# A Haptic Emotional Model for Audio System Interface

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**Abstract.** The presented study deals with the problem of selecting music content in digital media, such as mp3 file collections. Usually, to select a specific music file (e.g. a song), one has to directly use some a priori data about the file content, e.g. the artist's name, genre, year of release, or the like. In many situations, however, this data is not visible, does not offer enough information, or otherwise does not provide for any immediately accessible mode for selecting the audio content. With the appropriate models of interaction, haptic output devices have a number of advantages for such selection tasks. First, as haptically enabled systems are becoming common, users are becoming more and more familiar with this modality of user-system interaction. Results of recent studies also suggest that the sense of touch may be more closely associated with moods and emotions than other modalities of interaction. Finally, the sense of touch is available without interference with visual or auditory channels. In the presented study, a model is proposed that links emotional states apparently evoked by music content to specific haptic stimuli. An experiment is conducted to verify tactile-emotive associations assumed by the model, and also to explore whether music specific characteristics, such as genre, would directly be related to haptic sensations. Experimental results obtained are discussed and used to design a novel user interface for an audio system. The envisaged interface would allow for selecting music through tactile interactions. The study's conclusions are drawn, and future work is outlined.

**Keywords:** User interface, music selection, haptic.

## 1 Introduction

The demand for online digital music services has increased dramatically over the past few years. For example, in Japan alone, the total sales of digital music content surpassed 767 billion yen (~ $8 billion) in 2009 [1]. Users own and manage large quantities of these digital music files on various devices, and require methods for retrieving the right music files at the right time for full enjoyment. Drawing on a long history of studies about the relationship between cognitive state (typically emotion) and music, researchers have developed systems for music recommendation. Such systems usually rely on user's a priori information and self-reporting of emotional state to infer and

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retrieve the "appropriate" music. Users, however, are not always able to unequivocally articulate their emotional state, while systems are not always able to readily communicate the emotional content of a musical selection via standard interfaces. Haptic interfaces are a means by which users may be able to quickly and habitually select appropriate music – without having to listen to each selection and without having to pay attention to visual or auditory interfaces [2].

Previous works have established the feasibility of communicating emotional states with haptic cues, including both semantic cues and tactile cues experienced by interaction with haptic force feedback displays [3, 4]. This paper utilizes one of these previous works for application to selection of emotive music via tactile stimuli. A study was conducted to further validate and expand the proposed model by investigating correlations between music, emotions, and tactile stimuli. Section 2 surveys related research. Section 3 presents the tactile emotive association model. Section 4 gives an account of the experimental methods for exploration of music-tactile and also music-emotive associations, and Section 5 provides the results. Section 6 discusses the results and puts forward the concept of a haptically enabled user interface for music selection. Section 7 draws conclusions and outlines directions for future work.

## 2 Related Work

Affective or emotional state can be hard to convey directly through words or actions. While certain situations and conditions may invoke strong emotive responses, it is sometimes still difficult to express these states. Various cultural, social, and individual differences also confound the ability to readily identify and communicate emotions. One possible mode of communication, inspired by actual human to human communication, is the recognition of emotion in facial expressions. Such studies have often been hampered by the natural human tendency to hide emotional responses under certain circumstances and even to substitute less-genuine expressions [5].

It has, however, been found that haptic and tactile modes of communication are associated with emotional states, and that these associations are common in a variety of societies and personality types [4]. On the other hand, research into the association of music and emotional response has a long history, going back at least to Hevner's definitions of six musical elements and their influence on emotions: key, pitch, rhythm, harmony, and melody [6]. More recently, Balkwill and Thompson showed that even music in unfamiliar tonal systems may be able to reach across cultural and social boundaries to communicate a common emotive content [7]. The authors were also able to identify some specific characteristics of music that influenced emotive content, and proposed a model of psychophysical cues common to all forms of music. Yang et al. proposed a fuzzy classification of the relative strength of emotive content in musical selections [8]. Cai et al. built an "Emotional Allocation" model and a contextual music recommendation based on Web documents which user reads, such as weblogs, and reported a positive correlation between the model and human selections [9]. Trohidis et al. evaluated four algorithms for clustering of emotional content of music as a multi-label classification task [10]. Odagawa et al. [11] developed a music recommendation system for car audio systems in which the user inputs semantic or

verbal impressions of the desired emotive content (adjectives such as bright, exciting, quiet, and healing). The system responds with music inferred to match the reported mood. It also incorporates machine learning as well as environmental factors in an effort to improve the recommendation. All these related works may contribute to the development of a music selection interface. So far, however, little has been done to address the problem of intuitive and minimally intrusive music selection.

