognitive perspectives.

In this study, based on the embodied music cognition started from an empirical study, we tried to search several examples of music as involuntary effect on human behavior and activity. Also theoretically effective guidance for designing games, user interfaces and decision making process in marketing based on auditory cues for behavioral changes were discussed.

Author Keywords
Embodied music cognition; auditory cue; behavioral cognition; design process; design application.

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INTRODUCTION AND BACKGROUNDS
Traditional studies of music cognition and psychology of music had been mostly prevailed by such effects of music training or listening for cognitive functions [1]. Additionally, studies such as Mammarella and colleagues covered (classical) music's positive effects on cognitive task performances [2].

Recently, in addition to these trends, several trials for analyzing music as embodied cognitive activity were arisen. Scholars such as Krueger insisted that music cognition is based on interaction between structure of body and musical environment [3], proposing concepts such as musical affordance and enactive properties of musical experience [4].

Also, in the view of embodied music cognition, supported by scholars such as Leman (2010) [5], human body acts as a mediator between mind and environment for listening music, so that perception of music is highly dependent on body. Moreover, some insisted that structural characteristics of mediator called body can affect representation of music.

These studies seems to indicate that not only passive analysis of music, which is focusing on internal process of music cognition, but active embodied music cognition that even our bodily behaviors might be affected directly through the music cognition.

Giving an empirical support for this indication, a study on embodied music cognition revealed that certain component of music (pitch) could affect participants' behaviors [6].

In the experiment of the study, participants were asked to copy given diagrams (such as an arrow, a house and a symbol of thunder) while they were listening several music which was differ from each other with respect to the pitch of the music.

The experiments suggested statistically significant results on the effect of direction (up or down) of musical note in pitch-wise. The participants draw wider pictures when they were listening upward melody than downward melody. Also they draw taller pictures while they were listening downward melody. However this result was not statistically significant ($p > 0.05$). Regarding these results, embodied cognitive aspects of music perception, especially pitch components, could affect our involuntary behaviors [6].

It indicated that, regarding music perception, in embodied cognitive perspectives, might have effects on human behaviors in various ways, so that several possible implications can be raised. Based on several proposal on embodied music cognition including involuntary effect of music [7, 8], we introduce three possible industrial fields that can be influenced by these academic findings of musical effect on behavioral change, and propose design implications based on the foundation from empirical embodied music cognition study.

GUIDANCE VIA SOUNDS

For Games

While gaming, people process various cognitive decisions continuously based on several sensory stimuli. Then, according to the development of new devices for gaming interface, more physical (direct) manipulations are now possible and used for many games and consoles such as Nintendo Wii or Kinect of Xbox. By this development, gaming is not about clicking and tapping keyboards now. In addition, various efforts of game development company to use music and sound for enhance the experience of gaming makes game as aptitude field for test bed of embodied cognitive auditory trials.

Several studies investigated the influence of auditory stimulus on gamer's experience [9 - 11]. It seems that not only visual information, but also corresponding auditory information could deliver immersive and fulfilling experience. Moreover, additionally, auditory cues might help reducing gamer's learning time on tutorial process, in addition to the abundant emotional experience making.

In this regard, Oren et al. showed that auditory information was enough for the task of recognizing the surrounding two-dimensional spaces in spatial information-based game playing [12]. Also, Sanchez and colleagues displayed the application of auditory information on game which needs navigating skills [13].

These studies were based on a concept of human as an information processing system (IPS), which sees every sensory stimulus as information that needed to be processed. This concept was a standard cognitive science viewpoint. However, in this viewpoint, additional cues from other sensory organs such as haptic or auditory sensations are basically considered as cognitive loads. Therefore, additional cues from sound should be considered not based on the IPS viewpoint, based on some empirical evidences above.

According to the embodied cognitive viewpoints, we could imagine appropriate auditory information might enhance gaming performance in many different games. For example, an avatar can be helped by auditory cues in way finding quests. And in some puzzle games, gamers are exposed to puzzles highly related to the spatial information. In this case, because gamers' cognitive loads are massive due to puzzle itself, only visual information is not enough to resolve the puzzle proficiently. Then, auditory cues could help gamers not based on cognitive functions, but behavioral urges based on auditory cues. Therefore, the gamers might use their cognitive resources more efficiently.

