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Technical note

The use of semantic differential scales in listening tests: A comparison between context and laboratory test conditions for the rolling sounds of office chairs

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ABSTRACT

Semantic differentials are frequently used to investigate sounds from a subjective point of view. The application of semantic differentials to the case of the rolling sound of office chairs is dealt with in this study. After a preliminary selection of the semantic differentials by fifty-two participants, another ninety participants took part in a listening test and described the acoustic stimuli of two office chairs, of high and low quality, respectively, rolling over polyvinyl chloride (PVC), ceramic and wood floorings, under context and laboratory test conditions. Under laboratory condition, recorded real stimuli were presented to the listeners via headphones, or under SounBe condition. SounBe is a new tool that has recently been conceived to explore sound at an early design stage. With this method, interactions between a chair and the floor are simplified, a mechanical sound is produced of a wheel moving across a flooring tile, and the recorded stimuli are then presented to the listeners through headphones. Four 7-point Likert scale semantic differentials, related to calmness, roughness, pleasantness and annoyance, were used to collect subjective data. Objective data were instead obtained from psychoacoustic indexes. Factors such as gender and weight were found to have no effect on the subjective and objective data. The flooring factor instead resulted to have much more influence than the chair factor. No statistically significant difference was observed between the test conditions on the semantic differential scales, thus proving the compatibility between SounBe and real sounds.

1. Introduction

Nowadays, the overall sound quality of a product is a key-factor in its acceptance by consumers. Sound quality is assessed considering several factors, connected to both objective and subjective aspects. Apart from the traditional sound measurements based on the physical description of sounds (e.g. sound wave, frequency, amplitude parameters), objective aspects, such as the psychoacoustic indexes [17], are often involved in perceptive investigations. However, subjective aspects are linked above all to the experience and the expectations of the users towards the products [45], to the identification and recognition of the sound [7], to emotional factors, and to many others. The semantic differential technique [35] applied to sound perception [51] still seems to be one of the most frequently used methods to investigate sounds from a subjective point of view in different situations [47,23]. Thus, both context [18] and laboratory listening test conditions are generally considered [24,53]. Nevertheless, the debate on the validity and plausibility of listening tests conducted in laboratory conditions, compared with those performed in context conditions, is still open [52,27].

1.1. Testing the perception of a product sound

Several methods [29,37] and tools have been developed over the last few decades to assess and predict the human perception,

Abbreviations: C1, context test condition; C2, laboratory test condition; C3, SounBe test condition; HLC, high level chair; LLC, low level chair; SD1, calm-strident; SD2, pleasant-unpleasant; SD3, smooth-rough; SD4, not annoying at all-very annoying.

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acceptance and emotion towards a product sound, as well as to support the design phase. A tool with an abstract shape was developed and tested to assess sonic feedback in tangible interfaces (i.e. a digital environment) [25]. Environmental sound categorization was found to be reliable as a sound design tool [20], and voice is also currently used by sound designers to simulate (i.e. reproduce) a product sound before, and then to design it later [26].

In 2011, a new toolandmethod, called SounBe, was conceived and patented to support architects and designers in the delicate meta-projectual phase of choosing the best material for an object, taking into account the sound aspect as a fundamental project requirement [14], as well as to assess a product sound quality. SounBe is a physical toolkit that is kept in a suitcase. It consists of a variety of instruments that are used to "sound" material samples and products (i.e. sticks and resting planes in different materials, a measuring cup, some support bars, etc.), and allows collecting and resubmitting sounds by a microphone and headphones; the method, i.e. a protocol, is conceived to analyse and design the sound of an object that interacts with another object, by a simplified procedure that splits the sound in its three generating variables: the material, the configuration form and the exciting mode interaction. Since the interactions are simplified, no prototype of the final product is required. It can therefore be applied in the early design phase of different product design contexts (e.g. for furniture design, packaging design, clothes design, etc.). In order to fit to different design contexts, the method has to be adapted case by case to the different sound sources to be reproduced and assessed. As an example, it considers the interaction between a wheel and a tile in order to investigate the sound of a trolley being dragged over a ceramic floor. Once a sound coming from the material-configuration and exciting mode interaction has been acquired and repeatably reproduced, the sound profile can be defined through a standardized descriptive procedure. It is well known that a specific and shared vocabulary is necessary to verbalise the characteristics of sounds [20,8]. Semantic descriptors that define the sensorial recall produced by the sounds themselves are attributed by a testing panel (also called acoustic "tasters", i.e. a group of experts, trained in acoustic sensorial analyses, who become the real judges of the perceptive characteristics of a stimulus). Following SounBe method, each sound is matched to the descriptor that has been judged the most suitable, and each sound-descriptor matching can be used by architects and designers as starting information on sound perception, and can be collected in a sound database. By means of a keyword search in the database, it will then be possible for anyone to be able to forecast and consciously design the product sound.

