Définition et représentation d'intentions liées à l'expérience d'utilisation en phase amont du processus de conception de produit

Alexandre Gentner

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Alexandre GENTNER

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Definition and representation of user experience intentions in the early phase of the industrial design process: a focus on the kansei process

Directeur de thèse : **Carole BOUCHARD**
Co-encadrement de la thèse : **Jean-François OHMOVER**

Jury

M. Toshimasa YAMANAKA, Professeur, Faculty of Arts and Design, Tsukuba University	Président & Rapporteur
M. Jean-Bernard MARTENS, Professeur, Department of Industrial Design, TU Eindhoven	Rapporteur
Mme. Shirley COLEMAN, Technical Director, ISRU, Newcastle University	Examinateur
Mme. Carole BOUCHARD, Professeur, LCPI, Arts et Métiers ParisTech	Examinateur
M. Jean-François OMHOVER, Maître de Conférence, LCPI, Arts et Métiers ParisTech	Examinateur
Mme. Carole FAVART, General Manager, Kansei Design, Toyota Motor Europe	Invité
M. Daniel ESQUIVEL, Senior Kansei Engineer, Kansei Design, Toyota Motor Europe	Invité

T H È S E

Arts et Métiers ParisTech - Centre de Paris
Laboratoire Conception de Produits et Innovation

DEFINITION AND REPRESENTATION OF USER EXPERIENCE INTENTIONS IN THE EARLY PHASE OF THE INDUSTRIAL DESIGN PROCESS: A FOCUS ON THE KANSEI PROCESS

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GLOSSARY

Below are short definitions of some of the key notions used in this dissertation. They explain the way these notions are to be understood in the following pages.

KANSEI PROCESS OF A USER:
Affective-centred mental process occurring during an interaction between a user and a product. It results from sensory perception and covers the notions of sensitivity, sensibility, feeling (more details about this notion in section 2.2.1 [p. 35]).

USER EXPERIENCE:
Subjective and affective outcome of a situation in which a user interacts with a product or service in a defined environment and over a defined period of time (more details about this notion in section 2.2.2.3 [p. 41]).

DESIGN TEAM:
Group of individuals involved in the same design development project. They usually cover complementary functions. The three main ones are engineering, (styling) design, and business. (more details about this notion in section 2.3.4 [p. 61]).

CONCEPT:
Embodiment of an idea that could contribute to a development project. In this dissertation, the concepts discussed will describe intentions related to future products' physical and interactive attributes and to the way they could impact their users' kansei process (when perceiving and/or using them).

DESIGN INFORMATION:
Information regarding concepts discussed among a design team (more details about this notion in section 2.4.3 [p. 73]).

EARLY REPRESENTATION:
Sensory construction that expresses design information in the early stages of the design process (more details about this notion in section 0 [p. 73]).

KANSEI REPRESENTATION:
Early representation focused on intended users' experience with the product and their kansei process.

CULTURE:
One's culture corresponds to his/her age, gender, nationality, function, and organisational affiliation. In this dissertation, the notion of culture can therefore be assimilated to "demographics".

LIST OF ACRONYMS

UX: **USER EXPERIENCE**

KQ: **KANSEI QUALITY**

PC: **PERSONAL CHARACTERISTICS**

AE: **ATTRIBUTES OF THE ENVIRONMENT**

NCD: **NEW CONCEPT DEVELOPMENT**

NPD: **NEW PRODUCT DEVELOPMENT**

SYNOPSIS

In the industrial context, users' experience with products recently became a major differentiation factor between competitors and can greatly influence the success of a product. In parallel, the interest from the design research community about this topic is also growing.

This research intends to contribute to both contexts by investigating the definition and representation of user experience intentions in the early phase of the industrial design context. When defining the theoretical background of this research a link will be created between the complementary notions of user experience and kansei process. Based on this original field of study, this dissertation will discuss design activities undertaken by design teams in order to nourish the much wider industrial design process. It will be observed that even though experience-centred tools and methodologies supporting design-activities do exist, the uptake of experience-centred approaches in the industrial design process have only been poorly studied.

With the five experiments that will be presented in this dissertation, I will explore the creation of tools and methodologies centred on potential users' kansei process and supporting the creation of intentions related to the user experience of products to be designed. I will also investigate how the nature of the resulting early representations can impact reciprocal understanding within multi-cultural design teams and finally how the developed approach (Kansei Design approach) can impact different types of new concept development projects. In each of five experiments, the multi-cultural dimension related to potential users and design teams will be a major topic of discussion.

Finally, this research led to both academic and industrial contributions. In terms of the former, it enabled the exchange of kansei-related design information among design teams and highlighted the reciprocal understanding and kansei qualities of multi-sensory early representations resulting from experience-centred design activities. Regarding the latter type of contribution, the different experiments made it possible to characterise the Kansei Design approach in terms of tools, methodologies, and early representations. Moreover a link was established between the different characteristics of this approach and three types of new concept development projects aiming respectively to impact the development of new breakthrough, platform, and incremental products.

1 CONTEXT OF THIS RESEARCH

1.1 INTRODUCTION

This Ph.D. research has been made as part of a long-standing collaboration between the Kansei design division of Toyota Motor Europe (TME-KD) and the "Laboratoire Conception de Produits et Innovation" (translated as "New Product Design and Innovation Laboratory") of Arts&Métiers ParisTech. The collaboration started in 2005 with a first Master's student hosted by TME-KD for his final research project. Since then, a total of seven Master's students participated in this collaboration. An eighth project is now on-going during the academic year 2013-2014. This work represents the first Ph.D.-level research. It focuses on the integration of user experience considerations in the early phases of the industrial design process of a product. Tools and methodologies related to a new approach will be presented. In the next sections, the industrial and academic context of this research will be presented.

1.2 INDUSTRIAL CONTEXT

1.2.1 TOYOTA MOTOR CORPORATION (TMC) AND TOYOTA MOTOR EUROPE (TME)

Founded in 1937 as a spinoff from Toyota Industries, Toyota Motor Corporation today belongs among the top car manufacturing companies in terms of car production, turnover and innovation according to data available and ranking from analysts. It sells cars under the following brand names: Toyota, Lexus, Scion, Daihatsu and Hino trucks. The company is famous for its outstanding production system, also known as "lean manufacturing." Even if it is focused on efficiency, it has the particularity to treat all employees as key contributors to continually improve production processes. This has been a source of competitive advantage for Toyota for many years. The company was for instance the first to apply principles such as "just in time," "kaizen" and "kanban." Toyota's production system has been extensively studied by academics and competitors since the mid-1980s. Production nevertheless accounts for only half of the manufacturing process, and according to Ballé and Ballé (2005) "Toyota's product development process is just as innovative and counter-intuitive to traditional engineering management as lean manufacturing is to mass production" (p. 18).

The product development process is actually more closely related to the context of this research than the production process. Some of its specificities will be detailed in this section. In order not to divulge any confidential information, I will base my explanation on the one by Ballé and Ballé (2005). According to them, Toyota's development process can take half the time and utilise a quarter of the human resources (150 instead of 600 product engineers) of one of its American competitors. They also detailed four key factors and four key activities of Toyota's car development process.

The four key factors that are targeted in every development process are as follows:

- Toyota wants its engineers to care about customers' expectations. In order to do so, a strong engineering vision is created and shared within the development team. This approach can be labelled "lean development."
- Toyota intends to solve key issues in upfront phases of the development process and thereby limit late engineering changes.
- Toyota focuses on mastering the flow of drawings and tool elaboration. Reaching the target detailed in point 2 (key issues solved upfront) helps to achieve this point.
- Drawing on its expertise in lean manufacturing, Toyota takes into consideration production quality and cost at early development stages.

Ballé and Ballé (2005) also described four key activities of the Toyota development process that enable the brand to reach the aforementioned targets (see also Figure 1.1).

- *A concept phase leading to the chief engineer's (CE) "concept paper."* The CE is a "heavy-weight project manager" that broadly coordinates a vehicle development project from concept to market (Clark & Fujimoto, 1991). The "concept paper" corresponds to his vision for the car and includes notions related to the car's intentional package (styling, engineering and production related) and market (sales related). Once the "concept paper" is fixed, the role of the CE is to prevent the development process from deviating from the original concept. Nowadays, very little information related to intended experiences are included in the concept paper or even discussed at this early stage. An objective of this research is to improve the definition of intentions and increase reciprocal understanding related to user experience within the development teams at this stage of the design process.
- *A system-designed phase with concurrent engineering.* Obsession with early problem solving and "obeya" (big project room with constant representatives from every department during early development phases) are part of the reason why Toyota is described as being better at concurrent engineering than its competitors.
- *A detailed design phase with design standards.* According to the authors, the high level of standardisation (e.g., tools such as checklists, standardised process sheets or common construction sections) serves to eliminate waste and the need to rework, and paradoxically opens the way for capacity flexibility.
- *A prototype and tooling phase with lean manufacturing.* Two series of prototypes are developed. The early phase is "open" and exploratory. The concept of the vehicle emerges from this stage. It then narrows down rapidly to a very tightly planned detailed drawing phase, which operates according to lean manufacturing principles.

Other aspects of the Toyota development process mentioned by the author are the platform centres, which appeared in the early 1990s to reduce the complexity of the organisational structure and increase transfers between similar vehicle projects, and lean practices that can be found throughout the development process (e.g., "genchi genbutsu" standing for "go and see for yourself").

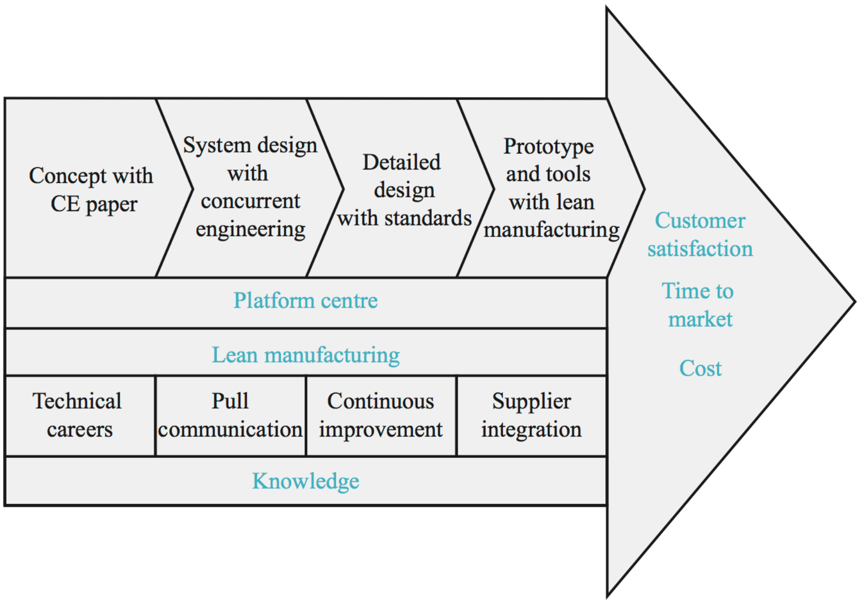


Figure 1.1: Toyota's lean development process (Ballé & Ballé, 2005)

Outside of Japan, Toyota has opened regional headquarters including research and development centres in the USA, South-East Asia, and Europe (Figure 1.2). In Europe, the Toyota Motor Europe (TME) research and development centre opened in 1987 in Zaventem (Belgium) and is located a few kilometres away from the European Headquarters, centralising European management and marketing activities. The European R&D centre works like a local antenna and is responsible for the vehicles released in Europe and for the manufacturing of vehicles produced in Europe. In its 27,000 m^2 facilities more than 650 employees, mostly coming from European countries and Japan, work for different divisions with missions mainly related to engineering-focused research and development (e.g., engine, electronics, chassis, evaluation) and purchasing.

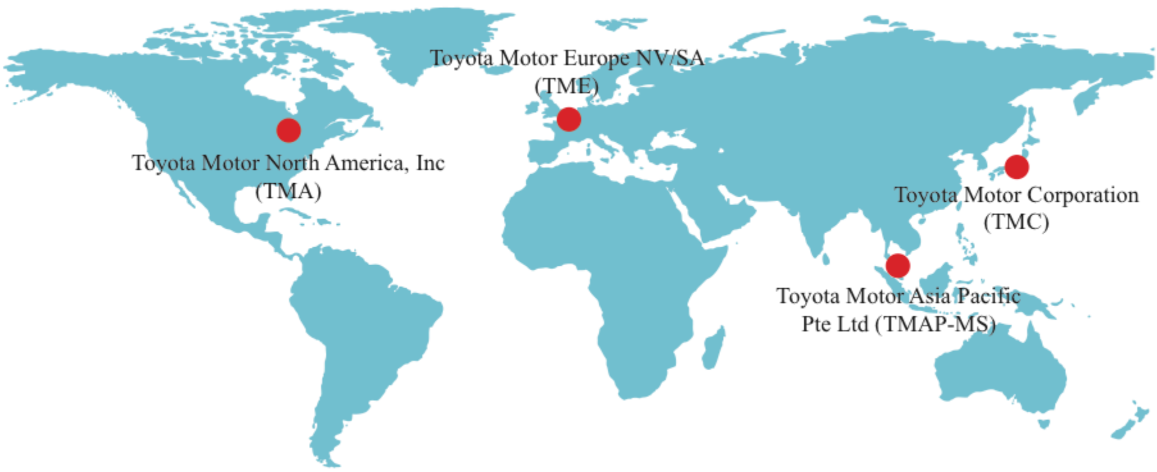


Figure 1.2: Toyota R&D in the world

1.2.2 TOYOTA MOTOR EUROPE - KANSEI DESIGN

This research was conducted in the Toyota Motor Europe's Kansei design division (TME-KD), which is part of the European R&D centre presented above. As mentioned is the glossary (see p. 9), "kansei" is a Japanese word that stands for people's affective-centred processes generation following sensory perception. It encompasses notions such as emotions, feelings, and impressions. It will be further detailed in section 2.2.1 (p. 35). The team has the particularity of being the only division with no head-division in Japan. It is also quite young (approach initiated in 2003 and division created in 2006) and relatively small (5 core members and around 7 non-permanent members). It focuses on the kansei and subjective aspects (mainly not rational and logical aspects) of consumers' perception. From that perspective it participates in research and development activities related to future vehicles and to mobility in general. TME-KD's approach and the fields tackled have evolved together with the maturation of the division (Figure 1.3).

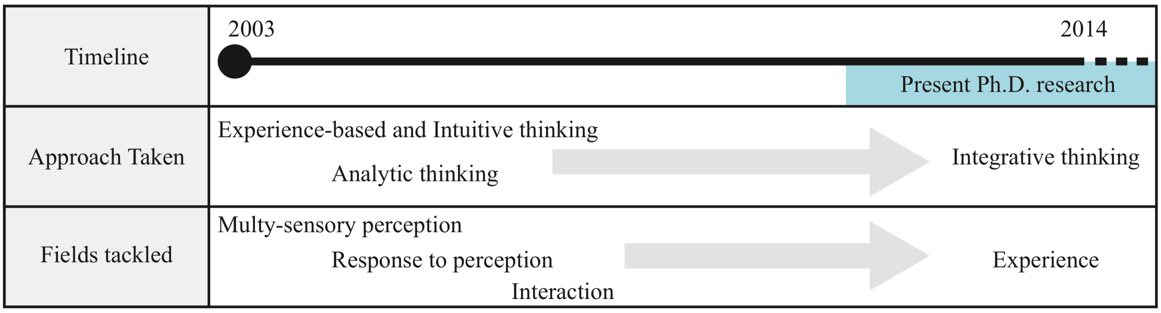


Figure 1.3: TME-Kansei Design over time

The approach initially followed a styling designer orientated approach (i.e. based on experience and intuition and on abductive reasoning) focused on the multi-sensory qualities of a car and its overall consistency (e.g., materials and colour). It rapidly integrated a complementary quantitative point-of-view based on a more scientific reasoning (i.e. analytical approach). The start of the collaboration with the CPI laboratory played a major role in this evolution. It also permitted better study of the response to perception (i.e. associated meaning, emotions) of potential users and thereby made it possible to better guide design directions. Both are now being combined in a set of integrative tools and methodologies. This Ph.D. research substantially contributed to establishing this approach inside (use in development projects) and outside (publications) the company.

With time, interaction also became an additional field of study. Recently, the notion of "experience" gained importance. It is now almost exclusively used when describing TME-KD's concerns and field of study. Indeed, this notion encompasses the previous fields mentioned (i.e. perception, response to perception, interaction) while staying focused on the user's affective-centred mental process. Additional explanations about experience and experience design will be found in section 2.2.2 (p. 37). As a whole, it is now referred to as the "Kansei Design" approach (integrative thinking and focusing on experience).

This Ph.D. research and the different activities conducted during my stay at TME-KD played a major role in the recent evolutions regarding the thinking used and the fields tackled by the division. This research also contributed to establish the structure of TME-KD research and pre-development activities. In that sense, this dissertation will highlight the main theoretical (i.e. framework, model) and some of the practical characteristics (i.e. tools, methodologies) of the "Kansei Design" approach. Without communicating confidential information related to on-going vehicle development projects, it will explain how the approach can be applied to the early phase of industrial development projects (i.e. tools, methodologies leading to early representations) and will give hints about how the approach contributes to down-stream design activities.

TME-KD's current activities impact the vehicle development process at different stages. In upstream phases experience-focused concepts are investigated. In later stages TME-KD is involved in the design development of specific vehicle parts and materials impacting the resulting user experience, as well as in the evaluation of perceived kansei qualities of the full vehicle under development. Most of these activities imply collaborative activities with other TME and TMC departments, suppliers and/or external partners. The cross-functional importance of such considerations was acknowledged by top-management and led to the recent creation (end of 2012) of the "Kansei Competency Centre" (KCC). It consists in a collaboration platform permitting the stakeholders of R&D projects to collaborate more easily on kansei-related topics and to communicate about them to Toyota headquarters with a unique European voice. Even though it does not much change the nature of the collaborative activities that were already in place, this structure enhances the visibility and acknowledges the utility of kansei-related collaborations between product planning, style design, and engineering departments.

As mentioned earlier and as indicated in the title, the focus of this research is the upstream phases of the development process. This means the research is related to experience-focused concepts. These concepts represent experience-directions that might influence different types of future development projects. Three contexts for these early representations of user experience can be distinguished: "exploratory concept" (propose new experience concepts for future *breakthrough products*), "product lining strategy" (identify user experience logics and directions for future *platform products*) and "pre-development direction" (prepare grade and character strategies for future *incremental products*). They will be further described in the fifth experiment of this dissertation (p. 142). During the three years I spent with the Kansei Design division and in parallel of my Ph.D. research activities, I had the chance to participate to many projects related to each of the three contexts. My role could be leader or support for "exploratory concept" and "product lining strategy" projects and mainly support for "pre-development direction" projects.

As part of the context presentation, I will present an example of "exploratory concept": the "Window to the world" project. It was created in collaboration with the Copenhagen Institute of Interaction Design (CIID). The starting points for the research were human values improving the interaction between human and nature. The design team then followed an iterative design thinking process. The final concept presented in the summer 2011 takes the form of an interactive window that enables backseat passengers to interact with their environment. The experience provided is simple, poetic and playful and enhances discovery and learning. The concept was communicated with a booklet summarizing the process, a narrative video and a storyboard showing the quality of the experience as well as a prototype using a touchscreen conveying it in a more tangible way (see Picture 1.1 and Figure 1.4). More information (video, prototype pictures) is available on the Internet using the following links: http://bit.ly/15sb6A3, http://bit.ly/114Gwhq. The project influenced subsequent (confidential) projects. These can be considered steps towards more tangible and short-term applicable concepts. The following projects could be characterised as "exploratory concept" or "product lining strategy" projects.

Picture 1.1: Snapshots from "Window to the world" video

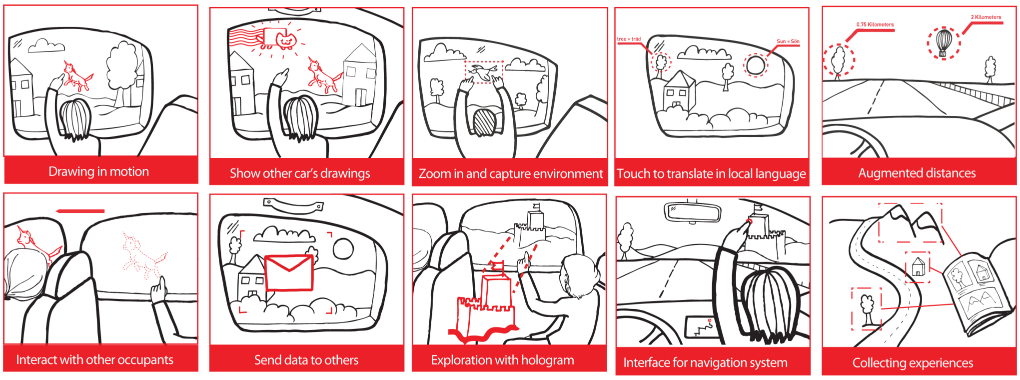


Figure 1.4: "Window to the World" scenario storyboard

1.2.3 PAST PROJECTS BETWEEN TME-KD AND LCPI

As mentioned in the introduction, seven Master's degree final projects have been completed to date as part of the collaboration between TME-KD and LCPI. The following points briefly present in chronological order the different focal points of these projects.

- Esquivel (2006) focused on the measurement of subjective responses to perception and especially on emotions. He integrated methodologies inspired from Kansei Engineering inspired into the practices of the ancestor of TME-KD. This contributed to the dual expansion of the range of approaches used by the division (covering "analytical thinking" in addition to "experience-based and intuitive thinking").
- Cochet (2008) focused on interaction design approach and was the first to introduce the notion of experience within the collaboration. He developed a co-design approach for the creation of "exploratory concept" based on iteration between generation and evaluation activities.
- Clos (2009) created a methodology permitting the exploration and mapping of the relations between sensory modalities, semantics, and emotions in the upstream phase of vehicle development projects (belonging to the "product lining strategy" and "pre-development direction" types of projects). He focused on vision and sound. In order to do so, he introduced the "Kansei Lab" methodology. It consists in sets of stimuli, created by designers, which are used in participatory design sessions. During these sessions, the participants select (affective process) and associate stimuli according to a given brief.

- Gentner (2010), the author of this Ph.D. research, expanded "Kansei Lab" methodologies introducing additional sensory modalities (touch, smell) as well as the notion of gesture and interaction. "Mood-boxes" were also used in order to represent concrete (e.g., sensory properties) and abstract (e.g., related semantic and emotions) design information related to a design brief. "Mood-boxes" were used as samples during the "Kansei Lab" experiments as well as to communicate the directions resulting from the participatory design sessions.
- Solinski (2011) focused on the aesthetic of gesture in interaction. He used different participative design methodologies such as "bodystorming" and "Kansei Lab."
- Lagadec (2012) worked on kansei and experience related to interaction sequences and more specifically to graphic layout and flow charts.
- Boisseau (2013) got interested in the representation of "target customers"-related design information in early design phases. In order to do so, he worked on a derivative of the "Kansei Lab" methodology, which he named "Portrait chinois." The retrieved design information has to be seen as complementary to information related to the product to-be-designed (focus of the previous studies). Additionally, he also investigated the factors influencing the understanding of kansei-related early phase representations.

1.3 RESEARCH CONTEXT

Having presented the industrial context of this Ph.D. dissertation, the research context will now be described. An historical view on design research will first be presented. I will then detail the user-centred design approaches that most influenced this research and position it relative to other recent studies that took place at LCPI, Arts&Métiers ParisTech. Finally, the last aspect covered by this section will be the research approach underlying this dissertation: the action research approach.

1.3.1 HISTORICAL VIEW ON DESIGN RESEARCH

Regarding the historical view on design research, I will start by presenting the scope of design research. It will be followed by a brief chronological review describing its almost 100 years of existence. The apparition of three major design research paradigms, as well as some of the related approaches will be placed on a timeline. Finally, two perception theories on which design research can be based will be presented and distinguished.

DESIGN RESEARCH

The word "design" is ambiguous because it covers both the notion of planning (of products and systems) and of "formgiving" (Koskinen et al., 2011). Figure 1.5 represents a contemporary description of design made by Deserti (2011). Clear tensions appear between the anchors of both axes (*creative act* vs. *technical act*, and *future* vs. *present*). The horizontal axis questions the notion of rationality in design, whereas the vertical questions its purpose: dealing with exploration of new opportunities or with exploitation within the limits of a given context (Mata Gracía, 2012). It appears that it is not easy to identify the current boundaries of design. The following paragraph consists in a short historical review of design research. It will help to explain the different paradigms that underlie these tensions.

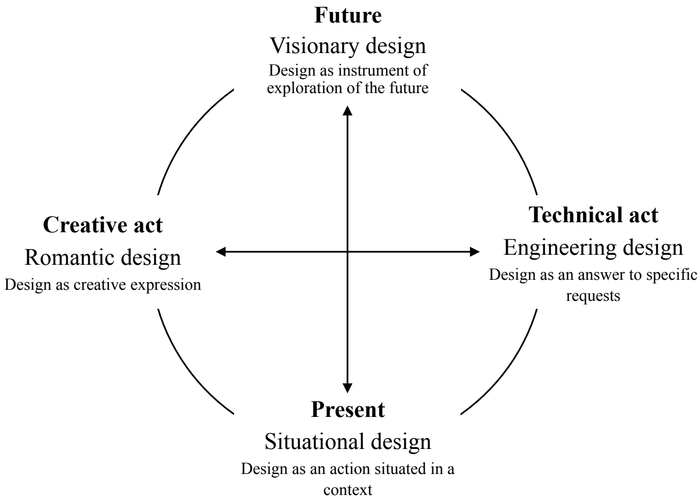


Figure 1.5: Design described by Deserti (2011)

DESIGN RESEARCH CHRONOLOGY

In the modern history of design research three paradigms are often distinguished. They arise at different periods of the 20th century: in the 1920s, the 1960s, and the 1990s (Figure 1.6).

Since the 1920s, scholars have intended to define design as a science combining its artistic dimension with science and technology (Cross, 2007). A key input happened in 1919 with the creation of the Bauhaus. The school intended to reconcile art and technology using a new set of practices and is considered by many as the first modern design school. Over the course of the century, efforts regarding methodologies as well as interactions with other disciplines have intended to rationalise its activities and describe it as a scientific and objective process (Bayazit, 2010).

Since the 1960s, design research has been very concerned with the creation of methods and processes. This period is described by different historical reviews on design as a turning point (Cross, 2006; Cross, 2007; Bayazit, 2010; Koskinen et al., 2011). Part of the effort deployed to develop these new methods and processes has accentuated the shift of part of the design research activity into a scientific activity (systematic approach to design). The approaches to design research from this paradigm are strongly connected to other fields of research such as cognitive psychology and human computer interaction. These fields started to gain importance at about the same period. Semantic differential scales (Osgood et al., 1957), originating from the field of cognitive psychology, for instance, greatly influenced research approaches related to this paradigm. It was the first tool permitting reliable quantitative measurements of user responses to product perception.

Since the 1990s, scholars started to question the idea of treating design as an exact science. They mention for instance differences in terms of culture and of values which are explained as follows by Cross (2006). Scientific culture consists in the observation of natural phenomena and uses methods such as controlled experiments, classification, and analysis in order to know more about these phenomena. Some of the key values in science are therefore objectivity, rationality, neutrality and a concern for the "truth." These are very different from the culture and values in design, which culturally deals with the planning and construction of an artificial world. The related values are practicality, ingenuity, empathy and a concern for "appropriateness." Constructive design research is one of the approaches that emerged as a pillar of this new paradigm (Koskinen & Lee, 2009; Koskinen et al., 2011). It consists in borrowing techniques from design as well as integrated models and prototypes in order to apply them to the research process.

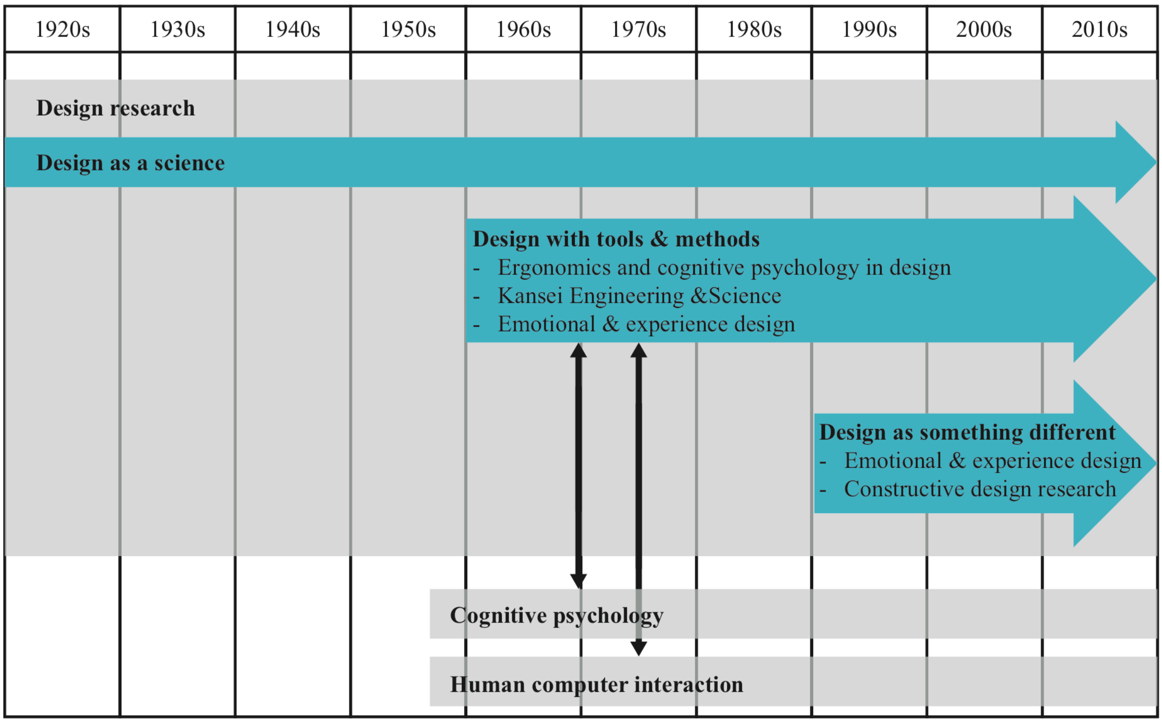


Figure 1.6: Design research chronology

PERCEPTION THEORIES IN PSYCHOLOGY

The previous paragraphs highlighted the influence of cognitive psychology on design research (see also Figure 1.6). A major theoretical issue divides psychologists on the way perception occurs. Two rather opposite views exist: the "bottom-up" and the "top-down" theories. Design research approaches related to both theories exist.

The "top-down" theory proposed by Gregory (1970) argues that perception is a constructive process that relies on hypothesis making. The information from the environment received from sensory receptors is combined with previously stored information about the world, which humans have built up as a result of past experiences. This approach states that when we are looking at something, we develop a perceptual hypothesis based on our previous knowledge. The hypotheses we make are almost always correct but they also can be disconfirmed by the sensory information we perceive.

In the "bottom-up" processing theory, also known as the direct theory of perception, the perception begins with the stimulus itself (Gibson, 1972). For Gibson there is enough information in our environment to make sense of the world in a direct way. In that case, perception is therefore not subject to hypotheses testing as Gregory proposed. In the "bottom-up" theory, the sensory information is analysed in one direction from the retina to the visual cortex. Along the visual system, the process evolves from simple analysis of raw sensory information to analysis of an ever-increasing complexity. In that way, the comprehension of the world happens between the human and the world.

For this research, I will consider both the information retrieved from sensory stimulation and from past experiences important for the perception process. Although acknowledging the existence and relevance of other approaches to design research based on the phenomenology of perception and "bottom-up" approaches, this work is therefore more closely related to the indirect theory of perception.

1.3.2 USER-CENTRED APPROACHES TO DESIGN

One main characteristic of this Ph.D. dissertation is that it tackles a rather recent field of design research: "Kansei Design." It is nevertheless also influenced by three established research fields: "kansei engineering and science," "ergonomics and cognitive psychology in design," and "emotional and experience design" (Figure 1.7). They can be characterised as user-centred approaches to design. This means that they have as common key concerns the processes of interaction and perception that will occur between future users and the product (or service) being designed. Their processes have the characteristics of being highly subjective and affective-centred. The different fields of design research mentioned above will be presented in this section.

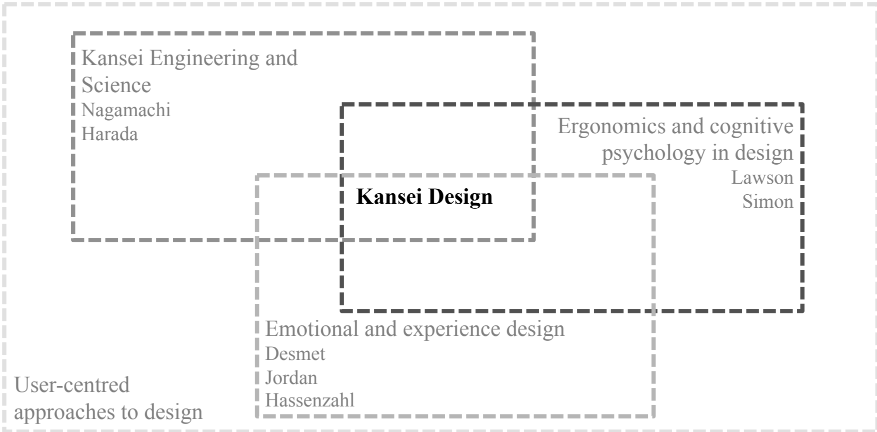


Figure 1.7: Kansei Design and the user-centred approaches to design

The first two design research approaches appeared approximately four decades ago in two different parts of the world (in Japan and in Western countries, respectively) and take a scientific approach to design research. They are representative of the paradigm identified previously as "design with tools and methods." The "emotional and experience design" field is more recent (end of 1990s/beginning of 2000s) and is symptomatic of the debate about the nature of design research. It appeared at a moment when some design researchers were looking at new approaches to deal with hedonic and emotional responses to perception.

KANSEI ENGINEERING AND SCIENCE

The term "kansei" appeared only recently in the Japanese language. It was introduced at the end of the 19th century in order to translate works from Western philosophers (Lévy, 2013). The term "kansei" was used to translate "sensitivity," described by Haven as the "the faculty of feeling" (in *Mental Philosophy: Including the Intellect, Sensibilities, and Will* originally published in 1857), as well as "sinnlichkeit," described by Kant as the faculty of intuitions, perception and mental imagery (in *Critique of Pure Reason* originally published in 1781). During the 20th century, the term was then successfully reinterpreted in the fields of marketing, engineering and cognitive science, the latter two giving birth to Kansei Engineering (Nagamachi, 1995) and Kansei Science (Harada, 2003). This happened at the end of the 1970s and of the 1990s, respectively. They both use scientific approaches to tackle user-centred issues. Kansei Engineering (KE) is for instance a methodology "specialised in the translation of affective values into concrete design parameters. To achieve this, Kansei Engineering uses Semantic Differential Scales (SD-scales) as a central pillar" (Schütte et al., 2008a: p.479). It is interesting to note that KE and kansei research in general spread rapidly inside and outside of Japan in both academic and industrial worlds. Table 1.1 represents most of the European research groups dealing with the notion of "kansei." Note that the list would more than double in length if scholars using similar approaches under other terminologies were added (e.g., affective engineering).

Table 1.1: Kansei in Europe - Research group leaders and affiliations

Country	*Institution*	*Researchers*
France	Arts & Métiers ParisTech	Bouchard
Italy	University of Genova	Camurri
Poland	University of Cracow	Saeed
Spain	Universidad Politécnica de Valencia	Solves, Campos, Artacho Ramírez
Sweden	Linköping University	Schütte, Eklund
The Netherlands	TU Eindhoven	Rauterberg, Lévy
UK	University of Newcastle	Pearce, Coleman
	University College London	Bianchi-Berthouze
	Cardiff University	Setchi
	University of Leeds	Henson

ERGONOMICS AND COGNITIVE PSYCHOLOGY IN DESIGN

At about the same moment that KE was introduced in Japan, ergonomics and cognitive psychology approaches were integrated to design research. Koskinen et al. (2011) note that these approaches were encouraged by “the demands of increasingly complex and growing industries” (p. 15). At first these approaches proposed to base design on rationalistic thinking and on system and operation analysis (Simon, 1969). With time they evolved and centred themselves fully on the user and the humans present in the design process (i.e. the designers) (Lawson, 2004; Lawson 2005). Key notions developed by these approaches are for instance usability and affordance (e.g., *Designing for People* by Dreyfuss [1955]). They are nowadays also used to study user’s hedonic and emotional responses to perception.

EMOTIONAL AND EXPERIENCE DESIGN

These topics (i.e. hedonic and emotional responses to perception) are at the junction between the three fields described in Figure 1.7.

“Emotional and experience design” approaches tend to break away from strict scientific approaches when studying interaction occurring between users and products. Based on direct or indirect perception theories, they investigate notions related to situations in which users experience products and intend to describe and/or enrich these experiences. They can for instance integrate non-scientific design skills (e.g., creativity session) or involve future users (e.g., treated as partners in participatory design sessions). This allows these approaches to deal with ambiguity. Some of them are therefore in line with the third paradigm detailed previously (“Design as something different”). Chronologically, researchers first tended to focus on single aspects of the user-product interaction such as pleasure (Jordan, 2000), semantics (Krippendorff, 2006), and emotion (Desmet, 2002). Recently, these notions were combined in frameworks and models that intend to foster a comprehensive perspective on the experience (Ortíz Nicólas & Aurisicchio, 2011).

TOWARDS KANSEI DESIGN

Whereas Kansei Engineering and Kansei Science are now established fields of research, Kansei Design is far less advanced. Lévy (2013) was probably the first to give a comprehensive picture of the status quo on “Kansei Design.” He distinguished three main groups using this terminology.

The first one focuses on the physical materiality of artefacts (i.e. their intrinsic properties), and their evaluation or preference by users. The approach taken is in this case rather similar to kansei engineering and science but differs from them by its attitude towards ambiguity and uncertainty. Whereas other kansei approaches “tr[y] to avoid ambiguity and uncertainty or tr[y] to ‘solve’ it by means of logical reasoning, […] Kansei Design deals with ambiguity and uncertainty by means of design skills" (p.89).

