International Journal of Industrial Ergonomics xxx (2017) 1–12

Contents lists available at ScienceDirect

International Journal of Industrial Ergonomics

journal homepage: www.elsevier.com/locate/ergon

Understanding the impression of product sounds by integrating quantitative and qualitative findings

Ga-Won Kim, Myung Hwan Yun*

Department of Industrial Engineering & Institute for Industrial Systems Innovation, Seoul National University, Seoul, 08826, South Korea

ARTICLE INFO

Article history:
Received 14 January 2016
Received in revised form
12 December 2016
Accepted 3 April 2017
Available online xxx

Keywords:
Smart sound
Product sound design
Mixed method
User interview
Keyword analysis
Psychoacoustic analysis

ABSTRACT

The aim of this study was to understand impressions of product sounds by combining quantitative and qualitative findings through an empirical study using 10 camera shutter sounds. The evaluated impressions were smartness, friendliness, and satisfaction. Subjective ratings using 29 sound descriptors and paper-and-pencil interviews were performed with 50 participants. Psychoacoustic analysis and determinant analysis were applied for quantitative analysis. Frequency analysis on keywords from interviews was conducted as a qualitative analysis. A framework for combining quantitative and qualitative findings on the product sound was developed. As a result, distinguishing factors relevant to each impression variable were identified. This study also derived several insights into how to capture sonic experience of products. The results of this study can help designers or executors to develop a basis for understanding a subtle distinction between the impressions of product sounds in terms of users and to establish design criteria for implementation of product sounds in early-stage product development.

1. Introduction

People experience various types of sounds during interaction with products in daily life, and these may shape the impression of product sounds. Impression of the product sound plays a central role in the user experience, and thus influences the overall evaluation of the product through the formation of subjective judgments and strong inferences about the product (Mahlke et al., 2007; Schifferstein and Cleiren, 2005; Spence and Zampini, 2006). Sound can lead people to have a positive experience of products or services, compared to an experience without sound (Nacke et al., 2010); however, incongruity between visual aspects and sound can result in doubts about the functionality of the product (Ludden and Schifferstein, 2007) and may inhibit provision of a coherent sonic experience. The product sound can also help to establish the brand identity (Lindstrom, 2006; Lyon, 2003).

Product sounds can be categorized into consequential sounds and intentional sounds (Langeveld et al., 2013). Consequential sounds are generated as a result of operating of the product. Intentional sounds are added as digital sounds into products in order to convey a certain meaning, such as feedback or alarms. Traditional approaches for sound design focused on noise reduction of consequential sounds induced by the product (Lyon, 2000; Özcan and van Egmond, 2004).

The traditional methods to design product sounds use a questionnaire consisting of an adjective set representing the sound, which is called the sound quality assessment (Blauert and Jekosch, 1997), or psychoacoustic metrics such as loudness, sharpness, and roughness to predict the user perception of the sounds (Fastl, 1997; Pedersen and Zacharov, 2008). One of their main concerns is to investigate psychoacoustic metrics and to identify verbal descriptors affecting user perception of annoyance, satisfaction, or hedonic value, such as pleasantness or luxuriousness, of the sound relevant to home appliances, vehicles, or open spaces (Jeon et al., 2007; Lageat et al., 2003; Li and Zuo, 2013; Poirson et al., 2010). Another interest is identifying a set of psychoacoustic metrics that can predict the annoyance inducement of the product sound (Nor et al., 2008; Willemsen and Rao, 2010).

These approaches are useful for modeling and identifying a relationship between affective factors consisting of verbal descriptors for sounds and the subjective perception of sounds. However, most research on sound design employs quantitative data only, such as the results of psychoacoustic analysis, while interpreting data obtained from the user assessment, and lack detailed description of the factors influencing people's judgment on a specific sound. The three main challenges related to this problem are as

* Corresponding author.
E-mail addresses: gawon05@snu.ac.kr (G.-W. Kim), mhy@snu.ac.kr (M.H. Yun).

http://dx.doi.org/10.1016/j.ergon.2017.04.002
0169-8141/

follows.

Firstly, the impression of product sounds can be affected by the individual or the social prejudice, preference, or memory (Demirbilek and Sener, 2003; Linn, 1987). As Augoyard and Torgue (2006) claimed, people usually perceive sounds through subjective interpretation, shaping the impression of sounds based on contextual factors such as attitude, psychology, or their culture. However, psychoacoustic metrics or verbal descriptors are predefined measures that are not suitable for capturing the contextual or cultural factors such as user's attitude, belief, custom, or prejudice toward the product. For example, the annoyance of railway sound is more affected by the prejudice toward railway sounds that people harbor, than by the results of psychoacoustic metrics from an experiment (Möhler, 1988; Nykänen, 2008).

Secondly, loss of data occurring in the process of the reduction of verbal descriptors may lead to missing the insights that are valuable to understand user experience (Bargas-Avila and Hornbæk, 2011; Swallow et al., 2005). When performing quantitative analysis in the field of sound design, a list of verbal descriptors is usually reduced to several dimensions based on factor analysis. This is necessary in order to extract a prominent factor or dimension to explain a target concept. Therefore, a strategy is required to complement the weakness caused by the data-reducing step using quantitative data.