## 3 Tactile Emotive Semantics

The model utilized in this paper is based on experimental results of mapping emotional content to tactile stimuli using Russell's circumplex model which were reported elsewhere [3]. Russell's circumplex model classifies emotional state into eight sectors of a two-dimensional space where one dimension is due to dynamics in the cognitive state of alertness, and the other in the cognitive state of pleasure. In the experiments, each sector of the model was identified by a set of semantic descriptors – adjectives suggested by those used in Desmet [12] and translated to Japanese (see Table 1).

**Table 1.** Emotion circumplex categories and elicitation terms

| | Circumplex category | Representative words |
|---|---|---|
| 1 | Neutrally excited (NE) | Surprised, concentrated, eager, astonished, amazed, aroused, longing, avaricious, curious |
| 2 | Pleasantly excited (PE) | Loving, jubilant, excited, desiring, inspired, enthusiastic |
| 3 | Pleasantly average (PA) | Entertained, admiring, joyful, fascinated, yearning, pleased, proud, surprised, happy, appreciating, amused, cheerful, sociable, attracted |
| 4 | Pleasantly calm (PC) | Fulfilled, intimate, satisfied, cozy, comfortable, relaxed |
| 5 | Neutrally calm (NC) | Composed, awaiting, deferent, passive |
| 6 | Unpleasantly calm (UC) | Gloomy, melancholic, isolated, sad, disillusioned, bored |
| 7 | Unpleasantly average (UA) | Contemptuous, disturbed, flabbergasted, jealous, aversive, grouchy, ashamed, cynical, embarrassed, disappointed, dissatisfied, disapproving, confused |
| 8 | Unpleasantly excited (UE) | Disgusted, frightened, annoyed, hostile, indignant, alarmed, irritated, frustrated, bewildered, nervous |

To select the tactile stimulus perception, the results of Hollins et al. [13] have been used, especially the demonstration that subjective interpretations of tactile surface texture perception can all be satisfactorily described in terms of three orthogonal dimensions. One of these dimensions is, however, composite and breaks down into two sub-dimensions. The adjective scales for tactile perception have thus been defined as "hard-soft", "rough-smooth", "sticky-slick" (or "sticky-slippery"), and "attractive-repulsive". (Note: The Japanese adjectives used in the study may not exactly correspond to the translations given here.).

Fig. 1 displays the model developed through generalization of experimental results reported previously [3]. In the model illustration, double-arrowed arcs indicate the dominant interpretations of the corresponding stimuli and thus specify the basic tactile

emotive associations. The model suggests that the surface rigidity-related tactile stimuli tend to be associated with low alertness and low pleasure. In the case of "rough/smooth", the dominant associations are "bored ⇔ smooth", and "unpleasant ⇔ rough". The elasticity tactile perception "sticky" and/or "repulsed" typically provokes unpleasant emotive states. On the other hand, perception of "slick" tends to be linked with relaxation (i. e. boredom), while perceiving attracting forces may induce emotional states related to anxiety. The model also assumes linking softness with pleasant-calm, and stickiness with unpleasant-elevated emotions. As described in the next section, these preliminary results were further used in experiments to examine correlations of music listening, emotive content, and tactile or haptic sensations.

