Investigating user experience as a composition of components and influencing factors

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Abstract: This paper is part of a Ph.D. research focused on the upstream design phases and aiming to develop knowledge and know-how in order to improve early user experience representations. In this article, the user experience is understood as a combination of components and influencing factors during the interaction of a user and a product. As input to this study, the authors collected 211 descriptions of user experiences from participants around the world. The database created puts user experiences components (aesthetic pleasure, semantic attribution, emotions) in relation with influencing factors: the personal characteristics of the user (e.g. gender, age, nationality, values) and product, interaction and context attributes (e.g. functioning mechanism, action enabled, type of interface, amount of users involved).

In this research, the database obtained is analysed with two different approaches. The first seeks to identify correlations between influencing factors and user experience components. The second organises the experience reported by the participants in clusters according to their components. Relating key influencing factors to these clusters permits to define 15 user experience harmonies representing 15 distinctive directions. Finally the added values for design practice of both approaches are discussed.

Key words: User experience components, User experience influencing factors, Personal characteristics, Product and interaction attributes, Early design stage, Kansei experience design

1. Introduction

The emergence of research fields such as kansei, semantic or emotional design puts emphasis on the fact that user experience is now a key element to focus on while designing a product. It can actually be seen as one of the most visible end results of all the activities undertaken during the development of a product. Moreover it has been shown that it is during the early design stages that the decisions taken have the highest impact on the user experience [17]. Therefore a better understanding of its influencing factors for a given situation (targeted user group and product and interaction characteristics) would be a key input at for the concept creation phase.

2. State of the art

2.1 Introduction

Depending on the focus of the study and on the point of view and background of researchers, different definition of user experience can be found in the literature [14]. They have in common the fact that they

investigate the situation in which a human perceives a product. This situation can be related to a human perceiving a product or an interaction between the user(s) and the product (Figure 1). The last one adds necessarily the notion of flow (and of sequence) and of context not always present in perception-only related experiences. An interaction can be studied from the point of view of the human, of the interaction or of the product [10].

Figure 1: User-product interaction: context of a user experience

This paper studies user experience with a human-centred approach. We will investigate its different components: the aesthetic pleasure and semantic interpretation from the user as well as his emotional response when perceiving a product and interacting with it [9]. In addition to these components, user experience influencing factors are also highlighted in the literature. They include user's personal characteristics as well as interaction [21], product [13] and context attributes [4].

This approach to user experience has been chosen as the best fitting to the kansei experience design approach [12], which combines typical qualitative design methodologies to quantitative analysis in line with the kansei research tradition that bridges users' subjective perception of an experience to the product's attributes [33].

2.2 User experience components (UXC)

Desmet and Hekkert identified three user experience components: the aesthetic pleasure and semantic interpretation from the user as well as his emotional response [9]. They can be divided into two types of user response: the cognitive response (aesthetics, semantic) and the affective response (emotions) [4]. It is important to note that there are intercommunication and interdependences between the cognitive and affective responses [9]. These responses can follow conscious and unconscious paths that are predominant depending of the situation [26, 28]. In the following paragraphs each of the three UXC will be detailed.

Aesthetic (cognitive response):

By perceiving products though their senses, people often find them attractive, elegant or beautiful or on the other side ugly or unattractive [3]. A study realized by Spence as well as many studies have suggested that the greater the number of senses modalities that are stimulated at any once time, the richer our experiences will be [34]. Often the activity of perceiving the object is pleasurable by itself, independently of other value judgments that might be made [1]. Some researchers even describe this activity as completely disconnected from cognition [26]. According to Coates, there is a part of subjectivity and a part of objectivity within the aesthetic impression [3]. Both of these parts are divided into 2 aspects, information and concinnity. Information takes into consideration the shape, colours, and textures that can be observed whereas concinnity considers the harmony of the whole together with the sense that it makes. In the design literature guidelines can be found to help designer to master the so-called objective aspects of the aesthetic impression such as for instance colour [16], graphic layouts [25] or interaction attributes [21].

