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# About the nature of Kansei information

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## ABSTRACT

Kansei studies refer to the more and more holistic consideration of the cognitive and affective processes which occur during user experience. In addition, few studies deal with the experience of the designers during the design process, and its influence on the final design outputs. Historically kansei engineering has been firstly focused on the semantic differential approach. Afterwards emotions were integrated into kansei approaches. The semantic differential approach enabled to evaluate products and then to generate automatically design solutions with semantic input data. Thereafter, evaluations have been completed by physiological measurements in order to reduce the subjectivity involved in those evaluations and also to capture some unconscious reactions. This implementation is still in process. Today kansei studies have been much enriched from the three disciplines of design science, psychology and artificial intelligence. The cross influence between these disciplines brought new dimensions into kansei approaches (multisensory design information, personality, values, and culture, new formalisms and algorithms) which lead progressively towards the consideration of a whole enriched kansei experience. We propose in this paper a description of the nature of kansei information. Then we present some major orientations for kansei evaluation. Finally we propose an overall table gathering information about kansei dimensions and formats.

**Keywords:** Kansei information, Measure of emotions, Kansei formats

## INTRODUCTION

During this last decade, user centred design has been much developed at a worldwide scale. More recently, new methods and tools have been established in the discipline of design science, which put emphasis on the emotional impact of product experience. Related dimensions such as semantics, sensory dimensions or brand values are often associated to emotions in the framework of these methods because they are the most impacting. In the light of this, the fields of emotional design and of emotional engineering are intensively spreading out in the communities of design science, psychology and artificial intelligence.

Nowadays, product design turns to be more considered as experience design. While product design was very much focused on the product, experience design considers the whole experience and the temporal sequence of the human-product interaction in real time. As emotions are considered as a main dimension of this experience, emotion-driven creativity, and at the same time emotional measurements, are more and more used in design methods. Behind usability, the analysis of the emotional reactions helps in the understanding of product experience. Even if the designers are themselves conscious of the importance of the emotional dimension in their work, this dimension is however still not well integrated in standard design methods. Kansei Engineering and Emotional Design, are such approaches which enable to integrate these dimensions.

In this paper, we will first describe the early design process, and the related design information, and then we will present some methods for measuring emotions in early design, with in a second time the description of some

methods we elaborated for the designers in a wide sense, including designers, engineers, and ergonomists. Some experiments will be taken as examples, which enabled to validate the relevance of these methods in an industrial context.

## **THEORETICAL BACKGROUND**

### **Emotional design**

The concept of Emotional Design was initially and principally disseminated worldwide in the community of design science by Donald Norman (Norman, 2004), Green and Jordan (Green & Jordan, 2002), and through the conference Design and emotion (Overbeeke & al, 1999). This research orientation is currently developing currently in several disciplines. It develops the topic of the integration of emotions not only in the field of design science but also in those of psychology, marketing, ergonomics and artificial intelligence. Lately, this current has been consolidated through establishing the Designing Pleasurable Products and Interaction two year conference (DPPI). Related research focus broadly on the theme of emotional evaluation in design and design science, in order to constitute input data for the generation of new design solutions. On the base of the semantic differential, many studies have been led in Europe (Osgood, 1969, Smets & al, 1995, Overbeeke & al, 1999, 2000, Van Dijk, 2004, Battarbee & al, 2002, Schütte, 2002, Desmet, 1999, 2000). These studies implement semantic analysis in order to measure the semantics of design stimuli by using the meaning of words. The semantic differential is a method which proved to be very useful in the field of design. This method involves Lickert scales which enable to position perception stimuli between two opposite or antonym adjectives. Nowadays, semantic and emotional evaluations tend to integrate explicitly the cognitive and physiological analysis of emotions in addition to des semantic analysis.