In the other case, in golf game running on movement-based gaming platform such as Nintendo Wii and Kinect of XBOX, gamers usually take time to get used to the controllers and gaming methods. For the gamers who are suffering from relatively long tutorial process, system could notify them throw their arms further by auditory cue with higher pitch. By this practice, gamers could perceive their control as inappropriate for powerful swing, so that they might change their swing form faster than just visual cue was existed.

Figure 1. Golf game

For Interface

Our daily life is now cannot be imagined without various appliances and digital devices. Therefore it has been more and more important that how we should interact with those devices and design the devices, which have been evolved to be more complicated and have more functions than ever before.

Recently, going beyond keyboards and mice, several trials have been made that reduce or even eliminate exterior interface components and get inputs based on natural human behavior. These natural user interfaces (NUI) might be more affected by embodied cognitive aspects and embodied music cognition, because one or more mediator (interface) are reduced within the interaction between user and the system.

With this regards, Reeves and Nass introduce their famous and somewhat helpful concept of CASA theory (computer as social agent), which indicates that people tends to interact with their computers (in this case, including smart devices) as if the computers are teammates, assistant, secretary or even friends [14].

Regarding diverse functions and light-speed performance of computer (or any other digital devices), CASA theory might suggest that more sensory channels, in addition to the visual-oriented current interfaces, will needed from now on including various auditory interfaces. These sensors are not for the additional information channels, but for the more efficient interaction-based coordinated cognitive activity.

We can observe various analyses from studies and adapt user experience with respected to the voice user interface (VUI) [15 - 18]. However, voice command and VUI have various limitations, and it might not be appropriate for the present immersive digital environment, regarding countless functions and natures of human voice interaction. [19, 20]

To overcome the limitations of voice interfaces, gestures are recently studied in order to design specialized interactions for each different device, as an alternative NUI [21 - 24]. However, similar to the voice-based interfaces, these gesture-based interfaces have innate limitations: It is relatively hard to train for the first time, to give feedback during gesture, and to define beginning and end of the gestures. To reduce ambiguity of manipulations and to promote efficient and effective interactions, auditory cues might be a useful option [25].

For example, if user is in tutorial process of hand gesture learning, it might be difficult to know how much stretch their hand in the air to operate certain function. In that case, sound guidance with high pitch can help users to stretch higher than the last trials. As empirically suggested, because auditory cues are related to the spatial perception, it might be more helpful for learning gestures, which are highly dependent on spatial perception and behaviors than any other interfaces [6].

Also, because gestures in the air (which are mostly studied currently) cannot get feedback in haptic sensation, visual cues and animations were used conventionally for the feedback. In addition to the visual feedback, auditory feedback might enhance effect of feedback, and in addition to the first feedback rotation, by recognizing user's gestures, secondary feedback interactions could be applied to the system based on the auditory feedback. This concept of auditory feedback loop is similar to the feedback circuits with logic elements.

Figure 2. Smart TV interface

For Marketing

Recently, many marketing studies focused on neuro imaging research for revealing decision making process of purchasing more directly [26]. In addition to this trend, not only neuro-marketing aspect of purchase, which is observing decision making process via our brain, but actual practice to 'nudge' consumers decisions based on embodied cognition study is also important in practical and academic sense. In this regard, auditory cues can be used for promoting purchase behaviors in subtle methods.

Auditory assistances to the cognitive functions can be powerful for the cases related to business and marketing, which are dependent of human decision making process. Generally, in marketing, similar to any other academic or industrial fields, visual information and cues are relatively importantly considered than other sensory information. In marketing's case, recent emerging of social commerce services are highly dependent on visual aspects of information [27, 28].

However, the influence of sound is more effective than conventional thoughts in the context of buying activity and decision making.

In the study of Neuhoff and colleagues, an auditory guidance (pitch and loudness of auditory displays) seems highly effective on decision making process, in the situation regarding stock market analysis [29]. Also, factors (such as music and scents) that are not directly related to the merchandises were empirically proved to have effect on pre- and post-purchase satisfaction [30]. That is, concerning power of sound in decision making, especially one linked to spatially related information, auditory guidance might be crucial in marketing sectors in practical or theoretical senses.

