PROCEEDINGS of the
23rd International Congress on Acoustics

9 to 13 September 2019 in Aachen, Germany

A Design Method for UI-sounds for Electrical Appliances

Sanae H. WAKE

[1]Doshisha Women's College of Liberal Arts, Japan

ABSTRACT

Electric products emit a range of artificial sounds. For example, a microwave may make button feedback sounds, play a "completion melody," or make an "alert" sound, in normal operation. These sounds are all part of the user-interface (UI) of a product, and are therefore called "UI-sounds." UI-sounds should be designed to be functional, to clearly convey messages to users, as well as to suit a particular product. In this paper, we consider the importance of designing UI-sounds for products, and detail a method for designing these sounds. We discuss how it is first necessary to determine the purpose of each UI-sound. Next, sounds should be designed logically using elements such as timbre, pitch, and on/off patterns, to express their function. In addition, sounds should be designed like art or music, to improve the user experience. Since UI-sounds follow an operation sequence, each sound is one component of a total UI-sound stream. This process is demonstrated by considering the case study of a POS cash register.

Keywords: Sound Design, User Interface, UI-Sound, Electrical appliances

1. INTRODUCTION

Modern electrical appliances typically have physical buttons and/or touchscreen displays that constitute a user interface (UI). In many cases, these appliances also employ beeps, alerts, or melodies as UI-sounds. For example, the microwave I have uses seven UI-sounds to convey eleven messages, including feedback from the function select and cancel buttons, a start message, a complete message, and a message to remind the user that a function has already been completed. In spite of this prevalence, at present, UI-sounds for electrical appliances are inadequately designed.

Well-designed UI-sounds can improve a product's usability. Such sounds can convey information that supports users, reducing their cognitive load, and enabling them to operate appliances efficiently and comfortably. UI-sounds also contribute to the realization of universal designs, for instance, enabling visually impaired people to operate different appliances. In addition, well-designed UI-sounds can give users a good impression of a product, and, by extension, its manufacturer. In contrast, poorly designed UI-sounds can irritate users, leaving them with negative impressions of a product and its manufacturer.

The process of UI-sound design broadly concerns how to use a UI-sound, and designing the sound itself. In determining how to use a UI-sound, the information conveyed by this UI-sound and the time when the UI-sound is used are selected, decisions which are the fundamental part of the design process. Similarly, the process of designing the sound itself is also important. Since a UI-sound is required to convey information to users, the sound should be designed such that the function it signifies is understood intuitively. Finally, UI-sounds should be designed to be comfortable. The functionality of a UI-sound can be guaranteed if these design principles are applied successfully. In this paper, I introduce a UI-sound design method (1, 2) and a case study describing its implementation.

[1] swake@dwc.doshisha.ac.jp

2. UI-SOUND DESIGN PROCESS

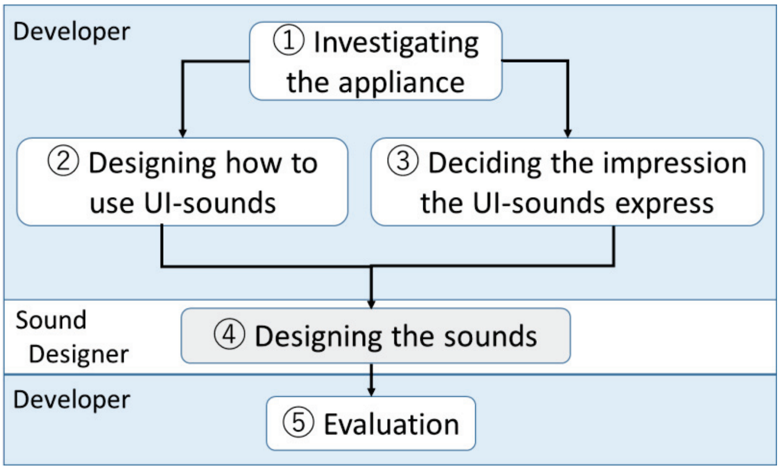


Figure 1 – An illustration of the UI-sound design process

Two kinds of UI-sounds exist: operation feedback sounds and message sounds. Our design process, illustrated in Figure 1, is applicable to both kinds of UI-sound. The process consists of five steps: "investigating the appliance," "designing how to use UI-sounds," "deciding the impression the UI-sounds expresse," "designing the sounds," and "evaluation."