### **Kansei engineering**

The technology of kansei Engineering is born at the University of Hiroshima in the seventies. They were initially developed in an experimental way by Mitsuo Nagamachi (Nagamashi, 2002, Schütte, 2002, Bouchard, 2005), after which they have been disseminated and applied in industry. Kansei engineering is used in order to determine which emotions are elicited by particular subjective responses by the products' end users. This methodology enables to develop some products by means of attributes which will provoke the expected emotions. Evaluation results are then integrated in the kansei engineering process in a pro-active way. As many approaches have already been formalised according to the semantic analysis in the framework of Kansei Engineering systems, (Jindo, 1995, Ishihara, 1997, Tanoue, 1997, Yang, 1999, Hsu, 200, Chuang, 2001, Suh, 2001) some authors ont par la suite suggéré de compléter ces mesures cognitives par des mesures physiologiques et comportementales des émotions (Lee, Harada, Yamanaka). Kansei engineering follows three main steps: data gathering, rules elaboration and rules implementation. Data gathering establishes first the main groups of data which are necessary for the system to work. Those can be keywords including semantic descriptors, product descriptors or representations. The elaboration of rules will be then achieved by applying semantic or emotional measurements, mainly through Lickert scales. The statistical data processing enables then to go towards some algorithms which make it possible to automate partially these rules. Kansei engineering has been disseminated lately through the conference Kansei Engineering and Emotion Research (KEER) which has been enlarged since 2010 out of Asia in Europe.

### **Kansei information**

Design information is very specific in the way that its integration and transformation involves affective processes. Kansei is a complex informational process carried out by a designer or a consumer who perceives a design stimulus. Kansei is a Japanese word which covers multi-dimensional meanings such as feeling, emotion, semantics, affectivity, feelings (Nagamashi, 2002). It can be seen as a function which processes information which is by nature analogical and fuzzy, Kansei also refers to the nature of the relations that the designers are used to establish between various levels of abstraction of information. It involves both cognitive and affective processes which are already involved when designers integrate information. Its content can be classified into information called high-level information, middle-level information and low-level information, according to a terminology on loan from artificial intelligence which defines the levels of abstraction of the information (Black, 2003). We retained this definition which is relevant in our case because it reveals well the skills of the designers and it covers the whole information

levels the designers deal with. Indeed the levels here go from very abstract values such as purity to concrete attributes such as the white color. Low-level information encompasses characteristics of shape, color and texture. Middle-level information includes concepts and artifact names. High-level information is translated at the same time by semantic descriptors, sociological values and affective and emotional dimensions, which leads us to the definition of kansei. This emotional dimension is a major one in those which are perceived and processed by the designers. They cover 46% of the whole information integrated and processed by the designers, the other dimensions being style, technology, user and aesthetics. We emphasized the variety of types of information which are behind the term of kansei. This information is non-homogeneous and this is a difficulty when trying to formalize the process. Kansei refers as well as the content of information as the expert relations that can be built by the designers between these various corpus of data involved into the design process. Designers' skills mainly lie in mastering the whole set of data categories working, and above all in the ability to link them together in an intuitive way. The core expertise of designers comes from their ability to link high-level information with low-level attributes and vice-versa. In particular, a main part of the expert rules involved of association, categorization, or generation carried-out by the designers, consists in linking low-level information with low-level information and to use various levels of abstraction at the same time. Kansei rules are brought into play in a quasi-continuous way in order to mentally or explicitly categorize design information. They are subtly crossed with other rules applying to the contribution of harmonies intra- or inter-levels which provoke positive emotional reactions. They are conjointly supported by analogical reasoning which will also contribute to provoke some feelings in the presence of more or less evident metaphors.

Kansei information refers to a complex system between human and artifact. Kansei information calls for heterogeneous forms of data. Indeed, if we step back from the methods and concentrate on the nature of information, we can recognize this information may encompass various dimensions under a variety of formats. Qualitative data are naturally involved in the design process by the designers from generative tasks. Quantitative data are mainly involved in design research or sometimes in design contexts in the evaluative part of design. In the context of early design, the kansei information system may include a set of dimensions such as color, shape, texture, sound, smell, which can be expressed or conveyed in the generative phase of design through different formats such as sample pallets, multi-sensory compositions, keyword's sets, mood boards, sketches and prototypes. In addition, kansei information may be conveyed in the evaluation phase through quantitative data, coming from physiological measures or from differential scales with keywords or labels used in order to grasp the user state in front when experiencing specific static or dynamic design stimuli. To summarize, the main formats through which kansei data are potentially expressed are threefold (see table 3):