Semantic (cognitive response):

Users also attribute a meaning to an interaction with a product. This is another component of user experience. This semantic can come from the shape of the object, from other of its attributes (e.g. colour, touch…), from ways the user can interacts with it [19] and from the evolution of these attributes in time [22]. Semantic permits to

communicate the functional attributes of a product and the way to operate it and to perform the task for which it has been made for. This is why an important portion of the value assigned to products may be attributed to their utility and usability [35]. This comprises practical qualities such as function, intuitiveness, performance, efficiency and ergonomics that should be taken into account from the early design phases [20]. Semantic approaches are available for designers in order convey these various aspects of the product usability through the different sensory channels, some of them being for instance the use of metaphors [15], of semantic layers or of affordances [20]. The meaning that the user gets from the product and from the experience is therefore the main component of the usability of the product.

Emotion (affective response):

Emotions are part of the user "affective response", which is an umbrella term for user response considering moods, feelings as well as emotions. Concerning response to product, emotions will be relatively mild when compared to the possible spectrum of human emotions [24]. Models explore their interrelations with other types of responses such as the one from Desmet. In his models he details five categories of emotional responses that products may elicit: instrumental, aesthetic, social, surprise and interest [7] and three universal key variables in the process of emotion elicitation: concern, product (stimuli) and appraisal [6].

2.3 Influencing an experience

In the previous section we detailed the different interdependent components of a user experience. Different researches have highlighted factors that influence these subjective components. They will be detailed below.

Personal characteristics (PC):

Bouchard et al. investigated users' response to the perception of shoes [2]. They found correspondences between users' profile (nationality and behavioural values) and the semantic and emotion they associate with a wide variety of shoes. In the field of automotive design Desmet et al. [8] found similar types of correspondences: this time between participants' instrumental values and their emotional response to perception. In the two previous cases, researchers build on a set of values by Rokeach [29] to map the scope of human values. Other aspects of the personal characteristics such as age [23] or gender [32] can also have an influence on people's response to perception. Correspondences between the different personal characteristics detailed above and the different components of user experience will also be explored through this survey.

Product, interaction and context attributes (PIA):

As explained in the section detailing UXC, products have attributes that elicit responses from the user. The attributes correspond to the products' multi-sensory appearance (e.g. shape, colour, texture, timber) [4] as well as to the way it used and to its functions [13]. The response of the user and therefore the user experience conveyed is highly influenced by these attributes [24].

Interaction is an abstract entity that is now studied on its own [21] as it appeared to researchers that this interaction event is a major influencing factor of a user experience. Its characteristics can for instance be detailed with interaction gestalt [5,10].

The context in which a user-product interaction occurs in clustered also has a great influence of the way human perceive this experience [10]. Different criteria influencing the experience are for instance its social aspect (amount of user involved), our ability to define it with a beginning and an end, or its location and context. The time spent interacting and the type of relationship that exists between the user and the product can also influence

the experience [18]. Indeed, Ocnarescu et al. have for instance explored the differences between different stages going from the first information gathered about a product that they name pre-experience (e.g. reading of a article about the object) to the post-experience perspective corresponding to a moment when the user will no longer be able to experience the object directly (e.g. when leaving a museum) [27].

2.4 Summary of the State of the Art

Figure 2 represents a user-product interaction. On this figure the main stakeholders (user, interaction, product) introduced in section 2.1 are detailed. We described the user experience as user-specific (section 2.2). It can be described by three main components: aesthetic pleasure, attribution of meaning and emotional response [9]. Different factors can influence user experience (section 2.3): they can be internal to the user such as personal characteristics or external such as product and interaction attributes and well as element of the context and externalities. The framework is naturally a simplification of the reality but permits to highlight the different elements taken into account in this research.

Figure 2: User experience from a product interaction framework: its components and influencing factors

3. Research question and Hypotheses

The research question uses the framework presented in the section 2.4 and focuses and the relation between user experience components and the different influencing factors described. It can be formulated as: *Can user experience trends be described in term of components and influencing factors?* Three hypotheses were identified.

H1 - Correlations can be highlighted between product, interaction and context attributes and the user experience provided in term of components.

H2 - Correlations can be highlighted between user's personal characteristics and the user experience components these users are seeking.