Our process has been designed as a collaboration between developers of appliances and sound designers. Although product developers are apt to create UI-sounds themselves, it is necessary to design sounds to convey a specific impression. To design sounds in this way, experience of design tools and techniques is needed. Therefore, developers should defer to sound designers on the practical aspects of sound design. In the following sections, each step of the UI-sound design process will be explained from the developer's and the designer's perspective, as appropriate.

3. DEVELOPER'S PART

3.1 Investigation of the Product

Before designing UI-sounds, the target appliance should be investigated, focusing on the following information about the appliance, and typical user behavior:

(1) User interaction flows and the state of the appliance
(2) Current UI-sounds and running noise
(3) Purpose of the appliance and frequency of use
(4) Environs of the appliances (environmental sounds and people around the appliance)
(5) Problems and needs of users with respect to the current appliance
(6) Sound system, data format, and speaker quality

Particular attention should be paid to user interaction flows, as the most important information detailing a user's control of the appliance. Sequence patterns for UI operations should be investigated, for example, in what order different buttons are pushed to produce a given response. It should be noted that several different interaction flows may exist for a single appliance. Hence, typical operations, as well as special/non-standard operations, should be characterized.

3.2 Designing how to use UI-sounds

In this step, the time when a UI-sound is used in the interaction flow, and the purpose of the UI-sound, are decided. Here, "when" refers to which operation(s) require a feedback sound, and which appliance state(s) require a message sound (e.g. errors). While the purpose of the sound can vary, from, for example, expressing information, assuring users about their operation of the appliance, or more generally, giving users and bystanders a good impression of the appliance, the reason for using the specific UI-sound should be clear. Following this, the order in which a UI-sound is activated in the interaction flow, as well as its frequency of occurrence, should be decided.

Next, "an explicit level" should be determined for each UI-sound, based on its purpose and frequency of occurrence. Table 1 illustrates our recommendations for assigning sounds to a scale of five explicit levels. Necessary UI-sounds, such as alerts that require the user to modify their behavior immediately, are assigned to level 5, meaning that the sound should be able to be heard in all contexts, and leave a strong impression on listeners. In contrast, a frequently used UI-sound, such as feedback sounds for number buttons, should be assigned to level 1, i.e., these sounds should be barely audible. Finally, a sound list (such as the example in Table 2), which details all UI-sounds along with their assigned feature, is generated.

Table 1 – Explicit levels for different UI-sounds

Explicit Level	Impressions of timbre and volume	Operation feedback sound		Message sound	
		Function	Examples	Function	Examples
5	**Can be heard by anybody in any situation, making listeners nervous.**	Critical operation	Start / Stop operation sounds for critical function	Announcement of Strong caution requiring immediate attention	Early earthquake alert
4	**Can be heard by anybody in any situation.**	Running/stopping an appliance	Start / Stop operation sounds for common function	Warning announcement requiring imminent attention	Error alert
3	**Can be heard in most situation.**	Accepting or rejecting an operation	OK / Cancel sounds	Announcement of important notice requiring attention	End signal
2	**Can be heard in most situations. Less audible/annoying than level3.**	Configuring an operation	Responce from digit keys and select button	Announcement of notice requiring less attention	Mail notification
1	**Can only be heard if users/bystanders are paying attention.**	Providing an good feeling during product operation	Response from alphabetic character keys or wheel while navigating through a menu	Ambient notice	Remaining unread mail

Table 2 – Example of a UI-sound list (for MFP)

	Sound name	When the sound is used	Explicit level	Frequency of occurrence	Remark
Operation feedback sound	**General operation sound**	Pressing digit keys or selection button	2	3-7times/ process	
	Invalid operation sound	Pressing an invalid button	2	0-2times/ process	
	Cancel operation sound	Pressing cancel button	3	0-3times/ process	
	Start operation sound	Pressing start button	4	1times/ process	Melody
	Pause on/off sound	Pressing pause button	2	0-2times /process	
Message sound	**End message sound**	When process is finished	3	1time/ process	Melody
	Pause stop error sound	When paper out error, paper jam error occur	4	Less than 1time/ month	
	Breakdown error sound	When the error you have to call a maintenance staff occur	4	Less than 1time/ year	

