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KANSEI PHYSIOLOGICAL MEASUREMENTS AND CONSTRUCTIVIST PSYCHOLOGICAL EXPLORATIONS FOR APPROACHING USER SUBJECTIVE EXPERIENCE

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1. Introduction

The aim of this article is to explore the suitability of psycho-physiological measures (e.g. levels of pleasure, excitement and comfortableness during the usage obtained from physiological measures) and psychological explorations (e.g. users' reflections about their needs for interaction obtained from an interview) for approaching user subjective experience during and after the interaction with a product takes place (explorative usage and reflection processes).

For this purpose the 2-point Electroencephalogram (EEG) comfort measurement is used to gather real-time information about how a person feels during the interaction with a product and the Repertory Grid Technique (RGT) interview is used to gather information about what people's primary goals and concerns are and about the meaning placed on the purpose outside the immediate experience (after interacting with a product).

These two different methodologies combined allows for analyzing not only the exploration and usage process, also the reflection process that occurs after the lived experience. Thus, it can be used for:

- Track the comfortableness level evolution through time during the interaction with a product (exploration and usage).
- Compare information from different tasks and see how the senses take part into the level of comfortableness during the exploration process. Precisely, it can be valuable to find out the effect of the task and the sense modality in relation to the level of comfortableness during the interaction (exploration and usage)
- Analyze the key factors that determine the consumer's decisions, creating mental maps of the consumer's response. Determine the strengths and weaknesses perceived by the users in relation to the interaction (e.g. product characteristics, functionalities, behaviors).
- Relate consumer's response (reflection after use) with the level of comfort (pleasantness and arousal) achieved during the exploration and usage of a product.

2. Gathering information about user subjective experience

Different studies on the topic of user experiences have lead to a variety of definitions of the term. User experience can be considered to be a very dynamic, complex and subjective phenomenon based on appreciation and the resulting relationship ensuing from an encounter between the object and the user. It is something that occurs continuously, because the interaction with the environmental conditions is involved in the basic process of living. It depends on the perception of multiple sensory qualities of a

design (visual, taste, olfactory, kinesthetic, auditory and touch). It is interpreted through filters relating to contextual factors.

Extracting information about user experience can be done in many ways, but each route to experience reveals a different story [Sanders 2001], for example:

- Listening to what people say tells us what they are able to express in words (explicit knowledge).
- Watching what people do, seeing what they use and how they react provide designers with observable information (observable knowledge).
- Discovering what people know helps us to communicate with them. Understanding how they feel gives designers the ability to empathize. This form of investigation provides knowledge that cannot readily be expressed in words (tacit knowledge).
- Evoking people's dreams shows their personal aspirations for the future. It can reveal inner needs not recognizable in the present time (latent knowledge) through a guided discovery process, putting them in touch with their feelings and dreams.

Mature methods and tools to evaluate pragmatic aspects of user experience (which are closely related to issues like usability and designed to be used at the task level) are not useful if practitioners want to apply them to evaluate other issues (i.e. emotions and affect, social interaction) that are strictly not related to aspects of product usage. Basic quantitative analysis and hypothesis and validation approaches (e.g. Conjoint Analysis, SUMI [Kirakowski & Corbett 1993], Product Semantic Analysis) have been used extensively and their limits have been pointed out: they cannot deal in a structured way with all the amount of information and the results obtained are ephemeral, thus complex to measure and analyze.

The emerging user experience gathering techniques offer new ways of dealing with subjective aspects, but at the same time the information obtained (e.g. PrEmo [Desmet 2003], Feeltrace [Cowie et al. 2000]) can hardly be used in designing the interaction without being interpreted and modified (there is no direct link between subjective information about users needs, desires and fantasies; and product characteristics, behaviors and context of use):

- Due to the hypothetic-deductive basis (hypothesis validation process), researchers do not have the security that aspects they have considered are relevant for the user.
- It is very unlikely that the user research, as broad as it may be, reflects everything affecting the user, as some aspects are really very difficult to observe or express.