H3 – User experience trends can be described in harmonies of matching components and influencing factors.

4. Presentation of the survey

In total, 189 participants filled the online questionnaire correctly and completely. It was available in five languages: English, Japanese, French, German and Spanish. Native speakers made all the translations. For the part concerning emotions the translation references from the Geneva emotion research group were used [11]. The distribution of the participants is presented in the figure 3. The participant pool can be considered homogeneous as no correlation in distribution is observed between *nationality*, *gender* and *age*.

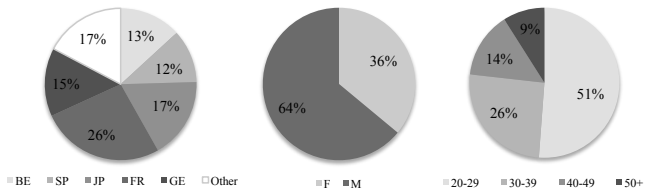

Figure 3: Age, gender and main nationality distribution of the participants

The questionnaire followed a simple procedure. First the participants were welcomed and introduced to the procedure that they will have to follow. A figure similar to the one on Figure 4 was presented to them. Then they were asked to report their personal characteristics (PC) such as gender, age, nationality(ies) and personality traits. For describing their personality, they had to use a 5-point scale (0= not at all, 2= moderately, 4= extremely) and relate appropriate behavioural values from a list adapted from Rokeach [29]. In the following page, they were introduced to the user experience, which was briefly described with the notions of "aesthetic", "semantic" and "emotions". Examples of products were presented to them using pictures arranged according to attributes related to three products attributes categories: amount of user involved, action enabled by the product and functioning mechanism. They were then asked to "name a product with which they had an experience they enjoyed" and to describe this experience in a few words. Participants choose a wide variety of products such as for instance computing related products, pieces of furniture, board games or transportation means. Following the selection of a UX, they had to describe it according to its aesthetic sensory properties, its semantic and the emotions triggered. The description was restricted to user experience components (UXC) selected by the authors. Indeed, participants had to evaluate on a five-points scale (from *not at all* to *extremely*) their aesthetic impression related to different perception channels (e.g. pleasant to *see*, *touch*, *interact with* - list on Figure 6), semantic keywords describing the product and interaction (e.g. *authentic*, *dynamic*, *natural* - list on Figure 7) and emotions they felt from their interaction with the product (e.g. *amused*, *proud*, *surprised* - list on Figure 8). The final list of UXC keywords was obtained through iterations using the results of pilot surveys. In the case of emotions the authors paid attention to cover the full scope of positive emotions from active to passive [31]. Finally they were asked to choose between describing another user experience and ending the questionnaire. At different moment during the questionnaire they had the possibility to leave comments.

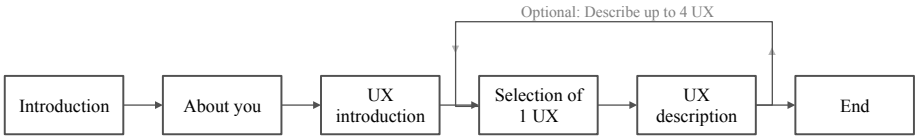

Figure 4: Procedure followed by the participants

At this stage the database contained for each UX described structured information related to the personal characteristics (PC) of the participants and details about the UX in terms of components as well an unstructured description of the product and the interaction attributes (PIA). In order to be able to compare the PIA described, the authors structured the description written by the participants written into attributes' categories. These categories are either related to the product itself, interaction related or referring to the context of use. The selection ratio of these different PIA categories is presented on Figure 5.

The experiences described by the participants correspond all to "direct experience" in the sense of Ocnarescu et al. [27]. They can be described as "episodic encounters that involve long term use and relation creation" (p. 5) and correspond in fact to the experience that we get from products that we use in our everyday life.