- Qualitative data (categories of words from various categories: brand or human values, semantics, sensory characteristics, emotions, styles, design elements, product sectors, multisensory design elements such as shape, color, texture, sounds, smells, and behavior).
- Quantitative data from differential scales associated to keywords (emotions, semantics, sensory, values, familiarity, numbers or icons, or from design elements digitization and description (global and local descriptors of shape and color),
- Quantitative data used in direct quantitative user measures (galvanic skin response, brainwaves...).

## **MEASURING EMOTIONS IN EARLY DESIGN**

The measure of emotions in design provides a way of interpreting the effect of style, of sensory dimensions, and of semantics. More subtle dimensions such as the adequacy of a style or semantics or sensory properties to human values can also be extracted from emotional measures. On the Japanese side emotional measurements, which were initially based on questionnaires and the semantic differential of Osgood, tended progressively to integrate physiological measurements in order to bring more objectivity and real time information for the interpretation of the emotional measurements. This trend is now developing in Europe where, historically, the measure of emotions in design started also on the base of the semantic differential. In our research group, we progressively developed some methods and tools which enable some physiological measurements through an integrated platform. Today we are still implementing this platform and developing methods including physiological and behavioral measurements.

Both physiological and behavioral measures will still be massively incorporated in the future in the field of design science. It is only through a cross approach between cognitive, physiological and behavioral measurements that we can extract robust and relevant information. In the context of design, we experienced most of the time secondary emotions instead of primary emotions which are very intensive ones and do not necessarily occur in experiencing design, both as designer or as user.

### Cognitive measure of emotions

The cognitive measure of emotions relies on carrying out and using questionnaires. The cognitive measure based on the semantic differential was largely used in design and emotional engineering. Lately, it has been proved to be relevant to add the sensory and emotional dimensions, while using the same Lickert scales. The only difference is, it is more appropriate to use mono-dimensional scales in the case of the emotional dimension, and antonyms for the sensory and semantic ones. This way, design representations can be assessed by using scales for evaluating some design elements with keywords, or/and fix or dynamic icons representing emotions. The keywords used are coming from more or less relevant and complete lists of emotion words which must be systematically reduced depending on the specific context of the experience. Some icons representing emotions can also be used but they turn to be more or less valid, depending on the way they are represented and also on the cultural differences of the assessers. A good compromise is the use of the list of Geneva University (Scherer, 1986) which includes about 100 emotion words translated in 5 languages. We used this list initially in the framework of the elaboration of an evaluation tool for early design. To get precise results, these emotion words must be completed by the Lang scales. The SAM (Self Assessment Manikin), created by Lang (Lang, 1993, 1997) is an illustrated questionnaire to measure intensity, valence, and dominance. The intensity corresponds to the amplitude of the emotional response. The valence is more related to a positive or negative polarity. The dominance for its part concerns the persistence in the time of the emotional reaction. Lang scales have been validated for a long time ago in the field of psychology, mainly first in medical contexts. A combination of emotion words and Lang's icons gives efficient results. Those are then analyzed through statistical approaches. We validated this method in various contexts and through several different industrial case studies.