Research studies for products and services require a great dedication of time observing the product or the user. Once this observation has been done, researchers still have to run a series of tests to see if they verify the hypothesis.

3. Constructivist psychology explorations

Psychological exploration has been the most investigated way to analyze user experience. It refers to the collective aspects of intellect and consciousness in relation to user experience which are manifest in some combination of thought, perception, emotion, will and imagination. Constructivist schools of clinical psychology base their therapeutic process on the clients' significant associations (a co-exploration method). Applying this approach in the User Experience (UX) field, consists on focusing the study on the relationship between the person and the product and not on general opinions or what has been established through conventions.

Using a co-exploration system for the information gathering, test designers exchange an objective observation for a systematic individualized guidance (see figure 1). Thus, users of the product studied will give a detailed view of it, including various dimensions (i.e. functional, emotional, physical characteristics). These characteristics will always be tailored to their personal experience while interacting with the product, and for this reason, the leading aspects will always be relevant.

3.1 Repertory Grid technique

Kelly's Repertory Grid (RGT) [Kelly 1955] structured interview is one of the most widely used explorative techniques based in the constructivist paradigm. This technique can be adapted to gather information about user's perception related to consumers' preference behavior in their own words from a subjective experience point of view. The RGT results are presented in a data matrix composed of three different basic components:

- Elements are defined as a representative sample of people, events, activities, places or objects from the area you want to explore. They are related to a specific personal experience domain.
- The rows of the matrix are filed with personal constructs (bipolar dimensions like semantic differentials), which represent personal views or judgments. Precisely, qualities people use to describe the elements in their personal, individual world (e.g. "comfortable hands position" vs. "it hurts", "right length, no more than thumb size" vs. "too long").
- Each cell of the matrix represents the quantitative evaluation of the elements by the constructs.

Figure 1. Socratic approach with a expert-to-expert relationship (left) vs, hypothetic-deductive with a expert-to-subject relationship (right) [Pifarré & Tomico 2007]

4. Kansei physiological measurements

Kansei is usually described as a mental function, and more precisely as being a higher function of the brain [Harada 1998]. The Kansei process gathers the functions related to emotions, sensitivity, feelings, experience, intuition (i.e. sensory qualities related functions), including interactions between them. Kansei is a mental process complex enough not to be measured directly, even with intrusive methods (such as Functional Magnetic Resonance Imaging) because what can be observed is not Kansei but consequences of it. Thus, Kansei can be measured only indirectly by measuring physiological and behavioral responses.

Kansei Engineering (KE) approach [Nagamachi 2002] associates products details and "kansei words" for design recommendations. Kansei words are words expressed by the user to tell his/her Kansei towards a design. One of the issues here is the Kansei words are only showing the upper part of the experience "iceberg" (only what can be perceived and said with words). Cognitive sciences and psychology are not so much involved (at least directly) in KE. KE is more related to database, statistics, mathematic models, and inference.

Kansei Studies [Harada 1998] are trying to understand more user's Kansei (even the part that cannot be expressed) and to find ways to measure or evaluate it. Physiological responses, which are readily and non-invasively observed and have been conventionally used, include:

- Central nervous responses to stimuli such as spontaneous brain waves, sensory evoked potential, or event-related potential.
- Peripheral response such as heart beat, pulse rate, breathing rate, or body temperature.
- Motor responses such as eye movement, blinking or muscle fiber contractions.

4.1 2 points EEG comfort measurement

Recently, various physiological measurement indices like heartbeat, breath activity, skin potential, eye movements and brain imaging have been used to measure the comfortableness rouse by visual,

auditory, tactile stimulus and also from product usage. Zhang [Zhang et al. 2007] had succeeded in relating ⟨-wave fluctuation from the brain and comfortableness and research in the automobile industry field had shown that the level of comfortableness could be extracted from this measures. As a result of finding this correspondence between ⟨-wave fluctuation and subjective alertness or comfortableness, it was discovered that the characteristics of ⟨-wave fluctuation change respond to changes in psychological conditions. The spectrum analysis of fluctuations in the ⟨-wave frequency (see figure 2) indicates that the frequency fluctuation of ⟨-waves exhibits a moderate rhythm (characteristic close to 1/f) during comfortable rest or a relaxing condition, while such characteristics fall down in uncomfortable conditions.