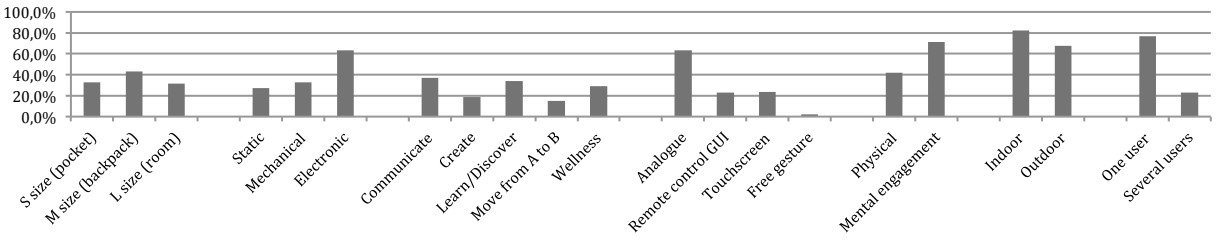

Figure 5: Selection ratio according to PIA categories (from left to right, **product**: size, functioning mechanism/ **interaction**: action enabled, type of interface, engagement required/ **context of use**: location, amount of users involved)

5. Analysis

It this research, the database obtained will be look at from two different point-of-views. In the first approach, correspondences between user experience influencing factors and components will be investigated. It permits to observe correlations between PIA and UXC (H1) as well as between PC and UXC (H2). For the two types of influencing factors, examples will be used to go one step further and illustrate significant different correspondences between keywords and UXC.

The second part of the analysis will focus on UX harmonies. These are compositions of UXC, PIA and PC to which a UX is particularly strongly correlated. In order to create these UX harmonies a hierarchical cluster analysis of the UXC will first be made. The 15 UX harmonies can be detailed in term of components and influencing factors correlated to them. Significant differences of these associations will also be investigated.

5.1 User experience influencing factors

Product, interaction and context attributes (PIA):

The database extracted from the survey puts each 211 UX in relation with all the keywords related to UXC, PIA and PC. This bond is either a yes/no relation (1/0) such as for PIA or an associated score going from not at all (0) to extremely (4) such as for emotions. From this database a correlation matrix including all the keywords can be created. By looking at the keywords related to PIA and to UXC it is possible to identify particularly strong correlations between these two categories of keywords such as for instance between *curiosity* ("emotion", UXC) and *mental engagement* (PIA) or between a *social* semantic (UXC) and *communication* ("action enabled", PIA) with in both cases correlation factors of 0,42.

In order to go further, significant differences in term of correlation between PIA and UXC will illustrate using the example of the PIA category "functioning mechanism". The three non-exclusive attributes contained it this category are *static*, *mechanical* and *electronic*. As example, a rug can here be described as *static*, a cooking mixer as *mechanical*, a smartphone as *electronic* and a standard car as *mechanical* and *electronic*. By looking at the UXC associated to these attributes differences in terms of aesthetic experience (Figure 6), experience of meaning (Figure 7) and emotional experience (Figure 8) can be observed. For all the following figures the Y-axis represents of the associated rate (0: not at all, 2: moderately, 4: extremely) of the corresponding UXC (X-axis). The positions of the points correspond to the average response.

When looking at the differences in term of aesthetic experience (Figure 6), it is possible to notice that the importance of *coherency/complementary between the senses*, *interaction*, *sight* and *touch* are similar for the three product attributes. For all of them *interaction* is the most important in term of aesthetic experience. Oppositely, significant differences can be observed (confidence interval: 95%) for smell and sound in the aesthetic experience

provided by *static* and *electronic* products. *Smell* is more important for the *static* product whereas *sound* it more important for the *electronic* ones. In both cases *mechanical* products occupy an intermediate position.

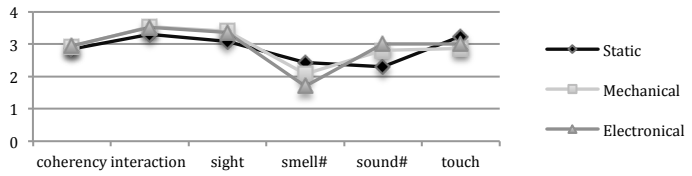

Figure 6: Aesthetic experience (sign. diff.: # *static* vs. *electronic*)