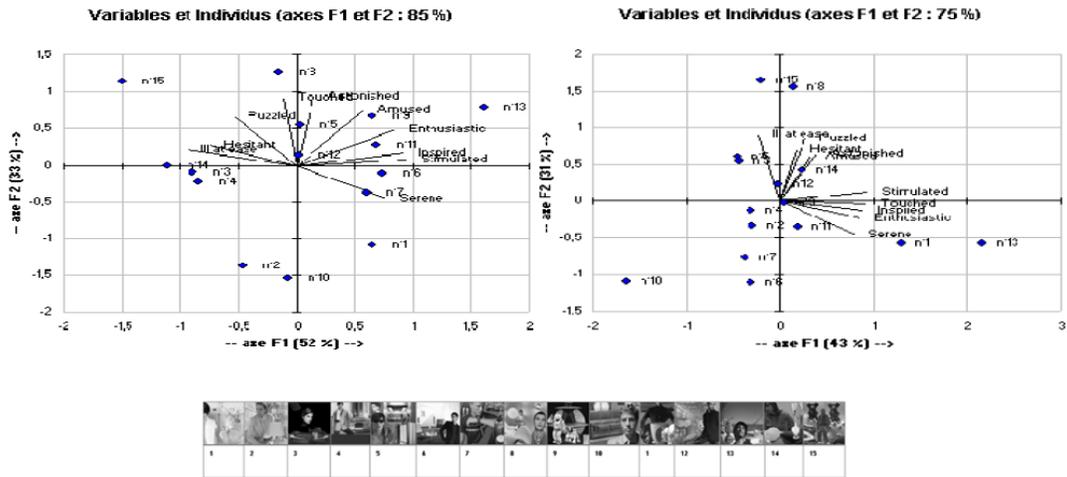


Figure 1. Semantic and emotional evaluation of moodboards (Bouchard & al, 2009)

We obtained efficient results so that this method can be considered as generic (Mantelet, 2006, Bouchard & al, 2009) (see figure 1). Some recent studies introduced in addition the notion of familiarity through which an artefact might be characterized (Sanabria & al, 2012). Indeed, in particular cases such as for the emotion of surprise, the emotional dimension alone does not necessarily provide enough information for further interpretation and

exploitation. Even if the cognitive approach is simple, quick and ecological enough in terms of resources and means, some questions have been raised. The limit of the cognitive evaluation of emotions comes from the subjectivity which occurs during the evaluation and the interpretation of the assessor. Moreover, this measurement is not continuous and does not provide a real time feedback. Furthermore the use of emotional scales with a long list of emotion words can cause a certain fatigue by the respondents. Besides, some of them have difficulty for expressing their feelings because they are not always conscious of those (Poels, Dewitte, 2006). In order to overcome the limits linked to the cognitive measure of emotional reactions, some recent studies were initiated in the field of Kansei Engineering in order to complete these measures with other physiological ones such as electromyography (EMG), skin conductance (GSR), heart frequency, electroencephalography (EEG), etc, as explained in the following paragraph.

## Physiological measure of emotions

The measure of emotions can also be done by using devices which enable to record physiological changes by the human beings and provide quantitative feed-back information. Most of these devices were initially used in the medical field. Now they tend to be progressively transferred into the field of design science. This democratization is accompanied by less intrusive devices and the increasing introduction of low cost materials. The advantage of physiological measurements is that, oppositely to the case of cognitive measurements, recording is done in real time and quantitative objective data can be extracted automatically. This enables to get very emerging information about cognitive and affective processes in design. Indeed the measures based on physiological devices and which are manipulated carefully enable a deeper understanding of unconscious emotional processes (Tran & al., 2003, Kim 2011). Consequently, we suggest that physiological measurements are essential to detect emotional reactions of design stimuli and to identify a correlation between cognitive measures and physiological ones. Criteria to determine physiological detectors may be the non-obstruction, the ability to interpret signals and above all a big reliability. As it is difficult to catch objectively an emotional state which involves secondary emotions, we use most of the time these devices in combination with the questionnaires which have been described in the previous paragraph. In order to do this, it is necessary to record the time for the automatic entry and filling-up of the questionnaire, in order to be able to apply some correlations between physiological data and those of the questionnaire. Even if it is possible to get robust cross results, there still exist some drawbacks by using these technologies. Indeed physiological measures can be intrusive, uncomfortable, obstructive and heavy with the risk to reduce the mobility, so to interfere against the natural activity process of the test takers and finally to influence results (Gaglbauer & al. 2009; Tran & al, 2007). Some potential drawbacks are also the costs for some of these devices and the lack of portability and of consistency due to the environment variations. Comfort and natural activity are potentially altered, and sweating problems can occur. Because all of these reasons, the results of any evaluation must be taken carefully in order to avoid the eventuality of biased interpretation. There is a wide range of ways of measuring the physiological changes in relation with emotions. We can notice some every devices focused on skin conductance, temperature (of skin, of body), electric activity of hearth (ECG), brain activity (EEG), muscles moves (EMG), blood pressure, heart rate and finally the magnetic resonance (FMRI).