For this research the "HSK center rhythm monitor slim" device (see figure 2) based in the Yoshida [Yoshida 2002] comfortableness evaluation model have been chosen due to its suitability to current research in the field, its simplicity and easy usage. In design and emotion research, comfortableness evaluation can be expressed by two axes known as valence (positive-negative) and arousal (excited-calm). In Yoshida comfortableness evaluation model, left frontal ⟨-wave frequency fluctuations express human's valence and the right frontal ones express arousal. The comfortableness degree is calculated from both left and right frontal ⟨-wave frequency fluctuation using the fast Fourier Transform algorithm. When both left and right frontal ⟨-wave frequency fluctuations are near the rhythm degree of "1/f fluctuation", it means human is in the state of "calm comfort".
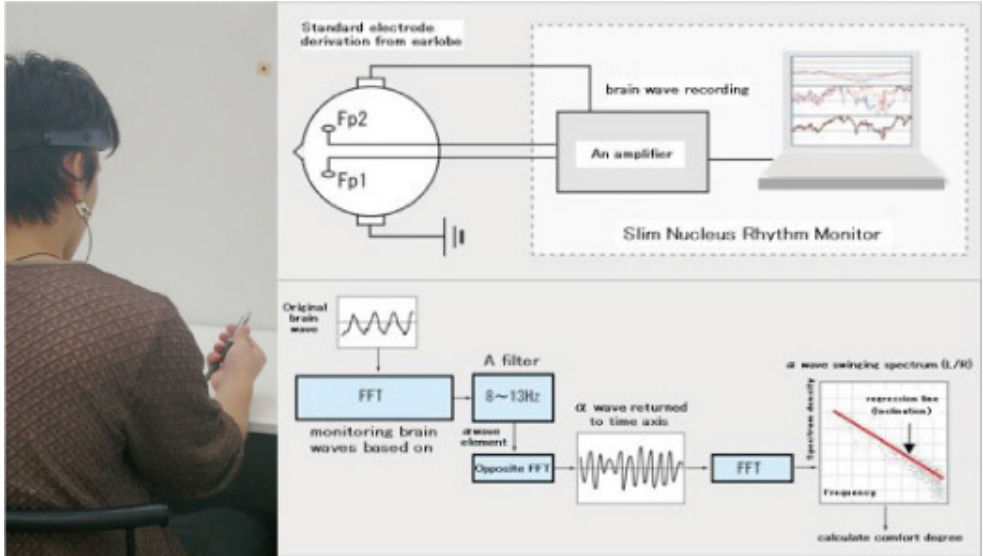

Figure 2. HSK center rhytm monitor slim device configuration and spectrum analysis of fluctuations in the <-wave frequency

5. Convining physiological measures and psychological explorations during and after product usage

In this research study 5 participants were used and the aim was to analysis of the subjective perception of different pens in the Japanese market by the comfortableness measure during the usage (HSK center rhythm monitor slim set up) and the physical, functional and behavioral characteristics extracted from a post-usage interview (RGT). This two approaches complement each other by relating consumer's response (reflection after use) with the level of comfort (pleasantness and arousal) achieved during the exploration and usage of a product.

5.1 Zebra pens Pilot test set up

The 6 products used for testing were selected out of 20 from previous research, where participants were stated to group the products they could buy, in order to have a homogeneous sample of well-perceived products (see figure 3). In order to standardize the results from the usage test and be able to compare results from different products and different participants, the was broken into a time-

Figure 3. Image of the tested products

controlled sequence of actions (simulated explorative process): look (30s), manipulate for the first time (30s), use (60s), manipulate for a second time (or play) (30s). By this means, stimulus from the different senses were added one by one: Look (visual stimuli), manipulate (tactile and visual stimuli from the pen), use (tactile and visual stimuli from the pen and tactile and visual feedback from the writing). The second manipulation was used in order to track also a global impression after using the product for the first time. Moreover, relax times (30s) were used as a separation time between products.