Interesting observation concerning the meaning conveyed by the different types can also be extracted from the database (Figure 7). For the three PIA groups *intuitive/easy to use* and *comfortable* belonged to the most important UXC in term of meaning. The other most important meanings conveyed by *static* product were *timeless* and *authentic*. It the case of *timeless* a significant difference can be observed with *electronic* and with *mechanical* products. Complementary top-ranked meanings are *dynamic* and *authentic* for *mechanical* products and *modern* and *intelligent* for *electronic* products. For the aforementioned adjectives *modern* and *intelligent* significant differences (confidence interval: 95%) can be observed (*modern*: *electronic* > *mechanical*, *electronic* > *static, mechanical* > *static* and *intelligent*: *electronic* > *static*). Other significant differences can be observed for *dynamic*, *in fashion* and *chic/elegant* (Figure 7).

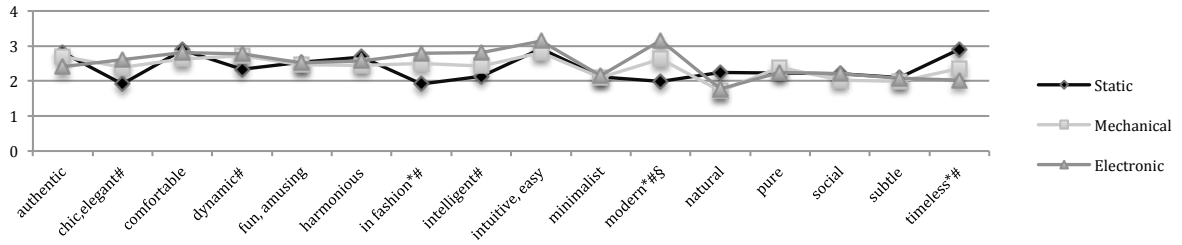

Figure 7: Experience of meaning (sign. diff.: # *static* vs. *electronic*, * *static* vs. *mechanical*, § *mechanical* vs. *electronic*)

Concerning the emotions conveyed through the human-product interaction, similar patterns could be observed for the three PIA used in this example (Figure 8). The very top emotions conveyed are in each case *satisfied*, *joyful* and *interested*. Only for *static* products another emotion interferes with this Top 3: *at ease* arrives second (sign. diff. *static* > *mechanical*). Other significant differences can only be observed for *curious*, *impressed* and *surprised*.

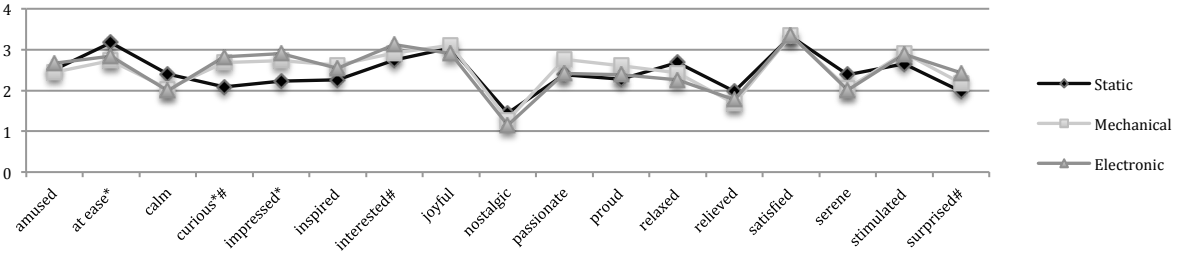

Figure 8: Emotional experience (sign. diff.: # *static* vs. *electronic*, * *static* vs. *mechanical*)

The previous analysis permits to quantify and to rank UXC for a given product attributes. The correlations between PIA and UXC identified at first and the significant differences illustrated after that with the "functioning mechanism" PIA validates H1. An analysis such as the one presented above gives a clear image about the UXC

related to a specific product attribute and confirm or not apriorisms one would have. The following step will enrich these results by taking into consideration the influence of users' personal characteristics.

Personal characteristics (PC):

As mentioned previously, a correlation matrix including all the keywords (UXC, PC, PIA) can be created with the questionnaire's output. By looking at the PC and UXC keywords, it is possible to identify particularly strong correlations between these two categories of keywords such as for instance between *satisfaction* ("emotion", UXC) and *capable* ("behavioural values", PC) and between the *subtle* and *natural* semantic keywords (UXC) and respectively *Spanish* ("nationality", PC) and *respectful* ("behavioural values", PC). In every case a correlation factor close to 0,30 could be observed.

