THE EMOTIONAL QUALITY OF MUSICAL SOUND INTERFACE TO UNDERSTAND CONTEXTS.
WITH THE CASE OF USING A SMARTPHONE

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ABSTRACT

Musical sound interfaces that were diverse in their tonality and pitch were employed to investigate the influence of emotions on contextual interpretation; two empirical studies using a smartphone platform were conducted. The measured appropriateness of the interfaces for several purposes determined the influence of emotions on the perception of context, revealing a significant relation between the interfaces' emotional qualities, which were rated in terms of pleasure and arousal, and the perceived context represented by appropriateness. In addition, the contextual attributes of the interfaces measured by verbal estimation were shown to be correlated with the sounds' pleasure and arousal. Throughout the studies the effect of emotional qualities on the musical interfaces' contextual attributes were verified, and the implementation of findings required further explorations.

Keywords: sound interface, emotion, context

INTRODUCTION

Current approaches to nonverbal sound interface design mostly rely on innate (e.g. bird's chirpings) or empirical (e.g. WindowOS starting signal) relations that connect sounds to specific circumstances (Bradley & Lang, 2000). However, building delicate meaning associations is difficult only with those resources. Consequently, there have been efforts to introduce new schemes of sound design to improve usability, such as the "Earcons" (Brewster, Wright & Edwards, 1993) and semiotics (Andersen, 2001; Jekosch, 2005). Yet, because of its impermanence, communicating a large amount of information with sound rapidly burdens the listener.

Application of musical feature on auditory interfaces might be an alternative. Recently, the creating of emotional auditory stimuli has been considered as an alternative because the emotional effects may be coherent with that of an interface (Larsson, 2010). In this regard, musical auditory interfaces are a feasible implementation because music is one of the best ways to compose sound to control emotional response (Hul & Chebat, 1997; Mcdermott & Hauser, 2005). Moreover, the perceptual abilities of music are believed to be universally predisposed (Dalla Bella, et al., 2001).
However, there have not been many attempts to relate the musical sound of auditory interfaces to the contextual attributes. This study, therefore, attempts to discuss the effect of applied musical sounds on the perception of context in order to suggest new ways to create sound interfaces.

BACKGROUND

Emotional Parameters of Musical Sound

Music is a powerful affective influencer. There have been extensive physiological investigations on affective responses to musical stimulations. Those attempts have revealed significant relations between musical parameters and emotional dimensions. Throughout this research, musical determinants of which the interest are tonality (i.e. the specific subset of pitches used to write a given musical excerpt) and pitch (i.e. the perceived frequency of sound). Happiness and sadness are the most reliable and distinguishable musically expressed emotions (Balkwill & Thompson, 1999) (Krumhansl, 1997). The major tonality is associated with happiness and the minor tonality is associated with sadness (Hevner, 1935; Rigg, 1937). Likewise, pitch of auditory

stimulation is significant determinant of pleasantness and emotional excitement (Scherer & Oshinsky, 1977).

Relations between Emotional Qualities and Contextual Perception

Sound, as a cognitive artifact, plays a significant role in cognition (Noulhiane, et al., 2007). The influences of music on a listener's perception and behavior have been investigated and implemented for practical purposes to intentionally adjust behavior (North & Hargreaves, 1998; Hul, Dube & Chebat, 1997) or to develop delicate meaning associations for auditory design (Larsson, 2010). In the same vein, music is influential on human behavior by activating contextually relevant knowledge (Areni & Kim, 1993). The characteristics of music that affect human behavior and perception were studied variously, e.g., music's relevance or appropriateness to the persuasion context (MacInnis & Park, 1991) or genre (Bruner, 1990). While some of the characteristics of music are not appropriate to sound interfaces, musical qualities of sound are expressible on sound interfaces, e.g., tonality, timbre, tempo, volume, pitch and so on. Most of all, the qualities are significant determinants of the emotional properties of a music piece. Consequently, it is relevant to assume that applied musical qualities in the sound interface will cause an emotional response that assigns qualities as parameters based on understanding of musical features and corresponding emotions (Figure1).