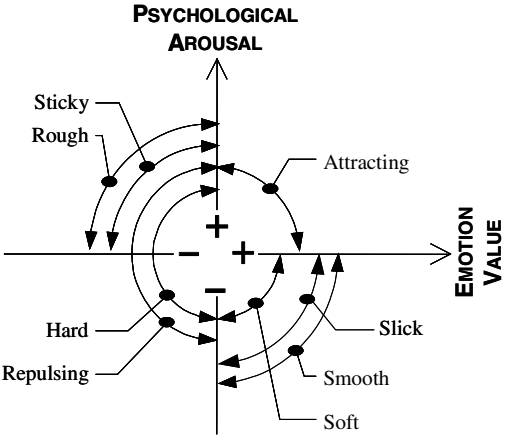


**Fig. 1.** Semantics of the tactile emotive associations (see [3] for details)

## 4 Experiment

### 4.1 Methods

23 subjects (16 male and 7 female) participated in the experiment, all students enrolled in an undergraduate or graduate university program. The average age of the subjects was 22. In order to simplify effects of culture or society in these investigations, the subjects were all Japanese nationals. The music contents used in the experiment were 40 track selections, including Japanese lyrics, English lyrics, and instrumentals. The contents were audited from two GX-70HD ONKYO speakers. The genres of music are categorized as Pop, Rock, Techno, Reggae, and Classical. The selections were intended to be relatively unknown works in order to reduce possible effects from previous listening experience. Subjects were also asked not to speak to other participants in order to reduce cross-subject interference or priming.

### 4.2 Procedures

Subjects were asked first to listen to the 40 selected tracks of music and then to fill in a questionnaire. Each track was played for at least 1 min. The first question of the

questionnaire was used to collect data on tactile associations: "After listening to the music track, please select the tactile perception or perceptions that would best match the music track from the following: A: Hard, B: Soft, C: Rough, D: Smooth, E: Slick, F: Sticky, G: Repulsing, H: Attracting, I: No matching response". The second question collected data on the emotional content in listener responses: "After listening to the music track, please select the numbered emotional category or categories that would best match the music track." The categories given were those shown in Table 1, with the added option of "No matching category". Subjects were allowed to answer with multiple choices. Subjects were also asked to indicate on the answer sheet if they had previously heard the music track.

## 5 Experimental Results

The results obtained in the experiment are shown in figures 2 and 3. In Fig. 2, the graphs show emotional states selected when subjects listened to every genre of music (i.e. Classical, Rock, Pop, Reggae, and Techno). In Fig. 3, each bar graph describes tactile perceptions selected as the subjects listened to the different genres of music. The black bar represents the statistically dominant response or responses for the given music genre. Tactile perceptions "sticky" and "rough" were selected infrequently in the experiment. There was no significant difference detected between the genders in these results.

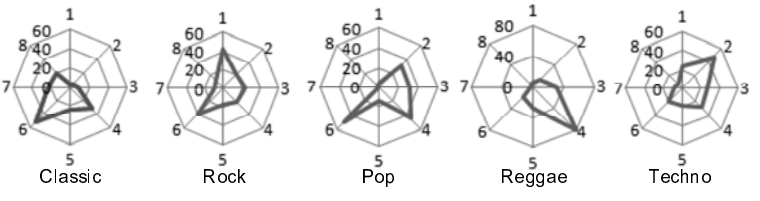


**Fig. 2.** Music-emotional associations showing total responses for each of the Russell circumplex emotional categories

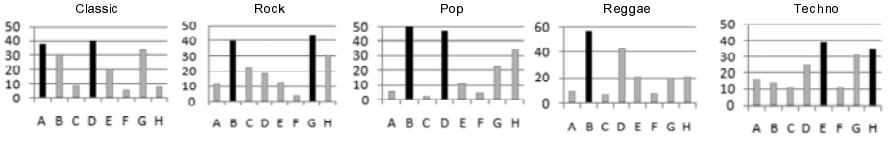


**Fig. 3.** Music-tactile associations with bars indicating total responses for each tactile perception and black bars indicating statistically dominant responses

## 6 Discussion

The results of the presented experiment were used to explore tactile and emotional responses to music listening. They first were compared with the model shown in Fig. 1, following the algorithm below:

1. Select music genre and emotional state as presented in Fig. 2. Only statistically dominant results obtained are used for comparison.
2. Use the model given in Fig. 1 to find the tactile perception that best matches the emotional state selected in Step 1.
3. Compare the tactile perception selected in Step 2 with the dominant tactile perceptions obtained as indicated in Fig. 3 for the music genre selected in Step 1.