Finally, product sound design should be able to encompass an interdisciplinary approach while maintaining the independence of the field (Özcan and van Egmond, 2009). For example, the professional domain of a sound designer involves engineering, musicology, acoustics, psychoacoustics, and psychology. This means that effective product sound design can only be derived through a sufficient understanding of both the psychological impact and the characteristics of the sound itself.

Above all, the main interest of sound design is to create sounds that are suitable for a given product concept (Blauert and Jekosch, 1997) and to induce the intended impression of the product sound. To do so, it is important to bridge the perceptual gap between users and designers (Chuang and Ma, 2001; Hsu et al., 2000; Khalid, 2006) by gathering the users' own descriptions of product impressions in order to provide meaningful insights (Demirbilek and Sener, 2003). Thus, the method for identifying product sounds should entail overall understanding of the user perception of a product by collecting qualitative data that can explain the results from an experiment, not only by relying on quantitative data such as psychoacoustic metrics.

Hence, to solve these problems, it is necessary to consider the inclusion of qualitative data on the product sound, from data collection to data analysis, as a strategy to overcome the weakness of the quantitative data in terms of a detailed description of user perception of product sound. To this end, this study aims to identify the first impression of product sounds by means of combining quantitative and qualitative data that are relevant to the user perception of a specific product sound.

2. Combining quantitative and qualitative data for understanding sonic experience

Recently, qualitative data has gained increasing importance in the field of user experience, compared to quantitative data. Quantitative data refers to information that is originally expressed by numeric value. Qualitative data is data that is originally descriptive such as text, photo, audio, or video data. However, most user experience research utilizing qualitative data is reported without describing the data collection process or data analysis method (Bargas-Avila and Hornbæk, 2011). This is due to the difficulties in collecting and analyzing qualitative data, as well as data interpretation problems (Vermeeren et al., 2010), and it hinders reliance on qualitative research on user experience. Moreover, the advantage of quantitative data in terms of time reduction and efficiency cannot be ignored. Therefore, user experience researchers should focus on the integration of quantitative and qualitative data; however, there have been few attempts to do so as a means to understand user experience or design product sounds.

The merging of quantitative and qualitative data, so-called mixed methods, is with the purpose of complementarity, completeness, development, expansion, confirmation, compensation, and diversity of data collection and analysis, and has several advantages (Venkatesh et al., 2013). A mixed method can provide an opportunity to draw stronger inferences compared to a single method, but also can achieve comprehensive understanding of conflicting results from quantitative and qualitative analysis (Teddlie and Tashakkori, 2009). The key to success of mixed methods is to trigger and then elicit the proper reasoning, meta-inferences. Meta-inferences can be drawn after merging of qualitative and quantitative findings, analyzing quantitative findings prior to qualitative findings, or analyzing qualitative findings prior to quantitative findings, according to the purpose of the study (Venkatesh et al., 2013). Regarding the study of product sound, combining the quantitative and qualitative findings can provide a deep and coherent understanding of the sonic experience by combining the benefits of psychoacoustic measures and free descriptions of product sounds by users.

Quantitative data on product sounds can be obtained by questionnaire using sound descriptors and by psychoacoustic analysis on product sounds. Although psychoacoustic analysis focuses on the subjective characteristic of the sound in terms of user perception, the results of analysis are basically numerical, and can be treated as quantitative data. Administering a questionnaire with sound descriptors is a basic way to evaluate the product sound using numerical indicators (i.e., a Likert-type scale) of how people feel toward a product sound. In quantitative analysis of product sounds, it is important to effectively extract important sound descriptors and to link those results with psychoacoustic analysis.

Qualitative data of product sounds involves a non-numeric data type, and the interview is a typical way to collect qualitative data in the field of user experience. There are various methods to analyze interview data in order to identify user experience or user value of the product, such as content analysis (Krippendorff, 2012), laddering technique (Reynolds and Gutman, 1988; Zaman and Abeele, 2010), or semantic network analysis (Kim et al., 2012). Regardless of the type of analytical method, the main concern of qualitative data analysis is to extract proper and meaningful keywords that can effectively represent the text from the interviews.

In the consideration of the above issues, successful integration of quantitative and qualitative findings depends on how to generate a meaningful linkage among the results of psychoacoustic analysis, major sound descriptors, and the representative keywords from interviews. Thus, combining quantitative and qualitative findings should focus on deriving those three components in a systemic way and finding a consensus among them with the purpose of providing a cohesive and logical explanation.

3. Method

This paper identifies which affective experience factors determine the impression of product sounds by combining quantitative and qualitative findings, based on the empirical study of camera shutter sounds. Smartness, friendliness, and satisfaction were used as the three impression types of camera shutter sounds. Smartness is a pervasive term in a modern society, with the advent of sensors and new interfaces for personal devices based on the development

Please cite this article in press as: Kim, G.-W., Yun, M.H., Understanding the impression of product sounds by integrating quantitative and qualitative findings, International Journal of Industrial Ergonomics (2017), http://dx.doi.org/10.1016/j.ergon.2017.04.002