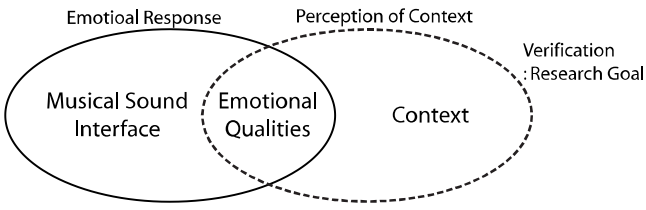

Figure 1. Hypothesized model of context perception based on emotional responses to musical sound interface.

HYPOTHESIS

Based on the assumption on the effect of emotional qualities on cognition, we can further assume that a person can perceive specific contexts from an affective auditory stimulus. Emotional reactions toward sound interfaces can be adjusted intentionally through applying musical parameters to the sounds. Thus, musical parameters applied to a sound interface will make it possible to affect a user's perception of the context, by manipulating the emotional response of the user. Based on this assumption, the influence of emotion on the user's perception of the context was investigated through empirical studies.

EMPIRICAL STUDY I

In this empirical study, tonality and pitch of sounds were employed as independent variables to control emotional qualities of sound interfaces because those two variables are easily controllable and their correlated emotional qualities are clearly verified.

HYPOTHESIS

The participants were expected to judge a sound interface's appropriateness for a specific context in accordance with contextual circumstance perceived from the sounds. Thus, the observation attempted to measure a sound interface's appropriateness for several contexts by the participants' evaluations. In this regard, hypotheses for investigation into musical sound interface and perceptions of context were developed.

- [H1] Different tonality and pitch of a sound interface will evoke different emotional responses.
- [H2] Perception of context will be affected by tonality and pitch of sound interfaces.
- [H2-1] Sound interfaces with divergent emotional qualities will be evaluated differently of its appropriateness for a specific context.
- [H3] Perception of context will be affected by emotional responses toward sound interfaces.

METHODS

Participants

30 college students, age 18~27 (M= 20.866, SD= 1.775) were assessed the experiment through on-line.

Materials

For this empirical experiment, a sound interface was implemented on a smartphone platform. The sound interface employed one of four musical stimuli, which is a set of four single sounds as four buttons'

sounds. The four musical stimuli were generated of which the profile was characterized in terms of tonality and pitch: (1) C-major/Low pitch, (2) C-major/High pitch, (3) B-major/Low pitch and (4) B-major/High pitch (Figure1).

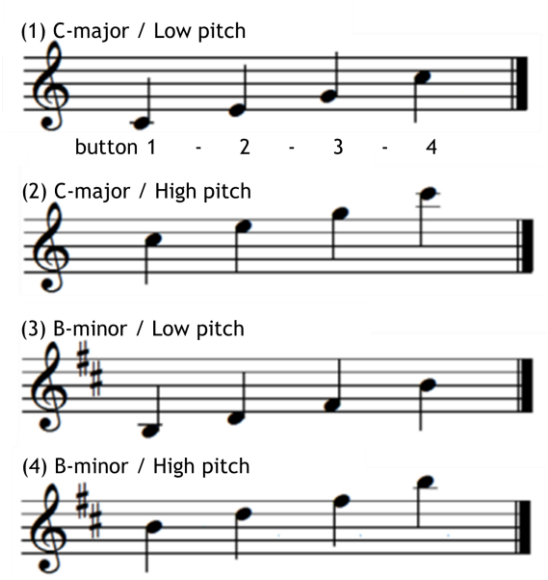

Figure 2. The four sets of sounds used in empirical study I.

Procedure

The subjects were asked to push buttons in the order given by a program's demonstrations. A demonstration consisted of a random order of four pushes. There were six demonstrations per sound interface to give enough opportunity for the subjects to perceive the musical features of the sound stimuli. After completing the tasks, subjects were asked to answer a survey to evaluate the sound interface. After a demonstration, the program changed its musical stimuli and the participant repeated the task again. Each participant experienced all four musical stimuli and the orders of the conditions were arranged randomly.