Results of the comparison are summarized in Table 2. In the table, "○" stands for "the correlation between the model of Fig. 1 and the experimental results is significant at α=0.001," "◎" means "the correlation between the model of Fig. 1 and the experimental results is significant at α=0.05," and "△" indicates that no statistically significant correlation was detected.

**Table 2.** Comparison of results obtained in the experiment and the tactile-emotive association model

| Music genre | Emotion category from Table 1 | Tactile perceptions | Evaluation result |
|---|---|---|---|
| Classic | 4 (PC) | Smooth, soft | ○ |
| Classic | 6 (UC) | Hard, repulsing | ◎ |
| Rock | 1 (NE) | Hard, sticky, repulsing, attracting | ◎ |
| Rock | 6 (UC) | Hard, repulsing | ◎ |
| Pop | 6 (UC) | Hard, repulsing | △ |
| Pop | 4 (PC) | Smooth, soft | ◎ |
| Reggae | 4 (PC) | Soft | ◎ |
| Techno | 2 (PE) | Slick, attracting | ◎ |

As can be seen from the table, the semantic tactile associations established in earlier work [3] are generally supported by the results of the given experiment.

On the other hand, the results revealed no clearly discernible patterns in music-tactile associations. The results in Fig. 3 show that the same tactile stimuli were often linked with quite different music genres. This finding, as well as the established existence of emotive-tactile associations suggests that emotion can be used, rather than genre, as a mediator when one attempts to relay the content of music to the user via tactile stimuli. The apparent music-tactile associations may well be due to user's individual preferences (i.e. specific genre "likeability") which invoke corresponding emotional states (e.g. enjoying pop music while getting irritated with rock). This conjecture leads us to a design of a user interface for selecting music through tactile interactions as depicted in Fig. 4.

In the proposed system, the user can interact with the music selection interface through two modalities. When the user prefers and is able to focus visual attention on the device, she or he interacts with a GUI in a manner common to other media selection interfaces. The system then uses data from this and other interactions to build a model of the user's preferences. User preferences and the tactile-emotive associations described previously determine appropriate force feedback responses as the user navigates the selections available with the haptic interface. Unlike auditory and

visual interactions, the haptic sensations are immediate and, after a short period of habituation, allow for intuitive selection of "liked" music with little involvement of the user's attentive cognitive system. The user only needs to initiate and stop the selection scan, based on perceived tactile "representations" of different tracks, where the user's taste is reflected in the tactile stimuli associated with positive emotions.

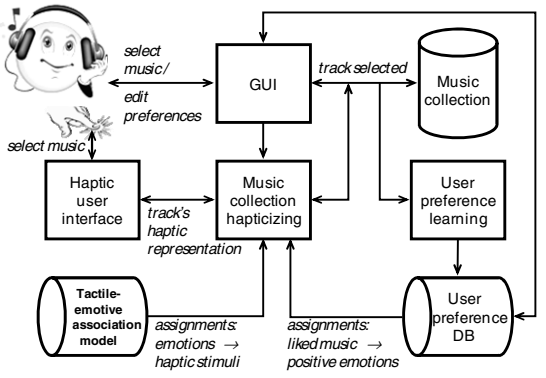


**Fig. 4.** General outline of proposed interface for haptic music selection

## 7 Conclusions

This paper described a model to link music and tactile perception via emotion, and put forward the concept of a user interface for music selection in the haptic modality. Data was collected on associations with tactile sensation adjectives and emotional state categories after listening to a track of music. This data and previous results were used to develop and validate a model linking emotional and tactile responses to music listening. The results of this study suggest that human response to music is consistent with semantic associations of emotional state to tactile perception, while the same may not be true for music-tactile associations. In subsequent steps, the authors plan to increase the number of subjects, aiming to obtain more detailed classifications, and further refine and validate the perceptive associations observed. A system prototype is currently under development, which implements the envisaged user interface design, and which would allow the user to select music, based on tactile representations.

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