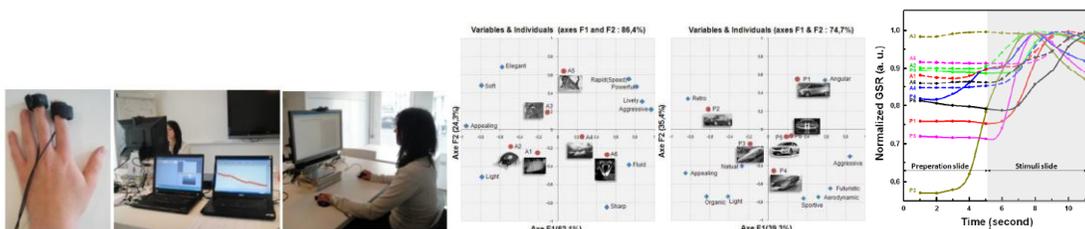


Figure 2: Physiological measuring system instruments and results ACP + GSR (Kim & al, 2010)

According to our experience, one of the most appropriate physiological measurements in design is the analysis of the electro-dermal activity (GSR) (see figures 2 and 3). We experimented this kind of measures in various contexts, such as evaluating the experience of visualizing inspirational images, evaluation of the early design activity of the

designers when visualizing traditional or immersive mood-boards (Rieuf, 2013), or when producing traditional (Kim, 2011) or immersive sketches (Rieuf, 2013), evaluating the experience of users when manipulating a software with gesture controls (Blanchy, 2013). In all of these contexts, we noticed some congruence with the results coming from the questionnaires. This indicates that GSR is a good means to evaluate the experience in all of these contexts. To complete this, it is likely that an optimal measure of emotions should also integrate behavioral measures such as the tracking of eyes movement, gaze, body movement, postures, gesture, and facial expressions, as explained in the next part.

## Behavioral measure of emotions

The measure of emotions can finally be done by using observation, recording and indexing behavioral changes. These measurements can be achieved by audio-video recording and information coding, or by the direct tracking of movement, posture, gesture with a more or less automatic information processing. The main types of behavioral markers are facial expressions, postures, pupil size, gaze direction and saccades. Prosody and verbal expression can also be considered in this part. Broadly, depending on the context, it is necessary to explore which type of markers will be the most appropriate. For instance, eyes movements and face expression can be combined with physiological measurements. This way, it is possible to depict precisely which visual stimulus will provoke which emotional effect. Facial expressions are involved when eliciting intensive emotion. We did observations during the early design activity of designers and more precisely during the creative phase of sketching. This phase is by essence hedonic and emotional. Facial expressions were not clearly a marker of the emotional activity in this context where the emotions, even if they exist, are not intense enough to get a clear effect on face expression. However, we stated the usefulness of onomatopoeia to complete the interpretation of video information in this specific context. In another study, we observed the relation between emotions and postures when using gesture commanded interfaces. The tracking of eye movements, when analyzing results such as the number and the length of fixations, the size of pupils, the frequency and the length of eyes blinking, is very rich, providing at the same time physiological and behavioral information. But as in the case of facial expressions, the intensity of emotions must be high in order to be able to apply the pupil size measure and to extract relevant results. For instance, we did some experiments with people visualizing and/or touching some textural 3D information, and we did not notice any exploitable result in terms of emotions felt. Brainwaves have already been applied with satisfying results in the context of people visualizing art paintings in museums. High frequency brainwaves tactile experience increases neural reactions.