3.3 Deciding the Impression that UI-sounds Project

In this step, the impression projected by the UI-sounds should be determined by considering information such as the purpose of the appliance, where it will be used, the manufacturer's corporate identity (CI), and attributes of a typical user. Following this, a list of descriptive words, phrases, and/or images detailing this impression (e.g., "pretty," "high class," "cool," or "natural") should be collated, to aid the sound designer in creating an appropriate sound.

In addition, the three different sound types, defined as "Beep type," "Rich-timbre type" and "Melody type" for UI-sounds, should be considered. Beep type sounds are formed from simple timbres (like sine-waves or square-waves), and have simple rhythmic patterns and pitch patterns. Rich-timbre type sounds are made using more complex timbres that are similar to the timbres of musical instruments, sound effects in video-game-UIs, or animation content. As inadequate attention to these timbres means that sounds of this kind might be perceived to be hokey or unnatural, they should be selected or designed to fit the target product's UI. Finally, melody type sounds consist of a complex series of pitches and timbres, typically played at the start or completion of a task.

3.4 Instructions to Sound Designer

Listed below is information a developer should share with a sound designer following completion of the first three steps of our procedure.

(a) Information about the product
(b) UI-sound list
(c) Image concept
(d) Sound type
(e) Sound data format and specifications of the product's sound system.

In addition to this information, when possible, the designer should be supplied with "an interactive UI-prototype" of the product, such as software running on a tablet PC, which enables easy replacement of UI-sound files to verify their effectiveness in the user interaction flow. This UI-prototype simplifies the trial and error process for sound design, such that the quality of the UI-sounds can be improved. Similarly, providing an opportunity to adjust and equalize UI-sounds using the product's system, in a process similar to the mixing and mastering performed in music production, is recommended.

3.5 Evaluation of UI-sounds

In the final step, the effect of individual UI-sounds and/or sets of UI-sounds are evaluated. These tests are conducted by the users of the appliance, evaluating the sounds emitted directly from it (or the UI-prototype) in its typical environment (or a simulated noise environment), as well as people who will be around during its normal operation. In evaluating the UI-sounds, the UI itself should also be evaluated for factors such as ease of operation, ease of identifying information, and ease in maintaining operation. Favorableness or harmoniousness to the environment should also be evaluated.

4. SOUND DESIGNER'S PART

4.1 Designing UI-sounds

At present, there are few dedicated UI-sound designers, with music composers and game sound creators often fulfilling this role. In cases like this, it is important that the differences between UI-sounds and music or game sounds are understood. Unfortunately, a user's primary expectation is not to hear a good sound, but for the product to function efficiently; the user's aim is to operate the product, not to listen to UI-sounds, which are to aid users in their smooth operation of these products. In spite of this, it is possible to improve the user experience (UX) with UI-sound, as this can make users feel good when they operate a product, or intuitively relay information to the user. UI-sound can be considered to be analogous to sound effects in a movie, which heighten the sense of reality in a scene without the audience realizing this. Similarly, the aim is not that users are made conscious of the UI-sound, but the usability of a product is improved by the sound.

4.2 Individual UI-sounds and Sound Stream

Each UI-sound delivers a distinct message to the user, indicating, for example, the completion of a process, an error occurring, or button touch feedback. In addition to this, individual sounds are a piece of the product's total UI-sound stream. The role of each sound and the sound stream desired for the UI should both be considered during sound design, such that when pieces of UI-sound are activated in the interaction flow during the product's operation, they are perceived to have a musical quality. This improves the UX, and contributes to the product establishing a distinct identity.

4.3 Evidence Based Sound Design

In creating sounds, designers should refer to evidence of the effect of these sounds on users wherever possible, conforming to the relevant standards relating to sound generation for the particular product field. Sounds should be designed such that their selection for a particular purpose is easily explained.