Measures

Through questionnaires, the subjects assessed the emotional quality of the four musical stimuli in terms of pleasure and arousal (Mehrabian & Russell, 1974; BRADLEY & LANG, 1994) by using a Likert-scale ranging between -3 (very unpleasant/ very unaroused and +3 (very pleasant/very aroused). They also evaluated whether each sound is appropriate for the three different usages: (1) mobile phone banking, (2) phone-locking and (3) game ID access. Those three contexts are proved about their differences in terms of seriousness, which means one's sense of secure and safety in certain situation, by an online survey from 27 participants (p<.05) (ANOVA). The evaluation of appropriateness used Likert-scale ranging between -3 (not at all) and +3 (very much). By doing so, the relationship between the emotional quality of musical stimuli and their contextual attributes is expected to be demonstrated.

RESULTS AND ANALYSIS

Emotional Response

To evaluate affections, participants' answered; C-major/Low pitch rated as pleasure *M*= 0.83, *SD*= 0.87 and arousal *M*= -0.17, *SD*= 1.42; C-major/High pitch rated as pleasure *M*= 1.23, *SD*= 0.97 and arousal *M*= 0.60, *SD*= 1.16; B-minor/Low pitch rated as pleasure *M*= -0.77, *SD*= 1.22 and arousal *M*= -0.13, *SD*= 1.25; B-minor/High pitch rated as pleasure *M*= -0.40, *SD*= 1.33 and arousal *M*= 0.27, *SD*= 1.31. Those differences among evaluations were statistically significant in both pleasure (F= 24.781, p= .000) and arousal (F= 2.818, p= .044), to support [H1] (ANOVA) (Figure3).

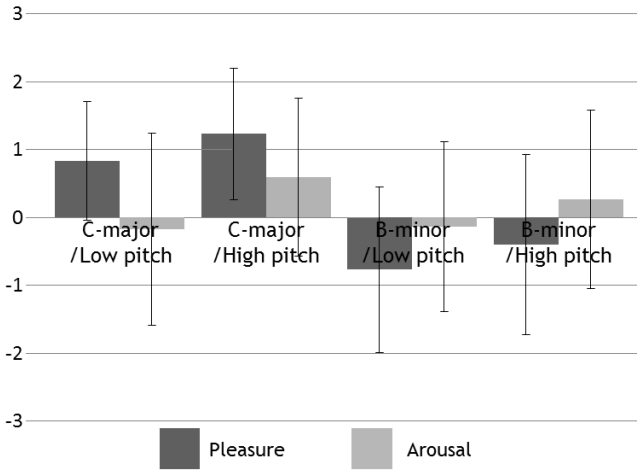

Figure 3. The mean pleasure and arousal rating of the four sounds.

Evaluation of Appropriateness

Appropriateness of each sound for mobile phone banking: C-major/Low pitch, *M*= 0.57, *SD*= 1.36; C-major/High pitch, *M*= -0.57, *SD*= 1.50; B-minor/Low pitch, *M*= -0.30, *SD*= 1.71; B-minor/High pitch, *M*= -0.37, *SD*= 1.19. The differences among evaluations were statistically significant (F= 3.814, p= .013) (ANOVA). Appropriateness of each sound for a phone-lock interface: C-major/Low pitch, *M*= 0.47, *SD*= 1.38; C-major/High pitch, *M*= 0.63, *SD*= 1.45; B-

minor/Low pitch, *M*= -0.20, *SD*= 1.63; B-minor/High pitch, *M*= -0.53, *SD*= 1.28. The differences among evaluations were statistically significant (*F*= 5.278, *p*= .002) (ANOVA). Appropriateness of each sound for game ID access: C-major/Low pitch, *M*= 0.00, *SD*= 1.34; C-major/High pitch, *M*= 0.47, *SD*= 1.74; B-minor/Low pitch, *M*= -0.73, *SD*= 1.31; B-minor/High pitch, *M*= -0.80, *SD*= 1.06. The differences were significant (*F*= 5.380, *p*= .004) (ANOVA) (Figure4).