The second group of research using the terminology "Kansei Design" focuses on the interactive materiality of artefacts (i.e. the qualities of the artefact in interaction) and is grounded in the direct theory of perception (i.e. based on phenomenology of perception).

Finally, the third approach mentioned is the one used at TME-KD. This Ph.D. research contributed greatly to the creation of this approach. It focuses on the creation of representation centred on user experience and intending to influence the early stages of the industrial design process. It distinguishes itself from the other approaches by its context and by the way it combines KE approaches with design skills during different design activities (information, generation, evaluation and decision). In that sense, the Kansei Design approach as it is used in this research is at the boundary between the three design research fields presented previously (Figure 1.7).

1.3.3 Positioning this dissertation within the field of research of CPI laboratory, Arts&Métiers ParisTech.

This research can also be positioned within the research activities of the CPI laboratory, which was a French pioneer in the modelling and optimisation of design processes dealing with innovation (Aoussat, 1990). This Ph.D. fits into a group of recent studies that investigate different ways to take into account users' kansei process (i.e. affective-centred process occurring during an interaction with a product) in the design process. Notably, the works from Ocnarescu (2013) and Bongard-Blanchy (2013) were the first ones to also tackle explicitly the notion of user experience.

This group of studies employed three types of measurement of the kansei process: psychological (questionnaires and interviews), physiological (physiological measurements), and behavioural (kinetic measurements) (Figure 1.8). The research presented in this dissertation only touches psychological measurements. These measurements nevertheless have the characteristics to involve participatory design sessions (with users) and to include multi-sensory samples.

The design activities covered by this Ph.D. research can also be discussed. To describe them, I will use the design informational cycle and its four design activities presented by Bouchard and Aoussat (2003), professors at LCPI Arts&Métiers ParisTech. Previous Ph.D. researches studied in depth the link existing between individual design activities and the kansei process (*information* activity by Mougenot [2008], *generation* activity by Kim [2011], and *evaluation & decision* activity by Mantelet [2006]).

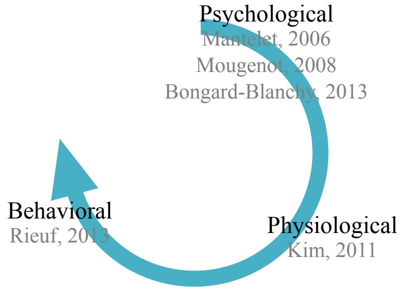


Figure 1.8: Measurement of the kansei process used at LPCI, Arts&Métiers ParisTech

Due to the fractal nature of this model, it can be read at different levels. The way the research presented in this dissertation covers the design activities related to two of these levels can be seen in Figure 1.9. When used to describe the creation of early representations, it deals with all the design activities from *information* to *communication*, but when looking at the design activities of a development project, it only represents input for the transition between *information* and *generation* activities.

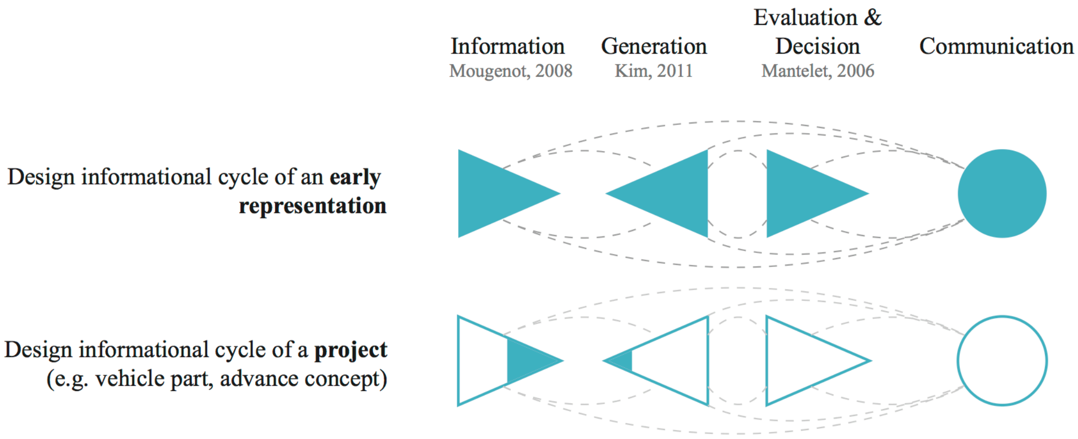


Figure 1.9: Design informational cycle (Bouchard & Aoussat, 2003)

1.3.4 Research approach: the action research approach

During the three years of this Ph.D. research, I had two perspectives on the fields of kansei and experience design: that of an academic researcher (as Ph.D. student at Arts&Métiers ParisTech) and that of a practitioner (as part of the TME-KD team). Figure 1.10 illustrates well the way these roles belonging to the realms of theory and practice can be interlocked (Owen, 1998). Knowledge is used to work in design practice, and knowledge from practice is evaluated to build new knowledge and model in design theory. This led to an iterative research process involving cycles of inquiry and application.

In that sense, the research approach of this Ph.D. can be characterised as an *action research* approach. It fits indeed to the following definition. Action research is described as following an iterative process involving researchers and practitioners acting together on a particular cycle of activities, including problem diagnosis, action intervention, and reflective learning (Avison et al., 1999).

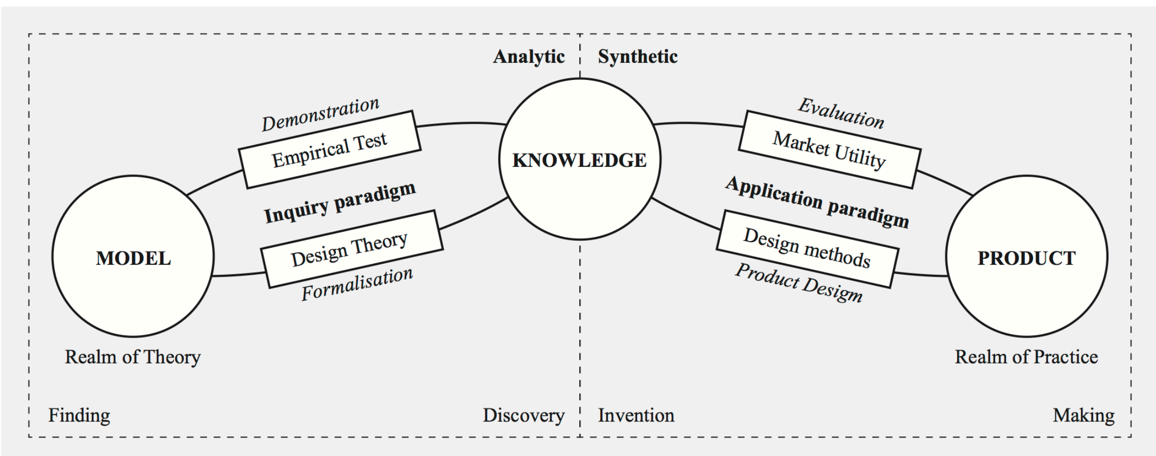


Figure 1.10: The processes of using and building knowledge in product design (Owen, 1998)

This research approach originally comes from the social sciences, is context related, and addresses real-life problems. It is a form of reflexive process that encompasses theoretical and practical concerns while contributing to a scientific method or a model (Liu, 1997). According to Reason and Bradbury (2001), this approach is very beneficial to design practice as it enables a better understanding of some of the problems faced and at the same time permits changes. Lawson (2004) also observed that many things happening in practice in design processes are implicit, and in that sense are almost impossible to perceive from an external point of view.

As it is addressing the design process from an internal point of view, the action research approach has in this regard a major advantage when compared to "lab studies" related to the industrial design process. On the other hand, drawbacks also exist: with an action-research approach is for instance very difficult to perform comparative studies (between tools, methodologies…) in a similar context (i.e. same project). These studies do indeed not correspond to the notions of profitability and efficiency embedded in any industrial context.

1.4 SUMMARY OF THE INDUSTRIAL AND ACADEMIC CONTEXT OF THIS RESEARCH

The context of this Ph.D. research has been detailed in the previous sections. For that purpose, the industrial and academic contexts were presented one after another. A similar interest for the emerging notion of user experience could be identified. On the industry side, it came originally from an interest in the multi-sensory attributes of the product to be designed. This context of study evolved with time from simply focusing on static perception to now also include interaction sequences. In parallel, affective-based keywords (e.g., semantics, emotion) and sensory representations were used more and more in order to set guidelines that were able to follow the very subjective design process from the definition of intentions to the evaluation of prototypes and finally to commercialisation. On the academic side, several fields of research dealing with users' subjective perception process were identified (see Figure 1.7 [p. 26]). The Japanese word "kansei" emerged at this stage. It can be briefly defined as the affective-centred mental process of a human resulting from sensory perception. In our case this occurs during an interaction between a user and a product (it will be detailed more in depth in section 2.2.1 [p. 35]). Correspondences between notions from the different design research fields (e.g., kansei process and user experience frameworks) must be explored in order to be able to describe precisely the field of study and the intentions of experience-centred design activities.

The other main notion introduced in the presentation of the context is the industrial design process and especially the early stages of this process. A question underlies this dissertation and links the two main notions: "How can user experience be (better) handled in early phases of the industrial design process?" The use of tools and methodologies to support design activities appears already as a key enabler. More broadly, this Ph.D. dissertation will present key elements, including practical and theoretical results, establishing the Kansei Design approach as it is now used at TME-KD.

2 LITERATURE REVIEW

2.1 INTRODUCTION

The literature review of this dissertation establishes a connection between the two major notions introduced in the context: the *experience* one can get when interacting with a product and the *industrial design process* of such a product. Figure 2.1 represents schematically this connection. It also introduces two additional notions that are key for this research: the *design activities* and the *cultural environment*.

The *cultural environment* is represented around the other notions because it is embedded in all of them (i.e. the culture of the user experiencing the product and the culture of the design team members involved in the *industrial design process*). The particular interest of this dissertation is the way *user experience* can be taken into account during the *industrial design process* and particularity at its early stages. This is why *user experience* is at the centre of the figure. Finally, experience-centred *design activities* are represented in between the two major notions as a way to deal with *user experience* in the industrial context. The structure of the following three sections is presented in Figure 2.2.

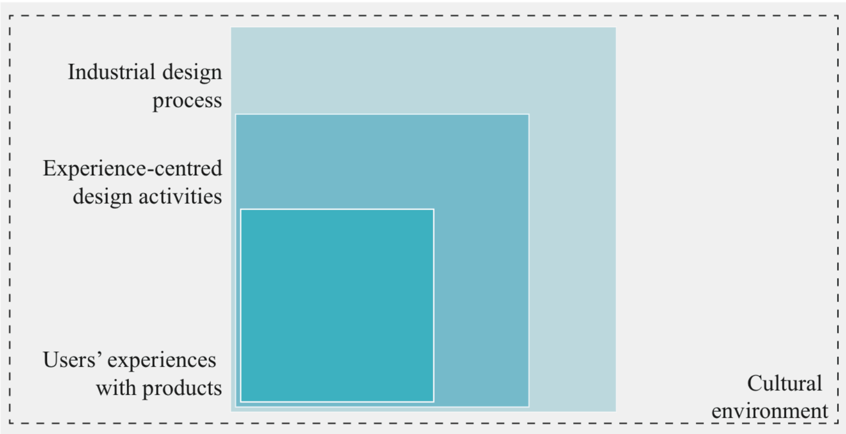


Figure 2.1: Notions covered by the literature review

In the section 2.2 (p. 35), I will review the literature related to *user experience* and to the processes following the perception of an object. Experience design, kansei, and cognitive psychology views will be covered. The different factors influencing the experience one can have with a product will be investigated. In section 2.3 (p. 55), I will then detail descriptive and prescriptive models of the *industrial design process* that are currently used in design research and practice. Innovation and multi-cultural design teams will also be discussed. Finally, experience-centred *design activities* will be presented in section 2.4 (p. 67). Topics including the approach and thinking of designers, the notions of design information, early representation, as well as tools and methodologies supporting *design activities* will be tackled.

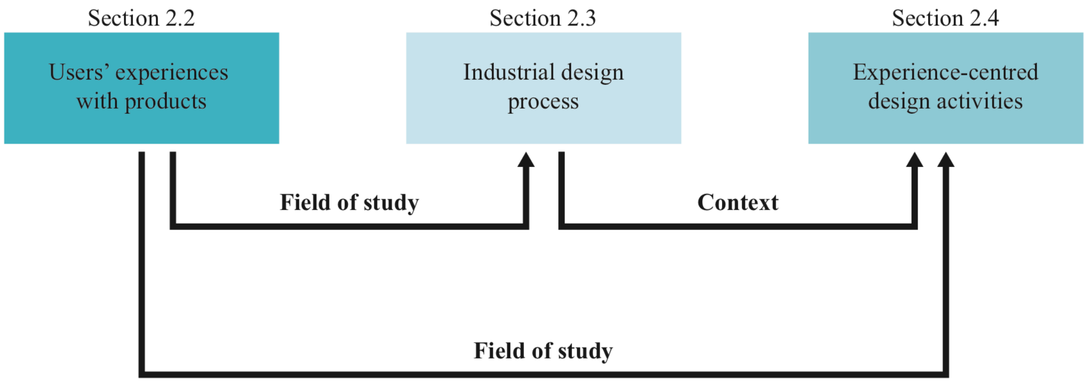


Figure 2.2: Structure of the sections

2.2 USERS' EXPERIENCES WITH PRODUCTS

In the following sections, the description of aspects related to user's affective perception process will be discussed from different perspectives: kansei, emotional design, and experience design. A recent model from neuroscience makes it possible to bring together the perspectives and build the kansei-experience framework that will then be used as basis for the rest of this research.

2.2.1 FROM A KANSEI PERSPECTIVE

As explained in the introduction, kansei studies are usually cross-disciplinary and involve researchers from fields such as brain sciences, psychology, and engineering design as well as design or marketing research. Although the word kansei is widely used in Japanese design research literature it is usually only briefly defined as an introduction to the context of the study presented and is interpreted in a variety of ways (Lee et al., 2002). Some of the reasons pointed out are that the notion is impossible to transpose directly into English, that it is closely connected to the Japanese culture (Schütte, 2005), and the literature intending to provide a definition struggled over time to come up with a single and clear definition (Lévy et al., 2007). The following paragraph will provide an overview of the discussions related to the definition of kansei and will present the point of view taken by the author for this research.

Harada (1998) intended to clarify the description of kansei with the following five major dimensions. They are based on a statistical analysis of the propositions of 60 researchers working in the field.

- Kansei is a subjective and unexplainable function.
- Kansei, besides its innate nature, consists of the cognitive expression of acquired knowledge and experience.
- Kansei is the interaction of intuition and intelligent activity.
- Kansei is the ability of reacting and evaluating external features intuitively.
- Kansei is a mental function creating images.

In addition to the five major dimensions, Harada concluded by defining kansei as *an internal process of the brain, involved in the construction of intuitive reaction to external stimuli*. The internal process (or high function) is described as combining objective and subjective aspects as well as logical and physiological aspects.

Kan Sei						
感性	⇨	感	+ (	心	+	生)
sensitivity, sensibility, impression, admiration		feel, touch, tactile, sensation, emotion, impression, appreciation		heart, mind, soul		Be born, alive, dynamic

Chi Sei								
知性	⇨ (	矢	+	口	) + (	心	+	生)
understanding, intellectual		arrow, acute		month		heart, mind, soul		Be born, alive, dynamic

Figure 2.3: Etymology of kansei and chisei (Lee et al., 2002)

Lee et al. (2002) used the etymology of the word *kansei* and compared it to *chisei* in order to further clarify the context of kansei studies. *Kansei* and *chisei* are presented as two complementary mental processes in human minds following the perception of sensory information from the external world. They both have "the same level of power to stimulate human behaviour" (p. 2). On the one hand, *kansei* is presented as a process that involves sensitivity, sensibility, emotions, and impressions and that results in increase of creativity. On the other hand, *chisei* is described as an analytical and descriptive process resulting in an increase of knowledge and intellectual understanding (Figure 2.3). As emphasised by Levy, Lee and Yamanaka (2007), *kansei* and *chisei* are complementary notions and therefore not opposed. *Risei* (close to "logic process") is presented as a far better candidate for an opposite term to kansei. Shimizu et al. (2004) added to the discussion that kansei is not only describing mental processes (defined as "sensibility, recognition, identification, relationship making, and creative action") but also the "process of binding together these concepts." They describe therefore kansei as an internal concept with three basic pillars: "taste/sentiment," "feeling," and "emotion" continuously influencing each other.

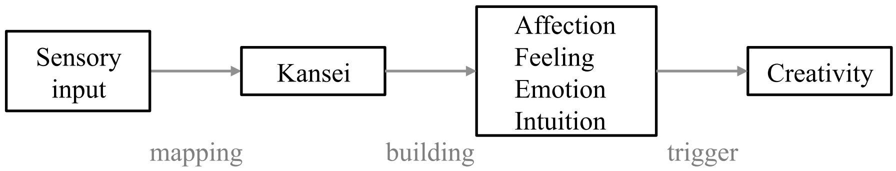


Figure 2.4: Model of the concept of kansei (Schütte, 2005)

Nagamachi (2001) positioned kansei as a result of the mental process following perception and not as the process itself and defined it as one's subjective impression from a certain artefact, environment, or situation using all the senses of sight, hearing, feeling, smell, taste, as well as recognition. Schütte (2005) adopted Nagamachi's definition and adopted a similar point of view. He only added the sense of balance to the list of senses included in the aforementioned definition. In an additional explanation he described kansei as an intermediate concept resulting from a mapping of sensory inputs and building affection, feeling, emotion, and intuition (Figure 2.4). In this way, he bridged Nagamachi's definition (2001) with notions already present in the definitions from Lee et al. (2002) and Schimizu et al. (2004).

Lévy, Lee, and Yamanaka (2007) intended to improve the reciprocal understanding related to the notion of kansei (academic vs. industrial worlds and East vs. West) by providing a comprehensive definition. They took into account previous research in the field (e.g., referenced previously) that presented diverging descriptions of the nature of kansei: defined as a process, as the result of process, and as a concept. They presented three important aspects in order to comprehend the notion of kansei: *kansei process*, *kansei means*, and *kansei results*. Notably, the authors characterised kansei as a process (i.e. *kansei process*), but presented it in a clear context: including what precedes it (i.e. *kansei means*) and what follows it (i.e. *kansei results*).

- "*Kansei process* gathers the functions related to emotions, sensitivity, feelings, experience and intuition, including interactions between them." (p. 9)
- "*Kansei means* are all the senses (sight, hearing, taste, smell, touch, balance, recognition…) and—probably—other 'internal factors' (such as personality, mood, experience, and so on)." (p. 9)
- "*Kansei result* is the fruit of kansei process (i.e. of these function processes and of their interactions). It appears to be a unified perception providing a qualitative meaning and value of one's direct environment. In other words, kansei result is how one perceives qualitatively one's environment. Therefore, kansei is a synthesis of sensory qualities." (p. 10)

As mentioned above, the *kansei means* provide information to *kansei process* (i.e. a high function of the brain) that leads to *kansei results*. The flow between the three aspects is not strictly linear as *kansei means* and *kansei results* influence each other (Figure 2.5). Note also that the nature of *kansei results* is still mental (i.e. neither physiological nor behavioural) but consequences of kansei can be observed at psychological, physiological, and behavioural levels. This implies that only causes (point 1 in Figure 2.5), internal factors (point 2) and consequences (points 3 to 5) of kansei can be measured.

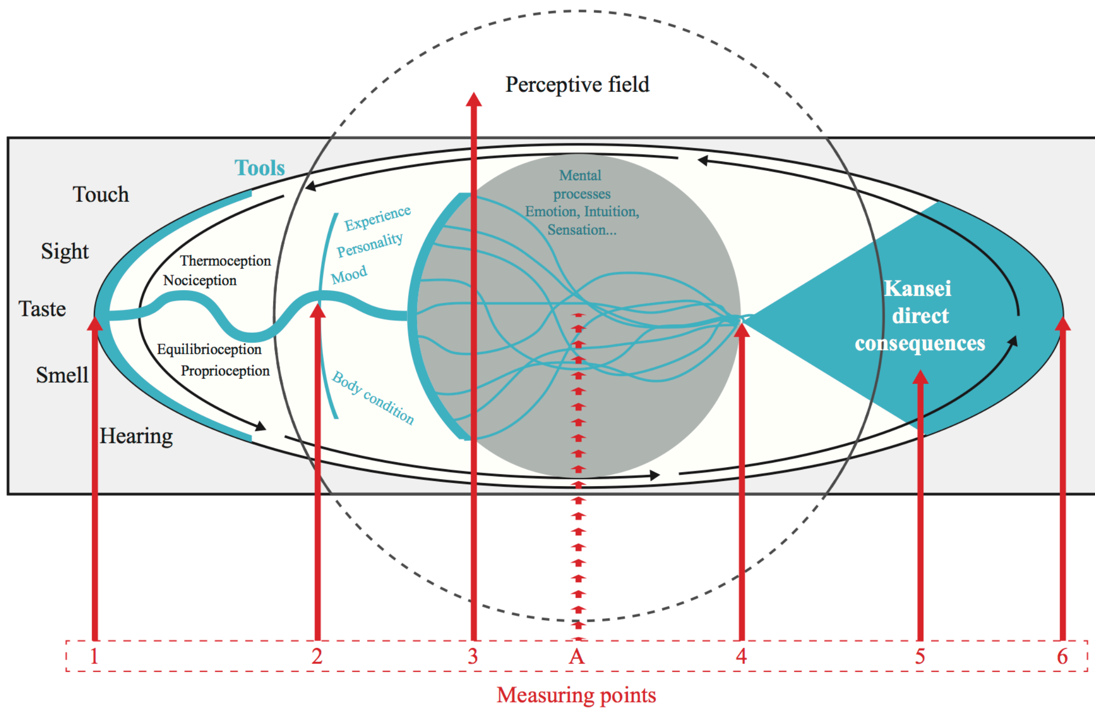


Figure 2.5: A visual description of Kansei and kansei studies (Lévy et al., 2007)

2.2.2 From the perspective of emotional and experience design research

As mentioned in the context, the design research community recently started to tackle topics related to human mental processes following sensory stimulation with new approaches. It is interesting to notice that the frameworks developed also focus either on processes or on results.

As Christoforidou and Motte (2009) explained: “models in [emotional and experience] design research are not intended to be ‘true’ to reality (realism), but to be useful (instrumentalism)” (p. 9). Therefore the frameworks that will be presented hereafter do not necessarily match neuroscience models completely. Correspondences between frameworks from the emotional and experience design research literature and neuroscience will then be discussed in section 2.2.3.

2.2.2.1 PERCEPTION OF AN ARTEFACT

Three major frameworks describing the perception of an artefact will be briefly presented. They are interesting because their authors have very different backgrounds: Norman comes from the field of cognitive science, Crilly from the field of engineering design, and Jordan from the field of design practice.

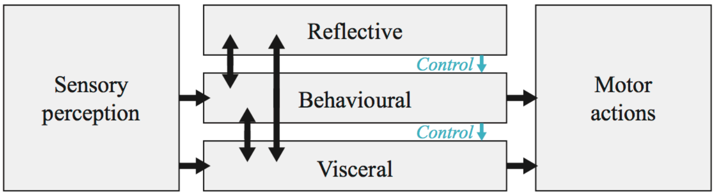


Figure 2.6: Three levels of processing (Norman, 2004)

Norman (2004) detailed three levels of processing that all human beings have in common: the *visceral*, *behavioural*, and *reflective levels* all interacting with each other (Figure 2.6). The *visceral* and *behavioural levels* receive information from the senses and can lead to a motor response.

- The *visceral level* is fast and makes quick judgements (e.g., good or bad, safe or dangerous): it is strongly related to emotions and aesthetics as well as reflexes and "natural" inclinations. The *visceral level* of processing can be inhibited or enhanced by the other levels.
- The *behavioural level* is the origin of most motor actions. These can be enhanced or inhibited by the *reflective level* and, in turn, it can enhance or inhibit the *visceral level*. It focuses on aspects such as "functionality," "performance," "understandability," and "usability."
- The *reflective level* "watches over, reflects upon, and tries to bias the *behavioural level*" because it has no direct access either to sensory perception or to action. It pays attention to the meaning of the information retrieved and expressed.

Crilly et al. (2004) described and organised the human response to the perception of artefacts into three types of response processes: *cognitive*, *affective* and *behavioural*. In this framework, *cognition* and *affect* are described as parallel mental processes influencing the product user's *behaviours*. Although the structure of their discourse and their framework do not show it, the authors admit the interaction between affective and cognitive processes: "Thus, whilst the division between the cognitive and affective phases presented in the framework is convenient, considerable interdependence exists" (p. 554). The results of these processes are the core of the authors' discourse and can be summarised as follows (Crilly et al., 2004).

- The results of the cognitive response process are *aesthetic impression, semantic interpretation, and symbolic association. Aesthetic impression* "may be defined as the sensation that results from the perception of attractiveness (or unattractiveness) in products" (p. 552). It is described by the authors as related to Norman's *visceral level* (2004). *Semantic interpretation* assigns a meaning to the artefact perceived and recognised by the human being. It also comprises the four semantic functions of products (describe, express, signal, and identify) described by Monö et al. (2003). Semantic interpretation is described by the authors as related to the *behavioural level* previously described by Norman (2004). *Symbolic association* "is determined by what the product is seen to symbolize about its user, or the socio-cultural context of use" (p. 562). In this framework, what an artefact symbolises about its owner is therefore dissociated from what it is seen to indicate about itself (i.e. semantic interpretation). The symbolic association is also described as related to the *reflective level* described by Norman (2004).
- The result of the affective response process consists in reflexes, sensations, feelings, emotions, moods, drives. They have been listed here according to their life-span (Salem et al., 2006). Desmet (2003) presented five categories of emotions that a product may elicit: instrumental,

aesthetic, social, surprise, and interest. These categories will be considered in further detail in section 2.2.5.1.

- The result of the behavioural response process corresponds to approach or avoid. The framework is described in a context of non-instrument user-product interaction. Therefore, it does not cover interaction sequences and simply refer to "approach" and "avoid" behavioural responses. They correspond to an overall interest or disinterest of the human perceiving the artefact.

In order to describe what impacts the processes described by Crilly et al. (2004), the four types of factors presented by Bloch (1995) were mentioned. They are presented hereafter:

- *Innate factors* correspond to deep-seated preferences that are relatively universal and constant. Gestalt principles (Koffka, 1935) and colour harmonies (Itten, 1967) belong to this group.
- *Personal factors* correspond to characteristics of the human perceiving the product. For instance, it encompasses the user's age, gender, experience or personality.
- *Cultural factors* correspond to established conventions of taste, general trends and transient fashions. These zeitgeists correspond to taste and values shared at a specific period of time and by a specific group of people sharing the same culture (or sub-culture).
- *Situational factors* encompass aspects such as the surrounding (perceived simultaneously as the artefact) as well as motivation and opportunities depending on the moment the perception is occurring and related to notions such as personal goal, brand image, financial criteria and marketing.

Finally, Jordan (2000) focused on pleasure, a particular type of result from mental processes. He investigated the notion of pleasure with products, which does not appear in the other two frameworks presented in this section. Based on Tiger's work on pleasure (1992), Jordan distinguished four types of pleasure with products.

- *Physio-pleasure* derives from sensory organs (vision, touch, taste, smell…).
- *Socio-pleasure* arises from relationships with others and society as a whole. It is the result of an appraisal of the perceived stimuli on the basis on its social value.
- *Psycho-pleasure* results from cognitive and emotional processes and attests to mental wellbeing.
- *Ideo-pleasure* is related to one's personal values and aspirations and to how the artefact is perceived to be consistent with them.

Pleasure appears to be an additional result of human response to sensory stimulation resulting from both affective and cognitive processes.

2.2.2.2 INTERACTION WITH AN ARTEFACT

Instrumental interactions are missing from the frameworks described previously. They do not take into consideration the interaction sequences occurring during a human-product interaction and in that sense the changes that the human behaviours are causing on the product's sensory properties and actions. Taking into account instrumental interaction would add complexity to the previous frameworks because the sensory perception described as input is constantly evolving over the course of the interaction.

Krippendorff (2006) descibed three modes of attention that a human can have when interacting with products (Figure 2.7). These three modes of attention represent three contexts in which interactions between humans and products can take place. They focus on the meaning one can interpret from the interaction and from the product. For each mode of attention, one would also have different expectations and motivations. Cognitive and affective processes occur naturally at every mode and their results also play a major role in transitions from one mode to another.

- One starts by *recognising* the meaning of a product. During this mode, one intends to correctly identify what a product is and what it can be used for. In order for designers to better deal with this mode, Krippendorff listed different relevant concepts that should be reflected when thinking about the meaning of a product at the "recognition" stage. The list contains concepts such as the positioning of the product within its product category (related to Loewy's [1951] MAYA—most advanced, yet acceptable—principle), the use of visual metaphors, and attractiveness it can express in terms of newness, simplicity, unity, regularity, etc.

- The second mode is the *exploration* of the meaning. It still precedes the use and contains the process of figuring out the working logic of the product, testing it and understanding the relation between actions and feedbacks. Again Krippendorff describes relevant concepts that designers can focus on in order to permit a smooth "exploration" of the product they are designing. These notions are user conceptual models, constraints, affordances, metonyms, semantic layers, etc.
- Engagement leads to the third mode of attention: *reliance*. It is the ultimate stage of use. During this mode the product responds naturally and one's attention can be transferred onto the perceived consequences of its use. Related concepts are in this case habitual scenarios and intrinsic motivations.

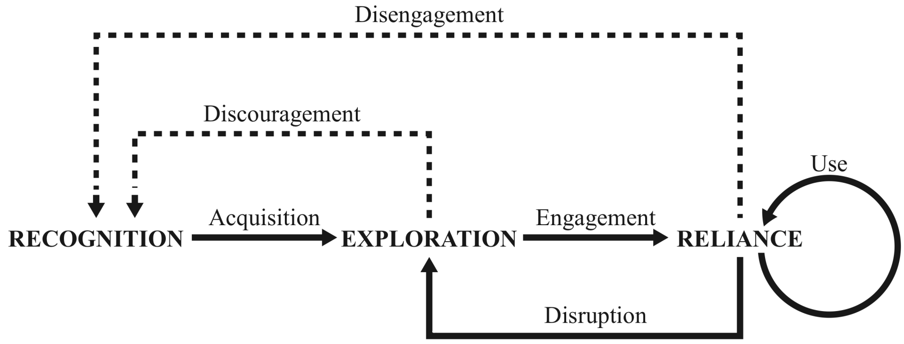


Figure 2.7: Transition between three modes of attention *(Krippendorff, 2006)*

Other notions close to the Krippendorff's modes of attention can be found in the literature. The element behaviour described by Rasmussen (1983) is one of them. He notably highlighted that the use of a familiar product is very different from when the product was used for the first time.

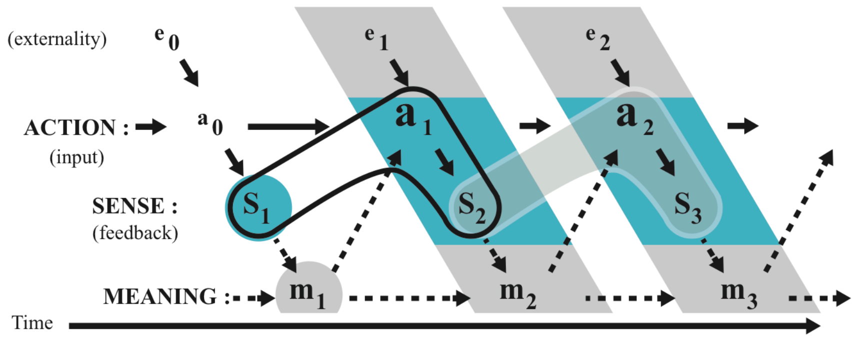


Figure 2.8: Interaction protocol *(Krippendorff, 2006)*

In order to deal with the complexity of instrumental interaction, Krippendorff (2006) described an interaction protocol based on meaning. In his description of interaction protocols (Figure 2.8), he highlighted the role of meaning as the connection between the user's sensing and his acting. According to him, this is what involves reflection, interpretation or explanation (and not the user or the action themselves). Every action from the user is therefore guided by meanings elicited from the product's present state, as well as from past meanings that appeared in the sequence. In Figure

2.8 the solid arrows delineate the product mechanism, whereas the dotted lines represent user processes. The protocol starts at the moment a user gets his image of the product's meaning (m_1) depending from the sensory signals he captures (s_1). It allows him to trigger the first move of operations (a_1). After executing the first action, followed by product feedback, the user achieves the first part of the sequence. Meanwhile, products could be treated as being constructed to comply with a collection of triplets: sensing the present state (s_t), capturing an input from the action (a_t), and providing an action and feedback defining the next state (s_{t+1}). Following this, the user then perceives the next state (s_{t+1}) and can initiate another sequence (i.e. triplet).

2.2.2.3 EXPERIENCE

The notion of experience (used in the terms *user experience, product experience,* and *experience design*) is now used more and more in the literature when describing a (instrumental or not) human-artefact interaction. Different definitions can be found. They reflect the different point of views and focus points that researchers have on this wide topic. A brief overview of definitions from authors of influence in the field will be presented hereafter:

- Desmet and Hekkert (2007) defined product experience "as a change in core affect that is attributed to human-product interaction" (p. 59). The notion of "affect" is defined as referring "to all types of subjective experiences that are valenced, that is, experiences that involve a perceived goodness or badness, pleasantness or unpleasantness" (p. 58).
- "User experience focuses on the interactions between people and products, and the experience that results. This includes all aspects of experiencing a product—physical, sensual, cognitive, emotional and aesthetic" (Forlizzi & Battarbe, 2004: p.261).
- "User Experience is the consequence of a user's internal state, e.g., predispositions, expectations, needs, motivation, and mood; the characteristics of the designed system e.g., complexity, purpose, usability, and functionality; and the context (or the environment) within which the interaction occurs, e.g., organisational/social setting, meaningfulness of the activity, and voluntariness of use" (Hassenzahl & Tractinsky, 2006: p. 95).

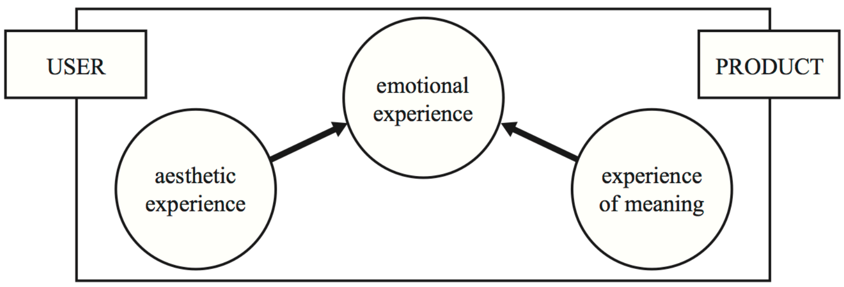


Figure 2.9: Product experience framework (Desmet & Hekkert, 2007)

Before drawing a global panorama from existing user experience frameworks, we will focus on the one developed by Desmet and Hekkert (2007), which had a particular influence on the course of this Ph.D. research. It describes a product experience with three levels. They will be detailed hereafter.

- *The aesthetic level of experience* refers to the "product's capacity to delight one or more of our sensory modalities" (p. 59). This type of experience contains the aesthetic impression described by Crilly et al. (2004), as well as the concept of "aesthetics of interaction" (Overbeeke & Wensveen, 2003), which comes from interaction with a product and focuses on tactile and kinaesthetic stimulations.

- *The experience of meaning level* represents the meaning one attaches to the product and to the interaction. It corresponds to the semantic interpretation and symbolic association described by Crilly et al (2004).
- *The emotional level of experience* corresponds to the emotions that are elicited by the product. Their origin is described in the basic model of product emotions (Desmet, 2002). This model indicates that emotions arise from the perception of products that are appraised as having beneficial or harmful consequences for one's individual concerns. These concerns can be personal values, goals, motives or other sensitivities (Lazarus, 1991).

Desmet and Hekkert (2007) expressed that even if the three levels of experience "can be clearly conceptually separated, they are very much intertwined and often difficult to distinguish in our everyday experience" (p. 61). In their framework, this can be represented with mutual interrelationships between the three levels of experience. Notably, the authors highlighted two situations containing causal relationships between the experience types: aesthetic experience leading to emotional experience and experience of meaning leading to emotional experience. Many correspondences can be seen between this framework and the one from Crilly et al (2004) regarding response to perception. This indicates that when looking only at the results of mental processes, product perception and user-product interaction can be described in similar ways.

Desmet and Hekkert's framework nevertheless does not capture the influence of time and interaction sequences captured by Krippendorff (2006) (p. 39). Another limit of this framework is that the context in which the interaction takes place (amount of people involved, surrounding, situational factors, etc.), which appears as a key element in other studies (Forlizzi & Battarbe, 2004; Hassenzahl & Tractinsky, 2006), is not taken into account.

It is also interesting to note that most researchers differentiate the notion of experience from the one of usability arguing that as usability does not reflect a change in core affect it cannot be considered as a type of user experience. They mentioned nevertheless an interdependent relationship between the two notions as according to several studies usability influences the user experience (Buxton, 2007; Desmet and Hekkert, 2007).

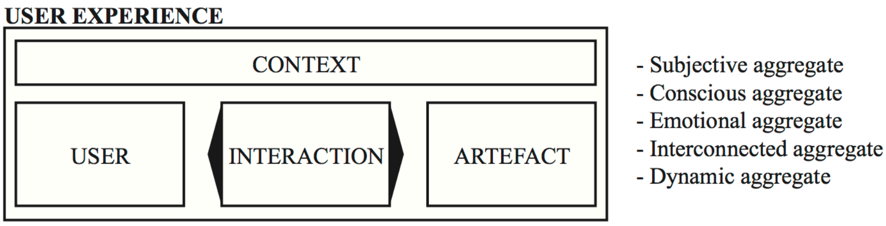


Figure 2.10: Synthetized user experience framework (Ortíz Nicólas & Aurisicchio, 2011)

Ortíz Nicólas and Aurisicchio (2011) analysed 11 user experience frameworks from the literature in an attempt to bring together in a consistent overview the rapidly growing and disjoint literature on the subject. The conclusion of this research suggested that even if the perspectives and focus points of the 11 researchers are different, common constituent elements and aggregates of user experience were actually acknowledged by the majority of the perspectives reviewed (Figure 2.10). They will both be outlined in the following paragraphs.