Since these evaluations are possible, thanks to the new tool, and the prototyping phase can be avoided, the method represents a low cost and effective data collection opportunity [12]. An experiment on the semantic differential technique applied to sounds obtained by this tool was considered appropriate, considering the widespread and easy use of the semantic differential tool.

1.2. A comparison between context and laboratory listening tests

This work considered two main issues. The first issue pertains to the comparability of the results of listening tests, with semantic differential scales, in context conditions and laboratory conditions. In fact, the correspondence between conditions represents a crucial point for a large number of studies [52,27]. Many researchers have raised the problem of the "ecological validity" of laboratory experiments, questioning whether the perception of a reproduced sound or complex acoustic environment is the same or different from what might be expected on site [19,41,13,57],. Moreover, the possibility of reducing the investigations to laboratory listening tests with semantic differentials would simplify the product sound testing process to a great extent. The second issue pertains to the validity of the semantic differential scales to sounds generated with the new tool. The proved comparability of alternative methods for the sound quality investigation could represent another opportunity of forecasting the perception of a product sound, and of avoiding the prototyping phase. In fact, firms could reproduce the future sound with the new tool, and collect subjective data on perception by means of semantic differential listening tests.

The rolling sound of office chairs was selected as the stimulus for this experiment, because of its non-stationary and unpredictable nature [4], which has proved to negatively affect workers' comfort [5,43]. Non-stationary noises have been investigated much less than stationary noises in the workspace [22], and there is still a gap in literature concerning the rolling sound of office chairs. On the contrary, an extensive amount of literature already exists on the perception of outdoor rolling sounds, i.e. for vehicles [50,21,34,49]. Finally, increasing interest in furniture sound design in different living environments has been observed [15,3,59],.

The experiment was carried out in three different test conditions: the context test condition (C1), the laboratory test condition (C2) and the SounBe test condition (C3). Subjective (qualitative) and objective (quantitative) data were collected during the experiment.

2. Materials and methods

The study was designed in two phases. A preliminary phase was carried out to select the most suitable semantic differential scales from scientific literature, in order to evaluate a rolling chair sound. Subsequently, in the main phase, the rolling chair sounds were evaluated by means of the selected semantic differentials scales.

2.1. Preliminary phase: the selection of the semantic differential scales

The Von Bismarck semantic differential scales were chosen as a reference [58]. Since it has been proved that the translation process can affect the connotation of a word [31], each descriptor was first translated into Italian using general English-Italian and Italian-English bilingual dictionaries [30,42] and specific bilingual ones [32]. Furthermore, each term was validated by a group of 3 English-Italian bilingual subjects, who picked the most suitable translation in Italian from among those proposed in the dictionaries. A summary of the original semantic differential pairs by Von Bismarck and the Italian translations is shown in Appendix B.

In the same way as in the case of Von Bismarck [58], a selection of semantic differentials pairs was necessary to reduce the number of pairs proposed in phase 2.2, and to avoid cognitive overloading and test annoyance [6]. Since the pre-selection made by the experimenter could have affected the results of the test to a great extent, and the descriptors may not have necessarily conformed with those a participant would spontaneously use [56], a first objective pre-selection was necessary.

2.1.1. Participants

A group of 52 participants (28 women and 24 men, $\bar{x}$ = 37.7 years, σ = 17.2 years) took part in this preliminary selection. All the participants were Italian, but from different regions. The group included both "experts", e.g. people who declared they had had physical acoustics and/or a formal musical education (No. = 20), and some "laymen" in these topics (No. = 32), in order to verify whether background knowledge affected the choice of vocabulary and the selection of the pairs.