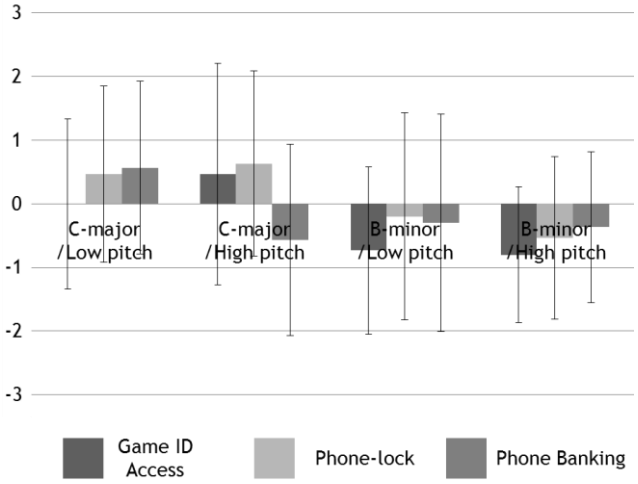

Figure 4. The ratings of the four sounds' appropriateness on three context of smartphone usage.

Overall, for the three contexts the stimuli's appropriateness were divergent, and the result statistically support [H2-1] and [H2].

Effect of Emotional Qualities on Evaluation of Appropriateness

To see whether participants referred the sounds' emotional qualities for the evaluations of their appropriateness for the three usages, relations between the emotional qualities and the appropriateness were investigated. The pleasantness of the musical interfaces positively correlated with all appropriateness evaluations; with the appropriateness for banking, *r*= .205, *p*= .024; with the appropriateness for phone-lock, *r*= .440, *p*= .000; and with the appropriateness for game ID access, *r*= .462, *p*= .000 (Pearson correlation). However, arousal only had a significant correlation with appropriateness for game access, *r*= .204, *p*= .026 (Pearson correlation). Thus, [H3] was partially supported and the investigation clarified significant effect of musical sound interface's pleasantness on its appropriateness for the contexts.

DISCUSSION

The results of empirical study I demonstrated the influence of emotional qualities of sound interfaces, especially the pleasure, on their appropriateness to specific usage. However, all appropriateness and pleasantness of each stimulus were positively correlated regardless of the contextual features, i.e. seriousness. This suggests a general preference for emotionally positive sounds, which might affected the sense of appropriateness to obstruct observation. Thus, this primary research should be complemented with a modified scheme. In empirical study II, the evaluation of contextual attributes using bipolar adjectives will complement the appropriateness scheme in order to observe the perception of context more accurately.

EMPIRICAL STUDY II

Though the empirical study I partially proved that emotional qualities of a sound interface were deciding parameters of its proper usage, it is not clear that whether the participants associated the diverse sounds with different contextual attributes. In empirical study II perceived context from the sounds were described linguistically. The effect of emotional qualities on perception is expected to be proved by different descriptions for emotionally diverse sounds.

HYPOTHESIS

- [H1] Different tonality and pitch of sound interface will evoke different emotional responses.
- [H2] Perception of context will differ according to tonality and pitch of sound interfaces.
- [H2-1] The sound interfaces with divergent emotional qualities will be evaluated differently from their appropriateness for specific contexts.
- [H2-2] Descriptions of perceived context from different sound interfaces will be divergent.
- [H3] Perception of context will be affected by emotional responses toward sound interfaces.

If the emotionally divergent sound interfaces are described about their contextual circumstance differently, it can be inferred that the emotional qualities of sound affect contextual perception.

Consequently, verification of [H2-1] and [H2-2] will reasonably certify [H3].

METHODS

Participants

31 college students, age 19~28 (*M*= 21.419, *SD*= 2.964) were assessed in the experiment. 14 of participants were male, and other 17 were female. The experiment was conducted off-line to maintain quality of data.

Materials

The sound interface developed in empirical study I was used with a minor change in the number of buttons. The sound interface employed one of four musical stimuli, which is a set of ten single sounds, as the ten buttons' sounds. The four musical stimuli were divergent in tonality and pitch; (1) C-major/Low pitch; (2) C-major/High pitch; (3) B-major/Low pitch; and (4) B-major/High pitch (Figure5).