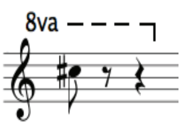
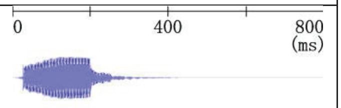
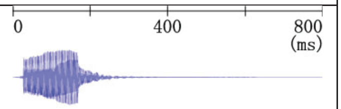
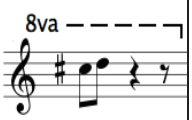
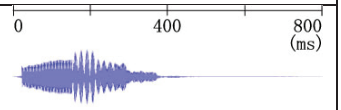
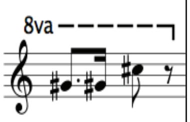
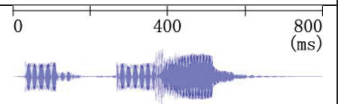
Standards such as "ISO 24500 Ergonomics -Accessible design- Auditory signals for consumer products," which dictates the beep patterns to be used with consumer products to convey information, are a form of evidence to be used in sound design. Similarly, findings from the range of existing psychoacoustic studies can also be used as evidence informing the design of UI-sounds. For example, our previous study considered the message conveyed to the user by the musical interval between two pitches, from which we determined that a descending major third interval conveys an "OK" message to the user, while an ascending minor second interval conveys an "error" message (3). Other psychoacoustic findings regarding the effects of timbre, pitch, melody, and the relationship between sounds are introduced on our web-site (1). While such findings should be used as much as possible, they should not be the exclusive basis for sound design. Rather, the designer should consult these findings in executing "artificial sound creation."

5. CASE STUDY – POS CASH REGISTER

In this section, I discuss sound design for a POS Cash Register (4), as a case study of our process. As self-check-out systems have become increasingly prevalent in Japan, our team decided to design four feedback sounds for a barcode scanner: a "scan confirmation sound," a "second scan (in a row) sound," an "error sound," and a "discount sound."

To design these sounds, we defined three conditions: ease of hearing, ease of distinction, and ease of message comprehension. We previously designed three different UI-sound sets to project "simple," "ambient," and "Halloween" impressions. In this paper, I discuss only the simple UI-sound set. Waveforms of the resulting UI-sounds of the "simple UI-sound set" are depicted in Table 3, with the reasons and evidence for selecting these designs discussed below.

Table 3 –UI-sounds designed for a POS cash register

	score	waveform (envelope)
scan confirmation sound		
second scan sound		
error sound		
discount sound		

5.1 Ease of Hearing

The ISO 24500 standard directs that "the fundamental frequency (the pitch) of auditory signals should not be higher than 2.5 kHz." This is because older users with age-related hearing loss have difficulty hearing high-frequency tones. Conversely, low frequency sounds are more easily masked by environmental noise. Therefore, the fundamental frequencies of all sounds designed for the cash register were between 831 Hz and 1662 Hz. We selected waveforms that are similar to sine waves, as these are easily distinguished from noise.

5.2 Ease of Distinction

To design memorable sounds that are easily distinguished from other UI-sounds, it is effective to make use of differences in rhythm (sounding pattern) and timbre (5). With the sound-set for the cash register, we designed sounds with distinct rhythms, with the exception of the scan confirmation and the second scan sounds (discussed further below). The scan confirmation and second scan sounds were configured with “one note,” the error sound was configured with “two notes,” and the discount sound is configured with “three notes” (Table 3). It should be noted that in this instance, “notes” refer to rhythm units, not pitches.

The purpose of the second scan sound is to alert operators to the fact that they have scanned the same product twice. As doing so is not always an error, we designed this sound to be similar to the usual scan confirmation sound, with a difference in pitch to attract the operator’s attention. While the scan confirmation sound consists simply of a single pitch (C#6), the second scan sound is configured as two simultaneous pitches (a chord), with a higher pitch (G#6) included with that of the scan confirmation sound. In addition, since both sounds are always played sequentially, the differences in pitch are easily distinguished.

5.3 Ease of Message Comprehension

Configuration of sounds to ensure their messages were understandable was performed as below:

5.3.1 Scan confirmation sound

This sound provides operators with a “feedback feeling” following a scan. It has been shown that to realize this feeling, the attack of a sound should be short, its length should not be too long, and the sound should be played immediately after the scan (6). Therefore, we designed our scan confirmation sound with a short attack and a duration of 0.18 s. This sound was designed with reference to the reception signal section of ISO 24500.