According to couple of studies, it is proved that most profitable layout of merchandizes in market shelves could be calculated by mathematical algorithms [31, 32]. Based on the mathematical modeling, scholars showed that by modeling customers and testing the model, selling and profits could be maximized.

In addition to the layouts of shelves in these studies, if the merchandizes with higher price can be promoted to be taken by auditory guidance, not only layout for merchandize itself, but also layout of sounds can be used for another factor in the model and the practice. By adding this factor, mathematical model could regard embodied cognitive aspect, and at the same time, approach to the real world phenomenon one step closer.

For example, in practices, if today's target product is displayed on top of the shelf, higher pitched sound might be helpful for promoting the product. Also, if there is certain effect, slower or faster rhythm of music could be used for stimulating customers to go further in the market places or stay longer in front of specific merchandizes. These hypothetical scenarios are based on the effect of auditory guidance on involuntary spatial behaviors

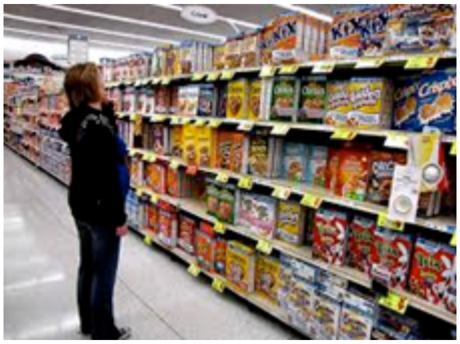

Figure 3. Merchandise display for stacked shelves

CONCLUSION

Conventional concepts for relationship between music and cognitive science were remained mainly on emotional or internal processes. On the other hands, in other domains, several approaches such as focusing on direct link between dance movements and musical rhythm were performed [33]. Also, scholar like Leman (2008) [5] analyzed behavioral aspects of music as an embodied cognitive activity, so that understood role of body as a mediator among mind, music and environment [5].

Moreover, as a practical approach, Graham and Bridges showed a specific designing method for gestures in terms of embodied (metaphoric) music cognition, focused on the relationship between music and spatial performance [34].

Also in the study of Wooyong et al., direct effect of musical element to the involuntary behavior might shed a light on the new possibilities for music as enabling design factors [6]. Based on these references, we summarized possibly effective designing examples with respected to the perspectives of embodied music cognition for game playing, tutorials for gestural interface, and decision making on marketing (table 1).

It seems that embodied effect of auditory cues is relatively new, but has not significantly massive influence on academic fields. However, considering academic prevailing of visual information studies, auditory cues, including music, might have potentials to be investigated widely.

The suggestions in the Table 1 are mere examples that are not from experimental research. However this paper might give possibilities for the future studies; there must be a study for investigating causes of the auditory effect on such empirical evidence of drawing study [6], also examples in table 1 could be tested in the experiments.

In addition, this study might suggest in industrial fields that using auditory 'information' is not the only answer to the application of the sound. The behavioral change by the auditory cues could be effective.

	Spatial Cognition in game	**User Interface Control**	**Decision Making Process in Marketing**
Guidance Practice (usage)	Navigation supporting in first person and puzzle game; Helping tutorial process in movement based controllers in active gaming	Help adaptation to newly designed gesture interfaces	Promote planned merchandises in addition to the visual layouts
Effect	Reduction in spatial cognitive loads and learning time; enhancing of game experience by reducing learning time and efforts,	Supporting on gesture learning and feedback accuracy; Enhancing user satisfaction on usability of early process	Better sales in designated marketing plans; Prediction of consumer behaviors for future plans

Table 1. Suggested applications of auditory cues based on embodied cognitive perspectives.

For design principles regarding this effect, first of all, designers or engineers should consider that auditory cues including music (melody) might affect not only user's perceptions, but also user's behaviors directly.

Second of all, because abundant research have not done yet, we cannot be assured of the effect of auditory cues will be whether positive or negative.

Lastly, auditory cues might not be perceived as designated information no matter how design was precisely as planned. Therefore, at least pilot test for few participants should be performed in order to find out the consequences of collection of the designs.

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