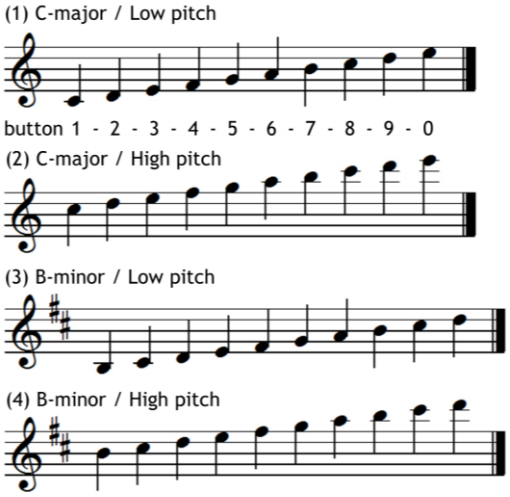

Figure 5. The four sets of sounds used in empirical study II.

Meanwhile, the complexity of each stimulus was increased because each stimulus now consists of ten single sounds, making it difficult for the subjects to notify musical features during a short experiment. Thus, complementary sounds of 'confirmation' and 'cancelation' were generated for four types of sounds and added to the stimuli (Figure6).

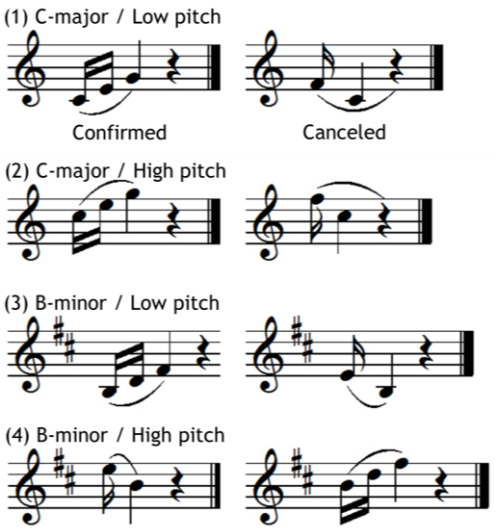

Figure 6. The four additional sounds of confirmation and cacelation used in empirical study II.

Procedure

Empirical experiment II was proceeded mostly in same way of previous study except few changes; the participants advanced through the tasks by pushing the 'confirmation' button and the 'cancel' button. When a demonstration was finished, the program changed its sounds and repeated the demonstrations. The orders of the conditions were arranged randomly.

Measures

In the same vein as the previous study, emotional quality of the four musical stimuli was assessed in terms of pleasure and arousal by using a Likert-scale ranging between -3 (very unpleasant/very unaroused) and +3 (very pleasant/very aroused). It was followed by an evaluation of each sound's appropriate for the three different usages: (1) new text message alarm, (2) 3G data usage alert and (3) recommendation of new application. Those three contexts were proved about their differentness in terms of seriousness by an online survey from 46 participants (p= .00) (ANOVA). The list of contexts changed for more accurate observation. The evaluation of appropriateness used a Likert-scale ranging between -3 (not at all) and +3 (very much). An evaluation using bipolar adjectives, which describes perceived contextual atmosphere, was added to observe the participants' contextual perception. The vocabularies that consider the common context in a smartphone were designed referring several tools for measures of user satisfaction and perception (BAILEY

& PEARSON, 1983; PETIOT & YANNOU, 2004). The pairs were 'private-public', 'serious-light', 'safe-dangerous', 'interesting-bored', 'continuous-temporary', and 'relaxed-urgent.' The evaluation used a 7-point Likert-scale.

RESULTS AND ANALYSIS

Emotional Response

In the ratings of affective reaction, participants' answers were for C-major/Low pitch, pleasure *M*= 0.10, *SD*= 1.58 and arousal *M*= -0.36, *SD*= 1.70, for C-major/High pitch, pleasure *M*= 1.23, *SD*= 1.48 and arousal *M*= 1.13, *SD*= 1.50, for B-minor/Low pitch, pleasure *M*= -0.39, *SD*= 1.38 and arousal *M*= -1.00, *SD*= 1.51, for B-minor/High pitch, pleasure *M*= 0.65, *SD*= 1.54 and arousal *M*= 0.84, *SD*= 1.46. The differences among affective evaluations stimuli were statistically significant for both pleasure (*F*= 6.385, *p*= .001) and arousal (*F*= 13.178, *p*= .000), to support [H1] (ANOVA) (Figure7).