5.3.2 Second scan (in a row) sound

As mentioned above, we configured the second scan sound as a chord. By selecting the first pitch to be the same as the pitch of the scan confirmation sound (C#6), we are able to convey that these two sounds are in the same category. In addition, G#6 was selected as the second (higher) pitch because it harmonizes well with C#6, since both pitches are separated by a major fifth interval. Hence, distinguishing between the two UI-sounds is easy because the top note of the second scan sound is different from the scan confirmation sound. In addition, by configuring this sound as a “double” pitch, we expect that users can infer that it refers to a “second scan.”

5.3.3 Error sound

This sound expresses an error feeling based on the interval between two notes played sequentially. As an ascending minor second interval is known to suggest an “error” message to users, we made the “C#6 -> D6” phrase, which is an ascending minor second interval, our error sound.

5.3.3 Discount sound

It has been shown that sounds that short melodies associated with a “message word” can remind users of a message, even when the word is not pronounced (7). This means that melodies that are made to fit the intonation of the message word can remind users of the message. For example, some subway melodies in Japan have been created to be associated with the name of the terminal station. For instance, the subway melody for the “Tsu-ru-mi-ryo-ku-chi” terminal is created with six notes whose melody simulates the intonation of “Tsu-ru-mi-ryo-ku-chi,” informing passengers of the destination without them having to hear the word itself. Using this effect, we created the discount sound based on a melody associated with the word “Yat-ta-ne!”, which expresses the joy of a discount.

5.4 Projecting an Impression

To maintain the simplicity of our UI-sound set (in keeping with the sound sets for typical POS cash registers), we adopted a simple waveform that is similar to the sine-waves used on current POS cash registers. However, we designed sound envelopes with long enough decay forms to make the sounds feel soft. In keeping with this principle of simplicity, we used only four different pitches for all four UI-sounds (Table 3).

6. CONCLUSIONS

Recent UIs in electrical appliances have become more complex, making the effective use of UI-sounds more important. Since UI-sounds can convey information to users, to aid in their smooth operation of an appliance, and give them a good impression of the appliance, they should be well designed. In this paper, a new design process for UI-sounds for electrical appliances was described, and the case study of a POS cash register was introduced. It is hoped that this design method and case study can help developers and sound designers in the creation of UI-sounds.

ACKNOWLEDGEMENTS

The author wishes to acknowledge Ayane Takemoto and Mayu Shintani, students of Doshisha Women's College, and Yasumasa Yamada, a sound designer, for their help in designing the UI-sounds for the POS cash register. One part of this work was supported by JSPS KAKENHI Grant Number JP 16K00726. And I would like to thank Editage for English language editing.

REFERENCES

1. Wake S. The guide of UI Sound Design for products for UX. http://uisound-ux.main.jp/, 2019.
2. Wake S. Design Method for User Interface Sounds Used in Appliance. Proc. of HI2015 September 2015, Hakodate, Japan 2015. No.3122.
3. Wake S. Nishikawa S. What do people associate with a two pitch auditory signal -2. Proc. of Research Reports on Human Interface; Vol.12, No.1, 2010.
4. Takemoto A. Shintani M. Wake S. UI-Sound Design and Evaluation for POS Cash Register. Proc. ASJ 2018 Spring Meeting 2018. 1-13-2
5. Wake S. Uwakubo S. Fukuzumi S. Asahi T. Hiroaki T. A case study on establishing an "Matrix Design Method for Auditory Signals" for Human Interface. The IEICE Transactions on Information and Systems; D-II Vol.J82-D-II No.10, 1999. pp.1721-1728
6. Kimura A. Oomachi H, Shibata F. Tamura H. A Study for Presentation of Tactile Sensation with Sound Feedback to Touch Sensor. IPSJ Transactions on HCI. 2007. 20007-HCI-124, 2007.
7. Ichikawa S. Wake S. Mitsumoto M. Melody Sign Designed Based on Intonation of the Word. ASJ 2013 Spring Meeting 2013. 3-3-5.