Applied Ergonomics 61 (2017) 1–11

Contents lists available at ScienceDirect

Applied Ergonomics

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

Kansei engineering as a tool for the design of in-vehicle rubber keypads

Joana Vieira [a,*], Joana Maria A. Osório [b], Sandra Mouta [a], Pedro Delgado [c], Aníbal Portinha [c], José Filipe Meireles [d], Jorge Almeida Santos [a,b,e]

[a] Centro de Computação Gráfica, Campus of Azurém, 4800-058, Guimarães, Portugal
[b] University of Minho, Centro Algoritmi, Campus of Azurém, 4800-058, Guimarães, Portugal
[c] BOSCH Car Multimedia, Rua Max Grundig, 35, Lomar, 4705-820, Braga, Portugal
[d] University of Minho, Department of Mechanical Engineering, Campus of Azurém, 4800-058, Guimarães, Portugal
[e] University of Minho, Department of Basic Psychology, Campus of Gualtar, 4710-057, Braga, Portugal

ARTICLE INFO

Article history:
Received 10 May 2016
Received in revised form
20 November 2016
Accepted 26 December 2016

Keywords:
Kansei engineering
Rubber keypads
Automotive HMI
Snap ratio

ABSTRACT

Manufacturers are currently adopting a consumer-centered philosophy which poses the challenge of developing differentiating products in a context of constant innovation and competitiveness. To merge both function and experience in a product, it is necessary to understand customers' experience when interacting with interfaces. This paper describes the use of Kansei methodology as a tool to evaluate the subjective perception of rubber keypads. Participants evaluated eleven rubber keys with different values of force, stroke and snap ratio, according to seven Kansei words ranging from "pleasantness" to "clickiness". Evaluation data was collected using the semantic differential technique and compared with data from the physical properties of the keys. Kansei proved to be a robust method to evaluate the qualitative traits of products, and a new physical parameter for the tactile feel of "clickiness" is suggested, having obtained better results than the commonly used Snap Ratio. It was possible to establish very strong relations between Kansei words and all physical properties. This approach will result in guidance to the industry for the design of in-vehicle rubber keypads with user-centered concerns.

1. Introduction

Industrial facilities producing keypads have to deal with design requests and demands regarding several mechanical and/or technical properties of rubber keypads. These properties include actuation force, contact force, stroke and snap ratio. However, the guidelines provided by the industry are rarely based on empirical metrics of consumers' perceptions, or are kept confidential when a more systematic validation is applied.

Customers of a given service or product often provide feedback using emotional and subjective descriptors. For example, customers' reviews and comments include words such as "Fantastic", "Cheap" or "Comfortable" related to a given product. However, the objective quantification of what exactly is a cheap-looking car seat, an unpleasant button or a comfortable driving wheel is seldom approached in the literature. Is there a quantitative correlate to all these subjective descriptors? Nowadays, more and more manufacturers adopt a consumer-centered philosophy (Nagamachi and Lokman, 2010), and investigate customers' qualitative demands in order to apply them in their production plan (Yang et al., 1999). The popular phrase stating that "we no longer buy products, we buy experiences", emphasizes the idea that, to be purchased, products need to add *something* more to their functionality (Norman, 2004), and that *something* must differentiate them from all other products with the same function.

The concept of experience in itself has evolved from a collection of practical acts resulting in a given competence or skill (Dewey, 2005) into something holistic, built on contextual and personal relations. In sensory terms, the *look and feel* of a product might be as determinant in using it, as its functional possibilities (Wright and Mccarthy, 2005). Considering this new focus, some authors state that, to succeed, manufacturers must benefit aesthetics and subjective quality of products as much as properties like reliability and physical quality (Liu, 2003; Rösler et al., 2009).

In the automotive industry, context of the present study, there

* Corresponding author.
E-mail address: joana.vieira@ccg.pt (J. Vieira).

http://dx.doi.org/10.1016/j.apergo.2016.12.019
0003-6870/

are deep concerns about the best way to address certain target groups or characteristics in order to evoke given emotions, feelings or subjective experiences. At the same time, it would also be important to know where and what to address exactly when vague complaints arrive from customers. The latter is one of the main motivations for the present study in the specific context of the construction of rubber keypads, as clients communicate having "unpleasant" or rubber keys they "dislike" for *some reason*. Thus, the goal of this study is to analyse the relations between the physical properties of rubber keypads used inside the vehicles, and the subjective perceptions they evoke. As a result, the subsequent data would serve to create guidelines for the tactile feel of interaction elements such as auto radios or other devices using rubber keys, also demonstrating how an experimental approach can be used to provide a robust support for manufacturing guidelines.

1.1. Kansei engineering

Significant concerns have been expressed about the lack of engineering and scientific methods to study aesthetics concepts. Liu (2003) suggests most decisions are based on the "educated guesses, talents or gut-feelings" (p. 1273) of product designers, and a more systematic approach should be used. As an example, psychophysical methods could quantify fine aesthetics distinctions among given product dimensions. Other methodologies, like Kansei Engineering, might be considered an answer to this appeal, as its procedures are systematic and statistically validated.

