

Building a Semantic Differential Scale as Tool for Assisting UX Evaluation with Home Appliances

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Abstract. This paper presents the development process of a semantic differential scale, to support the UX evaluation with home appliances, specifically, generating a database of Portuguese adjectives related to the interaction with home appliances. We performed a survey with three fonts: users and designers perception about home appliances usage; perception from researchers on home appliance UX, towards efficiency; and marketing search, examining disclosure materials of a home appliance manufacturer. Then, we performed a data analysis from hierarchies, binary matrix of correlation and antonyms generation. After the method application, the research resulted in 20 adjectives, which can assist the UX evaluation with home appliances.

Keywords: Semantic Differential Scale, Home Appliance, User Experience.

1 Introduction

Home appliances are products developed to help individuals on accomplishing daily activities. These products provide several interfaces of usage; sometimes by user control panel, sometimes by interacting with three-dimensional interfaces, such as handles, doors, knobs, and so on [1]. In addition, home appliances are products designed for the domestic environment, where different users can share them [2]. These users can vary on age, familiarity with technology, physical and mental abilities, desires and goals [3]. Despite this variety of users, tasks and features, home appliances should provide intuitive use in every possible situation [4].

With regarding this need for intuitive use provided by home appliances, User Experience (UX) studies become paramount. By taking into account the UX, the designer plan the home appliance focusing on the user and its real needs, comprehensions and abilities [5]. Evaluating the UX is a path for understanding the user and all experiences that he/she engages with a product. An experience is not only the interaction itself; thinking about the product, using other times, experiences with similar products, and other aspects also composes the UX.

In order to operationalize the UX evaluation, professionals have been developing many methods and tools for measuring the User Experience [6]. Vermeeren *et. al.* [7] verified that questionnaires and scales are the most popular tools among industry and

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academy professionals. Scales allow the self-report of an experience and utilize predefined measures, generating easy to analyze data.

Semantic differential scales are versatile tools, first developed decades ago by Osgood. *et. al.* [8] but still employed in several fields of knowledge, supporting the measurement of a series of aspects. This scale presents opposite adjectives in pairs, connected by a certain space (it can be a line, likert scale, or even a blank space), in which the user marks the level of approximation based on a determined idea.

By literature review, we observed that authors [9;10] have developed studies on this tool's usage for specific contexts, such as the sound evaluation inside aircrafts. Given the lack of proper tools for UX evaluation with home appliances, we developed a database for constructing semantic differential scales for this scope.

This study's main goal was developing a proposal of a semantic differential, generating a database of adjectives collected specifically for the user experience evaluation with home appliances. The tool here presented can be adapted for different home appliances categories and it allows application on different stages of usage, such as pre, during and post interaction.

We applied a method divided into three phases: Questionnaire 1, about home appliances characteristics, answered by users and designers; Questionnaire 2, regarding perceived efficiency, responded by UX experts; and, Marketing Search, examining disclosure materials of a manufacturer. Then, was performed a data analysis using hierarchies, binary matrix of correlation and antonyms generation by researchers.

The study resulted into 39 adjectives in the first cut, and 20 adjectives in the final cut. We developed the entire research in Brazil, utilizing Portuguese adjectives. Nevertheless, we present a suggested translation for the usage of this research's results by other UX professionals, assisting the user experience evaluation with home appliances.

2 User Experience Evaluation

User experience (UX) is every aspect resultant from the interaction between an artifact and an individual, whether before, during or after usage. In UX, authors consider that those interactions occur in a context [11], taking into account that external factors also modifies the experience, as well as social and cultural contexts. Given that user experience as a knowledge field is still recent, there is a variety of concepts about what exactly is UX, as is observed by Rebelo *et. al.* [12].

Preece *et. al.* [13] consider that usability is a part of user experience, in which UX is a broader perspective of the entire experience, and usability considers aspects such as efficiency and effectiveness. Thus, the user experience contemplates not only the usability itself, but also all the aspects that composes the satisfaction. The user experience is unique, since each individual has its own repertoire of knowledge, skills and expectations.

The user experience study and evaluation supports the user centered design (UCD), enabling the creation of systems centered on humans. UCD aims the developing of

intuitive artifacts, allowing ease of usage, satisfaction during interaction and diminishing amount of resources spent on training and support. In order to evaluate the user experience, usability experts and UX experts perform UX studies, using specific methods, dimensions and metrics, enabling the comprehension and measurement of various aspects about the user experience with an artifact.

Many authors [14, 15, 16, 6, 7] present tools, methods and metrics for evaluating user experience, human factors and usability. However, the UX evaluation can result in a large amount of data. The UX expert has to consider multiple variables for the UX evaluation method selection, such as time to execute the method, participants required, need for specific software and hardware, location, among other aspects [17]. During the developing process, it is common to follow schedules and deadlines, so it is wise to anticipate which kinds of data the evaluation methods will result in, always paying attention on how will be the analysis of those data [6].