The four identified constituent elements of a user experience are the *user*, the *interaction*, the *artefact*, and the *context* (Ortíz Nicólas & Aurisicchio, 2011). As could be seen previously, user experience is not the property of an artefact but is one of the by-products of human-product interaction. The first three constituent elements of a user experience emerge actually from this statement.

Most of the references reviewed were based on an indirect theory of perception. This means that they rely on the fact that the understanding of the world by a human is the result of mental processes happening in the human body. The *user* is therefore generally described as perceiving, processing the stimuli and reacting to it. He/she has drives, motivations and other personal knowledge that push him/her towards certain types of thinking and behaviours.

The *interaction* corresponds to relationship between the human and the external world. It is distinct from a task or an action because it requires reciprocity (unnecessary for a task and for an action) but not necessarily any finality (necessary for a task) (McCarthy & Wright, 2004). Furthermore, the experience does not only result from the *interaction*: interactions accompany and guide the user and the experience they perceive, and thus affect it (Hekkert & Schifferstein, 2008).

Artefacts can also be referred to as product, object, item and system. It consists in a human-made thing that performs technical (e.g., movement, action) and non-technical functions (e.g., symbolic, aesthetic, social…) (Crilly, 2010).

Finally the *context* is composed of physical (surrounding the artefact and perceived by senses), social (related to multiple users), cultural (related to user's personal characteristics), situational (set of circumstances one finds himself/herself in), and temporal (related to the time span of the interaction) dimensions.

Ortíz Nicólas and Aurisicchio (2011) adopted the term "aggregate" from Varela et al. (1991: p. 64) in order to refer to the properties of a user experience. They detailed five types of aggregate.

- *Subjective aggregate*: It refers to the fact that an experience is personal. The same product will most likely be experienced differently by two different people.
- *Conscious aggregate*: Scholars agree on the fact that an experience occurs when a user interacts with a product in a state of consciousness.
- *Emotional aggregate*: As discussed previously, emotions appear to be one of the "visible" aspects of an experience.
- *Interconnected aggregate*: This property comes from the fact that UX emerges from the "interplay of cognition, affection, sensory input, behaviour, and all the other systems that humans rely on" (Ortíz Nicólas & Aurisicchio, 2011). Researchers therefore claim that it has to be understood, researched, and explained only by making references to the whole (e.g., Hassenzahl [2010]).
- *Dynamic aggregate*: Due to its interaction constituent, an experience is always evolving. This aspect differentiates experience from a situation in which the product would only be (statically) perceived (described in section 2.2.2.1).

2.2.3 Correspondences between the emotional and experience design research and neuroscience perspectives

Using the model described by Colombo (2012), I will summarise in this section some of the latest positions from the field of neuroscience. This will permit me to analyse the frameworks from the field of emotional and experience design research (described in section 2.2.2) from a neuroscience perspective and finally better put them in perspective with kansei studies.

Whereas older studies in the field of neuroscience and psychology focused only on cognitive processes ranging from decision-making to memory, the study of cognitive and affective processes appeared in the past decades and opened the door to rich areas of research at the interplay between both processes.

Figure 2.11 represents a visual and comprehensive model representing the neurological processes underlying elicitation of user response to sensory stimulation (Colombo, 2012). It has been made in an attempt to trigger discussions with design communities and to clarify the context of current design studies. The model is placed on two axes representing a cognitive-affective dimension and an unconscious-conscious dimension. The notions of "cognition" and "affection" can be explain with the following definition by Helander and Khalid (2006): "whereas affect refers to feeling responses, cognition is used to interpret, make sense of, and understand user experience" (p. 572).

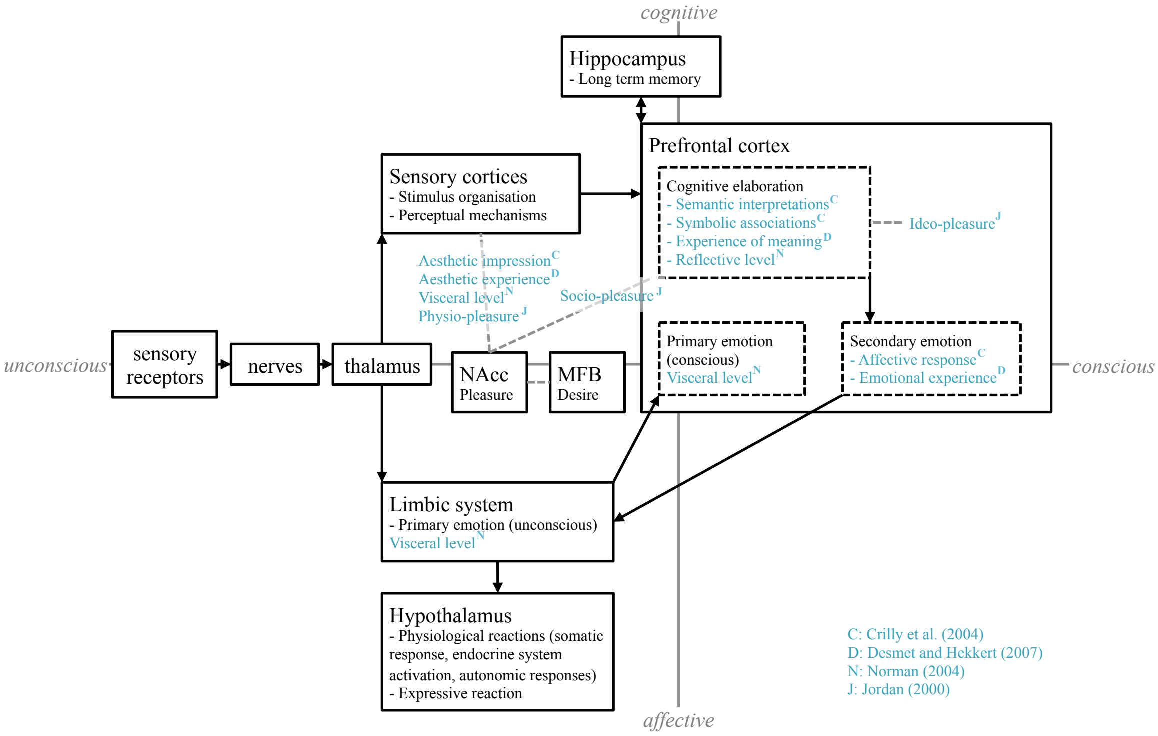


Figure 2.11: Model representing the neurological processes underlying elicitation of user response to sensory stimulation (Colombo, 2012)

Starting from "sensory receptors" (left hand side) the model describes two neurological paths: low road (bottom) and high road (top). These two roads are parallel and both involve affective and cognitive processes. The low road is described as faster and the high road as more precise in the signal treatment (Helander & Khalid, 2006; Christoforidou & Motte, 2009).

- "In the low road, the signal from thalamus immediately reaches the limbic system and other emotional centres […]. These areas are responsible for detecting stimuli which require the attention of the subject, and for evaluating them in a fast way, for instance to understand if they represent a danger for the subject" (Colombo, 2012: p. 6). This process elicits primary emotions (or "visceral" as referred to by Picard [1997]), which can be conscious or unconscious depending if the signal reaches the prefrontal cortex (centre of awareness) involving in that case cognitive processes. The low road can also activate unconscious physiological reactions without cognitive process as the limbic system is directly connected to hypothalamus.
- The high road guides the signal to the prefrontal cortex after it is pre-processed by the different sensory cortices (visual, auditory, olfactory…). There, it is matched with the hippocampus (area of conceptual memory). "Here the stimulus is perceived, recognised, interpreted and associated to meanings, memories and past experiences and the subject becomes aware of the stimulus and its meaning" (Colombo, 2012: p. 7). Secondary emotions (or "cognitive" as referred to by Picard [1997]) may arise deviating from cognitive elaboration assessing the stimulus on the basis of the subject's values, concerns, and objectives. The model shows that secondary emotions can provoke unconscious physiological responses by reaching the limbic system. This direct link is discussed in the literature as it is argued that other external factors could influence it (Picard, 2000).

Two additional centres are presented in the model (Colombo, 2012): the NAcc (Nucleus Accumbens, which mediate hedonic sensation) and the MFB (medial forebrain bundle, which is responsible for desire). Their existence demonstrates that pleasure is associated to specific centres and is therefore dissociated from emotions (Christoforidou & Motte, 2009). The NAcc centre is directly linked to the sensory cortices, which means that sensory stimulations can directly activate the pleasure system. NAcc and MFB are also connected to the prefrontal cortex. It gives them additional signals to evaluate.

Colombo (2012) also highlighted correspondences between the neuroscience model and elements from the design research literature (represented in blue in Figure 2.11). She explained that the signal processed in the high road by the prefrontal cortex corresponds to Crilly et al.'s *symbolic association* and *semantic interpretation*, Desmet and Hekkert's *experience of meaning* as well as Norman's *reflective level. Ideo-pleasure* described by Jordan also appears related to the prefrontal context as it comes from the appraisal of the signal according to personal values.

The model describes two types of emotions: primary emotions originating in the low road and secondary emotions originating in the high road. Primary emotions correspond partially to Norman's *visceral level,* whereas the context of secondary emotions derives from cognitive elaboration assessing the stimulus on the basis of the subject's values, concerns, and objectives. They correspond to the ones described by Desmet (2002) in his basic model of product emotion. Therefore, they also correspond to Crilly et al.'s *affective response,* and to Desmet and Hekkert's *emotional experience*.

Colombo (2012) presented the links between sensory cortices and the NAcc (mediating the hedonic sensation) as the source of *physic-pleasure*, *aesthetic experience,* and *aesthetic impression,* as well as part of *visceral response*. The one between NAcc and the prefrontal cortex (cognitive elaborations such as symbolic associations) enables a conscious and unconscious appraisal of the perceived stimuli on the basis on its social value and therefore *socio-pleasure*.

2.2.4 CONVERGENCE OF THE KANSEI AND USER EXPERIENCE DESIGN PERSPECTIVES?

Part of the originality of this research is that it intends to combine notions from the "Western" emotional and experience design research field as well as from Eastern kansei research. As could be seen in the previous sections, both have in common the fact that they describe the human subjective process involving an affective dimension and following the perception of artificial construction (product, interaction, service…). Indeed, in the same way experience is distinguished from usability (arising from the logical behavioural level [Norman, 2004]), kansei is distinguished from chisei (leading to intellectual understanding) and opposed to risei (logic process). In order to define a clear context for the experiments I will use this section to put both points of view in perspective and build a summary "Kansei-Experience framework" that will be used as a basis for the following discussions.

First, it is interesting to note that there is a difference in terms of focus point between the two notions: "kansei" is centred on one's subjective mental processes, whereas "experience" is described from a point of view that encompasses an environment (including at least a product) and a user. This second perspective is clearly expressed by the statement, "experience is not a property of the product but the outcome of human-product interaction" (Desmet & Hekkert, 2007: p. 63). The emotional and experience design perspectives generally only describe visible outputs of mental processes (e.g., pleasure, appeal, emotions, semantic association). These visible outputs correspond to the *kansei direct consequences* described by Lévy et al. (2007).

As mentioned previously, one reason for it, is that emotional and experience design models "are not intended to be 'true' to reality (realism), but to be useful (instrumentalism)" (Christoforidou & Motte, 2009: p. 9). It is only very recently that researchers (Colombo, 2012) have attempted to link up emotional and experience design frameworks and models from the field of neuroscience.

This initiative is very interesting because it puts them at the same level as kansei research frameworks. The *kansei process* (Lévy et al., 2007) and the neuroscience model (Colombo, 2012) both describe mental processes taking their origins in signals captured by one's senses and influenced by one's personal characteristics such as personal values, past experiences, and socio-cultural references. In that sense, *Kansei process* corresponds to both roads (i.e. high road and low road) presented in the neuroscience model as it is defined as "gather[ing] the functions related to emotions, sensitivity, feelings, experience and intuition, including interactions between them" (Lévy et al., 2007: p. 9).

Both perspectives can actually be combined in a framework covering the context of a user-product interaction in a given environment (context of an experience), the *kansei process*, and the result of this process: *perceived kansei qualities*. They correspond to kansei direct consequences (Lévy et al., 2007) including user responses such as pleasure, meaning elaboration, primary and secondary emotions (Colombo, 2012). This framework is presented in Figure 2.12.

As explained previously, *understanding* (related to understandability of functions, usability) is dissociated from the *perceived kansei qualities* but is still represented on the framework as a factor influencing the *kansei process*. The other influencing factors represented include the *user's personal characteristics* and *attributes from the environment*. Both have been introduced as such in the previous sections (see for instance Figure 2.5 [p. 37]).

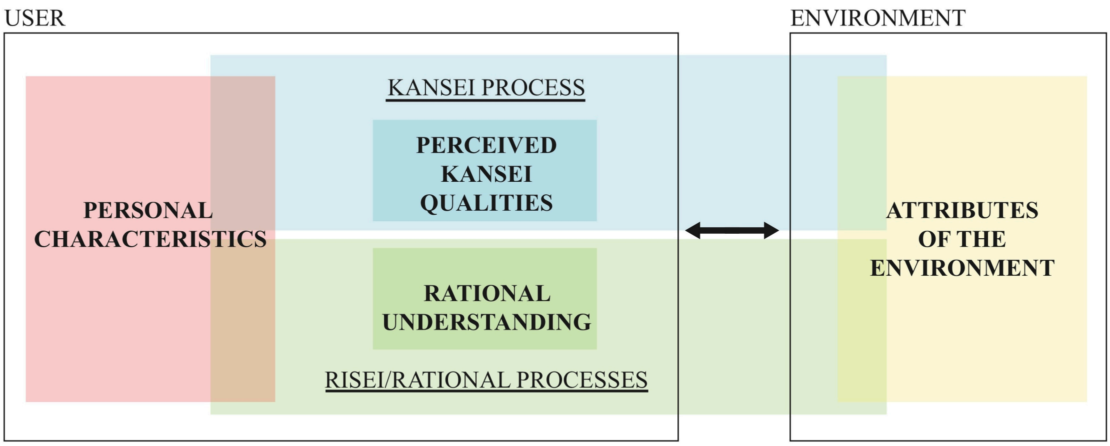


Figure 2.12: Generic framework combining kansei and user experience design perspectives

A simplified framework is introduced hereafter: the "Kansei-Experience framework" (Figure 2.13). It is centred on the specific focus of this dissertation. In this framework, the centres of interests are the notions of *experience* and of *kansei process* (i.e. not rational processes), as well as the three core entities of user experience: the user's *personal characteristics*, the user's *perceived kansei qualities*, and the *attributes of the environment*.

The *kansei process* is represented as creating a link between the three user experience entities. *Perceived kansei qualities* encompass notions such as pleasure, meaning, emotions, *personal characteristics* cover the notions of culture (i.e. demographics – e.g., age, gender, nationality, function, organisational affiliation), values, personality, mindset, as well as memory, and *attributes from the environment* include product, interaction, and context attributes.

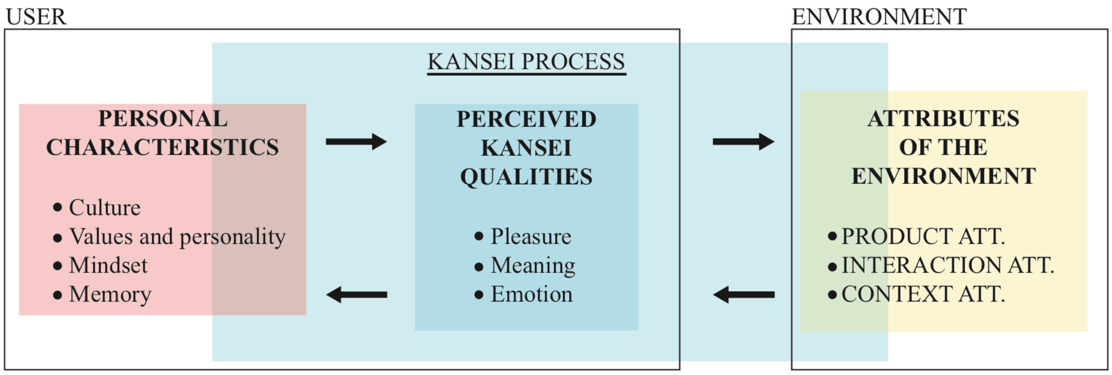


Figure 2.13: Kansei-Experience framework - Specific focus of this dissertation

Perceived kansei qualities will be used as markers of the kansei process as they have the particularity of being observable by a third party. In the case of this dissertation, these indirect observations will be made on psychological responses (questionnaires and interviews) using information expressed by users such as semantic associations, expressed emotions, appeal and/or pleasure.

The next section will cover the existing literature related to the influences of *personal characteristics* and *attributes of the environment* on the *perceived kansei qualities*.

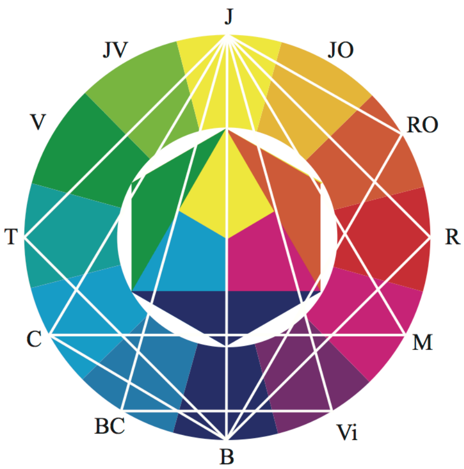
2.2.5 INFLUENCES FROM PERSONAL CHARACTERISTICS AND ATTRIBUTES OF THE ENVIRONMENT ON PERCEIVED KANSEI QUALITIES

In the field of design research, important efforts have been put towards the investigation of interrelations between *experience influencing factors* and *perceived kansei qualities*. Many sessions of major design research conferences (e.g., IASDR, DRS) are for instance directly tackling this topic and several events such as the "Design and semantics of form and movement" (Chen et al, 2008; 2010; 2013) and the "Kansei Engineering and Emotional Research" (Lévy et al., 2010; Lin, 2012) conferences are specifically focusing on it. It is interesting to note that this area is covered by researchers from all different fields of design research detailed in the context ("Ergonomics and cognitive psychology in design," "Kansei Engineering & Science," "Emotional and experience design" - section 1.3.2 [p. 23]). The underlying paradigms can therefore differ from one research to another.

In the following sub-sections an overview of the different experience influencing factors investigated in these studies will be detailed. The literature review will first cover the influence from *attributes of the environment* (product attributes, interaction attributes, context attributes) and then from *personal characteristics* (culture, values and personality, mindset, memory).

2.2.5.1 PRODUCT ATTRIBUTES – ENVIRONMENT

The research that Itten did on colours (1967), as well as on shape and textures (1983), while he was teaching at the Bauhaus (1919-1923), is probably among the first attempts to describe the influence product attributes can have on perceived kansei qualities. With respect to colours, he was able to determine and create detailed guidelines for aesthetically pleasing harmonies and contrasts. Regarding harmonies, he created a colour wheel from which different colour harmonies can be extracted (Figure 2.14). Concerning contrasts, he detailed a list of seven contrast techniques that contribute to make compositions harmonious. One of them is for example is the *cold-warm contrast* technique that involves the juxtaposition of cold and warm colours.



1st order harmonies
- J - JV
- J - JO

2nd order harmonies
- J - B (line)
- J - C - M (triangle)
- J - R - B - T (square)

3rd order harmonies
- J - R - B - T (polygon)
- J - BC - Vi (isosceles triangle)
- J - RO - B - C (rectangle)

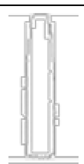
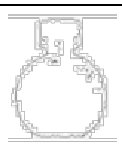
Figure 2.14: Three orders of colour harmonies (Itten, 1967)

More recent research has investigated the influences of other sensory modalities such as touch (Moussette, 2012) and sound (Özcan & Sonneveld, 2009). Zampini et al. (2003) and Schifferstein et al. (2008) also pointed out the importance of treating the multiple senses together when designing a product as they all influence perceived kansei qualities.

Karjalainen (2006) studied the product's brand as an additional product attribute. The notion of brand refers indeed to kansei qualities related to sensory information perceived by users during an experience, as well as to his/her memories of past experiences.

Berlyne (1971) proposed that the relationship between "arousals" (novelty, complexity) and hedonic value exhibits an inverted U function. In other words, some of the product attributes (i.e. "arousals") have a positive influence on some perceived kansei qualities until they reach a certain point (top of the inverted U function). After this point (too novel, too complex) they have a negative influence on the kansei qualities perceived by the user. The threshold presented here is in many ways similar to Loewy's MAYA (most advanced, yet acceptable) concept (1951). This U-shaped function has recently been observed in several empirical studies (Hung, 2009; Hung & Chen, 2012; Huang & Huang, 2013).

Table 2.1: Characteristic adjective presence or absence for cluster shape prototype (Lesot et al., 2010)

Cluster shape	*Significant presence*	*Significant absence*
	Ethereal, tangy, dynamic, mysterious, young, sport	Powerful, attractive, extravagant, aggressive, high-tech
	Playful, warm, sensual	Sport, ethereal, high-tech, austere, masculine

Lesot et al. (2010) proceeded to experiments with perfume bottles in order to identify influences that the product shape (i.e. one of the product's attributes) can have on semantic and emotional response. After having asked participants to report the kansei qualities they perceived from several samples of perfume bottles, the researchers employed hierarchical cluster analysis in order to generate new shapes of bottles related to specific kansei quality keywords (Table 2.1). This research illustrates how the use of scientific reasoning can combine product attributes and perceived kansei qualities for generation activities.

Kansei Engineering studies are by definition focused on the influence that product attributes have on perceived kansei qualities. I will illustrate this field of design research with the most famous example of Kansei Engineering (type I): the development of the roadster Mazda Miata (MX-5 in Europe). The chosen approach started with user research conducted with potential young drivers in order to classify their driving behaviours, lifestyles (Table 2.2) (Nagamachi, 1997). This information was used to identify and define the zero-level concept of the new product to-be-designed: "Human-Machine Unity" (HMU). The meaning behind it is that the driver has to perceive the car as a natural extension of his body. The zero-level concept was then broken down into more precise sub-concepts relying on intended kansei qualities. The break-down process continued until recognizable physical features of automobiles were found. At this stage ergonomics and Kansei Engineering evaluations (involving intended users and SD-scales evaluations) were conducted in order to identify physical features (product attributes) fitting the defined concept (HMU and sub-concepts). They were then translated into detailed specifications regarding the product development. The Mazda Miata is still today the most successful roaster of all times.

Table 2.2: The Kansei break-down process applied in the development of Mazda Miata (Nagamachi, 1997)

Kansei				*Physical characteristics*	*Ergonomic experiment*	*Automotive engineering*
Zero	*1st*	*2nd*	*nth*			
HMU	Tight feeling Direct feeling Speedy feeling Communication	....	....	• Size • Width • Height • Seat • Steering design • Shift lever • Speed meter • Open style • …	• Tight feeling experience • Interior kansei experience • Steering function • Shift lever length • Minus gravity • Noise frequency analysis • …	• Chassis design • Seat design • Interior design • Power train development • Steering jaw ratio • Steering yaw ratio • Steering design • Shift lever • …

Finally, I will close this sub-section by mentioning Desmet's work on emotions (2003). He was able to distinguish five groups of emotions that products can elicit. They are defined as follows.

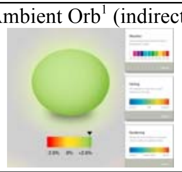
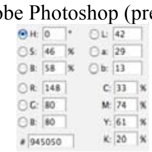
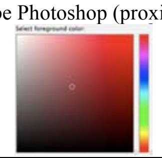
- *Instrumental emotions* (e.g., disappointment, satisfaction) come from the assessment of whether or not a product will assist the user in achieving his objectives.
- *Aesthetic emotions* (e.g., disgust, attraction) relate to the potential for products to delight and offend the user's senses.
- *Social emotions* (e.g., indignation, admiration) result from the extent to which products are seen to comply with socially determined standards.
- *Surprise emotions* (e.g., amazement) are driven by the perception of novelty in a design.
- *Interest emotions* (e.g., boredom, fascination) are elicited by the interpretation of challenge combined with promise.

2.2.5.2 INTERACTION ATTRIBUTES - ENVIRONMENT

Interactions are what bind users and products. This abstract bond, which was first omitted in kansei and emotional design studies, is now considered as a core component of the user experience (Ortíz Nicólas & Aurisicchio, 2011). Researchers are nowadays exploring its aesthetics qualities (Hummels & Overbeeke, 2010), as well as the impact it can have on the user's emotions and his semantic associations (Forlizzi & Batterbee, 2004).

Due to their abstract nature, interaction attributes require more effort to be described. Lim et al. (2007) developed a taxonomic scheme in order to describe interface logics (i.e. one type of interaction attribute). They proposed the concept of interaction gestalt composed of a list of eleven attributes: *connectivity*, *continuity*, *directness*, *movement*, *orderliness*, *pace*, *proximity*, *resolution*, *speed*, *state*, and *time-depth*. Three of them are presented in Table 2.3. They are thought of as a tool for designers and design researchers to understand and describe interfaces. "Standardizing" interaction attributes permits us to identify which attributes can be manipulated, and how to manipulate them when designing interactions (Lim et al., 2011).

Table 2.3: Example of three attributes of the interaction gestalt (Lim et al., 2007)

Attributes	*Definition*	*Examples*	
Continuity (discrete-to-continuous)	The level of continuity of users' manipulation toward interface elements.	SanDisk Sansa (discrete) 	Apple iPod (continuous) 
Directness (indirect-to-direct)	The level of directness of what is shown through an interactive artefact or its information elements	Ambient Orb[1] (indirect) 	Weather.com[2] (direct) 
Proximity (precise-to-proximate)	The level of proximity of controlling information.	Adobe Photoshop (precise) 	Adobe Photoshop (proximate) 

[1]http://www.ambientdevices.com/technology/glanceable-information
[2]http://www.weather.com/weather/today/Paris+FRXX0076:1:FR

Krippendorff's interaction protocol (2006) (see Figure 2.8 [p. 40]) can also be used as a taxonomic scheme. Lin and Cheng (2011) used it to study and compare the perceived kansei qualities resulting from specific interaction sequences. This sequential analysis showed that movements and gestures are important types of interaction attributes that influence the user experience. Research by Klooster and Overbeeke (2005) introducing the notion of *choreography of interaction* also highlighted these types of interaction attributes.

An evolution regarding interaction can also be observed in our everyday life as most interfaces are progressively moving from traditional supports such as buttons and pointers (e.g., computers equipped with keyboard and mouse) towards tactile surfaces and other types of gesture recognition interfaces: the nature of interactions is changing. Gesture-based interactions allow more freedom to the designers and embed at the same time more kansei qualities. A trend of more "natural" communication between users and products can for instance be observed. In terms of interaction attributes, it can be translated by the use of gestures similar to the ones people are accustomed to making when interacting with other humans or with iconic objects (e.g., "next page" gesture on most tablets and E-book readers evokes the turning of a real book page). The interaction attributes selected also impact the kansei qualities perceived by the users (e.g., "next page" gesture relates to *natural*, *comfort* semantic association and *at ease* feeling).

At the same time, the more users are using the gestural modality, the more they are actively engaged in interaction. Deckers (2013) showed that human mental and physical involvement could be the source of rich experiences. By manipulating the related notion of "perceptual crossing," the hedonic quality of an interaction can be directly impacted (Deckers et al., 2012).

Complementary to the interaction gestalt taxonomic scheme enabling the description of interfaces, different researchers also developed taxonomies of gesture inputs. Table 2.4 summarises the findings of two of them (Karam & Schrafel, 2005; Rime & Schiaratura, 1991). Design researchers have used such interaction attribute categories in order to analyse the results of bodystorming generation and evaluation sessions (Solinski, 2011; Bouchard et al., 2013). It enabled them to better describe particular sets of gestures and related kansei qualities perceived by users.

Table 2.4: Taxonomy of gesture in interaction design (Karam & Schrafel, 2005; Rime & Schiaratura, 1991)

Gesture type	*Description*
Gesticulation	Natural forms of gesturing commonly used in combination with conversational speech interfaces.[1]
Manipulation	Gestures whose intended purpose is to control some entities by applying a tight relationship between the actual movements of hand, arm and the entity being manipulated.[1]
Deictic	Gestures which involve pointing to establish the identity or spatial location of an object within the context of the application domain.[1,2]
Iconic	Gestures conveying information about shape while moving hands through the air (size, shape, orientation of the object, etc).[2]
Pantomimic	Gestures mimicking the movement of some invisible tool or object.[2]
Semaphoric	- Gestures conveying symbols to be communicated to the machine. They rely on a gesturing system (e.g., involving arms, flags, lights) that employs a stylised dictionary of static or dynamic hand or arm gestures.[1] - These gestures include symbolic and/or cultural meanings.[2]
Sign language	- Gestures used in sign languages. They are considered as independent of other gesture styles because they are grammatical and lexically complete and often compared to speech.[1] - These gestures include symbolic and/or cultural meanings.[2]
Multiple styles	Combination of several types of gestures such as deictic and manipulation, or semaphoric and manipulation.[1]

[1] Karam & Schrafel (2005)
[2] Rime & Schiaratura (1991)

2.2.5.3 Context attributes – Environment

The context in which a user-product interaction occurs also has a great influence on the way users perceive the related experience (Forlizzi & Battarbee, 2004). Ortíz Nicólas and Aurisicchio (2011) listed different types of contexts for an experience. These are the *physical*, *situational*, *social* and *temporal contexts*. Their relations to kansei qualities will be discussed in the following paragraphs.

Physical context

The physical context consists in the physical elements surrounding the artefact at the centre of attention of an interaction sequence. Research has shown that it also influences the perceived kansei qualities (e.g., influence of the point-of-sale) (Underhill, 2000). This is one of the reasons why experiments related to experience do not necessarily have the same results whether they are conducted in a lab or in a "real" context.

Situational context

Different researchers have argued that situational factors play a role in experience. Hassenzahl notably distinguished two types of situational contexts: the work-state and play-state (2010). Another research showed that the overall judgment in term of kansei qualities of a website differed depending on the situation in which it was presented to the participants (Hassenzahl et al., 2002).

SOCIAL CONTEXT

Forlizzi and Battarbee (2004) described co-experience as a major context in which an experience can take place. In this context the creation of meaning and the emotions triggered are the result of a collaborative activity coming from the joint use of the product. This type of experience is special because the kansei process not only comes from the perception and the interaction with the product but from interaction with the other users as well. The layer added by the additional user(s) therefore greatly influences the way the interaction affects the perceived kansei qualities. If taken into consideration in the development phase, co-experience opens new possibilities in the design of user experience (Battarbee & Koskinen, 2005).

TEMPORAL CONTEXT

With the introduction of the “modes of attention,” Krippendorf (2006) stressed the importance of the notion of time during the different stages (or “modes”) of a user-product interaction (see section 2.2.2.2 [p. 39]). The time spent with a product also influences the perception of the experience (Karapanos et al., 2009) and the relative importance of its multi-sensory properties (Fenko et al., 2010).

Ocnarescu et al. (2012) explored the differences between different stages going from the first information gathered about an object, named *pre-experience* (e.g., reading an article about the object), to the *post-experience perspective* corresponding to a moment when the person will no longer be able to experience the object directly (e.g., when leaving a museum). The researchers could relate the *pre-experience perspective* with different mindsets such expectation (mindset is a personal characteristic – see section 2.2.5.6 [p. 54]), and the *post-experience perspective* with the notion of memory. Regarding *post-experience*, Norman (2009) stated that the emotional retrospective view of a user experience could be considered as another experience. This time, it is only led by memory and no longer by sensory perception. Due to the subjective nature of memory and possible changes of personal characteristics (e.g., mindset, values) the remembered kansei qualities are subject to change over time.

2.2.5.4 CULTURE – PERSONAL CHARACTERISTICS

In the previous sub-sections, I detailed research dealing with *attributes of the environment* influencing the kansei qualities that one can perceive during an interaction. Starting from this sub-section, the literature covering experience influencing factors related to *users' personal characteristics* will be detailed.

One’s culture can be defined by characteristics such as one’s gender, nationality, age, or function. In that sense the notion on culture is very similar to the one of demographics. Empirical studies from the fields of cognitive science, kansei, and experience design research have investigated widely the influences that one’s culture have on the way a user perceives and interacts with products.

For example, Medeiros et al. (2008) observed the influence of age on the perception of experience and Schroeder (2010) compared differences between women and men. Differences of perceived of kansei qualities were also observed between easterners and westerners such as in the research from Haring et al. (Japanese vs. European) (2012), Lee and Ho (East vs. West) (2008), and Tomico et al. (Dutch vs. Japanese) (2009). Regarding studies covering more than one language-region (i.e. nationality-related researches), the evaluation phase has to be treated with care. When using keyword-based evaluation, Fenko et al. (2010) observed differences of literal and metaphorical meaning between the different translations of keywords. Laurens and Desmet (2012) also observed differences of understanding of non-verbal measurement tools (i.e. emotions represented with animations in PrEmo and PrEmo 2).

In his cultural dimensions theory, Hofstede (2001) relates one’s nationality to predispositions for certain values. Thanks to extensive empirical research, he was able to observe disparities between nations for six values-related dimensions. The six dimensions (or indexes) were *power distance*, *individualism vs. collectivism*, *uncertainty avoidance*, *masculinity vs. femininity*, *long-term vs. short-term orientation*, and *indulgence vs. restraint*.

The correlations observed by Hofstede lead to a discussion of the notion of personal values as another factor influencing the experience. This discussion will take place in the next section.

2.2.5.5 Values and personality – Personal characteristics

With the Rokeach Value Survey (RVS), Rokeach (1973) proposed two lists for two different types of values. The terminal values refer to desirable purposes of existence (i.e. goals that one would like to achieve in his/her life), whereas the instrumental values refer to preferred types of behaviours (i.e. the manner one plans to reach his/her goals).

Bouchard et al. (2009) investigated users' response to the perception of shoes. When collecting demographic information they focused on participants' nationality as well as their instrumental values. Concerning the instrumental values they based their list on the one proposed by Rokeach. The researchers found correspondences between users' personal characteristics (nationality and instrumental values) and the semantic and emotional associations (i.e. kansei qualities) they held for a wide variety of shoes. In the field of automotive design, Desmet et al. (2004) identified similar types of correspondences between participants' instrumental values (as described by Rokeach) and their emotional response to the perception of several cars.

Table 2.5: Terminal and instrumental values of the Rokeach Value Survey (Rokeach, 1973)

Terminal values	*Instrumental values*
A Comfortable Life	Ambition
A Sense of Accomplishment	Broad-Mindedness
A World at Peace	Capability
A World of Beauty	Cheerfulness
An Exciting Life	Cleanliness
Equality	Courage
Family Security	Forgiveness
Freedom	Helpfulness
Happiness	Honesty
Inner Harmony	Imagination
Mature Love	Independence
National Security	Intellect
Pleasure	Logic
Salvation	Love
Self-Respect	Obedience
Social Recognition	Politeness
True Friendship	Responsibility
Wisdom	Self-Control

In addition to personal values, the relation between personality and perceived kansei qualities can also be investigated. It can be done using the Five Factor Model (e.g., McCrae and Costa [1999]). Co-developed by Goldberg (1990, 1992), this model consists in a set of five independent factors that enable the assessment of one's personality ("Openness to experience," "Conscientiousness," "Extraversion," "Agreeableness," "Neuroticism"). Each factor is defined by two opposite personality traits: the axis "Conscientiousness" is for instance defined using the opposite traits "Efficient, organized" and "Easy-going, care-free." Each trait of personality is related to several instrumental values from the RVS.

A recent study highlighted correlations between Hofstede's cultural factors and the average Five Factor Model scores of several countries (McCrae & Terracciano, 2005). For instance, the degree to which a country's inhabitants valued *individualism* appeared to be correlated with their average "Extraversion," and the ones accepting large inequalities in their *power structures* tended to score lower on "Conscientiousness."

2.2.5.6 MINDSET – PERSONAL CHARACTERISTICS

The mindset of the user is his mental attitude at the start of the interaction. It relates to his disposition (such as motivation, expectation, interest), emotions and moods (Spillers, 2010). Salem et al. (2006) defined moods and emotions as two types of affective functions of the brain which are different from each other in terms of lifespan (hours for moods vs. minutes for emotions). Dispositions, emotions, and moods seem therefore to be at the same time results and influencing factors of an experience (Veryzer, 1995). For example, intrinsically motivated users (activity- rather than goal-oriented) may be more tempted to focus on the artefact's kansei qualities than on its rational quality (Hassenzahl et al., 2002). Still dealing with the influence of the user's mindset, researchers showed the influence of expectation (disposition) (Yanagisawa et al., 2013) and interest (emotion) (Yoon et al., 2012) on perceived kansei qualities. It is also interesting to highlight here that there is a link between the situational aspect of the context (see section 2.2.5.3 [p. 51]) and the user's mindset (e.g., motivation, expectation). Practices in branding, marketing and advertising are for instance relying on these links (Bloch, 1995).

2.3 INDUSTRIAL DESIGN PROCESS

The industrial context gives a frame, as well as a set of objectives and constraints to design practice. This is also true for the people, activities and approaches associated to it. Within an organisation a team of individuals, called the design team, is responsible for the design process. It is composed of members with different functions ensuring, from their viewpoint, the effectiveness of the related operations. Because of the competition occurring between organisations (one of the foundations of capitalist societies), they need to be constantly sensing their environment and adapting the product they offer. One of the ways for a company to keep its assets and to overtake competition is innovation. It can be defined as a tangible improvement of the company's communication (e.g., marketing), offer (e.g., product properties), and/or practices (e.g., process, activities, approaches).

In this section, I will start by reviewing the literature related to the *industrial design process*. It allows an overview of the context of this research. The focus will then be put on two particular stages of this process: the *new concept development stage* and the *new product development stage*. In the fourth sub-section, research related to *multi-cultural design teams* will be presented. Finally, the *integration of design-driven approaches* at the early phases of the design process will be discussed.

2.3.1 INTRODUCTION TO THE INDUSTRIAL DESIGN PROCESS

The industrial design process of a product can be divided into several macro-phases. A representation of it by Buijs (2012) can be found in Figure 2.15. Four different macro-stages of the design process can be distinguished is this model: "new concept development" (represented in blue in Figure 2.15), "new product development" (represented in yellow), "commercialisation" (represented in orange), and "product use" (presented in green). These phases are relatively consensual among scholars and are not specific to Buijs. They can be found in the writings of some of the most influential scholars from the field such as in the works from Cooper (2008) and Cross (2008).