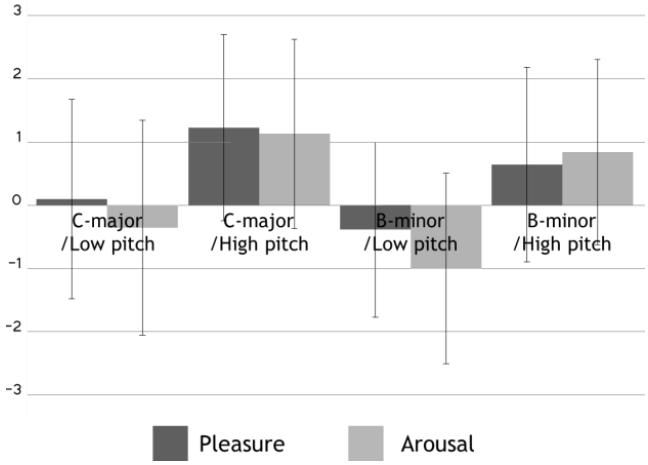

Figure 7. The mean pleasure and arousal rating of the four sounds in empirical study II.

Evaluation of Appropriateness

Appropriateness of each sound for recommendation of new application: C-major/Low pitch, *M*= -0.29, *SD*= 1.40; C-major/High pitch, *M*= 0.94, *SD*= 1.55; B-minor/Low pitch, *M*= -0.94, *SD*= 1.29; B-minor/High pitch, *M*= -0.13, *SD*= 1.054. The differences were statistically significant (*F*= 9.903, *p*= .000) (ANOVA). Appropriateness of each sound for text message notification: C-major/Low pitch, *M*= 0.65, *SD*= 1.28; C-major/High pitch, *M*= 0.97, *SD*= 1.54; B-minor/Low pitch, *M*= -0.39, *SD*= 1.61; B-minor/High pitch, *M*= 0.29, *SD*= 1.79. The differences among evaluations were statistically significant (*F*= 4.433, *p*= .006) (ANOVA). Appropriateness of each sound for a 3G data usage alert: C-major/Low pitch, *M*= -0.52, *SD*= 1.55; C-major/High pitch, *M*= -0.10, *SD*= 1.90; B-minor/Low pitch, *M*= 0.35, *SD*= 1.64; B-minor/High pitch, *M*= 0.42, *SD*= 1.63. Yet, the differences among evaluations were statistically not significant (*p*= .117) (ANOVA).

Overall, for the three contexts the stimuli's appropriateness were different from each other. However, the significance of result was not statistically supported for the situation of 3G data usage alert. Thus [H2-1] was partially supported (Figure8).

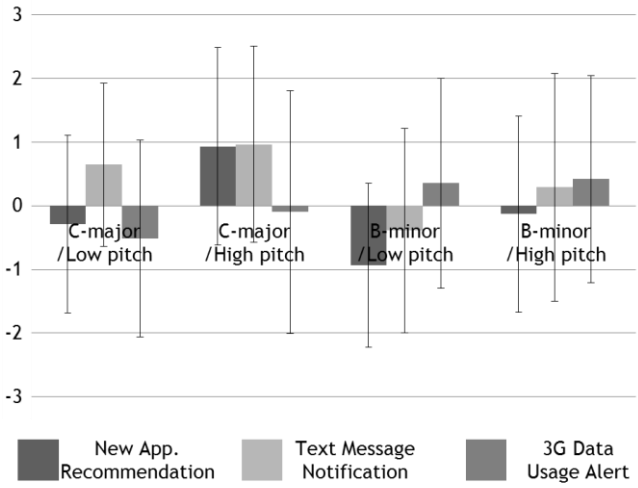

Figure 8. The ratings of the four sounds' appropriateness on three contexts of smartphone usage.

Evaluation of Perceived Context

In the ratings of perceived contextual attributes using bipolar adjectives, the four types of sounds were evaluated differently (Figure9.) and the significance of differences were valid for 'public-private' (F= 4.559, p= .005), 'serious-light' (F=12.578, p= .000), 'interesting-bored' (F=14.211, p= .000), 'continuous-temporary' (F= 3.336, p= .023) and 'relaxed-urgent' (F= 9.850, p= .000), except for 'safe-dangerous' (p= .082)(ANOVA). The majority of the results supported [H2-2] to indicate the biased recognition of contextual attributes from divergent emotional stimulations.