Questionnaires and surveys are popular methods, because they are easy to apply and allow fast analysis [15]. Questionnaires follow standards, which means that results are comparable, facilitating data analysis. In the research applied by Vermeeren *et al.* [7], the authors observed that many professionals (from industry and academy) apply questionnaires on their routines of UX evaluations; 42 of the 93 selected methods from the research collect UX data via questionnaires. The authors also state that questionnaires are one of the most versatile research tools.

Many questionnaires use scales to allow different possibilities on answering, but also utilizing predefined measures. The Semantic Differential, scope of this research, was developed by Osgood, Suci & Tannenbaum [8], and aims to measure the reaction of individuals through bipolar scales, ie, opposite adjectives [8]. Given its application versatility, the literature presents a variety of derivations of this scale, such as the Differential Emotion Scale, developed by Izard [18] and the AttrakDiff of Hassenzahl, Burmester & Koller [19]. However, even with its versatility, the UX expert should select proper adjectives for the semantic differential, considering type of audience that will respond, the product evaluated type and the scope of each survey.

Osgood *et al.* [8] observes that words help measuring a series of aspects, dimensions and meanings. Therefore, once the user has contact to a certain experience, the semantic differential helps evaluating multiple dimensions by presenting opposite pairs of adjectives, connected by a likert scale or even a continuous line, in which the user marks the approximation for each pair, as the Figure 1 illustrates. The semantic differential main goal is to measure the affective meaning on some experience. Pereira concludes that the semantic differential is a tool that enables the registering, quantifying and comparing meanings by various individuals, in one or many situations, in a specific moment or multiple instances, by one or a set of scales [20 *apud* 9].

Light ○ ○ ○ ○ ○ Heavy Light ————— Heavy

Fig. 1. Examples of semantic differential scales with likert scale (left) and with continuous line (right). Source: The authors.

Pereira [20] conducted a survey of adjectives to apply in the Semantic Differential in Portuguese, verifying high levels of accuracy using this tool on Portuguese. Considering the context of specifying the type of product evaluated in order to develop specific tools, Andrade *et. al.* [10] designed a semantic differential for evaluating aircraft interior sounds, and Neves [9] developed a Semantic Differential for evaluating UX with washing machines during a long period of usage. This procedure included the following steps: market research, brainstorming, collecting adjectives from literature, consolidation and classification of adjectives, adjectives selection, preparation of pairs of adjectives and preparation of questionnaires. Even though Neves developed a research specific tool for evaluating user experience with washing machines, the adjectives resulted from the study may not be applicable for home appliances in general. Therefore, this research inserts in this scope.

2.1 Home Appliances and User Experience Evaluation

Home appliances are products used by various kinds of people: people with varying ages, from young to older persons; with various levels of physical abilities; individuals with different levels of familiarity with technologies, and so on [21]. In addition, home appliances, like washing machines and ovens, are products used in a domestic context, where different users can share them. Therefore, home appliances in general must provide an effective and efficient usage, regardless the user abilities and repertoire.

Han *et. al.* [1] points out that hybrid products are those composed by union between software and hardware elements. In this sense, home appliances enable interactions with user control panel, as well with hardware interfaces, such as sockets, grooves, doors, handles, etc. Thus, home appliances are hybrid products, implying in evaluations that embraces this characteristic.

Another particularity about home appliances is the relatively long period of usage, which characterize them as durable goods. These various stages of usage allow different situations, as well as different user experiences, creating challenges for its evaluation. Freudenthal [2] highlights that home appliance usage can be representative of user self-sufficiency, i.e., elderly being able to perform daily activities by themselves, and at the moment the home appliance impose some barrier for usage, the user can feel a lack of independence, needing to recur for help.

Some few authors have been considering the user experience provided by home appliances. A perceived trend on these studies is the focus on usage by elderly, i.e., Higgins & Glasgow [3], Sandhu [22] and Hong & Ono [23]. Even though the literature presents specific tools for evaluating UX with some particular product category (i.e., Game Engagement Questionnaire [24] and Service User Experience Questionnaire [25]), we still have not found any specific tool for evaluating UX with home appliances, sustaining the reasons for this research.

3 Method

In order to create a Portuguese adjectives database for semantic differentials to evaluate UX with home appliances, we applied a method composed by the following three phases:

1. Questionnaire with users and designers, collecting adjectives related to home appliances;
2. Questionnaire with user experience experts that work with home appliances, regarding perceived efficiency;
3. Marketing search, examining disclosure materials of a home appliances' manufacturer.