Buijs' model (Figure 2.15) uses a ring-shape circular diagram is order to show the repetitiveness of the process as well as the two entities the design team(s) have to rely on: "the company" (centre) and "the environment" (exterior). The size of the different stages on the model is not representative of their actual durations. Note that even if it has a circular shape, the represented design process does not correspond to the life-cycle of a product. This notion is usually only related to the "commercialisation" stage and is used to map the lifespan of this product (using for instance stages such as introduction, growth, maturity, and decline).

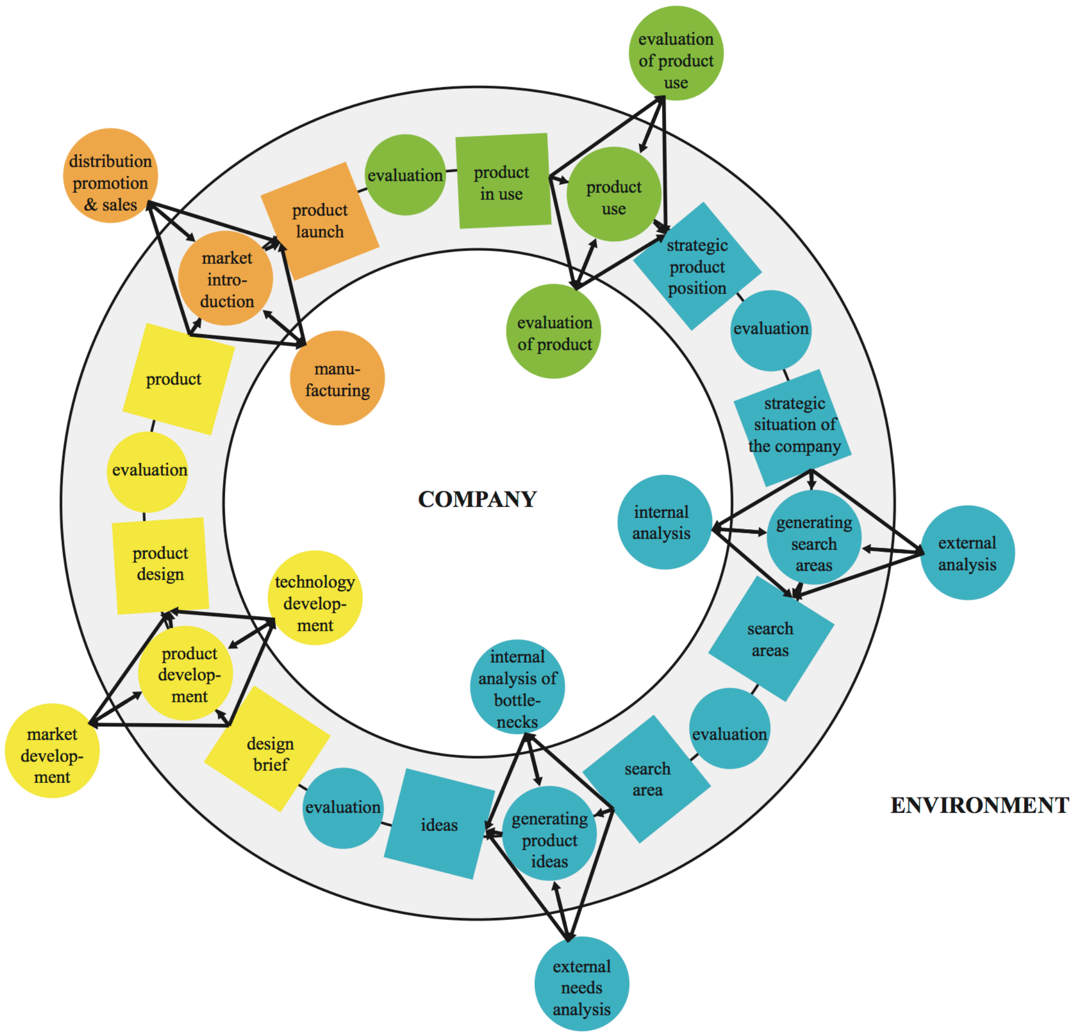


Figure 2.15: Delft Innovation model (Buijs, 2012)

Wheelwright and Clark (1992) distinguished between three main types of new products: *breakthrough products*, *platform products,* and *incremental products*. They characterise products based on the extent of product and process change induced by their development (Figure 2.16).

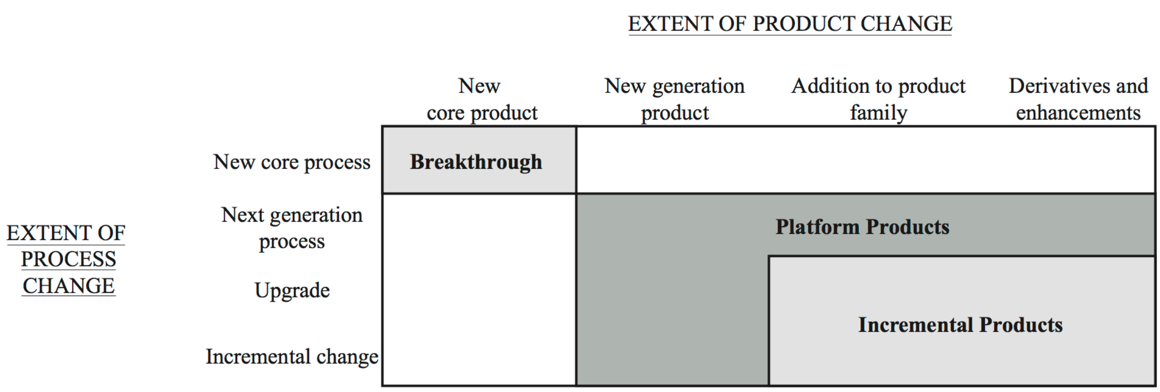


Figure 2.16: Typology of new products (Wheelwright & Clark, 1992)

Breakthrough products involve the most product and process changes. In the automotive industry, the introduction of the first hybrid vehicle in the 1990s and electrical vehicle in the 2000s are good examples of *breakthrough products* (in these cases, the breakthrough innovation came from the engine).

At the other extreme, *incremental product* developments involve only few process and product changes. In the automotive industry, such developments correspond to small vehicle updates that occur usually three years after the launch of a new vehicle. They involve minor styling and performance changes (but not deep architecture changes).

In between these two extremes are *platform product* developments. These developments establish a basic architecture for a next generation of product or process and are substantially larger in scope than for *incremental products* (Meyer & Lehnerd, 1997). The introduction of a new vehicle and the addition of new body styles (e.g., coupe, convertible, station wagon) are the result of *platform product* developments.

The following paragraphs will show that the nature of the earliest phase of the development process (NCD) is highly dependent on the type of products it is meant to influence.

This research touches mainly on three of the four stages of the industrial design process. The first is the *product use* (represented in green in Figure 2.15). It corresponds to the culmination but also to the starting point of any user-focused development process. It corresponds to the stage where users are experiencing products. When regarding it as the starting point of the industrial design process, it has to be seen as a stage where information is gathered from the use and experience provided by products already on the market (Buijs, 2012). Insights from these observations, combined with the vision of a company lead to decisions regarding research directions (Koen et al., 2002). Structured frameworks related to the notions of user experience, kansei process, and perceived kansei qualities can be used to better describe these observations. When regarding the *product use phase* as the culmination of an industrial design process, is has to be seen as the result of all the efforts deployed by the design team. This stage is crucial because it is ultimately when the success or the failure of product development and of the related product can be determined (Buijs, 2012).

Two other stages will be covered by this research: the *new concept development* (represented in blue in Figure 2.15) and *new product development* (represented in yellow in Figure 2.15). Particular attention will be paid to the transition between the *new concept development* (NCD) and the *new product development* (NPD) stages. They both will be discussed in more detail in the following sections.

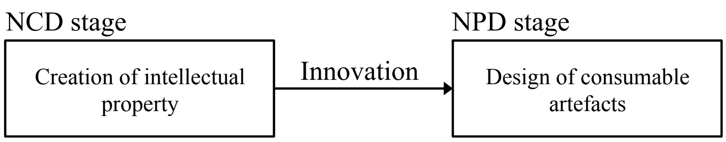


Figure 2.17: Interactions between Creation, Designing and Innovation (adapted from Gero [2010])

I will use the vocabulary introduced by Gero (2010) to start explaining distinctions in terms of purpose between the two stages of the design process preceding *commercialisation*. On the one hand, the NCD stage intends to create intellectual property, whereas on the other hand, the NPD stage is about the design of consumable artefacts (Figure 2.17).

Gero described *innovation* as being the introduction or uptake of intellectual property (created during the NCD stage) into *new product developments (*NPD stage). As was shown previously, these innovations can be related to products and/or processes. This means that both stages (NCD and NPD) are necessary for the innovation process. This definition of innovation also corresponds to the one by Van de Ven (1986): “new ideas that have been developed and implemented” (p. 590).

Depending on the changes they involve, innovations can range from incremental innovation to radical innovation. Their nature also impacts the typology of products they are related to (Figure 2.16) (Wheelwright & Clark, 1992). In that sense, the nature of the intellectual property created determines the product development strategy that will be adopted by project managers (Verworn & Herstatt, 1999).

Most of the models available in the literature focus either on NCD or on NPD. The coverage of eight of them is presented in Table 2.6. Information related to the nature of the different models (descriptive or prescriptive) is also indicated. The two following sections (sections 0 and 2.3.3) will focus on NPD and NCD, respectively.

Table 2.6: Eight industrial design models: stage covered and type

Author(s)	*NCD stage*	*NPD stage*	*Commercialisation*
French (1999)		Descriptive	
Pahl & Beitz (1999)		Prescriptive	
Ulrich & Eppinger (2000)		Prescriptive	
Koen et al. (2002)	Descriptive		
Sandmeier et al. (2004)	Descriptive		
Wormald (2010)	Prescriptive		
Cooper (2008)	Prescriptive	Prescriptive	Prescriptive
Buijs (2012)	Prescriptive	Prescriptive	Prescriptive

2.3.2 NEW PRODUCT DEVELOPMENT (NPD) STAGE

The analysis of the five NPD models presented in Table 2.6 showed that they have some common characteristics. They all represent the NPD stage with flowchart diagrams showing the different sub-stages as boxes and their orders with arrows connecting them. The NPD process is therefore represented as a succession of stages logically linked together, and depending on each other. Due to the presence of a clear project plan and milestones, Koen et al. (2002) describe the work in the NPD stage as structured (distribution of tasks among functions), disciplined, and goal-oriented. NPD projects also have as common characteristics the fact of having a target, a rather defined commercialisation date, structured and budgeted funding, and rather clear forecasts of expected revenues (Koen et al., 2002). It will later be shown that these characteristics of the NPD stage are very different from what occurs during the NCD stage.

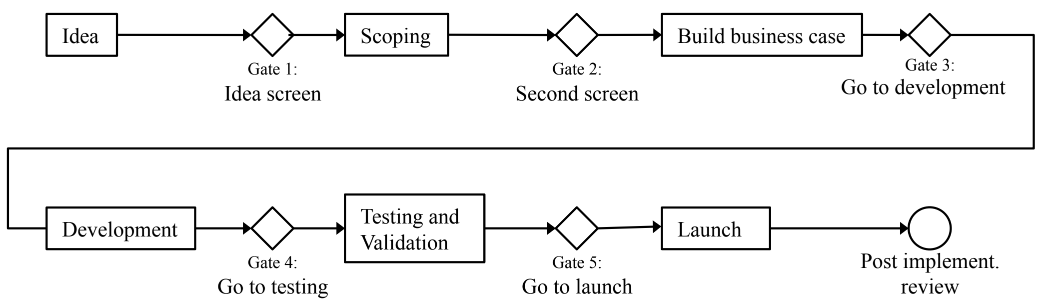


Figure 2.18: The Stage-gate model (Cooper, 2008)

The "Stage-gate model" (Cooper, 2008) even goes one step further into the representation of causal links between stages. It includes explicitly the notion of "gates" (close to the "evaluation" stages described by Buijs in Figure 2.15 [p. 56]). These are additional assessment stages located at the end of each of the five stages (*Discovery, Scoping, Build business case, Development, Testing and validation*) (Figure 2.18). The gates correspond to project reviews during which the company's decision-makers would allow the process to continue, request to repeat the stage, or stop the on-going process.

A major concern related to structural organisation of this type of NPD processes is the stage-to-stage information dependency. It excludes non gate-specific information from decisions at the gates, reduces the project flexibility and can lead managers into traps (Jespersen, 2012; Rajesh Sethi & Iqbal, 2008). For these reasons academics and practitioners are moving towards more flexible processes, even at the NPD stage. The strength of this movement depends on the type of industry for which the development process is used. It is clear for IT and new technology related industries (waterfall vs. extreme development), but much slower in traditional and more consolidated sectors of the industry (e.g., automotive industry).

2.3.3 New concepts development (NCD) stage

It has been shown that the new product development stage is rather structured and organised. This is not the case for NCD as authors described it as a much more chaotic process with uncertain outputs (Koen et al., 2002; Kim & Wilemon, 2002; Sandmeier et al., 2004) (Table 2.7). This is why it is also referred to as the fuzzy front-end (FFE) of new product development. Because of fundamental differences, the structure of the NPD stage cannot necessarily be transposed for front-end activities. Koen (2004) showed that this is especially true in the case of platform and breakthrough product developments. The NCD stage can bring major competitive advantages but is at the same time recognized as being the most difficult part of the innovation process because of its uncertainty (Kim & Wilemon, 2002; Verworn, 2009). This uncertainty is visible at several levels such as work, commercialisation date, funding, revenue expectation, activity and measure of progress. Table 2.7 summarises the key differences between NCD and NPD.

Table 2.7: Differences between NCD and NPD (based on Koen et al. [2002], Kim and Wilemon [2002], and Sandmeier et al. [2004])

	New concept development (NCD)	*New product development (NPD)*
Work	Experimental, often chaotic, eureka moments	Disciplined and goal oriented with a project plan
Commercialisation date	Unpredictable and uncertain	High degree of certainty
Funding	Depends. In the beginning stages many projects may be “bootlegged”	Budgeted
Revenue expectation	Often uncertain with a great deal of speculation	Believable with increasing certainty as the release date gets closer
Activity	Organised around individual or small teams. Interactions with other functions of the organisation	Structured multi-functional product/ process development teams
Measure of progress	Strengthened concept	Milestone achievement

Even if scholars agree about some characteristics and properties of NCD projects, the models they use to describe this stage of the industrial design process are actually very different. Five of them are summarised in Table 2.8. The five different models can be divided into two groups describing either a “structured process” or a “chaotic process.”

Models belonging to the first one cover the NCD process with a highly structured process alternating creation and evaluation activities. This is the case of Cooper’s and Buijs’ models which cover NCD and NPD stages with the same linear logic (see Table 2.6 for an overview and Figure 2.15 [p. 56] & Figure 2.18 [p. 58] for details). The authors of NCD-specific models argue that these linear processes are unable to transcribe the specific nature of NCD projects, especially in the case of breakthrough and platform product development (e.g., Koen et al. [2004]). Kurkkio (2011) also observed that these descriptions are mainly focused on assembled product development and are not particularly adapted to deal with innovation in domains strongly related to user experience such as services, IT, and fields dealing with interactions. Another concern related to the highly structured organisation of these processes remains the stage-to-stage information dependency. When these models are taken as prescriptions, the project flexibility is reduced and this dependency can also lead managers into traps (Rajesh Sethi & Iqbal, 2008; Jespersen, 2012).

The models focusing specifically on the NCD stage try to allow for more accurate representation of the activities of this stage. The three models belonging to this group are the ones from Koen et al. (2002), Sandmeier et al. (2004), and Wormald (2010). The last one is presented in detail in Figure 2.22 (p. 66). Because they try to allow for more accurate representation of activities, they are more complex and do not follow a single-line flowchart (note that Table 2.8 only represents simplified versions of these models). Sandmeier et al. (2004) nevertheless admitted that because of their complexity, practitioners have more difficulties transposing and applying the prescription contained by this types of models.

The NCD model by Koen et al. distinguishes itself from the others because of its round and non-sequential structure. It is organised around three key parts:

- In the core of their model, Koen et al. (2002) represented the *engine* of NCD. It corresponds to characteristics of the organisation in which the development process occurs such as leadership, culture, and the business strategy.
- The core is influencing *controllable activity* elements through which the flow of ideas circulates and iterates. These different elements are opportunity identification, opportunity analysis, idea generation and enrichment, idea selection, and concept definition.
- External *influencing factors* surround this circular model. They affect the flow occurring between the *controllable activities* and correspond to the competitive environment, enabling sciences, organisational capability, and the outside world.

Table 2.8: Comparison of 5 NCD models

References	*NCD stage*	*NPD stage*
Koen et al. (2002)	- Engine (*leadership, culture and business strategy*) - Controllable activity elements (*Idea generation and enrichment, Opportunity identification Opportunity analysis, Idea selection, Concept definition*) - Influencing factors (e.g. *Competitive environment, enabling sciences, organizational capability*) →	
Sandmeier et al. (2004)	Market and Technology opportunities ↔ Product and Business Ideas ↔ Draft Concept of Product and Business Plan →	
Wormald (2010)	Context analysis: - User research - PEEST research - Brand research → Context representation: - Persona boards - Experience boards (scenarios) - Insight/Opportunity boards - Brand boards → Value proposition: - Combine information from different context researches - Creativity involved → Design brief formulation: - Expression of a value proposition →	
Cooper (2008) *partial*	Idea → Gate 1: Idea screen → Scoping → Gate 2: Second screen → Build business case → Gate 3: Go to development →	
Buijs (2012) *partial*	User research: - Evaluation of strategic situation of the company → Strategy formulation: - External/Internal analysis - Identify search areas → Design brief formulation: - Use of information gathered internally and externally - Idea generation →	

By looking at the NCD models, it can be observed that understanding, ideation, and assessment are key activities for successful creation of intellectual property. Different studies have further investigated the factors influencing idea fruition (Griffiths-Hermans & Grover, 2006; Björk & Magnusson, 2009; Björk et al., 2010). These empirical studies have identified that design teams have to possess different and even sometimes opposite skills in order to achieve best the three sub-processes of idea fruition: idea creation, idea concretisation, and idea commitment.

The degree of creativity of the ideas generated appeared to be positively correlated to the design team members' *expertise*, *thinking style*, *failure value*, and *intrinsic motivation*, whereas their concretisation was positively correlated with the team's *extrinsic motivation*, and *access to knowledge and resources*. Finally the commitment to ideas appeared correlated with the members' *credibility* and *vision*. *Flexible organisation policies* regarding innovation as well as *transversal networks* are also reported as having a positive impact on all the sub-processes of idea fruition during NCD.

2.3.4 MULTI-CULTURAL DESIGN TEAM

In section 2.2.5.4 [p. 52], is was shown that a common culture exists among people who share the same nationality, organisational affiliation, function, or gender. Yet, nowadays most design teams working in industrial design processes are multi-functional (Dahlin et al., 2005). This means that the team members have different functional backgrounds, including that of designers (styling), engineers (technology), and business managers (product planning, marketing). Related to the phenomenon of globalisation, contemporary design teams are often composed of people of different nationalities and even different organisational affiliations. This is especially true in the automotive industry, which is organised internationally in networks composed of OEMs, suppliers and contractor companies (Miller, 1993). For all these reasons, many current design teams can be described as multi-cultural.

In the previous paragraphs, it has been shown that the design team members' capabilities and mindset (e.g., expertise, motivation, etc), as well as the way they are organised are major factors influencing idea fruition. The state of the art related to design team's operations as well as the opportunities and challenges related to the multi-cultural (multi-function, multi-nationality) nature of design teams will now be explored in detail.

The Input-Mediator-Outcome (IMO) framework, developed by Mathieu et al. (2008), describes the context and notions related to the effectiveness of design teams (Figure 2.19).

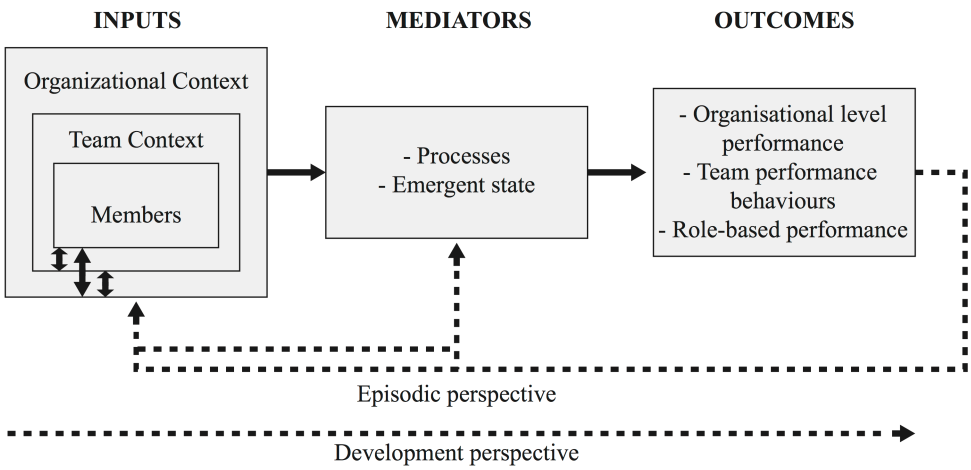


Figure 2.19: Input-Mediator-Outcome (IMO) framework (Mathieu et al., 2008)

The “inputs” describe the physical context in which a design team exists. Members are part of a team which is itself part of an organisation. The grey vertical arrows show that the different levels influence each other (left hand side of Figure 2.19). The authors nevertheless note that the outer layers influence the inner layers more that the opposite. In the IMO framework the team “inputs” influence to “mediators” and “outcomes.”

“Mediators” were introduced by Marks et al. (2001) in order to detail what was earlier only described as “processes” (McGrath, 1964). In order to do so, Marks et al. introduced in their description the notion of “emergent state” (collective efficacy, potency), which influence and are influenced by processes. From the point of view of the team members, three different categories of tasks can be distinguished in the design process: transition phase process (evaluation and planning of activities), action phase process (leading to task accomplishment), and interpersonal processes (interaction, explaining, conflict, and motivation).

Mathieu et al. (2008) described three types of “outcomes” characterising team effectiveness:

- *Organizational-level performance*, which focuses mainly on the performance of the team’s management.
- *Team performance behaviours* corresponding to actions undertaken by the team to accomplish the goals.
- *Role-based performance*, which relates to the degree to which team members have the necessary skills and competences to perform their tasks.

The IMO framework can be looked at from two different time perspectives (Mathieu et al., 2008). When describing the design process from an overview perspective (development method) the IMO framework permits one to describe the evolution of the teams’ effectiveness over a long period of time. It also allows taking into consideration the different tasks and processes occurring along the team’s life span (episodic method).

The function of team members is determined both by their education and work experience. According to Bunderson and Sutcliffe (2002), a person’s dominant function is that in which he/she has worked most of his life. Dominant functions give team members a functional perspective that influences the way they think, act, and behave. Differences in terms of functional perspectives between team members create “functional walls” that surround individuals and hinder interaction between team members (Bunderson & Sutcliffe, 2002).

Graff et al. (2011) discussed these “functional walls” in conjunction with the “jointness” principle developed by Douglas and Strutton (2009). This principle was at first intended to be used within the general organisational context. It relies on four factors: *functional competences*, *reciprocal understanding*, *cross-functional communication*, and *trust*.

Functional competences are presented as indispensable preconditions enabling other factors to emerge (Douglas & Strutton, 2009). According to the authors, *reciprocal understanding* and *cross-functional communication* can be acquired through education, training, and cross-functional team experience. *Trust* is then finally built on top of reciprocal knowledge, the result of the three other factors. Cantalone et al. (2002) also showed that while *trust* does not guarantee success, its absence increases the probability of failure.

The presence of these factors (especially *reciprocal understanding* and *cross-functional communication*) in a cross-functional design team opens the “functional wall” and impacts therefore both “mediators” and “outputs” of the IMO framework, increasing thereby team effectiveness (Graff et al., 2011).

In addition to the notion of “functional wall,” researchers observed other opportunities and challenges related to multi-cultural design teams. Table 2.9 summarises the strengths and weaknesses of multi-cultural (i.e. heterogeneous) and mono-cultural (i.e. homogeneous) teams identified by Gibson (2004) and by Graff et al. (2009).

Table 2.9: Multi-cultural teams: strengths and weaknesses (adapted from Gibson [2004] and Graff et al. [2009])

	Strengths	*Weaknesses*
Multi-cultural teams	- Improved decision quality[1] - More innovative [1,2] - Higher adaptability[1] - Inter-group and inter-organization coordination[1] - Personal growth[1]	- Lower cohesiveness, increased conflict[1,2] - Less positive mood[1] - Decreased communication[1] - Turnover[1] - Lower performance[2] - Lower competitive response[2]
Mono-cultural teams	- Cohesiveness[1] - Warmth and acceptance[1] - Strong communication[1] - Stability[1] - Higher performance[2]	- Less creative[1] - Less stimulating[1] - Less personal growth[1]

[1] Gibson (2004)
[2] Graff et al. (2009)

Table 2.9 highlights the importance of having multi-cultural teams at the NCD stage. It appears that even if they are more chaotic, such teams are also more likely to come up with ideas leading to breakthrough innovations (improved decision quality, greater innovation, higher adaptability) (Gibson, 2004: Graff et al., 2009). Brett et al. (2006) detailed four strategies that team members can adopt in order to deal with the weaknesses of heterogeneous teams, solve conflicts, and increase their teams' efficiency. These strategies are *adaptation* (discussing cultural differences with the team, involving the members), *structural intervention* (reorganization or reassignment designed to reduce interpersonal friction or remove a source of conflict), *managerial intervention* (arbitrary managerial decision leading for instance to the establishment of a set of rules), and *exit* (leaving the team, strategy of last resort [infrequent]).

Brett et al. (2006) also noted that multi-cultural teams can also be a challenge for managers. Additional qualities such as greater capacities to listen and communicate, as well as more empathy and patience are required. This is due to cultural differences regarding languages and working culture, as well as differences of attitude towards hierarchy and authority.

2.3.5 Integration of design-driven approaches at the NCD stage of the industrial design process

As can be seen in previous paragraphs, innovations have their roots at the NCD stage. Verganti (2009) detailed two characteristics of innovative products and services: innovation related to changes in technology and innovations related to changes in meaning. The latter can be assimilated to what has been defined in this dissertation as perceived kansei qualities. These two dimensions add a more precise way of defining the nature of the innovation underlying the different types of new products defined by Wheelwright and Clark (1992) (i.e. breakthrough products, platform products, incremental products).

Verganti (2009) identified three types of innovations: market pull, technology push, and design driven innovations. Market pull innovations correspond mostly to incremental products and are based on needs expressed by customers. Criticisms from scholars regarding this type of innovation are that customers (the market) have a short-term view and that their requirements are neither fully explicit nor stable (Sandmeier et al., 2004; Norman, 2010). This is why market pull innovations alone cannot induce the changes and intellectual property necessary for the development of new platform products and breakthrough products.

In recent years, new platform as well as breakthrough products (and services) providing new and well-achieved experiences gained in importance (e.g., Nintendo Wii, Apple music and app ecosystems) (Verganti, 2009). When dealing with NCD, organisations are shifting from a technology-only focus (the two examples given previously do not necessarily have the most advanced technical specifications) to a combination of activities centred on user experience and covering both technology- and design-driven (user-centred) approaches. The latter approach enables organisations to better deal with user experience and concepts that radically influence the meaning of the product. Scholars indeed highlighted both the non-sense of NCD processes focused only on users and their needs, and the importance of considering the UX at the conceptual stage (Norman, 2010; McCullagh, 2010; Karapanos & Martens, 2009).

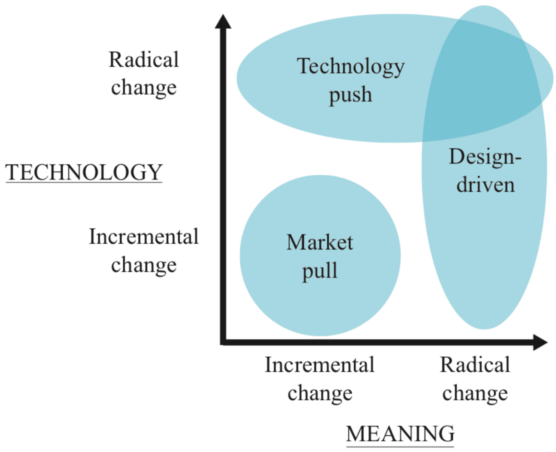


Figure 2.20: Different origins for innovations (Verganti, 2009)

In section 2.4, experience-centred design activities will be detailed. Before doing that, I will exemplify the integration of design approaches at NCD stage. Several authors have used NCD models to map how and when user experience centred design approaches can be used. Their contributions will be presented in the following paragraphs.

INTEGRATION OF SCIENTIFIC REASONING-BASED DESIGN APPROACHES IN NCD

In order to describe the added value that Kansei Engineering (KE) methodologies can have at different moments of the industrial design process, Schütte et al. (2008b) based their explanation on the Stage-Gate process. The authors thereby detailed the integration of methodologies based on *scientific reasoning* into a very structured description of the industrial design process (Figure 2.21).

They identified three stages (including two during the NCD) that can be impacted by different types of KE investigations.

- During the *scoping* stage, KE methodologies can be used to perform quick macro-level examinations on different competing products in order to identify valuable information for the pre-selection of concepts.

- During the *build business case* stage of the Stage-Gate process, more detailed investigations can be carried out. KE approaches can be integrated into the market studies included in this stage. They permit decision makers to support forthcoming decisions by focusing more carefully on selected product parts (micro-level investigations). The generated kansei-related design information can also be used in later development stages in order to raise the awareness of designers on issues related to experience.
- At the *testing and investigation* stage, KE evaluations performed on prototypes are able to reveal whether the new product will fulfil the requirements regarding intended kansei qualities. At this advanced stage of the process only small changes such as colour setting, tuning parameters and changing minor modules can still be impacted (Antoni & Schütte, 2002).

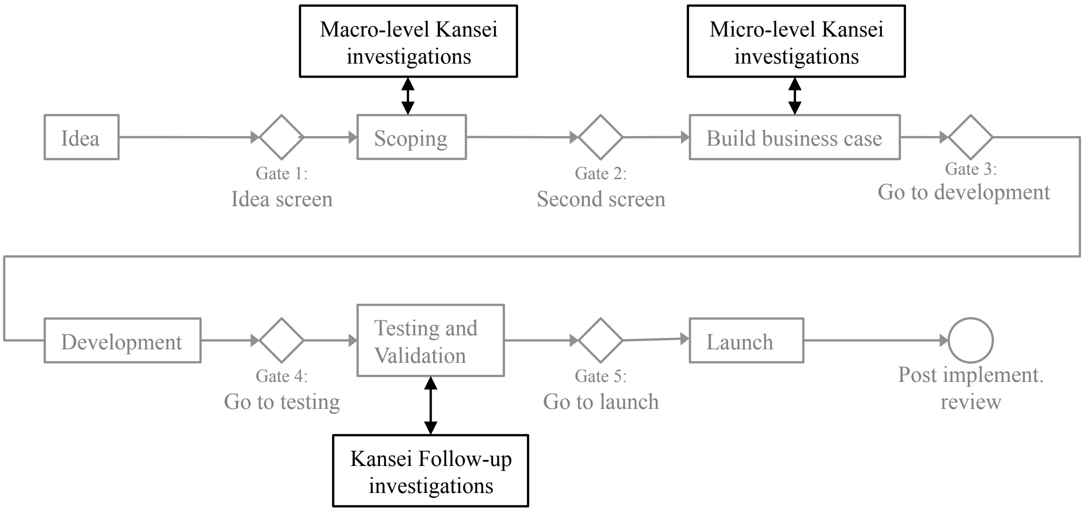


Figure 2.21: Integrating of kansei engineering in the Stage-Gate process (Schütte et al., 2008b)

INTEGRATION OF INTEGRATIVE DESIGN APPROACHES IN NCD

In addition to user-centred design approaches based on *scientific reasoning*, scholars also described the integration of *abductive* approaches in NCD stage activities (Hassi & Laakso, 2011; Dorst, 2011). According to them, this latter type is typical of designer approaches and can be implied when speaking about *design thinking*. It will be further developed in section 2.4.2.2 (p. 70). According to Mata Gracía, the fact that *design thinking* became a buzzword in the 2000s is symptomatic of the new role given to designers (2012). Whereas in the past they had mainly styling advisor functions within organisations, they are getting more and more integrated into the development process and now play a key role in the creation of the brand image and innovation strategies (Borja de Mozota, 2011). *Scientific reasoning* and *abductive reasoning* are therefore more and more associated. The combination of both is named *integrative thinking* (Martin, 2009).

Wormald (2010) identified four paths that design teams can take to create value propositions using *integrative thinking* approaches. They all touch on the intended kansei qualities of the product to be designed (Figure 2.22).

They are based on user research, PEEST (i.e. political, economical, environmental, social and technological) research, and brand research. These three types of research deal with the kansei qualities perceived from the different UX constituents (user, interaction, product, context) described by Ortíz Nicólas and Aurisicchio (2011). Wormald (2010) presented the collected data (quantitative and qualitative) as leading to *insight*, later translated by the designers into *intermediate representations* (i.e. persona, experience scenarios, insight/opportunity, brand). These different representations can then be combined in order to create *value proposition*. The intellectual property they contain can thereby be communicated to other NCD teams (e.g., technology-focused research teams) or transferred to the NPD stage.

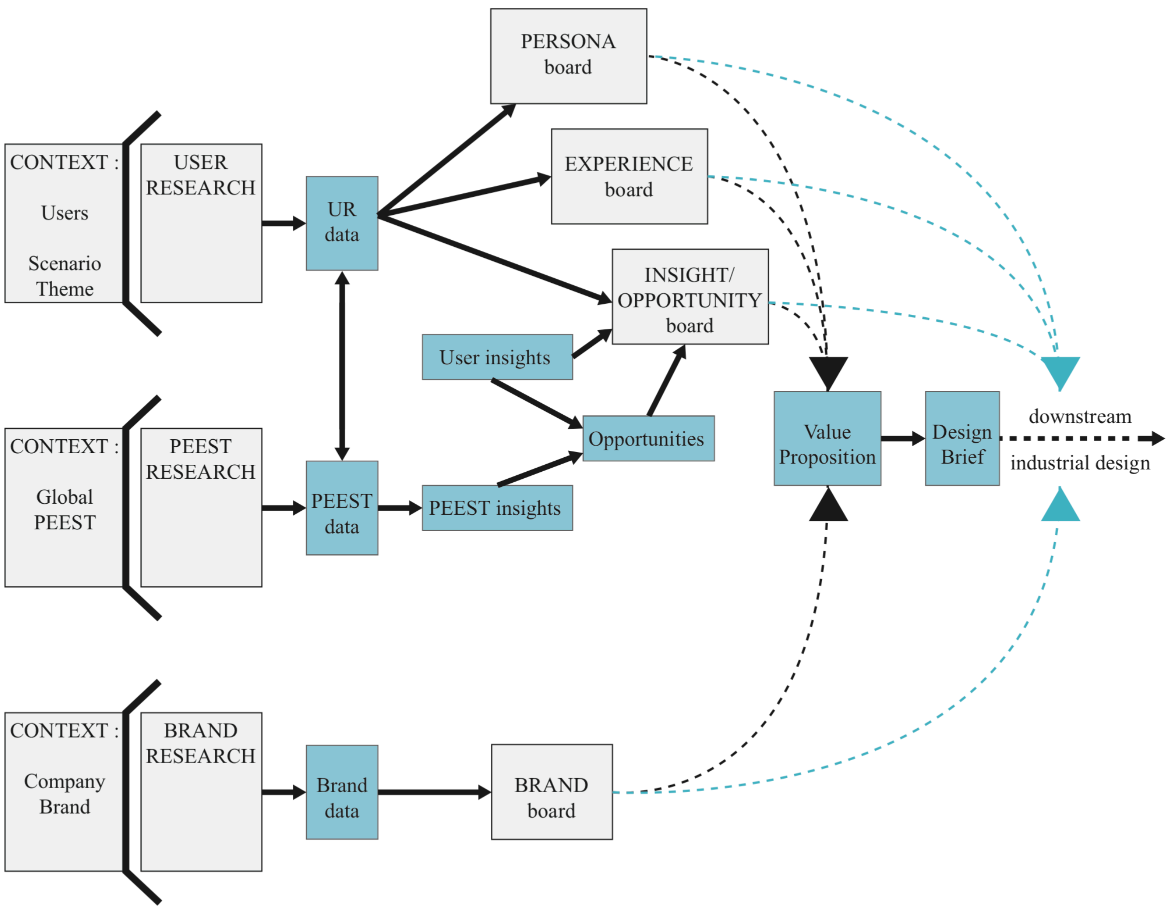


Figure 2.22: The Front End Industrial Design (FE-ID) process diagram (Wormald, 2010)

2.4 EXPERIENCE-CENTRED DESIGN ACTIVITIES

Section 2.3 detailed the literature review covering the industrial design process and investigated the state of the art related to the specific industrial context of this Ph.D. research: the transition between new concept development (NCD) and new product development (NPD) stages. It was shown that NCD contains the activities related to the creation of intellectual property that might later be integrated into the development of a new product and/or process (innovation process). Section 2.3 also highlighted the fact that the development of innovative products involves more and more design activities centred on user experience (UX) in addition to technology-focused researches.

In this third part of the state of the art, I will discuss experience-centred design activities. The particularity of these design activities is that they deal with the different constituents of an experience: user, interaction, product, context (and are therefore not only user-centred) and with intended users' kansei processes (and are therefore not focused on usability).

The literature related to the design activity (section 2.4.1) will first be detailed. It will lead to a focus on the designers including the way they think and behave (section 2.4.2). UX-related design information used in early design stages will then be discussed (section 2.4.3). The nature of the design information used, the way it is communicated, and its influence on subsequent design activities will be treated. Finally different tools and methodologies supporting experience-centred design activities will be reviewed (section 2.4.4).

2.4.1 DESIGN ACTIVITIES

Lawson (2005) criticised the sequential representation of design activities starting with a problem and ending with a solution. He described the design activity as a negotiation between the problem space and the solution space: the problem and solution emerge therefore together though the three activities of analysis, synthesis and evaluation. In complementary fashion, Laseau (1980) described the design process as an iterative process between idea elaboration (divergent phase) and idea reduction "convergent phase."