When filtering the database according to specific personal characteristics it is possible to get UXC particularly appealing for the user-group selected. As example, three groups of young (<30) Europeans having different behavioural values will be compared. The 3 groups are the *ambitious group* (defining themselves in the questionnaire as extremely *ambitious*), the *creative group* (defining themselves as extremely *imaginative/creative*) and the *loving group* (defining themselves as extremely *loving/affectionate*).

Using the database, the groups can be compared with each other as well as with the general trend for young Europeans. This analysis permits to highlight the specific interests of these user groups in term of PIA and appealing UXC. These correspondences as well as the correlation described above correspond to the second (H2). Figure 9 shows the "emotions" appealing to the *ambitious*, *creative* and *loving groups* relatively to the general trend for young European. The Y-axis represented the distance to this trend quantified with the 5-point scale detailed in section 4. Very important differences of appeal can be observed concerning the emotional responses of the user groups such as for *amused* (*creative>ambitious*), *nostalgic* (*loving>ambitious*) or *surprised* (*creative>loving*).

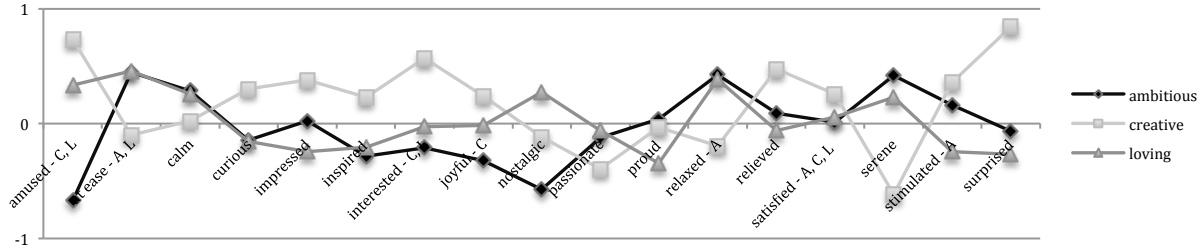

Figure 9: Emotions appealing to PC groups relatively to the general trend for young European (most important emotions are marked with A for the *ambitious group*, C for the *creative group* and L for the *loving group*)

5.2 User experience clusters based on user experience component (UXC)

Introduction:

In the first part of the analysis the authors were able to identify correlations between the user experience influencing factors and their components (UXC) (aesthetic, semantic, emotion). In this part they will take another viewpoint and analyse correspondences between UXC clusters and their related UX influencing factors. In order to do so the 211 UX described have been clustered according to their components using a hierarchical clustering method. The dendrogram represented on Figure 10 shows the distribution of the 15 clusters. Statistical analysis permits to correlate each cluster to all the UXC (from not at all= 0 to extremely=4). In that way they correspond to

15 different compositions of UXC. Three macro-clusters also appear on the dendrogram. UXC representing the most these trends are represented on figure 10.

Figure 10: Cluster of the 211 UX according to their components

An analysis of the variance confirms clear differences between each cluster. For each UXC (except *intuitive*, *harmonious*, *minimalist*), the clusters could be organised in significantly different groups (confidence interval: 95%). The amount of groups varies between two and six depending on the UXC.

UX clusters and influencing factors:

Because of the way they were constructed, the UX clusters detailed above are related to PC and PIA. It is therefore possible to compare the clusters' corresponding influencing factors. Trends can be highlights using a correlation matrix. It permits for each cluster to highlight keywords correlated above and below average. In this way UX clusters are not only described with UXC but also with PC and PIA particularly associated to them. This results validated H3. One example of composition of UX components and influencing factors, named UX harmony, is presented on figure 11. It corresponds to the cluster C6 (Figure 10) and is related to six user experiences coming from different types of board games and from a camping tent (descriptions from participants).