Kansei Engineering (KE) emerged in Japan in the 1970s with the purpose of connecting the customers' affective responses to the design process of products, in an attempt to translate emotions into measurable and physical design specifications. Whenever a customer intends to buy a product, a preconceived positive or negative image comes to mind. The Japanese word *Kansei* refers to the intuitive mental action of the person who feels some sort of impression from an external stimulus (Nagamachi and Lokman, 2010). This approach was developed in order to maximize customers' satisfaction with their purchases (Nagamachi, 2005). As today's customers grow more informed, demanding and sophisticated, the focus on Kansei might just be the differentiating factor.

There are several methods for performing Kansei Engineering (Type I, II, III, Hybrid, and Virtual), differing slightly in the number of evaluations or in the form of presenting items and analysing data (Nagamachi and Lokman, 2010). One of the most commonly used is a Type II-based method, adapted by Schütte (2002) into a general KE procedure. This procedure has less assessments with users, but was validated in several applications and industrial case-studies, like chocolate exteriors (Schütte, 2013), rocker switches (Schütte and Eklund, 2005) and wood flooring (Nordvik et al., 2009).

The model proposes the definition of the domain or target, which should be indicative of the target user and the product group (Dahlgaard et al., 2008). The following step concerns spanning the semantic space, by collecting a large number of words or expressions that could be used to describe the domain. The number of words could go up to 800 descriptors related to the target (Nagamachi and Lokman, 2010). These are the low-level Kansei words which will later be organized into high-level Kansei words, using simple categorization and group consensus, or methods like factorial analysis. In parallel, the space of properties should also be collected, consisting in physical product properties to be evaluated.

The evaluation experiment consists in presenting representative examples of the product and evaluating each according to all selected High-Level Kansei words which are usually presented in a *Likert* or continuous scale with two words on each end, and participants' answers are recorded. Finally, relations between the semantic space (Kansei words) and the space of properties (physical characteristics) are analysed, using statistical tools.

As an example of a possible outcome of KE, to evaluate the "roominess" and the "oppressiveness" of the interior of a vehicle, Tanoue et al. (1997) managed to identify that factors such as colour and shape influenced the perception of the participant, but more specifically, both dimensions were affected by the windshield rake angle, the distance between head liner and hip point, and the distance from the driver to the instrument cluster. Also in an in-vehicle study, Jindo and Hirasago (1997) applied KE to understand the best design for speedometers and driving wheels.

1.2. Semantic differential technique

The Kansei is evaluated using the Semantic Differential technique, developed by Osgood and colleagues (1957). The authors proposed that the human's mind image of a person, object or service spanned between two antonyms, like Good-Bad, and that a straight line connecting both words could be used to indicate where an opinion would be in the continuum or scale. The technique could also be used to measure the subjective perception of physical properties, like weight or brightness. Kansei Engineering thinks similarly, believing words could be used as sensors for emotions, only that it uses opposites instead of antonyms, using one word to deny the other, like elegant-inelegant (Nagamachi and Lokman, 2010).

The number of choices between the two words is flexible in Kansei Engineering, and these scales can range between 3, 5, 7, 9 and 11 levels presented in a Likert-scale style. Some authors use different scales obtaining equivalent results, such as the Visual Analogue Scale (VAS) (Dahlgaard et al., 2008). The VAS consists of a 100 mm long horizontal or vertical line, and is a reliable method commonly used for the evaluation of pain intensity (Bijur et al., 2001; DeLoach et al., 1998), but also applied in other contexts due to its simplicity. Each endpoint of the line is labelled with one descriptor representing the extremes of a continuum (Vu and Proctor, 2011). Participants indicate somewhere in the line where their judgement, opinion or perception is located, and the score is calculated by measuring the distance from the extremity on the left. Myles and colleagues demonstrated that the VAS score has ratio scale properties, and that changes in the VAS score reflect relative changes in the magnitude of what is under evaluation.

1.3. Physical parameters of automotive push-switches: F1, F2, stroke and snap ratio

Automotive push-switches - the push buttons of keypads or keyboards - use a variety of switch technologies, mostly mechanical. The silicone rubber keypads (elastomeric keypads) are the most commonly used in in-vehicle multimedia products, as they are a low cost and reliable switching solution. Each button of the keypad has a specific geometry that enables the collapsible behaviour of the angled webbing around a switch centre. Fig. 1 presents an example of an elastomeric key and its successive positions during the application of pressure. When the switch is pressured, the webbing, initially uniform, deforms to position s1 and secondly collapses to produce a tactile response, position s2. As long as the key is held, the carbon centre completes the circuit through the contact of a carbon pill with the PCB (Printed Circuit Board). The sC corresponds to the final position of the key that includes the collapsing of the membrane and the deformation of its top. When pressure is removed from the key, the webbing returns to its neutral position with positive feedback. Its overlay has led to advances in technology, including the use of hard plastic key tops assembled to a rubber keypad resulting in a general design with an enhanced tactile response.