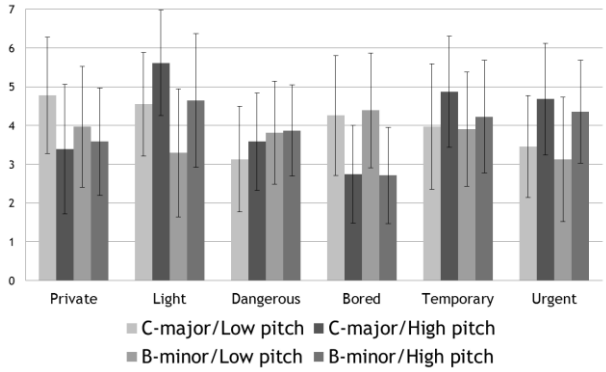

Figure 9. Contextual attributes of the four sounds

Effect of Emotional Qualities on Perception of Context

The pleasantness of the musical interfaces was positively related with the appropriateness ratings in new text message notification, r= .462, p= .000 and in recommendation of new application, r= .590, p= .000 (Pearson correlation). On the contrary, when it came to the 3G data usage alert, the relationship reversed negatively, r= -.316, p= .000 (Pearson correlation). However, the arousal resulted to have no significant correlation with any appropriateness ratings. According to the correlations between the sounds' emotional qualities and its appropriateness for the usages, it is possible to assume that participants reminded context of 'communication' (text message notification) or 'shopping/advertising' (recommendation of new item) from the interface of pleasant sounds, while they associated unpleasant interfaces with context of 'notification/alert' (3G data usage alert). Moreover, diverse patterns of perceived contextual attributes from different sound interfaces supports the assumption. The correlation analysis clarified the influence of emotional qualities of the sounds on the participants' ratings (Table1).

	Pleasure		Arousal	
	r (Pearson)	*p-value*	*r (Pearson)*	*p-value*
Private	-.001	.988	-.371	.000
Light	.495	.000	.387	.000
Dangerous	-.314	.000	.323	.000
Bored	-.316	.000	-.378	.000
Temporary	.244	.006	.395	.000
Urgent	.108	.234	.627	.000

Table 1. The relationships between the emotional qualities of the sounds and their contextual values.

In accordance with the results of appropriateness evaluation and contextual attributes ratings, the influence of emotional stimulation from the musical sound interfaces can be inferred, to support [H3].

DISCUSSION

The overall result of empirical study II demonstrated the influence of emotional qualities of sound interface on the contextual perception. Moreover, the result of appropriateness evaluation in this study suggested negative correlations between pleasure and seriousness, a parameter of context, by the reversed tendency of preference for pleasant sounds.

CONCLUSION

Throughout these studies, the participants predicted divergent applications for the emotionally different sounds, which are applied in sound interfaces. Moreover, their descriptions about contextual attributes of the sounds were not only divergent but also had significant tendencies according to the sounds' emotional qualities. From the facts, the diverse emotional sound interfaces turned out to have distinctive attributes of context.

These investigations clarified that emotional stimulation from sound influences one's perception of context. When the insight applies for sound interface, sound stimuli of sound interfaces can be intentionally designed to adjust user's conception. And the studies showed that tonality and pitch, typical parameters of music, can be effective tool to control users' emotional response.

DISCUSSION

Despite a concrete basis of stimuli design, the same combinations of tonality and arousal were differently arranged about their emotional qualities in two empirical studies. Though the musical parameters of the sound interface were expected to regulate the listeners' emotional response, uncertainty of affective reactions was increased in real applications. For practical application of relationship between sound-derived emotion and contextual circumstance, investigations for scheme of sound design which can control emotional response more accurately should be followed.

This research has served as an opportunity to find a meaningful relationship between sound-derived emotion and context. However, it is not valid to

apply the insights for real sound design, because the concept of emotional sound interface is yet extensively penetrate on practical fields. Thus, further studies are required to search for substantive effect of biased perception of contexts on actual use of sound interfaces.

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