The first questionnaire was both printed and digital, stating for the respondent to list at least ten adjectives, positive or negative, that he/she consider as a home appliance characteristic. This first phase intended to collect what adjectives users tend to relate when they think about home appliances. Thirty-two home appliances users and 32 home appliances designers (total: 64) answered the questionnaire 1. The second questionnaire asked which adjectives seven user experience experts and eight designers specialized on home appliances relate with efficiency of usage. This second questionnaire aimed on gathering words related with positive aspects of home appliances usage, adding the UX experts view. Brazilian individuals answered both questionnaires in Portuguese.

The third and last method phase was the research on disclosure materials provided by the marketing team of a home appliance manufacturer. In this phase, we aimed to verify which adjectives the manufacturers use to communicate with the target audience. This research used a retailer website, verifying various home appliances of a same brand, contemplating different categories (such as ovens, refrigerators and dishwashers). For the website selection, we selected five Brazilian retailer, choosing the one with a larger number of different home appliances categories of a specific brand. The chosen brand manufactures home appliances for Brazilian market, being a ramification of a multi international company.

In the purpose for adjectives reduction to representative words, we used spreadsheets and debates between three researchers. The spreadsheet helped eliminating repeats, and debates enabled the discussion on synonyms and non-representative words. When the number of words reached <40, we made a correlation matrix. The matrix presents all adjectives in alphabetical order on the first column and first row. With this matrix, the researchers evaluated the correlation of all adjectives between one another using binary values. We marked "1" if both adjectives were synonyms or strongly correlated, and "0" if the adjectives were antonyms or without direct relation. In instance: "automatic" and "technological" are closely related, so we marked "1"; "Simple" and "Loud" did not present correlation, so we marked "0". The matrix allows us to verify which adjectives are more representative (higher number of incidences), and which adjectives are more distinguished (lower number of incidences). The Figure 2 illustrates the correlation matrix.

	Automatic	Noisy	...	Simple	Technological
Automatic	1	0	-	1	1
Noisy	0	1	-	0	0
...	-	-	-	-	-
Simple	1	0	-	1	0
Technological	1	0	-	0	1

Fig. 2. Correlation Matrix example. Source: The authors.

4 Results and Discussion

The data research, composed by the three phases, generated 930 input data. After filtering repeats, the collecting resulted in 214 different adjectives. The questionnaire 1 resulted in Ninety-two adjectives and 343 entry data resulted. The second questionnaire produced 149 adjectives and 400 entry data. The marketing search enable us to raise 81 adjectives and 187 entry data. The adjectives with highest incidence per questionnaire are “Beautiful” from questionnaire 1, “Practical” from questionnaire 2, and “Easy” from Marketing Research. By curiosity, we highlight some unusual adjectives: “cautious”, “ethereal”, “stinky”, “Chinese” and “Oneiric”. We observed a higher plurality of different adjectives on the questionnaires responded by the 32 designers. It is important to clarify that we performed the research entirely in Portuguese, presenting on this document a suggested translation, made with dictionary aid.

Then, we arranged the 214 adjectives in a spreadsheet for reduction of similar or unrepresentative made by three individuals. All the adjectives were read by the researchers and debated about the meaning and possible synonyms, reducing for 25 adjectives from the first phase, 15 from the second phase and 22 from the third phase. We gathered the adjectives from all three phases in a same list, performing again the reduction by strong synonyms and non-representative words, resulting in 39 adjectives (that satisfies the previously established cutting line). There are both positive and negative adjectives in this 39-item list. We did not consider composed terms, such as “easy to clean”.

The 39 adjectives, ordered by incidence on the three questionnaires, were: practical, beautiful, modern, economical, easy, efficient, durable, resistant, secure, fragile, heavy, noisy, functional, spacious, simple, technological, fast, clean, innovative, elegant, intuitive, smart, large, silent, useful, robust, expensive, light, reliable, ergonomic, clean, compact, complex, comfortable, ecological, cheap, difficult, automatic and flexible.

Those 39 adjectives are, therefore, the database resulted from this research. However, in order to select the most representative adjectives, we used the correlation matrix. After creating the correlation matrix with the 39 adjectives, we made a sum of correlation incidences. We selected the higher frequency (20) and divided by 2, resulting in 10, which was the cutting line. Therefore, applying this cutting line, we selected 22 adjectives (in alphabetical order): automatic, comfortable, easy, ecological, economical, efficient, elegant, ergonomic, expensive, fast, flexible, functional, innovative, intuitive, modern, practical, reliable, secure, simple, smart, technological and useful. At last, we searched for antonyms for each of the 22 adjectives.