The basic model of design activity often used in the contemporary literature transcribes well the considerations from Lawson and Laseau (Bouchard & Aoussat, 2003; Cross, 2008). It is represented in Figure 2.23. It is composed of four symbiotic design activities: *information*, *generation*, *evaluation and decision*, and *communication*. Notably it is also referred to as the *design informational cycle* as it describes the way design team members process design information (collect, transform and generate, communicate).

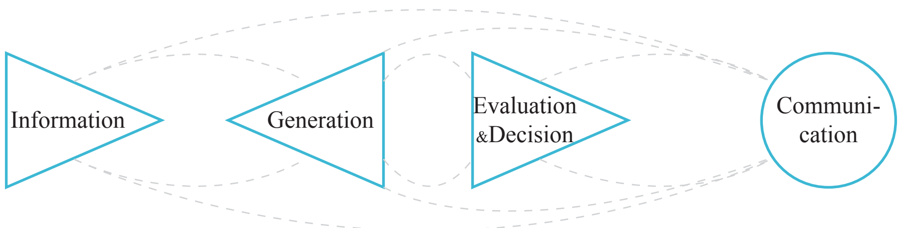


Figure 2.23: Design activities – design informational cycle (adapted from Bouchard and Aoussat [2003], and Cross [2008])

This model has the particularity of being fractal as it can describe information processes at different levels.

At a micro-level it can be used to describe the reflexive conversations between the designer's mental representations and externalised representations. In this case, the "Seeing-Drawing-Seeing" cycle described by Schön and Wiggins (1992) can be superposed with the "Information-Generation-Evaluation" cycle. The time span of such a cycle in typically counted in seconds or minutes.

At a macro-level, it can be used to represent intentional descriptive views (as it appears in websites or brochures—simple linear process—see for instance Figure 1.9 [p. 29]) or practical descriptive views (as it actually happened—see Figure 2.24) of a complete design project.

In the latter case, these descriptions can be linked together with the NCD design process (represented as the vertical axis in Figure 2.24). The time span to complete the full project is typically counted in months, whereas the task-related horizontal informational cycles' time span is counted in weeks. The information communicated at the end of each cycle takes the form of intermediate representations and can for instance be a design strategy or a draft 2D or 3D visualisation of the product concept (Bouchard & Aoussat, 2003). Figure 2.24 can therefore be seen as a design-driven descriptive model of the NCD stage (Bouchard & Aoussat, 2003). Notably, Pugh (1990) illustrated the design process as a funnel during which the generation (divergent) and evaluation (convergent) activities alternate with the process gradually converging to the final concept.

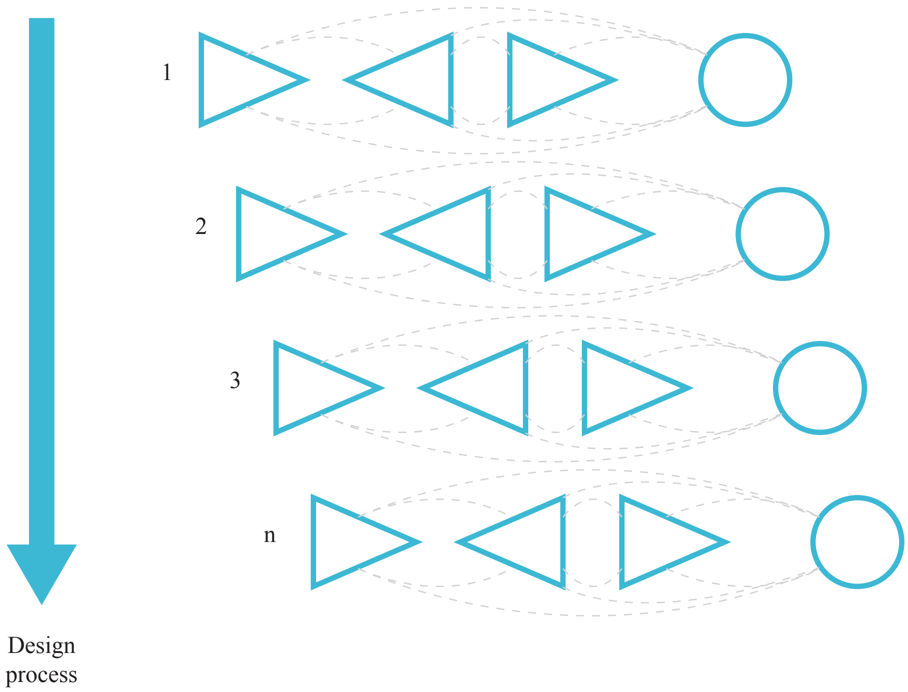


Figure 2.24: Description of the informational process in design activity (Bouchard & Aoussat, 2003)

The different design activities can be defined as follows (Bouchard & Aoussat, 2003).

- **Information**: Design team members gather various types of information in order to build knowledge related to the project's context. The activity consists in questioning the initial intentions from various perspectives (intended user, political, economical, environmental, social, technological, brand) by collecting and organising data. A wide variety of tools and methodologies exist in order to assist the design team (more information in section 2.4.4.1 [p. 78]). The knowledge built is thereby mutually shared and can also be used as a source of inspiration.

- **Generation**: This activity consists in the generation of new ideas and new concepts. This is achieved using the collected data, mental images and other information contained in the members' memory as well as with the help of different tools and methodologies (more information in section 2.4.4.2 [p. 81]). The design team members thereby generate physical or digital (intermediate) representations.
- **Evaluation and decision**: It corresponds to the activity of assessing the proposed concepts and deciding which ones (if any) should be maintained in the development process. Depending on the context, the decision can be taken by persons involved in the design process or by decision-makers external to it. Different tools and methodologies can also be used (more information in section 2.4.4.3 [p. 82])
- **Communication**: This activity consists in presenting the result of the design informational cycle to stakeholders of the design team and/or to prepare material to be used for upcoming cycles. The design team can adapt the type of representation and of design information conveyed depending on the audience.

2.4.2 THE DESIGNER

This section will focus on the sensibility and the specific abilities of the industrial designer. Along with engineers, product planners and members with other functions they are part of the "design teams" that have been discussed until now. Their unique abilities and their deeper involvement during NCD complement the technology-focused approaches of engineers with experience-focused approaches (see section 2.3.5 [p. 63]). They are not the only function involved in design teams using these types of approaches but their thinking and mindset contribute greatly to characterising the specificities of experience-focused approaches.

Nowadays, designers are also more and more involved in "problem-solving" activities no longer related to product design (e.g., IT, business, education, and medicine) (Dorst, 2011). This can be seen as a sign of the success of combining designer's approaches (abductive reasoning) and scientific reasoning.

2.4.2.1 THE EXPERIENCE AS COMMUNICATION BETWEEN THE DESIGNER AND THE USER

The experience occurring when a user interacts with a product was discussed in section 2.2 (p. 35). Crilly et al. (2008) stated that the designer, like the user, is characterised by his/her experiences that also occur during the design process. The implication for the designer's mental processes will be discussed in section 2.4.2.2.

One of the particularities of the function of designers is to deal with intentions in terms of kansei qualities (Crilly et al., 2009; Helander & Khalid, 2006). For that reason the experience perceived from the use of a product can be seen as a type of (imperfect) communication between the design and the user.

Designers are able to translate intentions in terms of kansei qualities into representations of a product (see "product as planned" in Figure 2.25). Although the product is generally produced in accordance with the representations made, the final artefact may differ from the one planned because of intended and unintended design changes during later development or production stages. The user then experiences the finished product. In addition to the different factors influencing the experience (related to personal characteristics and attributes of the environment; for more detail see section 2.2.5 [p. 47]), the user might also infer some idea of what response was originally intended by the designer (not corresponding in Figure 2.25).

In the case of consumer goods, the produced product can therefore be seen as enabling designers to communicate with the users (Crilly et al, 2008). As could be seen in previous sections, the communication is nevertheless disrupted because of the subjective nature of users' and designers' kansei processes.

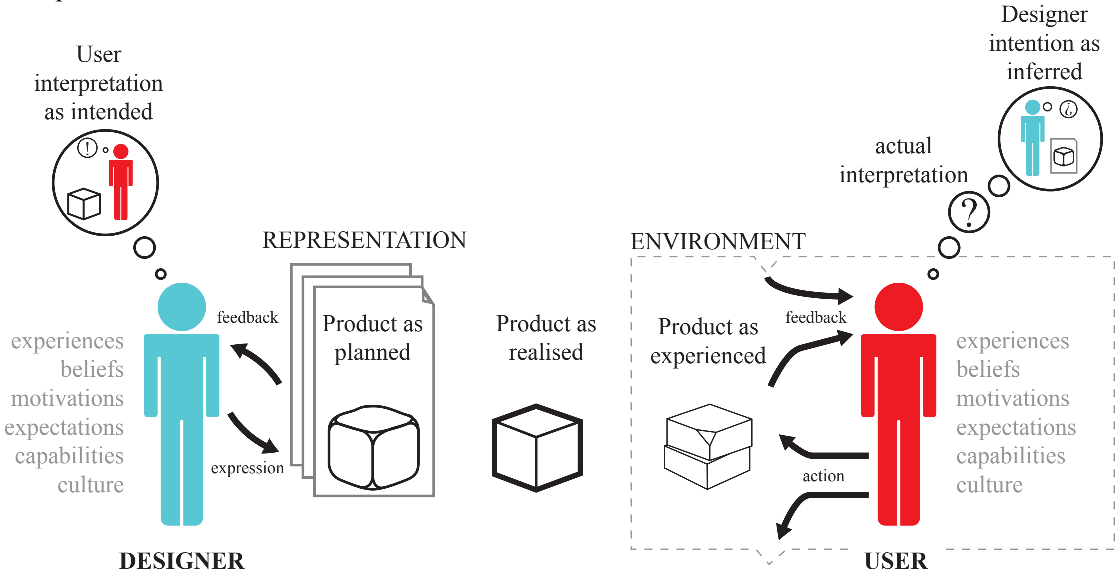


Figure 2.25: Communication based model of design (adapted from Crilly et al. [2008])

2.4.2.2 Designers' mental processes

In his book "How Designers Think," Lawson (2005) came to the conclusion that reasoning and imagining were probably the most important type of thinking for designers. He defined them as follows:

> *"Reasoning is considered purposive and directed towards a particular conclusion. This category is usually held to include logic, problem-solving and concept formation. When 'imagining', on the other hand, the individual is said to draw from his or her own experience, combining material in a relatively unstructured and perhaps aimless way. Artistic and creative thought as well as daydreaming are normally considered imaginative."* (p. 137)

This definition highlights two processes: the cognitive and affective processes. They appeared previously when discussing the perception of an experience in section 2.2.3 (p. 43) (Helander & Khalid, 2006). The specificities of these processes during design activities will now be discussed.

Cognitive processes

Understanding the design activity at a cognitive level has been acknowledged as an important research focus. Notably, the design activities related to NCD are considered to be among the most cognitively intensive in the design process (Nakakoji, 2005). Several studies related to designers' cognitive activity at this stage of the design process have been conducted.

From the perspective of cognitive psychology, these studies led for instance to the identification of the main cognitive processes involved: attention, perception, learning, remembering, speaking, problem-solving, reasoning, and thinking (Eysenck & Keane, 2005).

In the design research community, designers' cognitive activities can be described using three complementary notions: *problem-solving* (Simon, 1969), *construction of representations* (Visser, 2006), and *reflective-in-action* (Schön, 1983). They can be summarised as follows.

- **Problem-solving**: The designers start with ill-defined or ill-structured problems; they act as problem solvers and construct their mental representations of design problem, which are mostly incomplete and imprecise in the beginning (Simon, 1969).
- **Construct of representations**: Designers integrate various intermediate representations, both physical and mental to reduce the level of abstraction and increase the level of precision (Visser, 2006). The representations of designers evolve as the problem-solving progresses until they become precise, concrete, and detailed.
- **Reflective-in-action**: During this process, reflexive conversations (i.e. reflection-in-action) between the designer's mental representations and externalized representations (e.g., early sketches, prototypes) can be observed (Schön, 1983). The designers' efforts to solve problems yield new discoveries in the reflective conversation with the situation. This mechanism is referred to as the "Seeing-Drawing-Seeing" cycle (Schön & Wiggins, 1992).

Because of their specific way of thinking, designers contribute to the diversity of reasoning approaches in multi-functional design teams. Designers add abduction to inductive and deductive reasoning mastered by people with other functions on the design team (e.g., engineers) (Tomiyama et al., 2003). These three types of reasoning have complementary roles for the design activities at the NCD stage (Hassi & Laasko, 2011). Induction and deduction are typically used in research processes leading to scientific discoveries (Dorst, 2011). They can be characterised as scientific ways of reasoning. Induction permits one to discover working principles (or logics) based on observations and measurements and deduction validates the findings. In that sense, induction and deduction contribute to the formation of explicit knowledge *(you know what you know)* out of an uncertain context *(you know what you don't know)*.

Complementary to scientific reasoning, abductive reasoning permits one to evolve from ambiguity *(you don't know what you don't know)* to uncertainty *(you know what you don't know)*. It allows therefore the people using it to work in an ill-defined and ambiguous context (Leifer & Steinert, 2011). From this context, abductive reasoning converges progressively to proposals (e.g., attributes of the product or interaction to be defined) corresponding to aspired directions through the iteration of proposals and evaluations (Hassi & Laasko, 2011).

AFFECTIVE PROCESSES

As mentioned previously, designers are able to formulate intentions regarding the kansei qualities of a product to be designed and to translate these intentions into product and interaction attributes (e.g., shape, colour, gestures) (see section 2.4.2.1 [p. 69]). According to Helander and Khalid (2006), these abilities are due to designers' affective processes.

Kim et al. (2010) identified the specific impact of designers' affective processes during generation and evaluation activities. During generation activities, they regulate or activate the mental information process, whereas during evaluation activities they enable evaluative judgments of their ideas, the representations or even of themselves.

Kushi et al. (2005) observed three types of factors that influence the direction taken by the design activities of a project: the designer's *individual experience*, the *project* and the *organisation* (Figure 2.26). They also highlighted the interactions that occur between these three factors and observed that the kansei qualities of the project's output are particularly connected to the designer's *individual experience* and kansei process.

They showed that *individual experiences* significantly influence the inputs the designers will make to the different activities (information, generation, and evaluation) of the design process. Nevertheless, their *individual experiences* not only correspond to their tastes and past experiences but also to findings and interactions that occurred during previous design activities, as well as to interactions with the project (e.g., connection with the project's objectives) and the organisation (e.g., relationship to corporate strategy). This highlights the importance of the affective bond connecting the designers with the project and the organisation. Kushi et al. noted that this bond has only been observed for projects related to the development of innovative products.

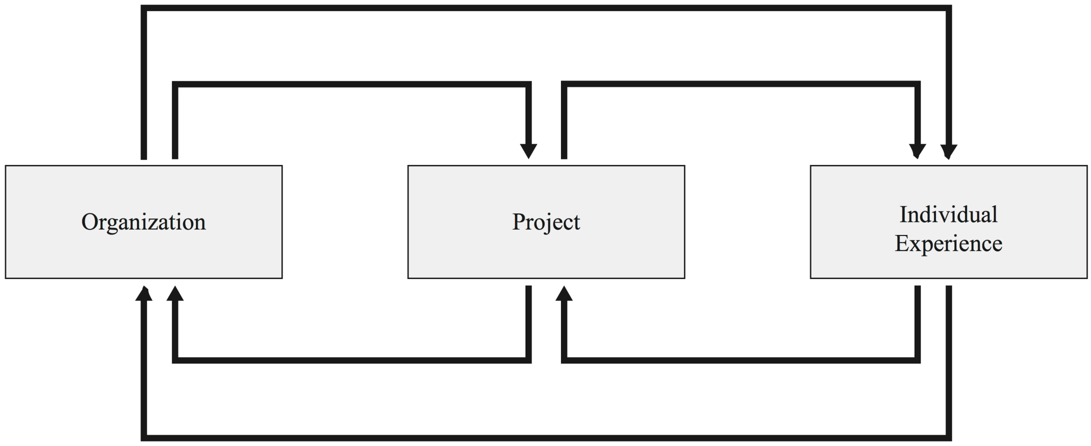


Figure 2.26: Relationship among three factors (Kushi et al., 2005)

2.4.2.3 FACTORS INFLUENCING DESIGNERS' MENTAL PROCESSES

Researchers have detailed different factors influencing the design activities of a designer. They refer to the *personal characteristics of the designer* as well as to the *design situation* (Gero & Sosa, 2002).

The design situation encompasses the moment and location in which the design activity occurs, as well as characteristics of the project and of the organisation. Through an empirical study, Crilly et al. (2009) distinguished two types of influencing factors related to the *design situation*: human-related (persons related to the project) and project-related factors. The authors organised the human-related factors into interactions with other team members (related to past experience, preferences, authorship), and interactions with clients and stakeholders (related to perception of user, design literacy, personal preferences). They also described the project-related influencing factors as being related to time, budget, and misleading data.

Regarding influencing factors related to *personal characteristics* of the designer, Rust (2004) highlighted the importance of tacit knowledge and pointed out that it might lead designers unconsciously to certain solutions. Drawbacks of designers' reliance on tacit knowledge were identified by Bonnardel (2011), who mentioned that "when faced with a new design problem, designers may tend to reproduce solution approaches they used in past designs and may not consider alternative and more effective design solutions" (p. 193). Designers' past experiences in design (related to work and education) have also been mentioned as factors influencing their mental processes. This is especially true for analogical mental processes (key for generation activities) for which Bonnardel and Marmèche (2004) observed major differences between novice and expert designers. On top of design-related past experiences, regular past experiences also come into play. They enable designers to construct socio-cultural references, which, according to Woelfel et al. (2010), are more influential than design-related past experiences. Leung et al. (2008) also highlighted the highly positive effect of rich personal experiences (e.g., immersive experiences in foreign countries) on mental processes and on creativity.

2.4.3 DESIGN INFORMATION

It was previously shown that design activities also correspond to a design informational cycle. It means that design teams identify (information activity), generate (generation activity), discuss and evaluate (evaluation and decision activity) design information. In this section, an ontology of design information, as well as ways to represent it during early NCD stages (before 2D and 3D representations are drawn) will be discussed.

2.4.3.1 CATEGORIES OF DESIGN INFORMATION

Bouchard et al. (2009) studied the design information expressed by design team members when discussing and brainstorming design intentions during early NCD design-driven activities. The authors gathered design information from empirical studies. They organised it into different design information categories, which were structured into three different groups depending on their abstraction level. The three groups identified corresponded to low, middle, and high levels of abstraction.

- **Low-level design information** corresponds to concrete and sensory attributes mainly related to the artefact to be designed (colour, shape, texture).
- **Middle-level design information** links up abstract and concrete design information. It links abstract design information (i.e. high-level) with information describing a design solution (i.e. low-level). Middle-level design information corresponds to intended functionalities, as well as to the context and sectors or objects used as references.
- **High-level design information** corresponds to abstract information that corresponds to the user's personal characteristics, his/her perceived kansei qualities, and the attributes of the product (users' personal value, semantic words describing the experience, and style inspirations related to the future product).

Table 2.10: Detail of the different types of design information (adapted from Kim et al. [2009])

Category name	*Description*	*Examples*	*Related UX entity*
Value (H)	These words represent final or behavioural values.	Security, Wellbeing	User's personal characteristics
Semantic word (H)	Adjectives related to the meaning and characteristics.	Playful, Romantic, Aggressive	Perceived kansei qualities
Analogy (H)	Objects in other sectors with features to integrate in the reference sector	Comparison with a rabbit to convey "speed"	Perceived kansei qualities
Style (H)	Characterization of all levels together through a specific style.	Edge Design, Classic	Product attributes
Context (M)	User social context	Leisure with Family	Context attributes
Functionality (M)	Function, usage, component, operation	Modularity	Product attributes
Sector/object (M)	Object or sector being representative for expressing a particular trend	Tennis, wearable computing	Product attributes
Form (L)	Overall shape or component, shape size	Square, long and thin	Product attributes
Colour (L)	Qualitative or quantitative chromatic properties	Light blue, Emerald	Product attributes
Texture (L)	Patterns and texture and materials	Plastic, striped surface	Product attributes

(H): High-level of abstraction
(M): Middle-level of abstraction
(L): Low-level of abstraction

Notably, the different categories of design information identified by Bouchard et al. (2009) relate to different entities of the intended experience (user's personal characteristics, perceived kansei qualities, product attributes, context attributes). The experience entities corresponding to each of them have been added to the summary table detailing the different categories of design information (Table 2.10). It was originally presented by Kim et al. (2009). In Table 2.10, the letter in brackets beside the category name indicates the level of abstraction (H: High, M: Middle, L: Low). Kim et al. used these categories in order to describe and structure of mental information and the cognitive links processed by designers during the early NCD phase (for association and transformation processes).

A parallel can be drawn between the three levels of abstraction detailed previously and Hassenzahl's (2013) *Why, What, and How levels* to consider when designing a product experience (Figure 2.27). The *Why level* clarifies "the needs and emotions involved in an activity, the meaning, the experience" (p.83). Once the *Why level* is discussed, the *What level* "determines functionality that is able to provide the experience" (p.83) and the *How level* determines "the appropriate way of putting the functionality to action" (p.83). In terms of design information tackled the *Why level* is therefore described as focusing on *High-level of abstraction* design information, whereas the *What level* tackles mainly *Middle-level of abstraction* design information, and the *How level* is centred on *Low-level of abstraction* design information. With the *Why, What, and How levels* Hassenzahl therefore adds a temporal dimension to the aforementioned discussions related to design information. He gives us an idea about how the attention of the design team evolves (i.e. design information exchanged) during an experience-driven design process (i.e. from *High-level* to *Low-level of abstraction*).

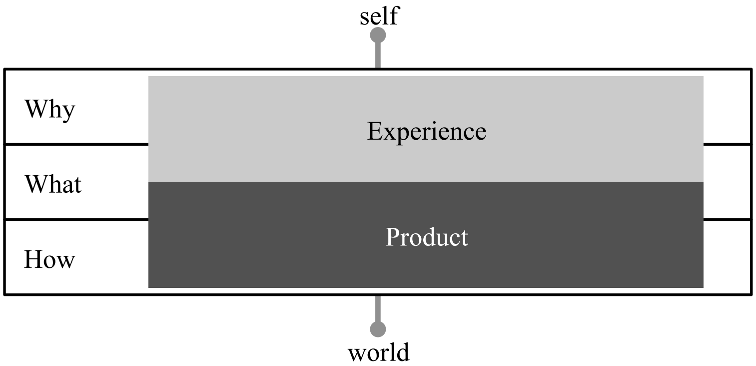


Figure 2.27: Three levels to consider when designing product experiences (Why, What, and How levels) (Hassenzahl, 2013)

2.4.3.2 EARLY REPRESENTATIONS OF DESIGN INFORMATION

Early representations permit the communication of information within a team or with project stakeholders during the early phases of a new development. They have the particularity of covering more modalities than speech and text. This notion appeared in the 1920s. Early representations were first used in engineering design approaches to communicate new technologies investigated with NCD projects (technology focused approach). During the 1950s they were adopted by industrial designers in order to communicate style studies related to concrete design information (e.g., exterior design of cars). A shift of these representations to earlier and earlier stages of the design process has been observed (Sanders, 2005). Therefore, they are not necessarily related to a design solution anymore but can also express an intention (e.g., use of inspirational images) (Mougenot, 2008). The type of design information that they convey has also evolved. They now cover a wider scope, combining low and high abstraction levels and referring to the different experience entities (not only concrete design information related to attributes of the product to be designed).

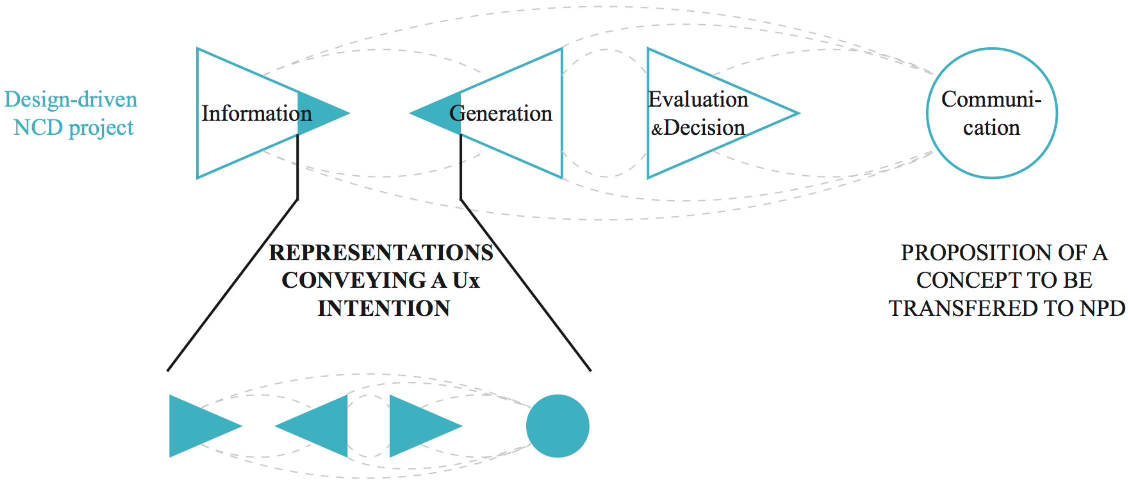


Figure 2.28: Creation of early representations relative to the design activities of a full NCD project

In the following paragraphs, I will review the literature describing early representations used to convey and discuss design intentions during early NCD projects. When looking at the design activities of the full NCD project (macro-level), they are situated at the transition between information and generation activities. As shown in Figure 2.28, the creation of these representations can be described with another layer of design activities (fractal nature of the design informational cycle). Eckert and Stacey (2000) observed that only a little research has been done on this transition. Five types of representations have nevertheless been identified. They have been organised according to their nature (*text based*, *image based*, *multi-sensory*, *narrative*, and *interactive*) and will be detailed hereafter.

They all translate in a tangible way (language, sensory) an intended user experience and cover (at least part of) the experience entities with abstract and concrete design information. They also share similar objectives within the design process. First, they intend to provide material that facilitates discussions about UX-related intentions. These discussions can occur within the design team or with project stakeholders (e.g., client, management, teacher). Secondly, they also intend to guide and/or inspire the designers for the generation activities (Goldschmidt & Smolkov, 2006).

Text based representations – Brief and persona

Design teams are usually given a brief (aka "design brief") that expresses an intention that will guide the design activities (Buijs, 2012). This document is mainly text based (includes usually also pictures and figures) and compiles the representation of an objective for the project. It is discussed with the client from the very beginning of the process. The client can be part of the design team (i.e. product planner) when the design process is integrated into an organisation. The design brief defines an intention regarding the product to be designed (with artefact-related low- to high-level design information), the targeted users, and context of use (Buijs, 2012). Because these documents are highly confidential only a few studies have dealt with this type of representation (Dibb & Simkin, 2004). The document is generally poor in design information related to intentions regarding intended kansei qualities.

Consequent literature regarding early representation of the targeted users (i.e. personas) can nevertheless be found. These are "fictitious, specific, concrete representations of a target user" (Pruitt & Adlin, 2006: p. 11). In other words, personas are short biographies of fake individuals representative of intended product users. They can include pictures, schedules, and storyboards (Miaskiewicz & Kozar, 2011). Numerous publications propose methods to create personas (Adlin & Pruitt, 2010; Faily & Flechais, 2011; Pruitt & Adlin, 2006).

IMAGE BASED REPRESENTATIONS – MOOD/TREND BOARDS

Baxter (1995) identified several types of image-based representations created by designers and used by design teams during research and development activities. These representations focus either on targeted users and represent abstract (high-level) design information related to these users ("lifestyle boards") or on the product itself ("mood boards" and "visual theme boards"). In the case of product representations, Baxter differentiated boards that "try to identify a single expression of values for the product" (p. 222) ("mood boards") and boards that represent a style direction that is more focused on visual aesthetics ("visual theme boards"). Therefore, these two types of representations convey different categories of design information. Whereas "mood boards" are focused on high-level design information such as *Analogy*, *Semantic descriptor*, and *Style*, "visual theme boards" convey both low- and high-level design information related to the attributes of the product to be designed (*Style*, *Sector/object*, *Form*, *Colour*).

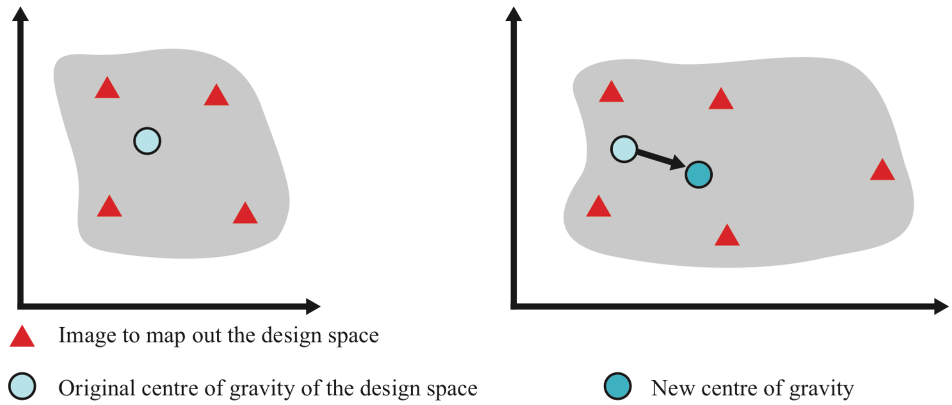


Figure 2.29: Images of a mood board mapping out the design space (Eckert & Stacey, 2000)

An ethnographic study undertaken in an industrial context has shown that these compositions of images play an important role in design communication (Eckert & Stacey, 2000). The boards described correspond to the "mood boards" defined by Baxter (1995) as they were composed of images describing an aesthetic impression direction and a specific semantic association. The researchers identified that the image boards were used from the early design phase to the end of the styling design process where they are used to illustrate sources of inspiration together with design propositions. They also highlighted the fact that "mood boards" have the property of defining and communicating a design space (i.e. design direction). As shown in Figure 2.29, the design space is influenced by the design information conveyed by each image included in the representation (Eckert & Stacey, 2000). Although the designers themselves cannot describe the dimensions on which the design space is represented, they are able to perceive the limits of the space and to modify them by changing the images used (Figure 2.29).

The research conducted by McDonagh and Denton (2005) contributed to confirming these findings. They also highlighted the importance of image-based representations as a tool supporting both information and communication activities occurring during the NCD phase.

MULTI-SENSORY REPRESENTATIONS

Schifferstein and Desmet (2008) developed a multi-sensory approach to product design in which designers explore different sensory modalities and create an *integrated sensory concept of expression* representing their intentions before styling design activities (Figure 2.30). The approach enables them to take into consideration from the early design stages the different modalities that a product uses to influence the user's experience.

The methodology related to these representations is composed of four steps: *sensitizing designers*, *sampling objects with sensory qualities*, *making and using sensory building blocks*, and *communicating with others* (Schifferstein & Desmet, 2008). It has shown a positive impact on designer's inspiration, especially regarding to the final product's functionalities, the sensory feedbacks that it can provide and the coherency in the semantic associations and emotions that the design evokes (perceived kansei qualities).

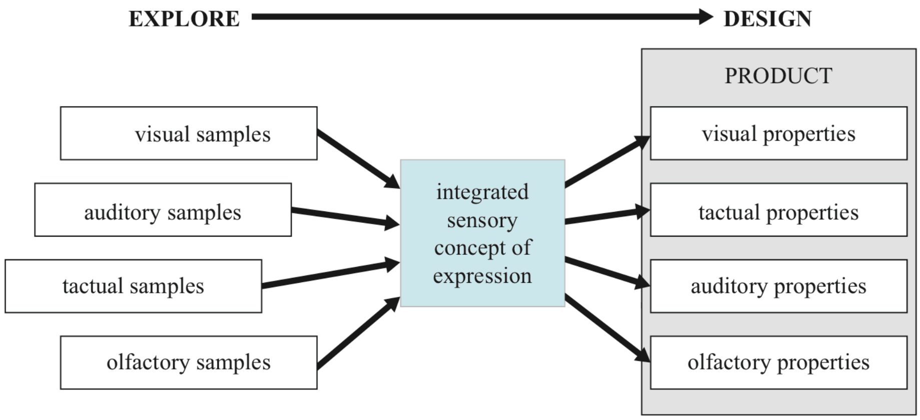


Figure 2.30: Framework for the multi-sensory approach (Schifferstein & Desmet, 2008)

NARRATIVE REPRESENTATIONS - SCENARIOS

According to Sanders (2006), scenarios are a very efficient way to communicate, in early design stages, intentions related to the intended experience that future users should have with the product designed. They focus on the interaction that it will enable and transcribe the ideal journey people will have with it. They are represented, often in a narrative way, using storyboard drawings, graphs, or videos (Sanders, 2006).

Scenario-based representations mainly permit designers to convey design information related to intended kansei qualities (perceived semantics, emotions felt by the future user) and possible ways of interacting with the product to-be-designed (interaction attributes) to the potential user (Buxton, 2007; Sears & Jacko, 2007).

INTERACTIVE REPRESENTATIONS - PROTOTYPES

Prototyping is a common practice in the final stages of product development (Buijs, 2012; Cooper, 2012). The use of prototypes has recently also been introduced at the new concept development stage (Sanders, 2005). The types of prototype created and their functions are nevertheless specific to the situation in which they are used. In product development and pre-production stages, prototypes represent physical and high fidelity versions of the product under development. Regarding design information, they are then mainly used to discuss and assess concrete product and interaction attributes. At the NCD stage the focus is different. Prototypes are used to explore diverse directions, very different in terms of the abstract design information they convey (*value*, *semantic descriptor*, *style*) (Koskinen & Lee, 2009). Because of their low fidelity nature, they often do not contain much concrete design information. These low-tech and low fidelity prototypes give more material to the design teams when constructing their opinions about the different directions explored. They also permit the gathering of constructive feedback from people external to the design teams (Buchenau et al., 2000). At this stage, their creation process needs to be flexible and quick. This is why rapid prototyping technics are used (Koskinen & Lee, 2009).

2.4.4 Design tools and methodologies

Experience-centred tools and methodologies have been created to support the different design activities. They can be used for activities leading to the creation of early representations, such as the ones presented in the previous section, or for activities related to a wider new concept development (NCD) project (Abras et al., 2004). The tools can be based on scientific or abductive reasoning. The first are based on quantitative data analysis, whereas the latter ones are based on qualitative data. Some of them also combine both and can be referred to as originating from integrative thinking approaches (Martin, 2009).

All the tools and methodologies that will be presented have as common characteristics the fact that they contribute to improving the user experience (through information, generation, or evaluation and decision activities), but they differ in the way they treat the "user." Depending on the tool or methodology, he/she can either be treated as a subject (observed and questioned) or as a partner (participatory design). When treated as a subject, "users" are either directly (e.g., interviews) or indirectly (e.g., field observations) involved in the design activities (Sanders & Stappers, 2008).

In fact, at this NCD stage it is preferable to speak about a "desired targeted user." For this reason, the term "user" will be put between quotation marks (i.e. "user").

In the following sub-sections, I have tried to cover a wide range of approaches. Given the diversity of tools and methodologies that exist it is nevertheless impossible to be exhaustive. The ones that are presented have therefore to be considered as a selection of examples of key types of approaches. Some of them were gathered from existing reviews of experience-centred approaches (Byttebier & Vullings, 2009; Forlizzi, 2008; IDEO, 2003; Vredenburg et al., 2002).

2.4.4.1 Tools and methodologies supporting information activities

At this early phase of the conceptual design process the design team has to gather information and to find inspiration in order to prepare generation or other subsequent activities (Sanders, 2005). The tools and methodologies presented hereafter cover at least one of these two aspects.

Desk research – abductive/scientific reasoning

Desk research permits the capturing of existing trends and allows access to a wide range of information from various fields (PEEST research – see p. 66). It can lead to reports and presentations, as well as visual representations (Wormald, 2010). For desk research, the design teams uses the Internet as well as other media (e.g., magazines) to gather information and inspiration (Bouchard, 1997).

- *Design-specific libraries* are tools that permit the collection of information related to specific product and interaction attributes (e.g., material libraries [Amaral Da Silva et al., 2012], taxonomy of gesture [Solinski, 2011]).
- *Benchmarks* are typical desk research activities. They consist in comparing characteristics of existing products and highlighting trends. These products can belong to the same category as the one being developed (direct competitors) or to related categories.
- The *conjoint trend analysis method* is an analytical methodology (scientific reasoning) that formalises the activity of searching for inspirational material into a hybrid semantic search of text and images. It enables the identification of formal trend attributes (shape, colour, textures)

linked to influencing sectors in order to use them in the early design phase of a new product. It leads to early representations such as semantic mapping and mood boards that inform and inspire the design team during the subsequent generation activities (Bouchard et al., 1999). A computing tool supporting conjoint trend analysis has been developed (EU-funded research project TRENDS). It improves the kansei qualities of the retrieved information (Kim et al., 2012).

- Other integrative methodologies enable design teams to learn from their environment. *Cross-cultural comparisons* (investigate behavioural and product differences between cultures) and *long-range forecasts* (intended to predict changes in behaviour, industry, or technology from the information available) are two examples of such methodologies (IDEO, 2003).

FIELD RESEARCH – ABDUCTIVE/SCIENTIFIC REASONING

Field observations are similar to desk research in their aim but they use the real world as their source of information (Vredenburg et al., 2002). They can be combined with discussions or interviews (see below). They can touch on the potential "users" and their environment as well as the organisations involved in the creation process and their operation procedure.

- *A day in a life* (observe and organise the activities and contexts that "users" experience throughout an entire day), *behavioural mapping* (track the positions and movements of people within a space over time), and *guided tours* (accompany "users" on a guided tour of the project-relevant spaces, activities, and experiences) are examples of abductive-centred observation methodologies which gather insights from people (IDEO, 2003).
- *Error analysis* (look at existing products and see what is wrong) and *flow & activity analysis* (list all tasks, actions, objects, performers, and interactions involved in a process) are examples of rather analytical methodologies focused on learning (IDEO, 2003).

USER INVOLVEMENT: INTERVIEWS – ABDUCTIVE/SCIENTIFIC REASONING

Interviews with "users" and experts are common information gathering tools. They can be unstructured (discussion), semi-directed, or directed. They can also contain activity (e.g., *card sorting*). In the last two cases the questions are prepared and the answers can be suggested using for instance semantic differential scales (Osgood, 1969). These can then be analysed following scientific reasoning. Different types of interviews are presented below.