Additionally to trends in term of correlation, significant differences (confidence interval: 95%) in term of influencing factors associated could also be identified between the 15 clusters. These were observed for 4 PC (Values: *loving, helpful, indulgent*/ Nationality: *Japanese*) and for 8 PIA (Functioning mechanism: *static, electric*/ Amount of users: *several*/ Engagement: *Mental*/ Action enabled: *display information, wellness, entertainment, learn&discover*).

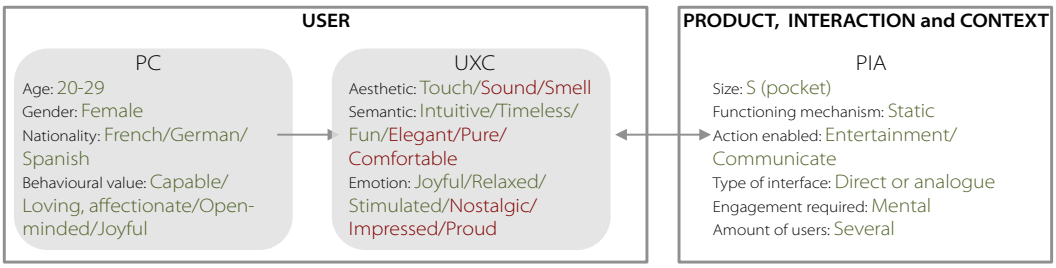

Figure 11: Cluster 6 (C6) – Example of a UX harmony combining PC, UXC and PIA (far above average and far below average correlated keywords)

5.4 Added value for design practice

Starting from the influencing factors:

It is during the early design stages that the decisions made have the highest impact on the UX [17]. Prior the concept creation stage, the design team needs to understand the context of a project and find inspiration. It is therefore relevant to define at that point an intended UX in term of components as well as the influencing factors to focus on. At that early stage, a target user (related to PC) and a product package (related to PIA) are usually defined for the product to be developed. Approaching the database by filtering according to specific keywords can be used as an additional inspiration source for the definition of an intended user experience based on such definition. The data resulting from the questionnaire is in that case used as a user research database gathering real user experience organised according to the framework presenting at the end of the state of the art (figure 2).

Starting from the user experience clusters:

The 15 user experience harmonies obtained in section 5.2 are described using the most and least associated UX components (UXC) and influencing factors (PIA, PC). They summarize 15 directions of what an appealing user experience can be. From that perspective they are interesting starting points to be used as design briefs when the frame of a project is still relatively open. Using them permits to explore a design brief starting from the user experience and explore multiple very different facets. It can for instance be used in an advanced design projects to investigate different atmosphere a vehicle interior can provide playing with the UX provided by design elements related to the multisensory perception and well as with the HMI. The other main advantage of the user experience harmonies is that they contain information relevant for different stakeholders of industrial design projects. They combine indeed information about the user (usually a key concern of product planners) and design information about inspirational products and interactions (usually a key concern of styling engineering and industrial/product designers). In that way they UX harmonies can also be used as a communication tool within a project while at the same time raising it's stakeholders awareness about UX topics.

6. Conclusion

This paper describes a research on user experience. An online survey permit to collect 211 UX detailed with components (UXC) (aesthetic and semantic impression as well as emotions conveyed) as well as with personal characteristics (PC) of the person having the experience and with information about the product, interaction and context attributes (PIA) of this experience. The database obtained has been analysed with two different approaches. The first identified correlations between influencing factors (PC and PIA) and UXC. A more refined analysis also permit to highlight significant differences in term of UXC associated between several PC and PIA. The second approach organised the experience reported by the participants in clusters according to their components. Putting in relation these UXC clusters with key influencing factors permit to define 15 user experience harmonies representing 15 distinctive compositions of UX components and influencing factors. Finally the added values for design practice of both approaches have been discussed. The first permits to add references that can be used as sources of inspiration for the definition of an intended user experience based a target user or a package description. The second can be used in more upstream projects as a workshop to widen the sphere of possibilities. This type of UX framework also shows promising strength as communication tool between industrial projects stakeholders (e.g. product planning, engineering and product design). Its qualities and added values are currently being investigated.

7. Acknowledgment

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