We observed that from the six adjectives with higher incidence in questionnaire 2 (answered regarding efficiency), five made into the final cut (22 adjectives). This evidences that the approach with UX Experts showed to be quite useful and relevant.

Comparing the first cut, 39 adjectives, with the 30 positive adjectives collected by Neves [9], eighteen adjectives were present in both researches; twelve adjectives from Neves did not coincide with the collect adjectives from this research; and twenty-one adjectives that we collected were not present on Neves study [9]. We present this comparison with Table 1.

Table 1. Comparison on collected adjectives between this research and Neves [9]. Source: The authors.

Adjectives collected both by this research and by Neves [9]	Adjectives collected only by this research	Adjectives collected only by Neves [9]
1)Automatic, 2)beautiful, 3)comfortable, 4)difficult, 5)ecological, 6)economical, 7)efficient, 8)ergonomic, 9)innovative, 10)smart, 11)clean (cleaning), 12)modern, 13)practical, 14)resistant, 15)secure, 16)silent, 17)simple, 18)technological	19)Cheap, 20)clean (aesthetics), 21)compact, 22)complex, 23)durable, 24)easy, 25)elegant, 26)expensive, 27)fast, 28)flexible, 29)fragile, 30)functional, 31)heavy, 32)intuitive, 33)large, 34)light, 35)noisy, 36)reliable, 37)robust, 38)spacious, 39)useful	I)Pleasant, II)neat, III)controllable, IV)dynamic, V)stimulating, VI)easy to clean, VII)easy to use, VIII)honest, IX)strong, X)multifunctional, XI)organized, XII)surprising

Even though some adjectives are represented by other synonyms in our 39-list, we point out some methodology differences that may be the reasons for these differences. Neves [9] accepted the usage of composed expressions, and this research considered only adjectives. In addition, this research considered the user experience as a whole on the adjective collecting, not dividing into dimensions or categories, activity that Neves performed (division between functionality, usability and pleasure, each category composed by 10 adjectives). In one way, Neves was able to balance three aspects of UX through the selected adjectives, on the other hand, by not dividing the adjectives, we used only those more representative. So, if, for instance, the

respondents on this research consider the “usability” aspect as the most important, this aspect will be more represented by the final adjectives. It is possible to recognize that, comparing our results (on home appliances in general) with Neves’ results (towards washing machines) the most contemplated categories are usability and functionality. We also highlight that Neves’ research [9] was performed taking into account only one category, and in this study we considered home appliances as a whole.

5 Conclusions

User experience is a growing area, each time more recognized by professionals and industry. In this context, tools that helps UX evaluation become relevant, supporting professionals on quantifying subjective aspects and operationalizing evaluation tasks. Semantic differential scales are versatile tools used for evaluating a certain experience or meaning, through the usage of opposite adjectives pairs. It is a tool developed several decades ago, but still stays current, facilitating the user experience evaluation.

However, since the semantic differential scale is fundamentally based on words and meanings, the application on different languages implies on adapting. Pereira [20] verified that semantic differential scale can be a successful tool if used in Portuguese. Based on Pereira [20] and many collecting activities, Neves [9] generated a semantic differential scale for evaluating long term UX with washing machines. After examining these two studies - one with a wide overview, and other with a very specific approach - we detected the possibility for creating a middle term collection of adjectives for semantic differential scales: the scope for home appliances in general.

The three phases of the applied method enabled us to collect adjectives from various sources: users, designers, UX experts and manufacturer. Designers provided a large variety of adjectives, contributing with different synonyms of many relevant aspects of UX with a home appliance. The collecting with User Experience Experts, even though resulted in a smaller number on variety, was paramount for detecting elementary words and meanings. Raising adjectives from users and marketing materials was fundamental on choosing words that are representative and part of the user’s vocabulary.

The adjectives reduction was a challenging step: it was important to reduce into representative adjectives, and still not leave behind relevant meanings from the UX with a home appliance. The correlation matrix supported us on verifying which adjectives had most correlation with one another. However, debating with other researchers was indispensable to compose a list of adjectives that contemplate many home appliances’ aspects. The researcher’s participation was also important on turning the adjectives into antonyms, enabling the further application on semantic differentials.

It was possible to select a first group of adjectives, with 39 adjectives, and a second group, with 20 adjectives. We presented both groups on this document, allowing professionals to choose if they prefer the larger or smaller group of adjectives.

Comparing with the literature, we consider that the collected adjectives from this research were representative and applicable for various home appliances categories. For further studies, we indicate the verification if the translation here presented is valid for other cultures, highlighting that we developed this study in Brazil, on Portuguese. We also suggest the application of these adjectives in a comparative manner using different home appliances. With this study, is important to check if all adjectives are applicable for all home appliances categories, or if it is more adequate to select specific adjectives from the 39-item list for each application.

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