To avoid biasing the results with the time variable and to present the products with the same order, the pens were arranged differently to all the participants. The area used to make the experiment was done in a separate room with the minimum set up to avoid any external disturbance: measurement and recording devices, the technician verifying the obtained data and the facilitator for the interview). Before the experiment, the participants were asked to answer brief questions about themselves and also about their writing habits (define and order what they usually use) and value analysis (what can be a suitable) in relation to the product to study.

After the experiment, the interviews (based in the RGT) were carried out for an average period of 60 minutes for participant, where the products were presented first in two groups of three elements (asking for which one they prefer and which not) to elicit the constructs and in the following iterations by grouping the best perceived products and the worst perceived ones. In addition, an ideal (ficticious) element was also use when the participants rated the elements with the elicited constructs.

5.2 Physiological measures

The $\langle$-wave frequency fluctuations give a continuous amount of values distributed in time. In order to reduce the amount of data and be able to make comparisons between different products and users, average values from the different tasks were calculated. The results represent the average value of comfortableness, which comes from the left and right $\langle$-wave frequency fluctuations. Moreover, the analysis of the results is done grouping the results by participants and tasks.

The analysis by participants is done in order to track the comfortableness changes from each participant in relation to the pens used in the course of the different tasks (simulated explorative process). From the results obtained, it can be said that different patterns relating the level of comfortableness for each participant during the explorative process emerge (see figure 4). Ascending trends can relate to an enjoyable learning process or discovery processes where the users suppositions or preconceptions are fulfilled (users needs are fulfilled in the different tasks). Inverted U shaped curves can relate to products that actually surprise the users when they manipulate and use them but

that at the end (second manipulation). Descending trends can relate to products, which have a nice look, but users suppositions are not fulfilled by the manipulation and use them.

By comparing the highest levels of comfortableness by tasks (see table 1) it can be noticed that the products with highest levels of comfortableness vary between the different tasks. It also have to be said that at least 50% (there is an agreement between participants) had similar results concerning the products with highest levels of comfortableness. For the first task (look), the product "Q" is the most comfortable one even though it has very low values for participant one ("Q" is the thinnest pen and the only one made with metal, the other ones were made of plastic). For the second task (manipulate for the first time) product "E" is the most comfortable one ("E" is a pen with the softest grip, where the fingers are placed). For the third task (use) "M" is the most comfortable pen ("M" pen also has a soft grip). For the fourth task (manipulate after use and play) "M" is also the most comfortable one.
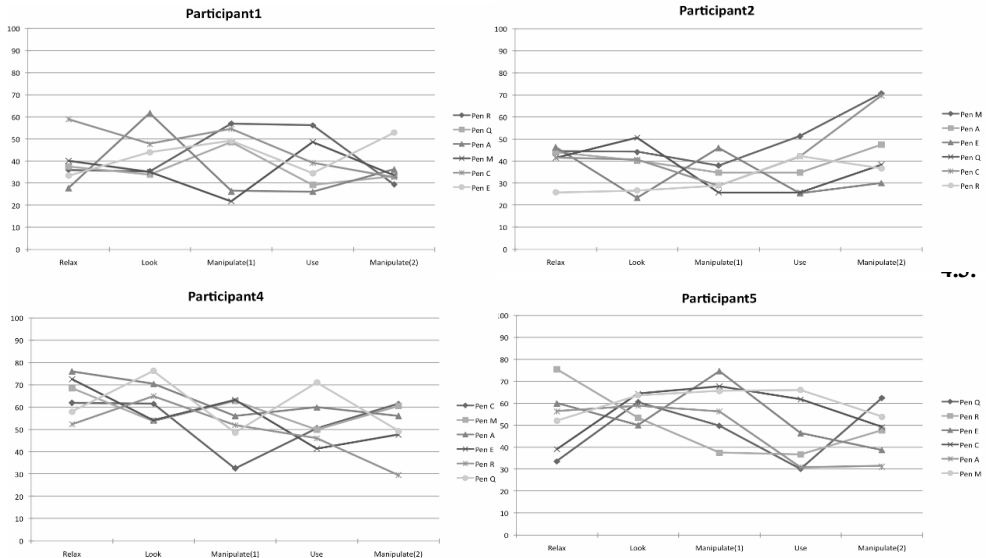