- *Macro-level kansei engineering investigations* can be used to perform quick macro-level examinations on different competing products in order to identify valuable information for the pre-selection of concepts (Schütte et al. 2008a).
- In the *mutual design approach with image-icons*, "users" are asked to select images that fit their impression of a given design brief (Lee et al., 2002). A computer-aided process permits them to construct image-icons from the selected inspirational pictures. These image-icons are used as inspiration for concept generation activities.
- *Laddering interviews* are structured interviews that permit interviewers to broaden a subject (laddering up) or to make a participant statement more explicit (laddering down). They highlight the links between product attributes, usage consequences, and personal values in the mind of the interviewed person (Wansink, 2003).
- *Repertory grid technique* is a structured interview methodology used for the comparison of existing products or interactions using bi-polar scales. Participants have to perform similarity-difference judgments related to dichotomous variables and compare thereby the different artefacts with each other (Tomico, 2007).

- Evaluation tools such as *iScale* allow the design team to evaluate the perceived kansei qualities of existing products over time (Karapanos, 2010).
- During *card sorting sessions* participants (representing potential future "users") are guided to generate a category tree. The analysis permits the researchers to extract patterns from the category tree generated and to identify the most important items (Rugg & McGeorge, 2005).

USER INVOLVEMENT: ELSE – ABDUCTIVE REASONING

"Users" can be involved in information activities either as subjects or as partners (participatory design). Their involvement helps the design team to capture new insights and identify needs or gaps.

- *Brainstorming* or *bodystorming* sessions are participatory activities during which "users" are asked to think from the point of view of the design team.
- For *rapid ethnography sessions*, "users" are asked to accomplish some tasks following scenarios of use (design team is observing). Asking them to think aloud can increase the quality and quantity of kansei-related information retrieved (Bødkur & Buur, 2000).
- *Diary* and *longitudinal studies* are demanding methodologies because they are longer than other methodologies. They allow nevertheless an in-depth understanding of the behaviour of "users" in an eco-system (Battarbee et al., 2002; Forlizzi, 2007).
- *Probes* provide field observation from the point of view of end-users as input to design teams. Objects such as notebooks or digital cameras are given to people, who are then asked to gather insights related to a given topic. The probes are then sent back and are used by the design team as inspiration without direct contact with the contributors. The goal of cultural probes is to inspire the design team with glimpses of the everyday life of those who will benefit from newly designed products (Gaver et al., 1999).
- *Camera journal* (ask potential users to keep a written and visual diary), *collage* (ask participants to create a collage) and *unfocus group* (invite a group of participants to diverge about a subject) are additional examples of methodologies permitting design teams to gather information without asking direct questions (IDEO, 2003; Sanders, 2006).

EXPLORATION ACTIVITIES – ABDUCTIVE REASONING

Exploration activities support design team members in exploring and understanding the user experience they would like to achieve.

- Tools such as *brainstorming* support the teams' exploration activities involving them mentally (Boess, 2006).
- *Quick prototyping* (using any materials available, quickly test possible forms or interactions), *experience prototyping* (test and evaluate prototypes), and *bodystorming* (test scenarios of use) are examples of methodologies involving people both mentally and physically (Boess, 2006; IDEO, 2003).

2.4.4.2 TOOLS AND METHODOLOGIES SUPPORTING GENERATION ACTIVITIES

Generation activities usually follow information activities. They are divergent phases during which ideas are conceptualized. Three categories of tools and methodologies will be presented hereafter.

CREATIVITY TOOLS AND SUPPORT METHODOLOGIES – ABDUCTIVE REASONING

Different abductive tools and methodologies support creativity. They improve the quality and/or the quantity of ideas generated by the individuals or groups using them (Byttebier & Vullings, 2009).

- Byttebier and Vullings (2009) presented tools and methodologies improving divergent phases for individuals. Some examples are presented hereafter: *biomimicry* (using analogies from nature to find inspiration), *Osborn checklist* (develop new concepts with existing ideas by adapting, modifying, rearranging…), *Harvey cards* (set of cards that help brainstorming: animate, transfer…), *lotus blossom technique* (structured exploration of a design problem), *random input* (use random notion as input for brainstorming).
- Other methodologies also improve generation activities for groups: *brainstorming* (group ideation session), *brainwriting* (ideation session during which participants write or draw their concept, they are then passed to other participants who refine them)*, reverse brainstorming* (change the wording from the design challenge from "how to solve it" to "how to cause it") (Byttebier & Vullings, 2009). Brainstorming sessions can be enhanced using tools presented as improving individual's creativity (e.g., *Harvey cards*, *random input*)
- *Early representations* are tools that are used during generation activities. In section 0 we saw that the use of adequate *early representations* (e.g., mood boards, scenario, early prototypes) has a positive influence on creativity (Goldschmidt & Smolkov, 2006).
- When working continuously on *tangible representations* of their UX intentions (iterative creation of low-tech prototypes) designers are able to better perceive the kansei qualities of their creation (Hummels & Overbeeke, 2010).

CREATIVITY TOOLS – SCIENTIFIC REASONING

In addition to abductive-centred approaches, some tools supporting generation activities also exist.

- Von Saucken et al. (2013) describe the creation and the use of *principles of good user experience design*, a creativity tool based on heuristics. The approach is described as an adaptation from the "Theory of Inventive Problem Solving" (TIPS/TRIZ) to the field of UX design (Altschuller, 1999). Instead of patent analysis, the principles originate from online reviews of products and interviews. For the moment, 21 principles have been created such as "trigger perception via several senses," "meet psychological needs," "create pleasant anticipation."
- Skippi, a *computer-aided tool* providing word links (putting together kansei keywords, product attributes, production processes) has been created in order to support creativity sessions (Bongard-Blanchy, 2013). It is based on the analysis of empirical studies.

PARTICIPATORY DESIGN SESSIONS – ABDUCTIVE REASONING

Participatory creation tools and methodologies enable the design team to collaborate with "users" for idea generation activities. They facilitate reciprocal understanding and improve the way multi-cultural groups (composed of design team members and "users") work together (Muller, 2003).

- *Scenarios* and *projections* can be used. These narrative approaches allow participants to better express themselves and better convey their views about new experiences (Sanders, 2006). They permit the validation of hypotheses (regarding the way users act, think, and experience) made by the designer during the information activities (Fulton Suri, 2003).
- Other methodologies relying on the use of a narrative approach allow exploring new solution spaces during participatory design sessions. *Storyboarding* (Chung et al., 2010), *bodystorming*, and *role-playing* (Larssen et al., 2007) are examples of such activities.
- Non-narrative approaches can also be used during participatory design sessions. *Collages* also make use of the engaging quality of images. In this methodology, "users" are asked to create picture-based representations similar to "mood-boards" or "visual theme boards" (Sanders, 2006). These collages are then used both as material to trigger discussions with "users" and as inspiration for the design team. Similarly *low-tech prototyping* (Buchenau & Fulton Suri, 2000) makes use of engaging material (foam, cardboards, paper…) to stimulate ideas and concept generation during participatory design sessions.

2.4.4.3 Tools and methodologies supporting evaluation and decision-making activities

It was previously discussed that the generation of ideas and their evaluation often follow an iterative path. Direct complements to the above mentioned generation activities are therefore evaluation and decision-making activities. They permit the convergence to a single (set of) proposition(s) by evaluating, combining, refining and selecting directions (Byttebier & Vullings, 2009). Related tools and methodologies permit for instance assessment of the kansei qualities that are experienced when perceiving or interacting with the concept generated. They are based on the different types of intermediate representations of the concepts that result from generation activities (prototypes, sketches, story-boards, videos…).

In the case of evaluation activities related to a complete NCD project, experience-centred activities are complementary to other types of evaluation related to concerns such as usability, cost, life cycle, and marketability. All these aspects have to be taken into account in the decision to take a concept into the new product development process (Buijs, 2012).

Convergence tools and methodologies – abductive/scientific reasoning

These tools and methodologies permit the combining and refining of concepts during group activities. They rely on both abductive and scientific reasoning.

- The *enhancement checklist* tool enables the team to test an idea by going through a structured set of steps. Each step involves questioning specific aspects such as shaping ("How can we modify the idea to address objections that would otherwise cause rejection?") or consequences ("What are the immediate and long-term consequences of putting the idea into action?") (Byttebier & Vullings, 2009).
- The following three tools and methodologies are less structured than the enhancement checklist but still rely on the design team's reasoning skills. The *hundred euros test* activity involves asking the participants to assign the different ideas generated shares of a defined budget (it is also used with points). Reviewing the decisions permits the team to weight the relative importance of the different ideas. *Idea advocate* involves discussing each idea with the group. The participants are assigned to the predefined roles of idea supporter and opponent. In the *six thinking hats* methodology, participants have to discuss the ideas with a defined role assigned to each of them. The roles are related to different concerns and types of thinking (e.g., white hat: information, facts, data /green hat: creativity, growth, new ideas, subjective opinion) (Byttebier & Vullings, 2009).

EXPERT PANEL – ABDUCTIVE/SCIENTIFIC REASONING

The evaluation of ideas and concepts can also be made by a *panel of experts* (Adams et al., 2011). Even with the different activities detailed hereafter, this type of evaluation and decision activity remains subjective (Vredenburg et al., 2002; Lawson, 2005).

- In order to assist the experts, they are often provided with the results from other evaluation activities (examples are detailed above and below).
- *Formal heuristic evaluation* can also assist them. They intend to objectify the evaluation of user experience and perceived kansei qualities (by nature related to affective processes) (Adams et al., 2011).

PSYCHOLOGICAL MEASUREMENTS – SCIENTIFIC REASONING

Psychological measurements evaluate the perceived kansei qualities that "users" can express after experiencing a product. This product can be a more or less advanced prototype, a picture of a product or even a storyboard scenario (Bongard-Blanchy, 2013). The perceived kansei qualities are usually reported using semantic differential (SD) scales method (Osgood, 1969), personality tests (Eysenck & Keane, 2005), or open questions. The assessment can take place in a lab or in a context closer to reality. The latter type of context enhances the accuracy of the evaluation (Mäkelä et al., 2000).

- *Kansei engineering methodologies* have already been presented in detail on page 49 (Nagamachi, 1997). Participants' perceived semantic associations and well as expressed emotions and appeal are measured by evaluating responses to specific external stimuli (traditionally products and recently interactions [Lin et al., 2011]). Semantic differential scales are usually used. This way, participants' assessments can be compared using statistical analysis tools.
- The *repertory grid technique* is a methodology involving a comparative evaluation of several products simultaneously. In is also based on SD scales (Tomico, 2007).
- *iScale* is an online-based tool that allows one to track the evolution of the perceived kansei qualities of a product over time. In this case, the participants' experience is assessed regularly over a defined period of time (Karapanos, 2010).
- Lang's *Self-Assessment Manikin* (1980) is a tool that uses human-like drawings to assess emotions. It is still widely used in psycho-medical fields. The assessment is conducted according to three dimensions: pleasantness, arousal and dominance. Lang also developed other psychological measurement tools such as the *international Affective Pictures System*, the *International Affective Digitalized Sound System*, and the *International Affective Lexicon of English Words* (Lang et al., 1999). They have all been tested in several countries and cultures (Dufey et al., 2011).
- The *Geneva Wheel of Emotions* and the *PrEmo software* are more recent tools focused on the assessment of emotions. The *Geneva Wheel of Emotions* (Scherer, 2005) proposes 20 major emotions (described by several words, and translated into several languages). Assessments regarding perceived kansei qualities are made using a 5-point scale (representing the intensity of each emotion). The software PrEmo (Desmet, 2002) is a tool based on 14 emotions (7 of which are pleasant, and 7 unpleasant) communicated to the participants using short character animations (about 1s). The assessment of each emotion is conducted using 3-point scales. It appears less exhaustive than the Geneva Wheel of Emotions but more universal (e.g., easier to use) (Güiza Caicedo & van Beuzekom, 2006).
-

PHYSIOLOGICAL MEASUREMENTS – SCIENTIFIC REASONING

Unlike psychological measurements, *physiological measurements* can identify kansei qualities of an environment that are perceived but not expressed. In that sense, they permit the observation of kansei direct consequences. In Japan, a field of research covering this area emerged in the 1990s. It is named kansei science (Harada, 2003) (see also section 1.3.2).

Different types of physiological measurements can be used: among them *electromyography*, *heart rate*, *electroencephalography*, *event-related potential*, *functional magnetic resonance imaging* (Lévy et al., 2007). These measurements provide accurate and detailed results. Their major drawback is that the measuring tools used are intrusive. This can bias the results as the sensation that the participants have of being "studied," influences the kansei direct consequences observed.

BEHAVIOURAL MEASUREMENTS – ABDUCTIVE/SCIENTIFIC REASONING

Behavioural measurements are another way to observe kansei direct consequences. Different types of behaviours can be observed and measured such as eye or body movements, and body or facial expressions. This type of evaluation activities permit researchers to gather many insights about the achieved product experience but require working prototypes with a relatively high level of fidelity.

- Unlike the physiological measuring tools, the behavioural tools can be very discrete as they are based on visual sensors: *camera*, *eye-tracking* (Kim, 2011; Lagadec, 2012), *motion sensors* (Rieuf, 2013). The information collected can then be coded and analysed in qualitative and quantitative ways (using software such as Interact).
- Participants can be asked to take part in *testing activities*, during which they interact with the prototyped concepts. During these tests, the design team can observe their behaviours and also communicate with the "users," possibly involving them as partners (Sanders, 2006).

2.5 SUMMARY AND STATEMENTS

The literature review established connections between the process user are going through when interaction with products (i.e. kansei process, user experience) and the industrial design context. The two additional notions described in this literature review are the design activities and the cultural environment. The section related to experience-centred design activities permitted to understand the how experience can be taken into account in NCD projects as well as important related notions (e.g. design information, early representation, related tools and methodologies). In that sense, it showed hints about how junctions can be established between users' product experiences and organisations' development processes. As they are all dependant of people, the notion of *cultural environment* was reflected in each section of this literature review. The users' and design team members' culture (demographics, function, organisation) has been identified as an important characteristics influencing the *industrial design process*, the *experience-centred design activities*, and the *users' experiences with products*.

Figure 2.31 summarises the points learned from each of these notions. It incorporates the structure of the Figure 2.1 (p. 33), already used in the literature review introduction, and shows the way they are interlocked.

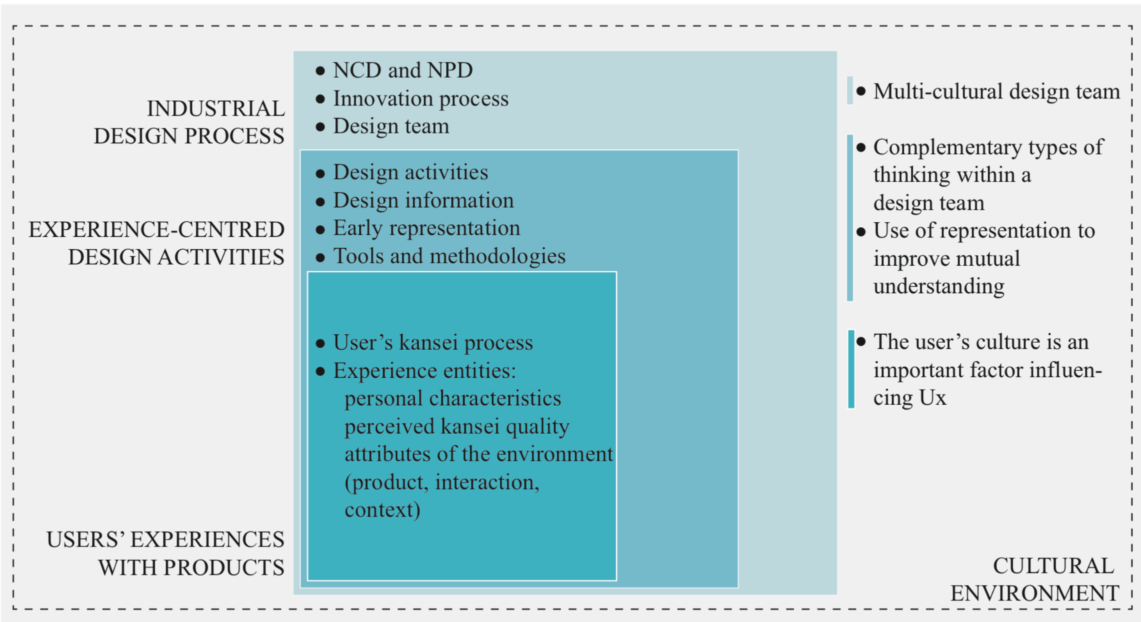


Figure 2.31: Summary of the literature review

The following statements have guided the definition of the research question and the hypotheses that will be presented in the following section. They come from observations made on the different notions made previously.

USER EXPERIENCE AND KANSEI PROCESS

- The literature related to user experience and the one related to the kansei process could be discussed together. Junctions could be identified.
- Interrelations between user experience entities are often studied one by one. Perceived kansei qualities are most of the time treated as dependant variables, whereas personal characteristics of the user and attributes of the environment are treated as independent variables.

- Only a few empirical studies deal with all of them together. This approach reflects best the holistic nature of an experience.

EXPERIENCE-CENTRED DESIGN ACTIVITIES

- Tools and methodologies supporting experience-centred design activities are either based on abductive reasoning or on scientific reasoning and rarely combine both types of reasoning. They are mostly addressed at a specific audience (particular type of function within a design team).
- Early representations enable communication in early design stages. Representations related to the notion of experience are rare.
- Only few types of early representation convey design information related to all the UX entities (user's personal characteristics, perceived kansei qualities, and the attributes of the environment [product, interaction, context]).

NEW CONCEPT DEVELOPMENT (NCD) PHASE OF THE INDUSTRIAL DESIGN PROCESS

- Innovation can rely on new technologies and/or on new kansei qualities.
- Research investigating new kansei qualities is less mature and established than research investigating new technologies. Only a few researchers have described the ways tools and methodologies supporting it can be integrated to NCD models.
- Communication within a design team and with the design team's stakeholders is crucial in new concept development projects.

3 RESEARCH QUESTION AND HYPOTHESES

This research investigates the definition and representation of experience in the early phases of the industrial design process. It focuses on the kansei process. To this end, it uses Kansei Design tools and methodologies. This dissertation therefore also contributes to the establishment of this new set of tools and methodologies combining different concepts presented in the state of the art.

The tools and methodologies of the Kansei Design approach permit the creation of representations conveying design information that connects intended kansei qualities, personal characteristics of the intended user, and the attributes of the design environment (product, interaction, context). They also have the specificity to rely on abductive and scientific types of reasoning.

3.1 RESEARCH QUESTION

The research question of this Ph.D. research is the following:

How can approaches centred on the kansei process support early design activities?

3.2 Hypotheses

H1 – Kansei-Experience framework

The first hypothesis relies on the section of the literature review dealing with the notion of "experience." It is based on the framework introduced in that section (Figure 2.13 [p. 47]). What underlies this hypothesis is the fact of being able to treat variables related to all the experience entities as independent and not to distinguish dependent and independent variables.

H1: *Experiences provided by products can be compared and clustered according to the kansei qualities that users perceive from them, the user's personal characteristics, and the attributes from the environment (product, interaction, context).*

H2 – Kansei Design approach

The second hypothesis is related to the nature of early representations: the output of the Kansei Design tools and methodologies that will be created and experimented. It aims to explore a domain that is poorly covered in the state of the art: early representations conveying information related to all experience entities.

H2: *Early representation[1] of the intended user experience of a future product can convey design information related to all the entities[2] of an experience.*

H3 – NCD in a multi-cultural context

The third hypothesis is related to way representations of UX intentions can be used in practice at the new concept development stage of the industrial design process. It considers also the characteristics of the design activities leading to their creation with a specific focus on communication (identified as a crucial aspect in the literature review).

H3: The developed Kansei Design tools and methodologies can be integrated into an industrial design process.

[1] Early representations are situated upstream of concrete representations (e.g. technology, styling) in the design process.

[2] The three UX entities are the user's personal characteristics, the user's perceived kansei qualities, and the attributes of
[2] The three UX entities are the user's personal characteristics, the user's perceived kansei qualities, and the attributes of the environment (product, interaction, context).

4 EXPERIMENTS

4.1 INTRODUCTION

This Ph.D. research is composed of five experiments. They will also be referred to as EXP 1, EXP 2, EXP 3, EXP 4, and EXP 5. As shown in Figure 4.1, together they cover topics related to the three sections of the literature review and address the three hypotheses detailed in the previous section.

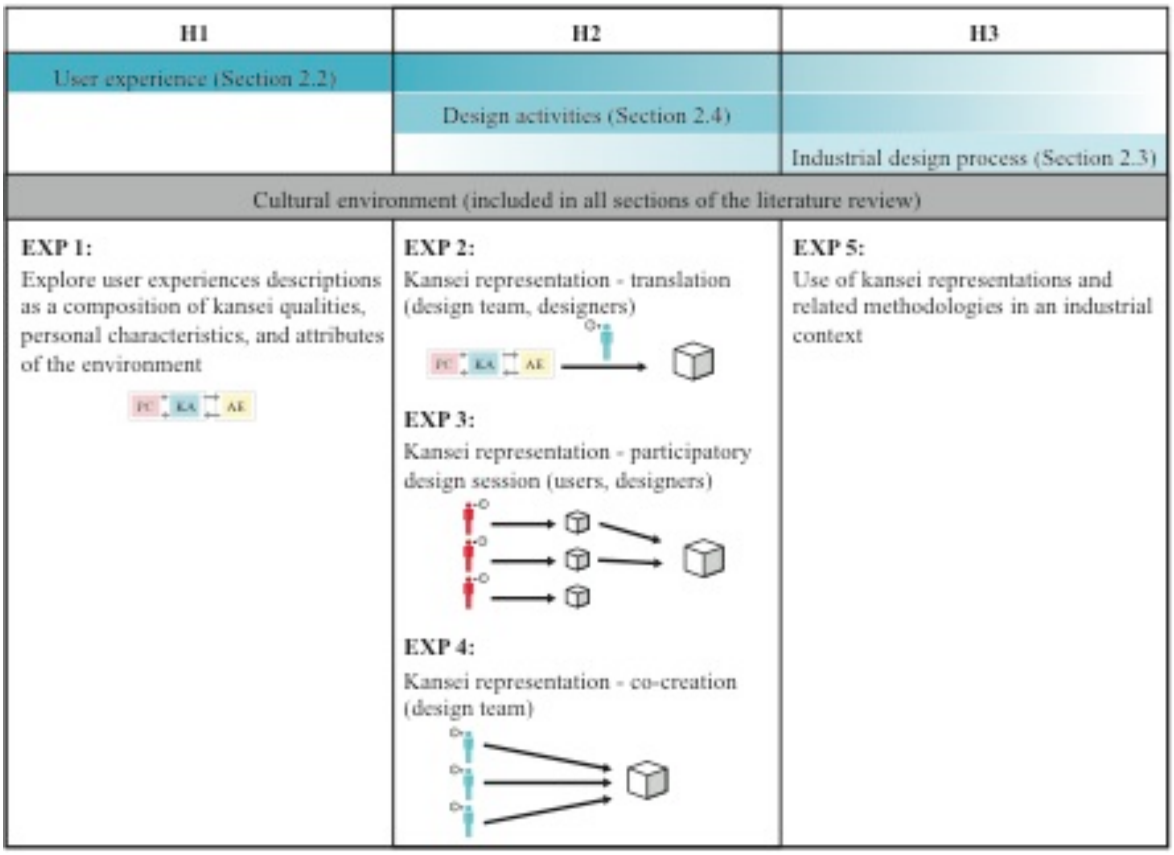


Figure 4.1: Overview of the experiments

EXP 1 addresses the first hypothesis (H1). It investigates through an online survey the nature of user experience as well as ways to describe and analyse it starting from the UX entities described in the literature review (considering them as independent variables and not as pairs of dependent and independent variables). It aims to identify patterns of user experience that can be described using relevant criteria related to all the experience entities.

EXP 2, EXP 3, and EXP 4 are testing three different methodologies aiming at the creation of design information-rich early representations. The intention of these early representations is not only to convey intended kansei qualities, but also to relate them to design information tackling other experience entities (personal characteristics of the targeted user, intended attributes of the product and interaction to be designed and of the context of use). The people at the origin of the creation of the representations are different for each methodology. The way they treat users and the tools they imply are also different. The three experiments will all contribute to discuss H2 from different angles. The broader purpose of these experiments is to investigate design activities supporting the establishment of a stronger connection between the experience occurring when a user interacts with a product (section 2.2 of the literature review) and the early stage considerations of the industrial design process (section 2.3 of the literature review).

EXP 5 focuses on the integration of the Kansei Design approach (including tools, methodologies, and related early representations) in experience-centred NCD projects. It will analyse the content of 27 past industrial projects in order to be able to distinguish different typologies of projects with specific context (purpose, design team), design activities, and design information conveyed by their output representations. The results of EXP 5 will address H3. In that sense it is very related to section 2.3 of the literature review focusing on the industrial design process (p. 55), but also touches on notions covered in the other sections.

4.2 EXP 1: User experience and the kansei process – A composition of components and influencing factors

4.2.1 Presentation

The first experiment (EXP 1) is an empirical study. It aims to better understand the different typologies of existing user experience by investigating the interrelations between the different entities of an experience (i.e. the user's personal characteristics [PC], the user's perceived kansei qualities [KQ], and the different attributes of the environment [AE]) (Figure 4.2).

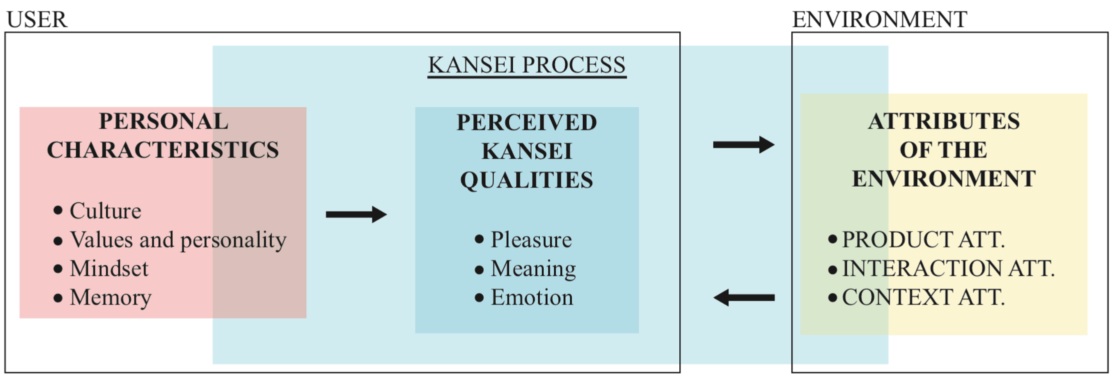


Figure 4.2: Kansei-Experience framework

As expressed in the literature (see section 2.2.5 [p. 47]), personal characteristics (PC) as well as product, interaction, and context attributes (AE) can be considered as experience influencing factors. These entities impact what a user captures from an experience: its perceived kansei qualities (KQ).

As input to this study, descriptions of user experiences with various products have been collected from participants through an online questionnaire. No constraint was put on the participants' choice. In that sense, the experiences gathered corresponded to some of their favourite ones.

4.2.2 Protocol

The "online questionnaire" format was selected in order to reach participants in different countries more easily. It was made available in five languages all reviewed by native speakers (English, Japanese, French, German, and Spanish). Figure 4.3 presents an overview of the questionnaire's protocol.

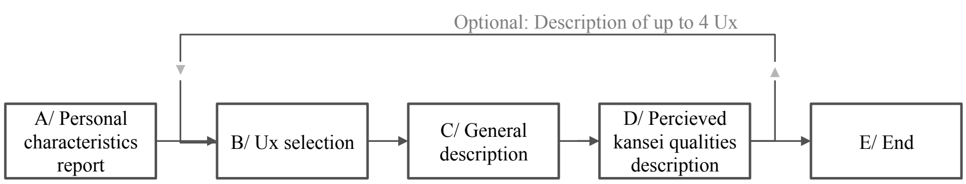


Figure 4.3: EXP 1 - Protocol followed by the participants

A/ Personal characteristics report

Participants were first asked to report their personal characteristics (PC) such as gender, age, nationality(ies) and instrumental values. The values were extracted from Rokeach's list of instrumental values (1973). To evaluate each of them, 5-point semantic differential scales were used. The anchors were labelled "not at all" and "extremely," whereas the central point was labelled "moderately." In that way, the scales were very close to the ones described by Schütte as combining the most advantages for kansei studies (2005).

B/ User experience selection

In section B, the notion of user experience was explained to the participants. It included references to the kansei process, perceived kansei qualities, and attributes of the environments. They were then asked to report a product that provided them with an enjoyable experience. No specific type of product was targeted. As a consequence, participants selected products from a wide range of categories such as high technology devices (smartphones, eBooks…), pieces of furniture, board games or transportation means.

C/ General description

In section C, participants were asked to describe the product and related experience they selected in a few sentences. The information gathered from the selection and descriptions were later analysed in order to identify AE related to each UX described.

D/ Perceived kansei qualities description

In section D, participants were asked to report kansei qualities they perceived from the experience. The information collected corresponded to kansei direct consequences as they came from participants' psychological responses (Lévy et al., 2007). In terms of kansei qualities this research took three aspects into account: the pleasure retrieved from sensory stimulation, the semantic associations and the emotions triggered. For each aspect, a question and a list of keywords were presented to the participants. The list of KQ keywords used can be seen in Figure 4.7 (perceived sensory pleasure: 6 keywords), Figure 4.8 (meaning attributed: 16 keywords), and Figure 4.9 (emotion felt: 17 keywords). They were evaluated with 5-point semantic differential scales identical to the ones used to evaluate instrumental values (labelled *not at all*, *moderately* and *extremely*). The final lists of keywords were obtained by refining the ones used in previous studies organised within TME-KD as well as inspired by the list of semantic keywords proposed by Kim (2011). For emotions, I was careful to cover the full scope of positive emotions (from active to passive [Scherer, 2005]) and used the translation table from the Geneva emotion research group to find the most appropriate word in every language (Geneva emotion research group).

After finishing the report of an experience, participants were asked to choose between describing another one (back to section B) and ending the questionnaire (going to section E). In total a participant could report up to four experiences. At the end of each section, they had the option to leave comments.

4.2.3 Results

4.2.3.1 Data description

In total, 189 participants returned valid questionnaires (all questions intelligibly answered). It permitted me to collect 211 UX descriptions (participants could reference up to four experiences). The experiences described by the participants all corresponded to "direct experience" in the sense of Ocnarescu et al. (2012). 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 people get from products that they use in their everyday life.

The distribution of the participants is presented in Figure 4.4. The participant pool can be considered homogeneous as no correlations in distribution were observed between the *nationality*, *gender* and *age* groups.

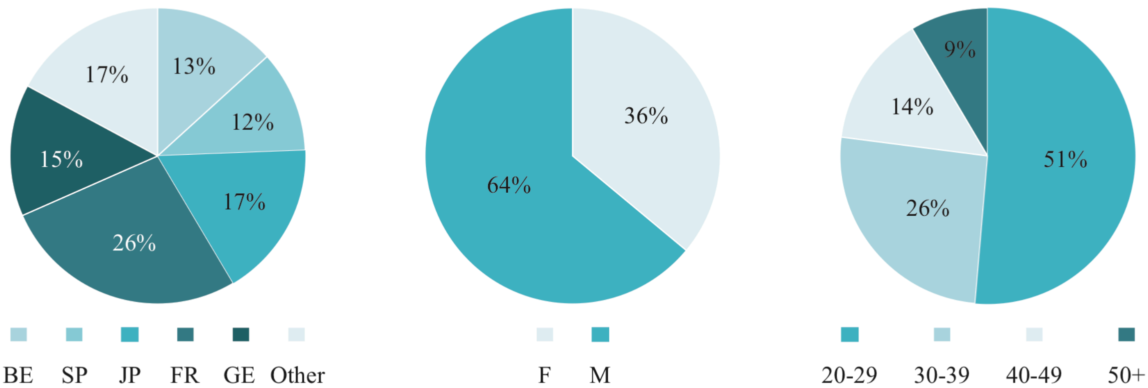
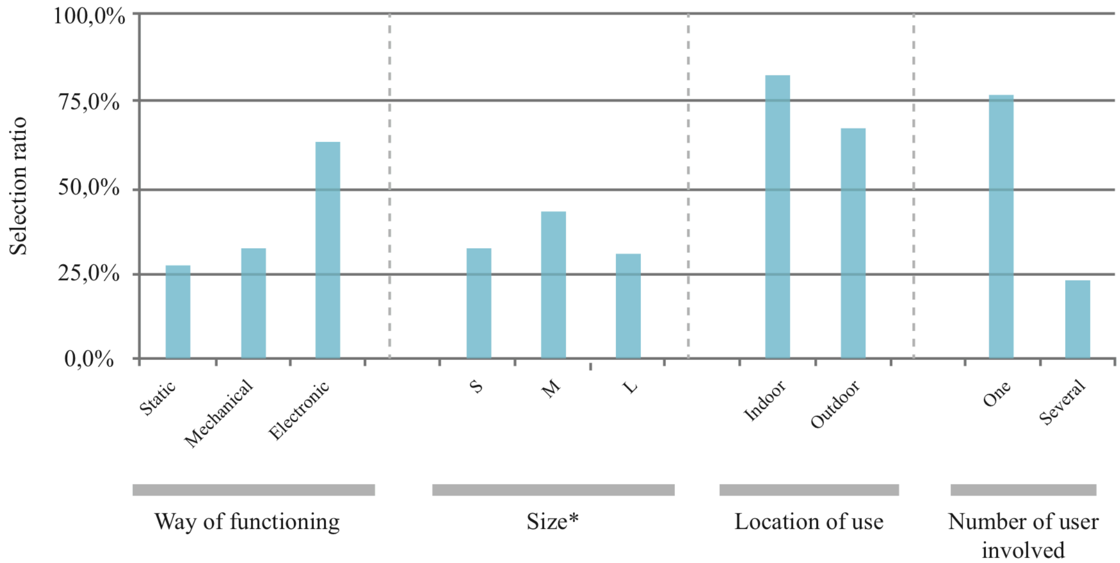


Figure 4.4: Age, gender and main nationality distribution of the participants

At this stage the database contained, for each UX described, structured information related to the *personal characteristics* (PC) of the participants and about the *perceived kansei qualities* (KQ) as well as unstructured description of *attributes of the environment* (AE). The text-based descriptions of AE were then analysed and gradually manually structured into attributes and categories of attributes. At the end of the process the unstructured descriptions were finally clustered attributes organised in seven categories related to the product (*size*, way of *functioning*), interaction (*action enabled*, *interface*, *engagement required*) and context (*location of use*, *number of user involved*). Each category contained several attributes. The selection ratio of *attributes of the product* and *attributes of the environment* are presented in Figure 4.5, whereas the ones of *attributes of the interaction* are presented in Figure 4.6.

After this activity, all the experiences collected were described with the same structured lists of keywords related to the different entities of an experience (PC, KQ, AE).



*S size products were defined as the ones fitting in a pocket, M size products are fitting in a backpack, and L size are the ones fitting in a room.

Figure 4.5: Selection ratio of the different product and context attributes identified

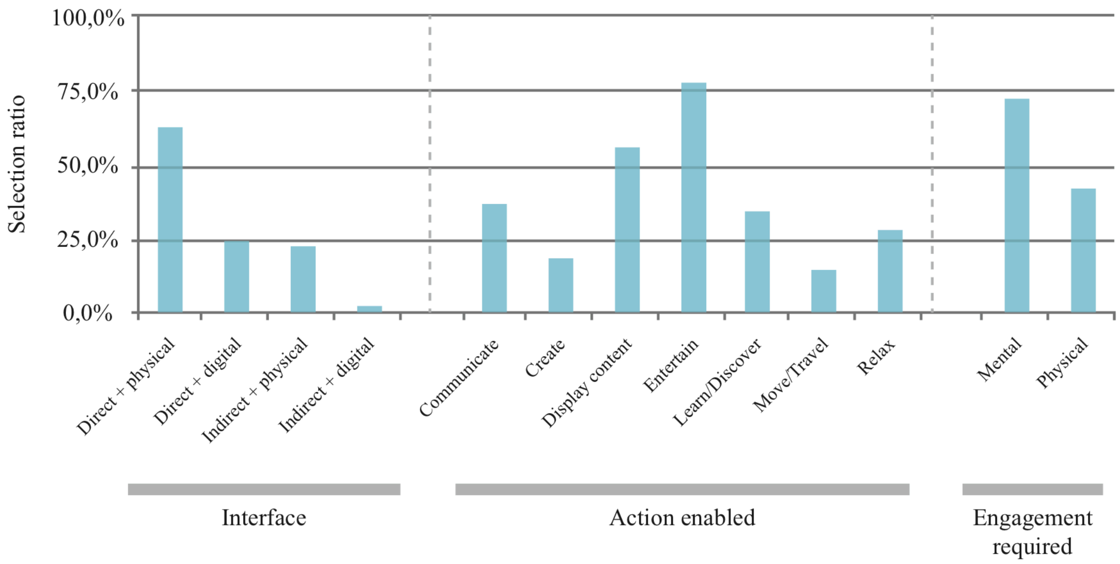


Figure 4.6: Selection ratios of the different interaction attributes identified

4.2.3.2 DATA ANALYSIS

The data analysis section will explore interrelations between the different experience entities. Special attention has been paid to the way the kansei process links together UX influencing factors and perceived kansei qualities. The database obtained from the survey connects each of the 211 UX described with keywords related to the different experience entities (Table 4.1). This bond can be a yes/no relation (1/0) such as for all the attributes of the environment (see previous section) and for some personal characteristics categories (gender, age, nationality). Otherwise, the bond is an association score going from 0 (*not at all*) to 4 (*extremely*) (originating from the SD-scales). This is the case for values (PC) as well as for every KQ: sensory pleasure, meaning attributed, emotion felt.