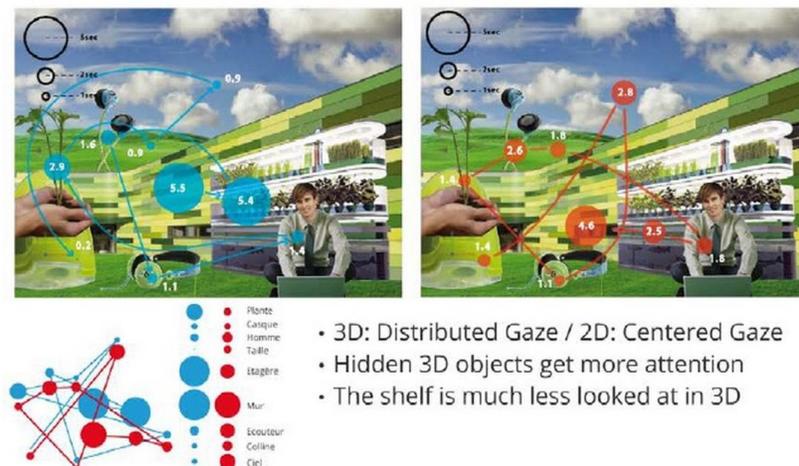


Figure 3: Distributed gaze in front of immersive moodboards (Rieuf, 2013)

## KANSEI DIMENSIONS AND FORMATS

Kansei vocabulary provides valuable formats because it makes possible to communicate every kansei dimensions, which are very heterogeneous when considering the various formats they are composed of. Moreover, kansei vocabulary it is such a language which is daily used by the designers. It is also well adapted to the early design phases, the generative and the evaluative ones. But even if kansei vocabulary is a format which helps to precise every dimensions of kansei, the limits of this format lie in the subjectivity they involve, and also the dependency to the context, and the necessary consciousness of the users to express it. Kansei formalisms, on the other side, must involve formats that are possible to implement with algorithms. Consequently, two formalisms which enable to formalize kansei design information into a lexical format are explored: ontologies and bag-of-words. Finally we propose a format which may be implemented by a hybrid technology.

<b><i>Kansei information</i></b>	<b><i>Dimensions</i></b>	<b><i>Formats</i></b>
<b><i>Qualitative data related to product design</i></b>	Color	<i>Keywords Sample Pallets Multi-sensory compositions Mood boards Sketches Prototypes</i>
	Shape	
	Texture	
	Sound	
	Smell	
<b><i>Discrete quantitative measures related to user cognitive appreciation through product perception</i></b>	Emotions	<i>Keywords Icons Numerical values from Lickert scales</i>
	Semantics	
	Sensory	
	Values	
	Familiarity	<i>Numerical values from region, contour, 3D descriptors</i>
	Shape descriptors	
	Color descriptors	
	Texture descriptors	
<b><i>Continuous quantitative measures related to user emotional response</i></b>	Galvanic skin conductance	<i>Numerical values from electro-dermal activity</i>
	Brainwaves	<i>Numerical values from cerebral activity frequency</i>
	Posture	<i>Numerical values from momentum</i>
	Gesture	
	Facial expression	
<b><i>Relations</i></b>	Inter-dimensions rules	<i>PCA, FA, ANOVA, MDS Algorithms (GA, NN, FS, RS, ...)</i>

Table 1: Kansei dimensions and formats

In this table we gathered all information related to kansei possibly found in early design. This goes from the design dimensions under the shape of keywords, pallets, moodboards, multi-sensory compositions, sketches and prototypes, which are linked to abstract dimensions such as semantics, values. This abstract information may be used in the generative phase not necessarily into visible formats, and they also are used for cognitive measurements. Finally, some other dimensions such as physiological changes observed by human beings may be measured through digital devices.

## CONCLUSIONS

Kansei information is naturally involved into design process. It may take various forms depending on the different phases of design activity. Recently there is a high interest in all of these dimensions because they have become crucial for innovation and differentiation. These dimensions can be used in a reciprocal way, for generation and for evaluation. Even if they are still used by the researchers more in evaluation methods, they tend now to be explicitly used by the designers in a more formalized way. Both approaches are important for design optimization.

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