Figure 4. Average level of comfort (%) obtained during the explorative process

Table 1. Pens ordered by the level of comfort obtained from the different tasks

LOOK

	1st	2nd	3rd	4th	5th	6th
p1	A	C	E	M	R	Q
p2	Q	M	C	A	R	E
p4	Q	A	R	C	E	M
p5	C	M	Q	A	R	E

Use

	1st	2nd	3rd	4th	5th	6th
p1	R	M	C	E	Q	A
p2	M	R	C	A	Q	E
p4	Q	A	C	M	R	E
p5	M	C	E	R	A	Q

Mani(1)

	1st	2nd	3rd	4th	5th	6th
p1	R	C	E	Q	A	M
p2	E	M	A	R	C	Q
p4	E	M	A	R	Q	C
p5	E	C	M	A	Q	R

Mani(2)

	1st	2nd	3rd	4th	5th	6th
p1	E	A	M	Q	C	R
p2	M	C	A	Q	R	E
p4	C	M	A	Q	E	R
p5	Q	M	C	R	E	A

The information obtained from the psychological measures combines quantitative and qualitative data. In this case, with the goal to help designers finding relations between user's needs with the existing products, quantitative data was used to ponderate and relate qualitative information from the different participants. A weakness analysis is done in order to find the best products (elements with higher values) and the major perceived drawbacks (constructs that have really low values) for each participant. From this results C (25%) and R (25%) are the most well perceived products and the major weaknesses of the products analyzed are: the effort you need to use to write, the sofness of the grip, the thickness of the line, the balance and control and existing security mechanisms to prevent leaking.

A sample of the results from one participant is presented to give an idea about how the information can be extracted. Table 2 has highlighted the most valued products and the worst perceived characteristics in products for participant 3. The results show how "C", "E" are close to ideal product and that the lightness of the plastic material and a moderate thickness of the axis are the worst perceived characteristics of all the products (things to be improved and where the redesign focus should be).

Table 2. Sample from the RG results for the 3rd participant. Translated from Japanese

negative pole	A	C	E	M	Q	R	Id	positive pole
heavy, ill–balanced, not easy to move	3	5	5	4	1	1	5	light, made from plastic, not so much tired although long time use
moves about in the pocket with my movement,disturbing,heavy	5	4	4	2	1	1	5	light, easy to carry, I don't have to consider it even if it is in pocket
seems to be expensive, I am strained when using. I will be shocked if I lose it. heavy material	5	5	5	4	2	2	4	plastic, cheap looks, low running–cost, fit to me
center of gravity is bad, the whole consists of uniform weight, the back is heavy, needs extra power and makes me tired.	5	5	5	4	1	1	5	light, I don't have to consider the existence of it, easy to use
thin, hard to grasp, makes me tired	2	5	5	4	2	3	5	moderate thickness, easy to grasp, easy to use
type not usually chosen, I do not choose to use, too loght	1	3	5	2	1	1	5	good balance and weight, accustomed to use, I make this a standard
The wick goes out unstably. The wick is loose. unpleasant	1	4	4	5	3	3	5	the wick goes out steady., drawing out mechanism, stress free

5.3 Cross-analyzing the results

Comparing physiological measures with psychological measures is not an easy task. Psychological measures are mainly qualitative and physiological measures are quantitative, thus difficult to combine. This article presents the use of the RGT as a way of solving this problematic. The Repertory Grid allows for obtaining both quantitative and qualitative measures in psychological explorations. Then the relation between higher levels of comfort in the different tasks and the subjective perception can studied. In table 3 light colored products are the ones with higher levels of comfortableness and dark colored ones are the products that are perceived as closer to the ideal one.