Table 4.1: Schematic representation of the database obtained

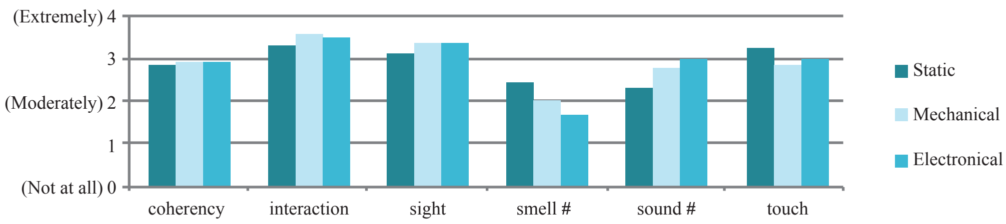
	PC			*KQ*			*AE*		
	$Gender_A$	*$Nationality_A$*	*$Value_A$*	*KQ_A*	*KQ_B*	*KQ_N*	*AE_A*	*AE_B*	*AE_N*
UX_1	0	0	2	1	2	3	0	0	0
UX_2	1	1	4	3	3	0	0	1	0
...	…	…	…	…	…	…	…	…	…
UX_M	1	0	3	4	4	4	0	0	1

The following sub-sections will describe examples of correlations between AE and KQ, as well as between PC and KQ. The last sub-section will discuss the findings and their added value for design practice.

CORRELATIONS BETWEEN PERCEIVED KANSEI QUALITIES (KQ) AND ATTRIBUTES OF THE ENVIRONMENT (AE)

Using the database obtained, a correlation matrix including all the keywords could be created. By looking at the keywords related to AE and to KQ it was possible to identify particularly strong correlations between some keywords related to these two entities, for instance between *curiosity* (emotion felt) and *mental engagement* (engagement required, interaction attribute), or between *social* (meaning attributed) and *communication* (action enabled, interaction attribute) with correlation factors in both cases of 0.42.

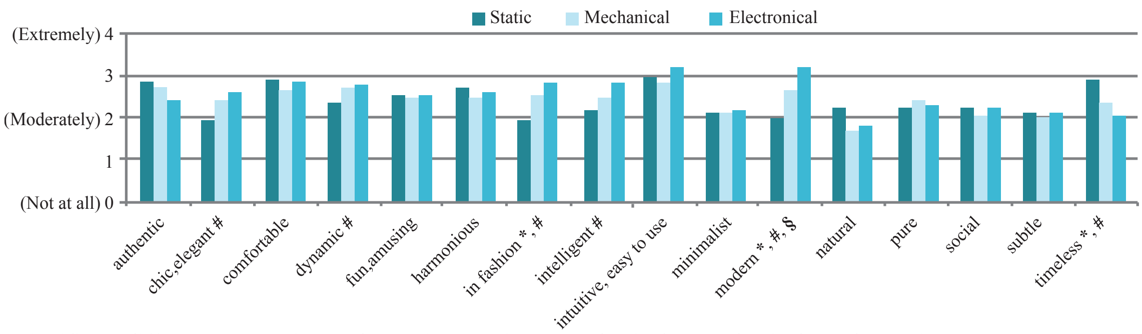
In order to go further, significant differences in term of correlation between AE and KQ were studied. They will be illustrated using the example of the product attribute category "way of functioning." The three non-exclusive attributes contained in this category are *static*, *mechanical* and *electronic*. A rug can for example be described as *static*, an automatic watch as *mechanical*, a smartphone as *electronic,* and a cooking mixer or a car as *mechanical* and *electronic*. By looking at the KQ associated with these attributes, differences in terms of perceived sensory pleasures (Figure 4.7), meaning attributed (Figure 4.8) and emotions felt (Figure 4.9) could 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 KQ keywords (X-axis). ANOVA were performance for each variable. The significant differences observed between means (confidence interval: 95%) are highlighted in the different figures with symbols (i.e. **#**, *****, and **§**). Even if visually tendencies might appear, no conclusions can be drawn when comparing two means for which no significant differences were observed.



Means with significant differences: # *static* vs. *electronic*

Figure 4.7: Influence of the way of functioning of a product on the perceived sensory pleasures

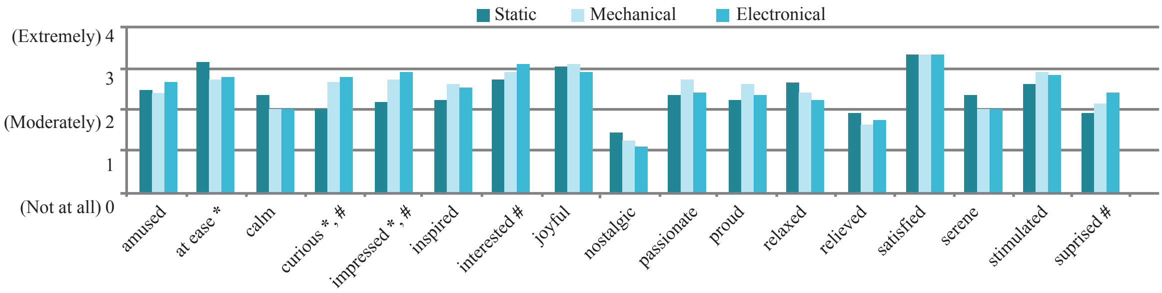
When looking at the differences in terms of perceived sensory pleasures (Figure 4.7), it was possible to notice that on the one hand the "intensity" of pleasure coming from *coherency between the senses*, *interaction*, *sight,* and *touch* were generally speaking similar for the three product attributes. When comparing them, *interaction* appeared to be the most "intense" source of pleasure. On the other hand, the pleasure provided by *smell* and *sound* seemed to be significantly different for *static* and *electronic* products (confidence interval: 95%). *Smell* was significantly more pleasing for the *static* products than for *electronic* products. The opposite could be observed for *sound* (annotated # in Figure 4.7). In both cases, *mechanical* products appeared to have an intermediate position.



Means with significant differences: # static vs. electronic, * static vs. mechanical, § mechanical vs. electronic

Figure 4.8: Influence of the way of functioning of a product on the meanings attributed to it

Interesting observations concerning differences in meaning attributed by the participants could also be extracted from the database (Figure 4.8). For all types of products, *intuitive/easy to use* and *comfortable* belonged to the more strongly perceived meanings. The other most important meanings conveyed by *static* products were *timeless* and *authentic*. For *timeless*, a significant difference could be observed with both *electronic* and *mechanical* products. Additional top-ranked meanings were *dynamic* and *authentic* for *mechanical* products and *modern* and *intelligent* for *electronic* products. For the aforementioned keywords, *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* (annotated #, *, and § in Figure 4.8).



Means with significant differences: # *static* vs. *electronic*, * *static* vs. *mechanical*

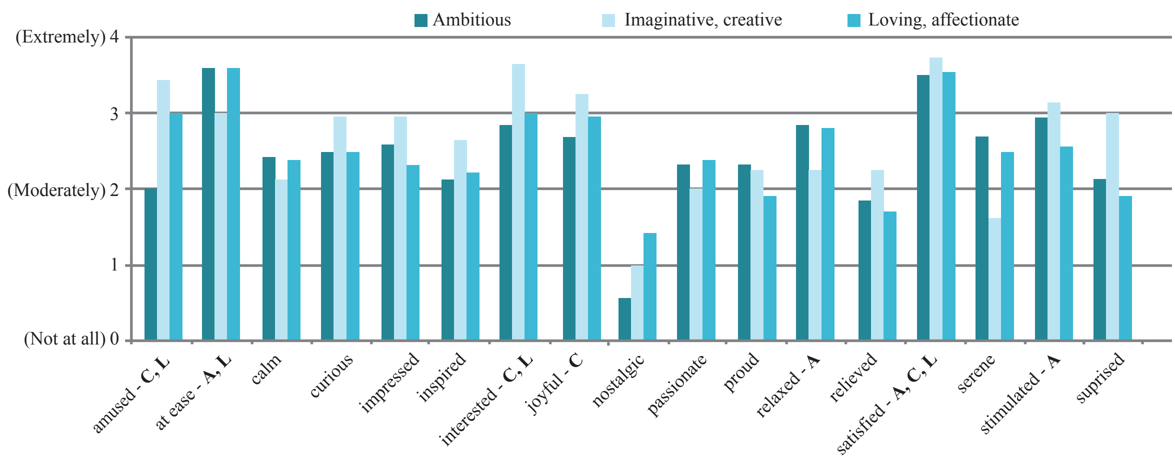
Figure 4.9: Influence of the way of functioning of a product on the emotions felt by its users

Concerning the emotions felt while interacting with products, similar patterns could be observed for the three ways of products' functioning (Figure 4.9). They all had at the top of their list the three following emotions: *satisfied*, *joyful* and *interested*. It was only in the case of *static* products that another emotion interfered with this Top 3: *at ease* was ranked second (sign. diff. *static* > *mechanical*). Other significant differences could be observed between the means of the emotions *curious*, *impressed,* and *surprised*. They are annotated # (sign. diff. between *static* and *electronic* products) and * (sign. diff. between *static* and *mechanical* products) in Figure 4.9.

For any given AE, the analysis process described previously permits one to quantify and rank KQ in order of importance. It highlighted the fact that different product, interaction or context attributes tend to convey (significantly) different KQ to the user. It also gave a clear image of the KQ related to specific attributes, and confirmed or invalidated apriorisms one would have about such correlations.

CORRELATIONS BETWEEN PERCEIVED KANSEI QUALITIES (KQ) AND PERSONAL CHARACTERISTICS (PC)

As mentioned previously, a correlation matrix including keywords related to every experience entity (KQ, PC, AE) was created with the database originating from the questionnaires. By looking at the PC and KQ keywords, it was possible to identify particularly strong correlations between these two categories of keywords such as for instance between *satisfaction* (emotion felt) and *capable* (users' instrumental value) and between *subtle* and *natural* (meaning attributed) and respectively *Spanish* (users' nationality) and *respectful* (users' instrumental value). In each case the correlation factor was close to 0.30.



Most "intense" emotions marked with **A** for the *ambitious group*, **C** for the *creative group,* and **L** for the *loving group*

Figure 4.10: Emotions appealing to the three PC groups

When filtering the database with specific personal characteristics it is possible to identify KQ particularly important for the selected user-group. For example, three groups of young (<30 years old) Europeans with different instrumental values were compared. The three groups were 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 could be compared with each other. As example, the *ambitious*, *creative,* and *loving groups* are compared in terms of emotions associated with their favourite products (Figure 4.10). Very important differences in appeal could for instance be noticed for *amused* (*creative>>ambitious*), *nostalgic* (*loving>>ambitious*), and *surprised* (*creative>>loving*). The most “intense” emotions for each group are marked with the letter A (*ambitious group*), C (*creative group*), and L (*loving group*) in Figure 4.10.

CORRELATIONS BETWEEN PERCEIVED KANSEI QUALITIES (KQ) AND PERSONAL CHARACTERISTICS (PC) FOR GIVEN ATTRIBUTES OF THE ENVIRONMENT (AE)

Complementary to the analysis of overall correlations between KQ and PC (detailed in the previous sub-section), I will here explore the added value ensuing from the study of these correlations for given AE. To facilitate this understanding, I will continue to use two of the aforementioned product attributes as examples: *static* and *electronic* products. For both product attributes, correlation matrices were created and ANOVA were performed. As a summary, significant differences in terms of perceived KQ between different PC-groups have been reported in Table 4.2 and Table 4.3 (confidence interval: 95%). These significant differences were always observed between the group having the highest score and the group having the lowest score. For instance, “Stimulated 50+>40-49” has to be understood as follows: the *50+* age group felt more *stimulated* than all the other age groups and significantly more than the *40-49* group (which was the one that felt the least stimulated).

For static products, it can be observed that there are almost no significant differences between the different personal characteristics groups in terms of sensory pleasures perceived (Table 4.2: left column). Except for gender sub-groups, they are all relatively close to the general trend observed for static products (presented in Figure 4.7). For gender, the strongest difference occurred for touch, which is a major modality related to pleasure for females but not for males (significantly less). Concerning the other KQ, Table 4.2 exemplifies that emotions triggered by static products are particularly sensitive to age (3 sign. diff.) and the semantic associations they convey are particularly sensitive to nationality (5 sign. diff.).

Table 4.2: Significant differences in terms of KQ for PC when interacting with static *products*

	Sensory pleasure (KQ)	*Semantic (KQ)*	*Emotion (KQ)*	*Total*
Age (PC)			Stimulated 50+>40-49 Satisfied 30-39>40-49 Inspired 50+>20-29	3
Gender (PC)	Touch F>M	Fun, amusing F>M Modern M>F		3
Nationality (PC)		Comfortable JP>GE In fashion JP>GE Subtle SP>BE, SP>GE, SP>FR	Calm JP>GE	6
Total	1	7	4	

Electronic products were also analysed. When comparing Table 4.3 with Table 4.2 it can be noticed that there are more significant differences between PC groups for *electronic* products than for *static* products. This is especially true for the *nationality* sub-groups for which many differences could be observed for all types of KQ investigated (sensory pleasure, semantic association, and emotion). Table 4.3 shows for instance that the sensory pleasure provided by *interaction* is significantly less perceived by Japanese users that by European users and that the Spanish sub-group is the one that attributes stronger meanings to *electronic* products (e.g., *in fashion*, subtle, social, *at ease* with sign. diff.).

Table 4.3: Significant differences in terms of KQ for PC when interacting with electronic *products*

	Sensory pleasure (KQ)	*Semantic (KQ)*	*Emotion (KQ)*	*Total*
Age (PC)	Sound *40-49>50+*	Harmonious *20-29>50+*	Amused *30-39>50+* At ease *20-29>30-39*	4
Gender (PC)		Social *F>M* In fashion *F>M* Chic, elegant *F>M*	Curious *F>M*	4
Nationality (PC)	Smell *FR>SP, JP>SP, BE>SP* Interaction *FR>JP, SP>JP, GE>JP, BE>JP*	In fashion *SP>GE* Subtle *SP>GE* Social *SP>GE, SP>JP, SP>BE, SP>FR* At ease *SP>JP, FR>JP*	Passionate *GE>SP, FR>SP, BE>SP* Satisfied *FR>GE, FR>JP, FR>BE* Surprised *SP>GE, SP>FR, BE>GE*	24
Total	8	12	12	

SUMMARY AND ADDED VALUE FOR DESIGN PRACTICE

The previous sub-sections demonstrated the use of different mathematical tools for the comparison of experiences provided by products. They all contributed to better understanding what is behind the arrows present in the UX framework from the state of the art (Figure 4.2 [p. 91]). Using correlation tables and analyses of variance (ANOVA), significant correlations between UX influencing factors (PC and AE) and perceived kansei qualities (KQ) could be identified. The strength of these quantitative analysis tools is that they are generic and that they permit one to explicitly name and describe correlations for any experience situation involving the PC, KQ, and AE covered by the experiment.

It is often stated that the decisions made during the early design stages have the highest impact on the UX (Karapanos & Martens, 2009). From this statement, we postulate that taking experience into account and discussing it early in the design process increases the chances that the final product will have a positive impact on its users' kansei. The intended experience can be expressed with intended kansei qualities, product, interaction, and context attributes of the environment, as well as targeted users with specific personal characteristics. At this stage, product planners usually share (more or less specific) information related to a target user (related to PC) and a product package (related to AE) with the rest of the design team. Filtering the database created in this experiment with the defined PC and AE could help the design team to identify the proper KQ to evoke. These could be used as starting point for the information design activities related to the creation of the new product experience.

More generally, the information resulting from the data analysis can be used as user research centred on experience, which helps the design team to better understand the context of a project and define missing aspects related to the experience (PC, KQ, or AE) of the product they are creating.

4.2.3.3 DATA INTERPRETATION

The data interpretation section will describe the creation of UX harmonics. These are compositions of PC, KQ, and AE related information, which together describe relevant directions of experiences.

In order to create these UX harmonics, a Hierarchical Cluster Analysis of the 211 UX described by the participants was performed according to their reported perceived KQ. The dissimilarity was measured with Euclidian distance and the agglomeration method used was *Ward's method* because it is the one creating the most homogeneous clusters. The truncation was done manually. Different numbers of classes were tested in order to identify the maximum number for which all the clusters were still composed of several UX description. The number of classes retained is 15. Figure 4.11 displays the dendrogram and the distribution of the 15 clusters (named C1 to C15). The biggest one is C4 (composed of 33 UX descriptions) and the smallest one is C14 (composed of 3 UX descriptions). The average amount of UX description per cluster is 14.06 (SD: 9.52).

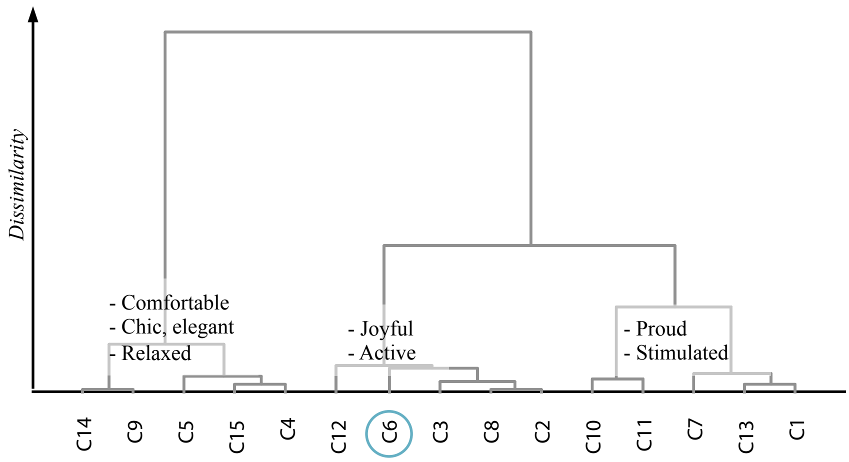


Figure 4.11: Dendrogram of the 211 UX clustered according to their KQ

All clusters can be described in terms of associated and dissociated KQ (variables used for the PCA) using the values of the barycentre of the classes. The KQ keywords best representing the three macro-clusters are also represented in Figure 4.11.

The clusters could also be described in terms of PC and AE. The means and standard deviations were calculated in this case. An analysis of the variance confirmed clear differences in the way each PC, KQ, and AE keyword was related to the clusters. This is especially true in the case of KQ. Significant different mean values (confidence interval: 95%) could be observed for 87% of the KQ keywords (except of *sound*, *coherency between the senses*, *intuitive*, *harmonious*, *minimalist*) as well as for 16% of the PC keywords and 35% of the AE keywords.

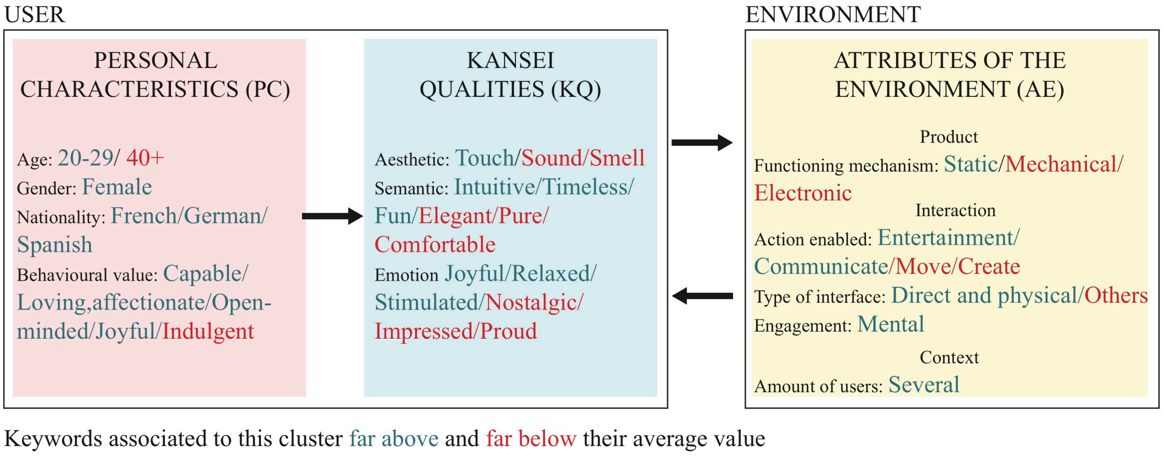


Figure 4.12: Example of a UX harmonic (C6) combining PC, KQ, and AE

One example of UX harmonic is presented in Figure 4.12. It represents a description of the essential KQ, PC, and AE related to a cluster of UX descriptions and uses as layout the kansei-experience framework presented in the literature review. The KQ, PC, and AE represented were interpreted from the data analysis as being the most specific to this cluster. They correspond to the keywords that have for this cluster a value far above the mean (considering the 211 UX description). The cluster C6 (circled in blue in Figure 4.11) was used for the creation of this example of UX harmonic (Figure 4.12).

The cluster C6, corresponding to this UX harmonics, is actually composed of UX descriptions of five different types of board games as well as of a book and of a camping tent. At first sight, these products do not seem to have much in common (Picture 4.1), but looking back at Figure 4.12 actually permits us to understand and agree that the experiences they provide share a common essence. This example shows the idea underlying the concept of UX harmonics.

Picture 4.1: Example of products corresponding to cluster C6

The UX harmonics summarise 15 directions of appealing user experience. These 15 directions are not the only ones that exist but they have the particularity of being relatively clearly defined in terms of PC, KQ, and AE as well as exemplified by the real products (the ones described by the participants).

From that perspective, they are interesting starting points to be used as design briefs when the frame of a project is still relatively open. Sharing them within a design team might bring the discussion to UX-related topics (and raise awareness) and could also help the team to identify the most appropriate UX directions for the project. Indeed, they contain design information relevant for different members of the design team: information about the user (key concern of product planners) and design information about inspirational products and interactions (key concern of styling engineering and industrial/product designers).

Using a selection of harmonics could also help tackle the design brief starting from the intended user experience and approach it from very different angles. In the case of a car interior the selection of harmonics could for instance help to investigate and discuss different possible experiences and related atmospheres that would later be translated in terms of interior design features (shapes, materials, functions…) and related services.

The two aspects described here as possibly relevant for design practice will be investigated in the methodology presented in EXP 2.

4.2.4 CONCLUSION OF EXP 1

The first experiment (EXP 1) is based on the Kansei-Experience framework presented as a conclusion of the state of the art (Figure 2.13 [p. 47]). It investigated the correlations between the UX entities represented by arrows in this figure. An empirical study based on a collection of 211 UX permitted the construction of a database associating each UX described keywords related to personal characteristics of the user, kansei qualities perceived by the user and attributes of the environment.

From there, correlations (using correlation matrices) and significant differences (using ANOVA) could quantify the bond between kansei qualities (KQ) and experience influencing factors (PC and AE). Using hierarchical cluster analysis permitted the identification of UX macro-trends (UX harmonics). These 15 UX harmonics are described with product examples as well as with associated and dissociated keywords related to each of the UX entities (PC, KQ, AE). The added values for design practice of the different outcomes were finally also discussed.

This experiment permits us therefore to discuss the validity of H1. This hypothesis expresses that “experiences provided by products can be compared and clustered according to the kansei qualities that users perceive from them, the user’s personal characteristics, and the attributes from the environment (product, interaction, context).” The 15 clusters identified from participants’ inputs, representing 15 different descriptions of UX related to all experience entities (all the measurements made), permit to confirm the internal and external validity of H1.

Because of the nature of the measurements made, limits can nevertheless be identified. Only the self-reported personal characteristics and perceived kansei qualities could be used as input data and only a certain number of attributes of the environment have been taken into account. This limitation addresses the construct validity of H1. Nevertheless, the psychological measurements used are the most common for this type of study and are also the only ones collecting such a wide variety of data related to each entity of an experience.

Table 4.4: Design information conveyed by the UX harmonics

Design information	*Related UX entity*	*Level of abstraction*
Value	User's personal characteristics	High
Semantic descriptor	Perceived kansei qualities	High
Emotion	Perceived kansei qualities	High
Action enabled	Interaction attributes	Middle
Interface characteristic	Interaction attributes	Middle
Sector/objet	Product attributes	Middle
Product characteristic	Product attributes	Middle
Physical context	Context attributes	Middle

Table 4.4 refers to the design information that is covered by UX harmonics such as the one described in Figure 4.12. The categories are inspired by the one presented by Kim et al (2009) and the level of abstraction refers to the notion developed by Bouchard et al. (2009).

Similar tables will be used to characterise the categories of design information covered by the kansei representations present in each of the experiments. In section 5 (p. 157), they will enable me to build a model describing the kansei-related design information used in early stages of the design process.

4.3 EXP 2: KANSEI REPRESENTATION – UX HARMONICS TRANSLATED BY DESIGNERS

4.3.1 PRESENTATION

The second experiment (EXP 2) introduces a methodology permitting the translation of the UX harmonics developed in EXP 1 into rich representations of UX intentions related a specific context. These early representations can be referred to as kansei representations because they convey design information related to the intended kansei qualities of the products and to the experience entities influencing these qualities (PC, AE). For a UX perspective, they are sensory representations of UX intentional directions.

The second part of the experiment will help evaluate the influence of different factors on the understanding of the kansei representations. The different factors investigated are the UX represented, the layout used (keywords, pictures, music), as well as the readers' function and gender. Particular attention will be paid to the nature of the kansei representation (layout used) for which the intrinsic kansei qualities will be discussed additionally to the notion of understanding.

4.3.2 GENERATION OF KANSEI REPRESENTATIONS

It is wrong to say that the 15 UX harmonics identified in EXP 1 are representative of all the directions that experiences with products can take. Nevertheless, they describe 15 distinctive compositions of perceived kansei qualities (KQ), personal characteristics (PC), and attributes from the environment (AE) fitting well together. Because of this characteristic, they were used as starting points in the process of defining intended experience directions at the front-end of a new vehicle development process (used as a case study). At this stage of the process, the product to be designed was only described in a brief containing intentions regarding features, size, and target customer (i.e. initial concept). The process followed for the creation of kansei representations is represented in Figure 4.13.

Figure 4.13: Protocol followed to generate the representations

A/ SELECTION OF FITTING UX HARMONICS

UX harmonics fitting with the concept description were first selected in a cross-divisional workshop including designers and product planners. The two-hour-long workshop started with discussions about the 15 UX harmonics and the initial concept, and later evolved into a voting activity. It was concluded with the selection of seven UX harmonics.

B/ REFINEMENT OF THE KEYWORDS

The second activity consisted in the refinement of the keywords describing each selected direction. Personal characteristics information from the initial concept and examples of products from the user research were added to each of the seven UX harmonics selected.

C/ ASSOCIATION OF PICTURES

The seven UX harmonics could at this stage be seen as keyword-based kansei representations of the initial concept. An iterative process of picture search and selection involving five designers permitted the addition of two categories of pictures referred to as "inspirational user experiences" and "inspirational movements and behaviours." Although very similar to the creation of mood boards, this activity had the specificity of being structured (i.e. two categories) and focused on the concrete representation of clearly defined abstract design information. The resulting boards included between three and four images per category.

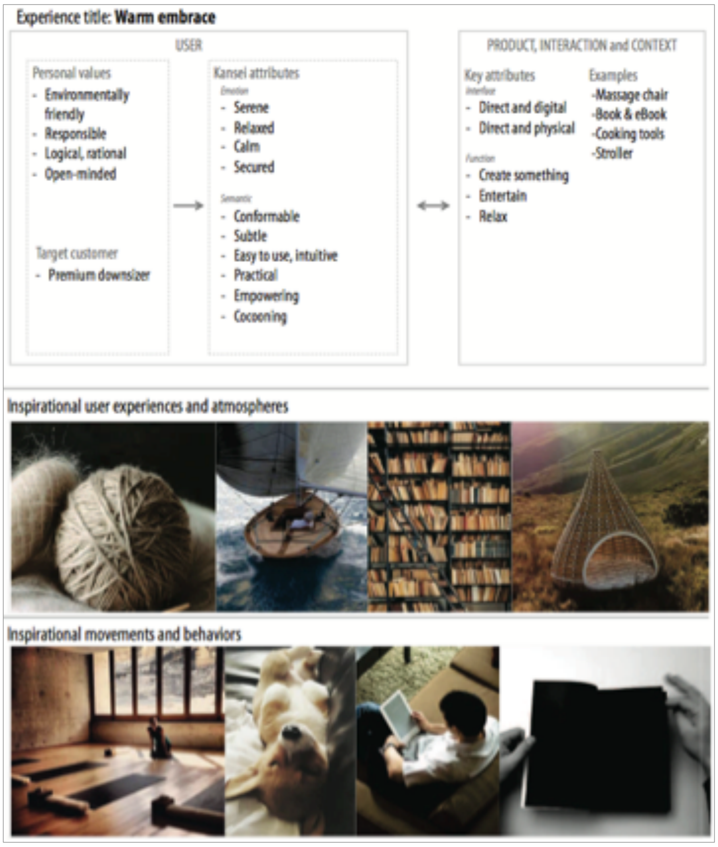
D/ ASSOCIATION OF MUSIC

A brainstorming session was then organised. It permitted designers to associate a music track to each board. Eight designers participated to this two-hour-long workshop. They used the Internet to search and present candidate tracks. The final selection included references to various musical styles including electronic music, classical music, acoustic guitar, and piano, as well as pop songs.

E/ SELECTION OF A TITLE

The last activity involved the five designers responsible for the picture selection and consisted in finding a title for the representations. This was done in order to simplify their designation when discussing them.

A kansei representation entitled "Warm embrace" is presented (visually) in Picture 4.2. The associated music track is "Sunday Morning" by the Velvet Underground. Note that for every creation-related activity, inputs came from a minimum of five designers. This was done in order to ensure a good level of congruity between design information coming from the title, keywords, pictures, and music.



Picture 4.2: Visual representation of a kansei representation

4.3.3 PERCEPTION OF THE KANSEI REPRESENTATION BY THE MULTI-FUNCTIONAL NCD TEAM

This activity analysed the understanding and intrinsic kansei qualities of the representations perceived by professionals with different functions. It also investigated the importance of sensory modalities in the representation of UX-related design information.

4.3.3.1 PROTOCOL OF THE EXPERIMENT

The protocol of the experiment is represented in Figure 4.14. 31 participants individually attended one-hour sessions in order to complete it.

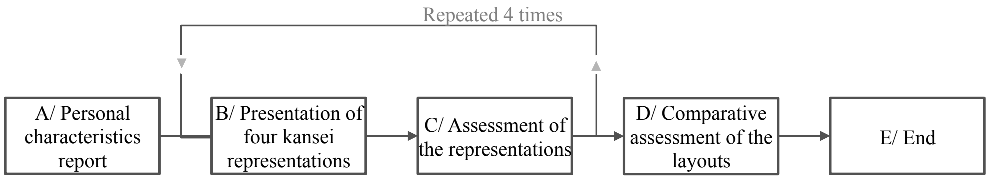


Figure 4.14: Protocol followed by the participants in order to assess the kansei representations

A/ PERSONAL CHARACTERISTICS REPORT

In this section, participants reported their gender, and function. In order to isolate the two between-subject variables that will be the focus of the experiment (gender, function), all the participants recruited were professionals involved in pre-development activities evenly distributed in terms of gender (male, female) and function (engineer, styling designer, product planner). They were all European (nationality variable was fixed). In that sense the difference of perception of Kansei representations between European and Japanese professionals is not addressed by this experiment.

B/ PRESENTATION OF FOUR KANSEI REPRESENTATIONS

In this section, four representations were presented to the participant. Four UX directions were used for the experiment (A, B, C, D). For each direction a different type of layout was used (1: keywords only, 2: pictures only, 3: keywords + pictures, 4: keywords + pictures + music). The order in which the UX directions were displayed as well as the layout used for representing them varied from one participant to another. When looking at the 31 participants (and at the gender and function sub-groups) both parameters (UX represented and layout) are distributed homogeneously among their four possible options.

C/ ASSESSMENT OF THE REPRESENTATIONS

This section was divided into three sub-sections evaluating the participants' understanding of the design information related to personal characteristics (PC), kansei qualities (KQ), and attributes of the environment (AE). They represent the three entities of an experience to which the design information conveyed by the representations can be related.

- PC-related information was assessed with the evaluation of the personality traits and age group participants thought of as being the most related to the UX represented. Personality traits were presented on SD scales (Osgood et al., 1957) based on the Five Factor Model (Goldberg, 1990) using synonym and antonym as the anchors (e.g., the conscientiousness axis is represented by "efficient, organised" and "easy-going, care-free"). The six possible age groups were represented on a linear scale.

- The understanding of the participants regarding perceived KQ was evaluated by asking them to assess the representation with semantic descriptors and emotions (e.g., *proud*, *serene*, *dynamic*). In this case, the semantic differential scales were similar to the ones used in EXP 1 (i.e. anchors labelled *not at all* and *extremely*).
- Two aspects of participants' understanding of AE were assessed. They were related to product and interaction attributes. Regarding product attributes, six style representations were first created. The styles were communicated to the participants with different materials arranged in a similar overall shape (Picture 4.3). The design information communicated was therefore both abstract (style) and concrete (visual, tactile). In this case, the participants were asked to relate the styles with the user experience representation studied (from *not at all* to *extremely*). Interaction attributes were assessed on SD scales using synonym/antonym interaction descriptors on the anchors (e.g., *physical interface* vs. *digital interface*, *active user* vs. *passive user*).

Picture 4.3: Example of four style representations

D/ COMPARATIVE ASSESSMENT OF THE LAYOUTS

Once the four UX directions (and therefore the four types of layouts) were assessed, participants moved on to the final section. At this stage they were asked to look back at all the representations they evaluated. They had to rate their layouts according to the intrinsic kansei qualities they could perceive in them (kansei oriented perception process and no longer chisei oriented process [p. 35]). They assessed the four types of layout on 5-point SD scales related to their *appeal* (i.e. how they liked to work with them), *ease of use* (in the context of a project), and *efficiency* (in order to communicate an experience). To conclude this affective evaluation, they ranked the layouts according to their overall preference.

4.3.3.2 UNDERSTANDING OF THE KANSEI REPRESENTATIONS

Section C of the protocol ("Assessment of the representations") measured participants' understanding of the design information contained in the kansei representation. Comparing them, the factors most influencing the participants' divergences in understanding will first be discussed. In the second part of this section, I will have a closer look at one of the factors: the representation's layout. Comparing the data collected with the intention from the designers that created the boards will then allow me to see how the type of layout (1: keywords only, 2: pictures only, 3: keywords + pictures, 4: keywords + pictures + music) influences the distance between intended design information and perceived design information.

FACTORS INFLUENCING RECIPROCAL UNDERSTANDING

The protocol of the experiment permitted to capture the influence of four different factors (types of qualitative variable) on the participants' reciprocal understanding of a representation. These factors are the representation's *layout*, the participant's *gender*, and the participant's *function*. ANOVA measures were conducted in order to identify if significant differences in terms of understanding (using the participants assessment) could be observed between the qualitative variables of each factor (e.g. between the three different types of functions tested). As the investigation of causal relationship between the qualitative variables (e.g. gender) and quantitative variables (e.g. perceived kansei qualities) are in this case out of scope, standard regression methods were not used.

For each of the factors (*layout*, *gender*, and *function*), I looked at statistically significant different assessments (confidence interval: 95%) between their related groups (e.g. for the factor *gender*: difference of assessments between male and female). This was done for each measurement axis meaning each of the 31 questions related to personal characteristics, kansei qualities and attributes of the environment measured with SD scales in section C of the protocol. ANOVA were done separately for each *UX direction* (i.e. A, B, C, and D) as it was assumed that this factor would have the strongest impact on the participants' responses. The analysis of the *UX direction* factor was done by comparing the evaluation of the four directions for the same measurement axis in a single ANOVA. This latter analysis was made in order to be able to verify the assumption explained above.

Once significant correlations were identified, I aimed to assess which factor was the most influential (i.e. which factor caused the most statistically significant differences per possible answer). I measured therefore the absolute differentiating level "AL_{diff}" defined as follows: for a given factor, let n_{sig} be the number of axes for which this factor is statistically influential (confidence interval: 95%), and let N_{axes} be the total number of axes.

Thus, $AL_{diff}(factor) = \dfrac{n_{sig}(factor)}{N_{axes}}$

In that sense $AL_{diff}(factor)$ corresponds to the percentage of axes for which the factor is the cause of statistically significant differences in participants' answers. It permitted me to determine which of the four factors most influences one's understanding of kansei representation. Table 4.5 presents the absolute differentiating level for the factors cited above.

Table 4.5: Absolute differentiating level of the four factors

Factor's origin	*Factor*	*Absolute differentiating level (AL_{diff})*
Representation	User experience	86.7%
	Layout	18.3%
Participant	Function	3.3%
	Gender	0.8%

Table 4.5 permits one to compare and rank the identified factors according to their absolute differentiating level. As expected, the *UX direction* represented appears to be by far the most influential factor on the participants' answers (i.e. measured understanding). It is followed by the representation's *layout*, the participant's *function* and finally his/her *gender*. This ranking is clear as the factors' absolute differentiating level decreases between every position by 4 to 6 times. The representations' *layout* is for instance about 5.5 times more influential than the participants' *function* and 4.7 times less than the *UX direction* represented. When looking at the factors' origin, it can be seen that the representation has much more influence on the participants' absolute understanding than the participants' own personal characteristics. These results confirm the relevance of the approach as the representations are meant to allow a design team (defined in terms of function and gender) to have a reciprocal understanding of design information related to distinct user experience directions.

INFLUENCE OF THE TYPE OF LAYOUT ON THE DISTANCE TO "RIGHT" UNDERSTANDING

Let's have a closer look at the representations' *layout*. It could be seen previously that this factor has a relatively high influence on the participants' response (i.e. ranked second). The influence that the four different types of layout have on the participants' distance to "right" understanding will be discussed in this section. As it is not a causal relationship between qualitative variables and quantitative variables (e.g. between the type of layout and the selection on specific keywords) that is investigated here standard regression methods cannot be used.

The selected technique was to calculate the distance between the participants' understanding of the experience described by the representations and the intentions of the boards' creators (considered here as the "right" understanding of the UX direction expressed). The impact of the type of representation-layout on the distance to "right" understanding could then be sensed. The designers that created the representations were therefore asked to follow together the assessment protocol (see Figure 4.14). It permitted the creation of an image of the intended understanding of each UX direction. For each response of each participant Δ was calculated. It corresponds to the absolute value of the difference between the participants' response and the designers' response (expressed as a percentage).

Significant influences from the *layout* on the Δ-value were calculated for each measurement axis (confidence interval: 95%). ANOVA were again done separately for each UX direction (i.e. A, B, C, and D). In order to compare the influence of the different layouts, the relative distance level "RL_{diff}" was measured. It is defined as follows: for a given *layout*, let m_{sig} be the number of axes for which this *layout* only belongs to the group with a significantly higher Δ-value, and let N_{axes} be the total number of axes.