From the results the existing overlap between the two measures in look and play shows that product perception of pens by Japanese participants can be related to the level of comfort in the first look and the manipulation after use from the exploration proces.

Table 3. Relation between higher levels of comfortableness and subjective perception

Look

	1st	2nd	3rd	4th	5th	6th
p1	A	C	E	M	R	Q
p2	Q	M	C	A	R	E
p4	Q	A	R	C	E	M
p5	C	M	Q	A	R	E

Use

	1st	2nd	3rd	4th	5th	6th
p1	R	M	C	E	Q	A
p2	M	R	C	A	Q	E
p4	Q	A	C	M	R	E
p5	M	C	E	R	A	Q

Mani(1)

	1st	2nd	3rd	4th	5th	6th
p1	R	C	E	Q	A	M
p2	E	M	A	R	C	Q
p4	E	M	A	R	Q	C
p5	E	C	M	A	Q	R

Mani(2)

	1st	2nd	3rd	4th	5th	6th
p1	E	A	M	Q	C	R
p2	M	C	A	Q	R	E
p4	C	M	A	Q	E	R
p5	Q	M	C	R	E	A

5. Conclusions

This article shows the first attempts to combine constructivist psychological explorations and Kansei physiological measures to obtain information about the user-product interaction during and after product usage. This article describes a way of addressing subjective judgement without preempting the dimensions of evaluation and at the same time without loosing rigour and a structured analysis.

The pilot test carried out with pens gives an idea about the potential of using the RGT quantitative results as a bridge for linking qualitative data from the interviews with quantitative data from the

comfort measures. Precisely, the quantitative data form the RGT allows for classifying and comparing qualitative information from different participants and at the same time correlate its values with other measurements like the comfort level. This opens the possibility to track the evolution of the comfortableness level in relation to the movements, actions and tasks done while interacting with the product (analyzing frequency fluctuation together with the video tracking different actions and behaviors with the comfort measures). It also shows the possibility of rating and clustering the subjective information obtained from the RG (weakness analysis) in order to define which characteristics are related and which of the senses that take part of it.

Acknowledgements

References

Cowie, R., Douglas-Cowie, E., Savvidou, S., McMahon, E., Sawey, M., & Schröder, M. "`FEELTRACE': An Instrument for Recording Perceived Emotion in Real Time", ISCA Workshop on Speech & Emotion, Northern Ireland, 2000, pp. 19-24.

Desmet, P.M.A., "Measuring emotion; development and application of an instrument to measure emotional responses to products". In: M.A. Blythe, A.F. Monk, K. Overbeeke, & P.C. Wright (Eds.), "Funology: from usability to enjoyment" Kluwer Academic Publishers Dordrecht, 2003, pp. 111-123.

Harada, A. "On the definition of Kansei", In Modeling the Evaluation Structure of Kansei Conf., 1998, vol. 2.

Zhang, J., Lei, S., Harada, A., Yamanaka, T., "Driver's comfortableness and vehicle's characteristics in linear movement", KANSEI Eng. Int. Journal, 2006, vol. 6 No.2, pp.51-60.

Kelly, G.A. "The psychology of personal constructs", Routledge London, 1955, vol. 1 & 2.

Kirakowski, J. & Corbett, M. "SUMI - The Software Usability Measurement Inventory". British Journal of Educational Technology, Vol. 24, No. 3, 1993, pp. 210-212.

Yoshida, T., "An evaluation-model for 'KAITEKISEI' by using frequency-rhythm of EEGs", Japanese Psychological Review (2002) Vol. 45, No.1, 38-56

Nagamachi, M., "Kansei engineering as a powerful consumer-oriented technology for product development". Applied Ergonomics, vol. 33 No 3, pp. 289-294.

Pifarré, M. Tomico, O. "Bipolar Laddering (BLA): a Participatory Subjective Exploration Method on User Experience". DUX conference,Chicago, 2007.

Sanders, E. "A New Design Space", ICSID News: Special Congress Edition, October-December (2001).

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