Thus, $RL_{diff}(layout\_type) = \dfrac{m_{sig}(layout\_type)}{N_{axes}}$

$RL_{diff}(layout\_type)$ corresponds therefore to the percentage of axes for which a *layout* (layout_type) is significantly distant from the designers' response relative to the other types of *layout*. Table 4.6 shows the relative distance level for the four types of *layout*. The results present the overall RL_{diff} value, as well as a detail according to the design information related to three entities of an experience (PC, KQ, AE).

Table 4.6: Relative distance level of the four types of representation layout

Type of layout	*Relative distance level (RL_{diff})*			
	PC	*KQ*	*AE*	***Overall***
1/Keywords only	7.1%	8.3%	2.3%	**5.8%**
2/Pictures only	7.1%	4.2%	0.0%	**3.3%**
3/Keywords + Pictures	3.6%	4.2%	2.3%	**3.3%**
4/Keywords + Pictures + Music	0.0%	2.1%	2.3%	**1.7%**

Table 4.6 permits the observation of slight differences of understanding provoked by the type of *layout* presented to the participant. The richest type of *layout* (type 4: "keywords + pictures + music") has the smallest overall relative distance level. Therefore, relative to the other types of *layout*, it provokes the least significant differences between the design information intended to be communicated and the understanding reported by the participants. "Keyword only" based layouts (type 1) have the highest relative distance level overall and for each category of design information. Finally "Pictures only" (type 2) and "Keywords + Pictures" (type 3) end up with the same relative distance level. Type 3 layouts appeared to better convey PC-related design information, whereas type 2 showed better results for AE-related design information.

CONCLUSION REGARDING THE REPRESENTATIONS' UNDERSTANDING

Let's now reflect on the two analyses presented in this section. The measurement of absolute differentiating levels (AL_{diff}) *showed* that participants' understanding of the design information communicated is mainly influenced by the *UX direction* of the kansei representation observed. In addition to this result, the analysis also permitted a better appreciation of the difference of scale between the various factors' impact. It appears that factors related to the participants' personal characteristics have more than 20 (i.e. *function*) and 80 (i.e. *gender*) times less impact on the participants' answers that the *UX direction*. The influence of the *layout* of the representation is located in between.

This shows that the UX-related design information communicated by a kansei representation is understood in a similar way regardless of the reader. The fact that participants' personal characteristics have such a small impact on differences of understanding suggests that the representations can increase reciprocal understanding within a design team. Additionally, as the representations were given to the participants with no further explanations, the results also highlight their self-explanatory qualities.

When looking at relative distance levels (RL_{diff}), the focus was on the influence of the representation's type of *layout* on the participants' understanding. According to the measurement made, the participants' understanding of UX-related design information embedded in the representations appeared to be closer to the intention when perceiving the rich kansei representations (type 4). This tends to support the idea that rich and multi-sensory representations (with high congruency between the modalities) better convey UX-related design information.

4.3.3.3 KANSEI INTRINSIC QUALITIES OF THE KANSEI REPRESENTATIONS

After reporting their understanding of the representations in term of design information (discussed in the previous section), the participants expressed their opinion about the different layouts (section D of the protocol). Table 4.7 displays the average *rating* for the different layouts' perceived *appeal*, *ease of use,* and *efficiency* (5 is best), as well as their average *ranking* (1 is best). They represent the intrinsic kansei qualities of the different layouts. For each measurement, the standard error (SE) is also indicated.

The analysis of variance method permitted me to identify, for each measurement axis (i.e. the four questions), significant differences between the means obtained with the four layouts (confidence interval: 95%). For each measurement axis, groups were identified (noted with letters in Table 4.7). If two layouts belong to different groups, it means that a significant difference was measured between their means for the related axis (e.g. between layout type *1 and 2*, *1 and 3*, and *1 and 4* for the measurement axis *appeal*).

Table 4.7: Affective assessment of the four types of representation layout

Type of layout	*Average rating (sign. diff. group(s))*						*Average ranking (sign. diff. group)*	
	Appeal		*Ease of use*		*Efficiency*			
	Mean (Group)	*SE*	*Mean (Group)*	*SE*	*Mean (Group)*	*SE*	*Mean (Group)*	*SE*
1/Keywords only	2.32 (B)	0.26	2.58 (B)	0.24	2.17 (C)	0.23	3.7 (C)	0.18
2/Pictures only	3.94 (A)	0.25	4.03 (A)	0.24	3.70 (B)	0.23	2.5 (B)	0.18
3/Keywords + Pictures	3.87 (A)	0.26	4.00 (A)	0.25	4.17 (A, B)	0.24	2.2 (B)	0.18
4/Keywords + Pictures + Music	4.39 (A)	0.26	4.26 (A)	0.25	4.61 (A)	0.25	1.7 (A)	0.19

Cohen's d was then used to measure effect sizes. It is here used as a complementary measure to ANOVA in order to be able to judge the strength of the distance between the means of the parameters tested (i.e. the strength of the effect). It is commonly accepted that d=0.2 implies that the effect is weak, d=0.5 implies that it is mild, and d=0.8 implies that is it strong.

Table 4.8 represents the effect sizes (*Cohen's d*) for *Appeal*, *Ease of Use*, *Efficiency*, and Ranking. The cells corresponding to situations in which significant different means were observed (see Table 4.7) are marked in bold.

Table 4.8: Effect sizes (Cohen's d) for Appeal, Ease of Use, Efficiency and Ranking

Appeal

	1/ Key.	*2/ Pic*	*3/ Key. + Pic.*	*4/ Key. + Pic. + M.*
1/ Key.	0			
2/ Pic.	**1.16**	0		
3/ Key. + Pic.	**1.07**	-0.05	0	
4/ Key. + Pic. + M.	**1.42**	0.32	0.36	0

Ease of Use

	1/ Key.	*2/ Pic*	*3/ Key. + Pic.*	*4/ Key. + Pic. + M.*
1/ Key.	0			
2/ Pic.	**1.12**	0		
3/ Key. + Pic.	**1.05**	-0.02	0	
4/ Key. + Pic. + M.	**1.23**	0.16	0.19	0

Efficiency

	1/ Key.	*2/ Pic*	*3/ Key. + Pic.*	*4/ Key. + Pic. + M.*
1/ Key.	0			
2/ Pic.	**1.23**	0		
3/ Key. + Pic.	**1.54**	0.36	0	
4/ Key. + Pic. + M.	**1.84**	**0.69**	0.33	0

Ranking (overall Judgment)

	1/ Key.	*2/ Pic*	*3/ Key. + Pic.*	*4/ Key. + Pic. + M.*
1/ Key.	0			
2/ Pic.	**1.28**	0		
3/ Key. + Pic.	**1.46**	0.23	0	
4/ Key. + Pic. + M.	**1.97**	**0.79**	**0.57**	0

The situation in which significant different means were observed are marked in **bold**

The intrinsic kansei qualities judgements expressed by the participants showed that layout type 1 ("Keywords only") is the least attractive. For every measurement axis, this type of layout obtained significantly lower means than any other layout. At the opposite extreme, the layout type 4 ("Keywords + Pictures + Music") had the highest means for each measurement axis. They were significantly higher than type 3 for *ranking* and than type 2 for *ranking* and *efficiency*. The differences observed between the layout type 2 ("Pictures only") and 3 ("Keywords + Pictures") are generally weak (Table 4.8). Only in the case of *efficiency* they tend towards mild. In this case the highest mean is the one of the layout type 3.

The results detailed above show that the intrinsic kansei qualities of the representations (*appeal*, *easiness of use*, *efficiency*, *ranking*) perceived by the participants tend to increase gradually from layout type 1 to type 4. This is especially true for the two extreme were significant superior/inferior mean values support this interpretation. Regarding the intermediate layouts (type 2 and 3) the differences are less clear (not significant). It can nevertheless be summarised that that the sensory and modality richness of a kansei representation tends to have a positive influence on the way its intrinsic kansei qualities are appreciated by the design team.

4.3.3.4 USE IN FRONT END DEVELOPMENT PHASE

The presented representation creation methodology has been used in the early phases of two distinct industrial development projects. In each case, the methodology was used to create approximately 10 different representations (type 4). The four UX directions used in this experiment were extracted from one of these projects. For both projects the representation created an additional communication channel between the different design team members (with different functions and focus) and increased the variety of UX-related design information exchanged. In both cases, they helped the team members to agree on the selection of UX directions.

Styling designers, product planning, design managers involved in the projects, and executives had very positive comments about this new activity. They recognised the value of the design information conveyed by the kansei representations and acknowledged the quality of their rich layouts (e.g., "the topic raised by the representation [i.e. the experience] is now something critical to take into account" [Product planning GM], "the representations are very clear, I can understand the message they are conveying" [Styling design Director]). The design team members (styling designers, product planners) also appropriated the representation as they used them as a tool for their internal communication and activities. As vehicle development processes are long and involve many stages and stakeholders, it is nevertheless impossible to guarantee at this stage that the resulting cars will keep a flair of the experience discussed here.

4.3.3.5 CONCLUSION ON THE ASSESSMENT ACTIVITIES

Kansei representations were designed to convey design information related to the three entities of an experience: personal characteristics of targeted users, intended kansei qualities, attributes of the to-be-designed artefact and of the environment. In this section, it could be seen that the panel of NCD design team members understood the kansei representations well relative to the intention of their designers. Moreover, the function and gender of the participants appear to have almost no influence on their level of understanding (see Table 4.5). Regarding the type of layout of the representation, it could be observed that rich and multi-sensory representations tend to be better understood by the design team members. Their intrinsic kansei qualities are also more appreciated.

4.3.4 CONCLUSION OF EXP 2

Two activities were part of EXP 2. They were related to the creation and the evaluation of a new type of early representation. These are based on UX harmonics resulting from EXP 1.

During the first activity, UX harmonics were translated into multi-sensory representations in order to convey intentions of UX direction. It is Kansei Design methodology because it deals with kansei and combines scientific (identification of the UX harmonics) and abductive reasoning (selection of the fitting UX harmonics, pictures and music association). The creators involved were first the full design team (for the UX harmonics selection) and then only designers (for the pictures and music association process).

The second activity consisted in assessing the quality of kansei representations created and understanding the importance of their layout (presence of keywords, pictures, sound). For that purpose interviews were conducted with professionals from different functions involved in early design phases (engineers, styling designers, product planners). This last activity showed that the panel understood the kansei representations and appreciated their intrinsic kansei qualities. This appeared especially true for the richest layout tested: "keywords + pictures + music." It is nevertheless possible that the novelty of this type of representation positively contributed to their higher intrinsic kansei qualities. Therefore, I would suggest not staying focused on the layout used for this experiment. More innovative layouts with high congruity are easily achievable.

Compared to the early representations presented in the state of the art (e.g., briefs, mood boards, scenarios) the type kansei representation developed in this experiment has the particularity to convey a wider spectrum of design information related to all three experience entities (characteristics of targeted users, intended kansei qualities, attributes of the artefact to be designed and of the user's environment in general). Table 4.9 lists the different categories of design information conveyed. In that sense, this type of kansei representation communicates at early design phases a rather complete user experience intention. Some of the design information categories were already present in the brief (e.g., culture) and in the UX harmonics (e.g., emotion, interface characteristics, sector/object). Some additional ones were added by the designers of the representations (e.g., gesture, style, sound).

Table 4.9: Design information conveyed by the kansei representations created in EXP 2

Design information	*Related UX entity*	*Level of abstraction*
Value	User's personal characteristics	High
Semantic descriptor	Perceived kansei qualities	High
Emotion	Perceived kansei qualities	High
Style	Product attributes	High
Action enabled	Interaction attributes	Middle
Interface characteristic	Interaction attributes	Middle
Sector/objet	Product attributes	Middle
Product characteristic	Product attributes	Middle
Physical context	Context attributes	Middle
Culture (demographics)	User's personal characteristics	Low
Gesture	Interaction attributes	Low
Feedback	Interaction attributes	Low
Visual attribute	Product attributes	Low
Auditory attribute	Product attributes	Low

The assessment of the representation showed that the function of the reader only had a minor influence on its understanding of the kansei representations. In also showed that the understanding (relative to the intention) was high (especially for the rich layout). This led me to deduce that kansei representations not only create a cross-functional communication related to UX but also permit a high reciprocal understanding of UX related directions. According to Graff et al. (2009), the presence of these two factors opens "functional walls" and increases "team effectiveness." It tends to show that, even though they do not improve people's competences nor improve the quality of the design process, kansei representations could be a breeding ground contributing to a better connection between design-driven and technology innovation seeds. One limit of this experiment is that it did not take into account the impact of the nationality of the board readers. This parameter was here fixed. Only European participants took part to the experiment.

The kansei representations creation process and evaluation presented in this experiment will contribute, together with EXP 3 and EXP 4 to discuss H2 (Early representations of the intended user experience of a future product can convey design information related to all the entities of an experience.). Indeed, EXP 2 exemplifies one methodology allowing the creation of early representation conveying design information related to all experience entities. This can be affirmed because the relative understanding between board creators and the board evaluators (design team members) was very low for measurement axes related to all experience entities (especially for multi sensory representation). Additionally EXP 2 also permits to discuss the influence on "correct" understand, appeal, and use of the layout (sensory/modality richness) of the representation.

4.4 EXP 3: KANSEI REPRESENTATION – INVOLVING PARTICIPATORY DESIGN SESSIONS

4.4.1 INTRODUCTION

The third experiment (EXP 3) is related to methodologies creating another type of rich kansei representations involving not only designers in their creation process (as seen in EXP 2) but also users (participatory design session). The context of this experiment is the definition of UX directions of the next generation of hybrid car (NGH) for European customers. The objective is to combine abstract and concrete design information in rich early phases representation.

This experiment has two iterations. The first one focuses on the visual medium to discuss kansei-related intentions and to represent design information. The second iteration takes four senses into consideration (multi-sensory medium) and discusses more categories of design information. For this iteration, a comparison will also be made between the contributions of European and Japanese users in participatory design sessions. This will allow me to see if UX directions can be directly transposed across markets.

4.4.2 FIRST ITERATION

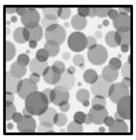
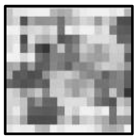
This first iteration uses the visual medium to investigate kansei-related intentions and to represent design information. For this purpose, a tool has been created: "kansei cards." It will be presented first. The protocol and the results of this first iteration will then be discussed in the following sub-sections.

4.4.2.1 KANSEI CARDS

The intention of this visual tool is to enable participants of (participatory) design session to identify and communicate their user experience-related expectations regarding a context (in our case NGH). In the state of the art it could be seen that pictures have the ability to convey a wide range of design information (section 0 [p. 73]). It was therefore decided to create different families of pictures. Each family should focus on particular categories of design information and the pictures from each family should cover the widest possible spectrum of variations within these categories.

In order to identify families of stimuli I based my pilot research on a French game called *portrait chinois* (literally "Chinese portrait"). In this game, participants have to describe themselves (or another person) working by analogy and picking the most fitting description from various "categories of things." They can for instance be colours, verbs, animals, cartoon heroes, cities… Typically participants then have to answer questions such as*: "If you were a [family name], what would it be?"* A short pilot survey including 15 participants was organized. The participant pool was very diverse and covered various nationalities and a wide age range. They were assigned to describe a current hybrid vehicle with items corresponding to ten different "categories of things." These categories correspond to possible "families" for the tool. The first learning point of the pilot survey is that it appears easy for participants to describe by analogy a rather concrete artefact (i.e. a current hybrid vehicle) with very diverse items. Qualitative observations also showed that the associations were made either because of similar sensory characteristics (e.g., shape, colour) or because of similar perceived kansei qualities (hedonic, semantic, emotions). The final learning point is that it was easier to understand and compare the association made with families of items commonly known across age groups and cultures (music instrument or animals vs. cities or cartoon heroes).

Table 4.10: Example of 11 families of kansei cards

Family topic	*Number of cards*	*Main category of design information*	*Example of pictures*
Simple shapes	59	- Semantic descriptor - Visual attribute (shape)	 
Patterns	95	- Semantic descriptor - Style - Visual attribute (shape)	 
Animals	47	- Value - Semantic descriptor - Emotion - Product characteristic - Gesture	 
Natural landscapes	30	- Value - Semantic descriptor - Emotion	 
Chairs	30	- Style - Semantic descriptor - Product characteristic	 
Sports	37	- Value - Semantic descriptor - Emotion - Interface characteristic - Temporal context	 
Flowers	31	- Semantic descriptor - Style - Visual attribute (shape and colour)	 
Arm gestures	29	- Semantic descriptor - Emotion - Interface characteristic - Gesture	 
Semantic keywords	16	- Semantic descriptor	Authentic 正真正銘、本物 Subtle さり気無い
Emotions	17	- Emotion	Amused 面白い Passionate 情熱的な
Instrumental values	18	- Values	Ambitious 野心的 Honest, Frank 正直、率直な

Fourteen families of *kansei cards* were then created: eleven families of pictures and three families of keywords. The families of pictures display simple shapes (59 samples), patterns (95 samples), landscapes (30 samples), products and ambiances (90 samples), chairs (30 samples), animals (47 samples), flowers (82 samples), music instruments (31 samples), localised gestures (35 samples), arm gestures (29 samples), and body gestures (28 samples). Each family of cards was created to focus on specific categories of design information (see examples in Table 1). For example, all the cards (except for those in the “flowers” family) were printed in black and white in order to remove the influence of colour. The three keyword-families correspond to semantic keywords (34 samples), emotions (33 samples), and instrumental values (18 samples). English and Japanese translations of each keyword were displayed together on the *kansei cards*. The dimensions of cards are 9x9cm for the pictures and 11x4cm for the keywords cards. Both sets of cards were made out of rigid cardboard.

4.4.2.2 PROTOCOL

The first iteration is divided into four main activities. Participants followed individually the step-by-step protocol detailed in Figure 4.15. Before going through the three activities, participants were greeted and introduced to the context and the overall content and purpose of the experiment.

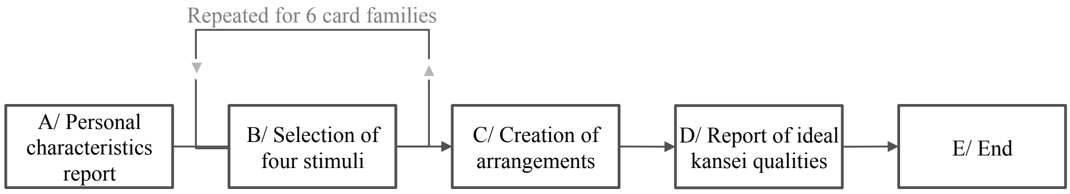


Figure 4.15: Protocol of EXP 3 – First iteration

A/ PERSONAL CHARACTERISTICS REPORT

When starting the experiment, the participants were asked to report information about their age, gender, and nationality.

B/ SELECTION OF FOUR STIMULI

The second section of the experiment involved five families of kansei cards: “animals,” “simple shapes,” “patterns,” “flowers,” and “products and ambiances.” Magnets were attached to the cards and they were organised by family on five whiteboards (see example in Picture 4.4).

Picture 4.4: Two families of kansei cards (“flowers” and “products and ambiances”) presented on whiteboards

The five families were selected because of their complementarity. Together they covered well the abstract design information related to the perceived kansei qualities, as well as those related to attributes of the product to be designed (e.g., emotion, semantic descriptor, as well as style) and concrete design information related to the product to be designed (e.g., shape, colour, harmonies, etc.). In order to even better cover concrete design information, colour samples (15x11cm) from the "Color-aid" colour model were additionally displayed on a table (314 samples).

At this stage, the participants were introduced to the different families of samples and asked to select four samples that they consider being the closest to their idea of NGH for each family. This selection was followed by a brief interview during which they explained their choices.

C/ CREATION OF ARRANGEMENTS

In the section C, participants were asked to investigate possible kansei-related directions for NGH. In order to do so, they were asked to create different representations by putting together samples they had previously selected. The directions created were composed of arrangements of three to six samples and always included one colour sample. Using that colour sample, the participants were then asked to create a colour harmony using additional samples from the colour model. An example of such an arrangement is represented in Picture 4.5.

Picture 4.5: Example of arrangement

Once the arrangements were created, a short interview was conducted with the participant. They were asked to comment on their compositions and the ideas they wanted to convey. To conclude this section of the experiment, the participants were asked to assess all their arrangements on 5-point semantic differential scales. A selection of six semantic keywords was used (e.g., *dynamic*, *premium*, *leading-edge*, etc.). The anchors were labelled "not at all" and "extremely," whereas the central point was labelled "moderately."

D/ REPORT OF IDEAL KANSEI QUALITIES

In the last section of the protocol, the participant had to decide the kansei qualities he/she would like his/her ideal NGH to convey. The keyword-based families of kansei cards "emotions" and "semantic keywords" had therefore to be positioned accordingly in areas labelled "not at all," "moderately," and "extremely."

4.4.2.3 ANALYSIS AND RESULTS

DEMOGRAPHIC INFORMATION

For confidentiality reasons the experiment took place in TME R&D centre and involved only TME employees. 33 participants took part. They took about an hour to complete the above-mentioned protocol. The participants were selected because they were driving hybrid cars. They were also considering them as an option for their future car purchases. This is why they can be considered as potential future users. Moreover, as having already experienced the technology, they had a more in-depth view about the experiences such cars could provide in the future. The gender and age distributions are represented in Figure 4.16. Regarding nationality, the participant pool covered nine different European nationalities. Belgium (where the experiment took place) was by far the most represented country (11 participants).

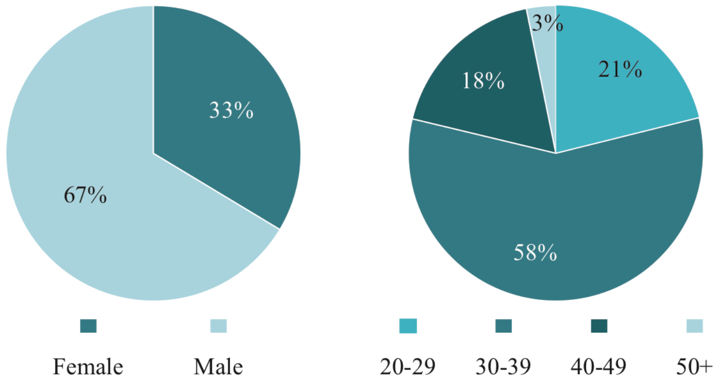


Figure 4.16: Gender and age distribution of the participants

KANSEI MAPPING PER FAMILY OF CARDS

For each participant, the selected of kansei cards and related comments were reported into a digital database. For the sake of comparison, the comments were coded manually into "comment categories" corresponding to the kansei qualities (e.g., *elegant*, *minimalistic*, *freedom*, *technology*, *joy*) associated by the participants to the different cards they selected. As mentioned above the coding was done manually, it required analysing multiple times the participants' comments. The result was a structured database in which all the kansei cards used were quantitatively put into relation with kansei qualities (0: not at all related, 1: moderately related, 2: extremely related). As a side result, the kansei qualities that were most often referred to could also be identified.

The structured database detailed above was then used as input for performing principal component analyses (PCA) on families of kansei cards. PCA is a mathematical procedure that uses orthogonal transformation to convert a set of observations of possibly correlated variables into a set of linearly uncorrelated variables called principal components. Using the first two principal components (that account for the highest possible variability in the data) as references permits to display on a 2-axes graph all the variables and one can observe the main correlations occurring between them.

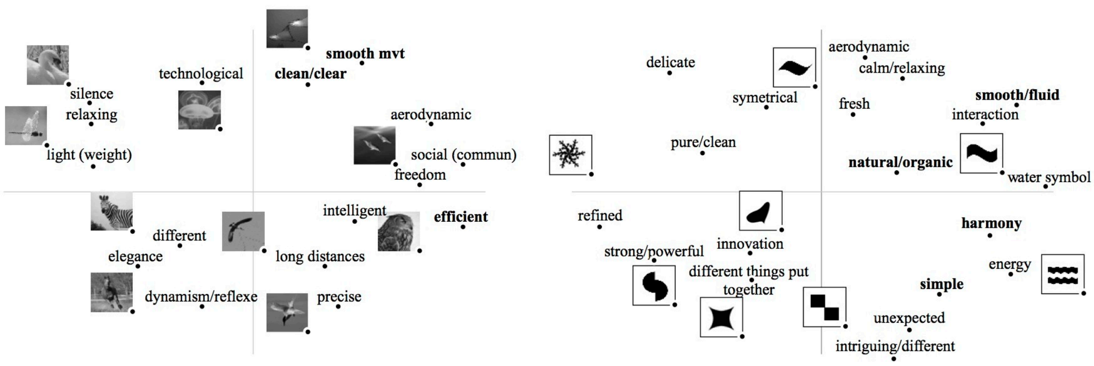


Figure 4.17: Kansei mappings related to "animals" and "simple shapes" families

In the context of this experiment, PCA (Pearson) permitted the creation of statistically robust kansei mappings (depending of the variability in the data represented by the principal components) related to each family of kansei cards. The ones related to the “animals” and “simple shapes” families are represented in Figure 4.17. They represent respectively 67% (animals) and 59% (simple shapes) of the variability in the related data. The PCA method is here conducted with ordinary data with three categories (i.e. 0, 1, and 2). It was indeed not possible to collect continuous data. The type of data used affects negatively the representativity of the output graph. Nevertheless the percentage of variability represented by each graph is high enough and allows me to interpret the graphs.

Several kansei-related directions combining keywords and images can clearly be identified on both graphs (areas on each mapping). The kansei qualities which participants referred to the most are represented in bold.

KANSEI MAPPING OF ARRANGEMENTS

The 33 participants created a total of 89 arrangements. Using the arrangements created and described as input, another database was constructed. For each arrangement, the selected kansei cards were first reported. Only the cards selected at least 3 times were taken into account. Ordinal values (0: *no* or 1: *yes*) were used to describe the relationship between arrangement and kansei cards. “Comment categories” regarding the arrangements were manually coded in a similar way than described previously. As result they were describing the arrangement with an ordinal value of between 0 and 2 (*not at all* to *extremely*). The rating of the arrangements relative to the six semantic keywords was also integrated to the database. These variables were interesting because they had the particularity of being common to every arrangement (5-point SD scale rating).

A hierarchical cluster analysis (HCA) of the different measurement axis available (kansei cards, comment categories, semantic keywords assessed) was performed according to the arrangements made by the participants. The dissimilarity was measured with Euclidian distance and the agglomeration method used was *Ward’s method* because it is the one creating the most homogeneous clusters. The truncation was done manually. Different numbers of classes were tested in order to identify the maximum number for which all the clusters were still composed of at least 10% of the measurement axis. This enabled an identification of the seven main clusters of arrangements.

A PCA (Pearson) was also performed in order to represent on a two-axis graph the different arrangement together with the cards and keywords representing the measurement axis. The PCA method was conducted with ordinary data as it was not possible to collect continuous data. The type of data used affects negatively the variability in the data captured by the principal components. Nevertheless the percentage of variability represented was high enough and allows me to interpret the results. Because of the PCA, each of the 89 arrangements could be related to one of the clusters on the PCA mapping (depending of their position relative to the area covered by each cluster). This interpretation will later only be used to put into relation the colours and the clusters.

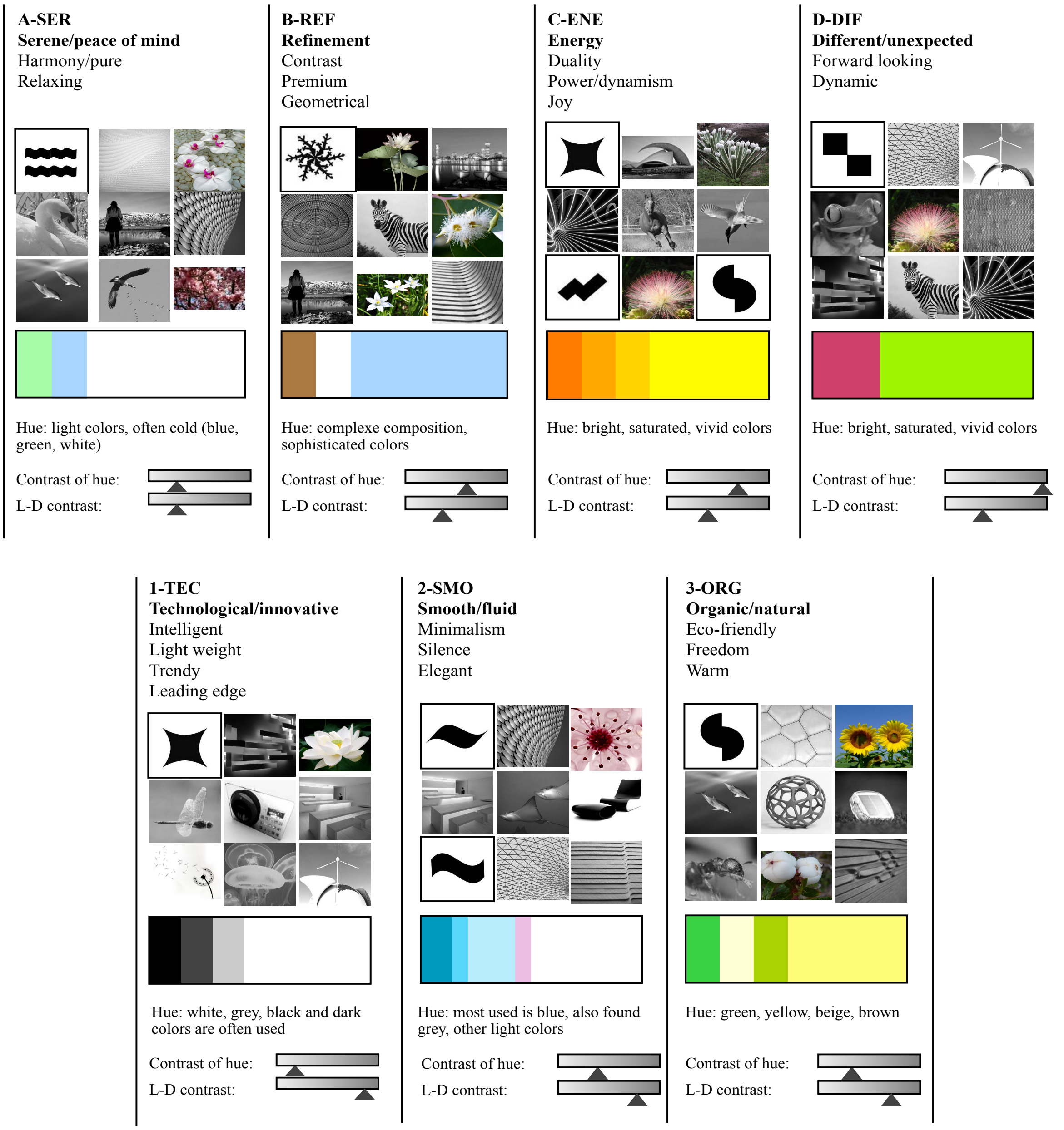


Figure 4.18: Seven visual kansei directions for NGH

Figure 4.18 details the seven clusters. In addition to the expressed and rated kansei qualities (top), the kansei cards that appeared the most in each cluster are also shown (middle). For each cluster, the most selected kansei quality is represented in bold. It will be used as title for the following sections. A specific activity was also conducted regarding colours and colour contrasts. Parts of the results are displayed at the bottom of each cluster. Each cluster also contains an example of colour harmony, description of the typical hue and of the typical intensity of contrast of hue and light-dark contrast (as described by Itten [1967]). This activity combined statistical analysis (colour and type of contrast related to each cluster) as well as interpretation of the arrangements made (description of the hue and contrast using pictures of the 89 arrangements).

A macro-analysis of the clusters permitted me to organise them into two categories: the concrete-oriented and abstract-oriented categories. The first one is composed of clusters conveying design information that is clearly related to the physical world (can have a visual interpretation). The “technological/innovative” (1-TEC), “smooth/fluid” (2-SMO) and “organic/natural” (3-ORG) clusters belong to this category. The latter one is composed of clusters conveying design information that cannot be related to a clear direction of concrete design information. It is therefore more relevant to focus only on the abstract design information they convey (i.e. kansei qualities). The “serene/peace of mind” (A-SER), “refinement” (B-REF), “energy” (C-ENE), and “different/unexpected” (D-DIF) clusters belong to this second category.

ABSTRACT DESIGN INFORMATION

The section of the experiment regarding ideal kansei qualities of NGH permitted the identification of overall trends. Regarding emotions the most associated keywords were *peaceful*, *confident*, *serene*, *inspired*, *at ease*, *relaxed*, *calm,* and *enthusiastic*. On the contrary the least associated ones were *astonished*, *amused*, *animated,* and *wondered*. Regarding semantic keywords the most associated ones were: *harmonious*, *clean*, *natural*, *finesse*, *elegant*, *intelligent*, *simple,* and *intriguing* and the least associated ones were *traditional*, *cute*, *aggressive,* and *sturdy*. Looking back at the previous section, it can be noticed that each cluster identified can be particularly related to some of the keywords.

4.4.2.4 CONCLUSION

This first iteration of EXP 3 can be seen as a Kansei Design methodology combining abductive (creation and selection of kansei cards) and scientific reasoning (data analysis). It also involved potential users in participatory design sessions.

It resulted in seven kansei directions (Figure 4.18) and overall associated kansei qualities. The design information related to this type of kansei representation (i.e. the kansei directions) is represented in Table 4.11.

Table 4.11: Design information conveyed by the kansei representations from EXP3, iteration 1

Design information	*Related UX entity*	*Level of abstraction*
Semantic descriptor	Perceived kansei qualities	High
Emotion	Perceived kansei qualities	High
Style	Product attributes	High
Sector/objet	Product attributes	Middle
Physical context	Context attributes	Middle
Culture (demographics)	User’s personal characteristics	Low
Visual attribute	Product attributes	Low

This table relates to the hypothesis H2: “early representations of the intended user experience of a future product can convey design information related to all the entities of an experience.” The protocol used for this iteration only involved kansei cards related to product attributes. The brief (NGH interior: context) and the participant (European nationality: culture) contributed to embed other types of design information in the representations. Interaction attributes are nevertheless not covered by the kansei representations issued. This part of EXP 3 therefore nuances H2 and shows an example of kansei representation not entirely covering all the UX entities (i.e. no personal values, no interaction attributes). Nevertheless, with the use of additional families of kansei cards, it appears that the same methodology could tackle interaction attributes and abstract personal characteristics such as user values. This could be investigated in further researches.

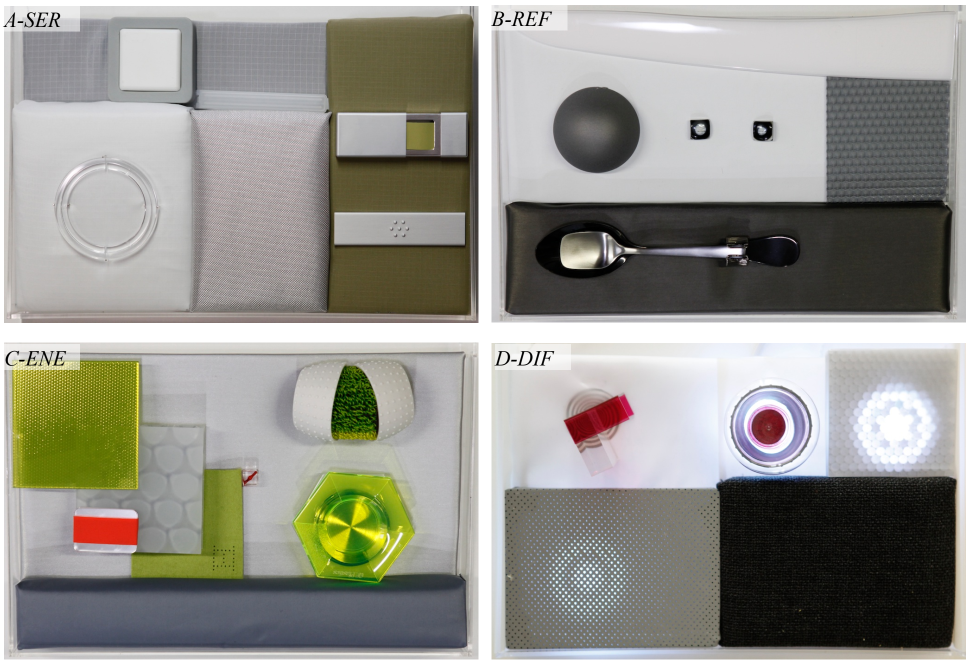
4.4.3 Second iteration

The second iteration takes four senses (sight, touch, smell and hearing) and again involves users and stimuli created by designers. The intention for this second iteration is to discuss in greater detail the abstract and concrete design information related to the product and interaction to be designed. The context is still NGH. This iteration also compares inputs from European and Japanese participants.

4.4.3.1 Mood-boxes

Based on the seven kansei directions (divided into two categories) identified during the first iteration, new representations were created as a starting point for this iteration.

In order to explore in greater depth the space identified by the seven kansei directions, it has been decided to combine each "concrete-oriented" direction with each "abstract-oriented" direction. As a result, 12 briefs composed of kansei quality keywords, kansei cards, and colour-related information were created. Each of them conveyed specific design information. In order to facilitate their designation, "concrete-oriented" directions will from now on be called "families" and "abstract-oriented" directions will be called "nuances." The 12 briefs were used as an input for the creation of kansei-oriented multi-sensory representations named the "Mood-boxes." Designers from TME-KD (used to focus on kansei aspects) managed the creation process.



Picture 4.6: The four "technological/innovative" Mood-boxes

The Mood-boxes created are transparent boxes (37x26x6cm), open on the top and displaying a composition of inspirational elements such as fabrics or products as well as metallic and paint samples. This way, they convey design information through vision and touch sensory channels. For the creation of the Mood-boxes, material was gathered from an internal material library, as well as from several visits in shops in Brussels and Paris (furniture, fashion, fabric, art and design).

This type of representation permitted me to convey a very specific atmosphere (combining concrete and abstract design information) in a small tangible space. A simplified version of Mood-boxes was already used once within TME-KD in order to communicate intentions related to colour and trim (focus on concrete design information). This attempt is the first to use the concept of Mood-box in the field of design research.

Picture 4.6 represents the four nuances of "technological/innovative" Mood-boxes. The top row corresponds to the "serene/peace of mind" and "refinement" nuances (from left to right) and the bottom row to the "energy" and "different/unexpected" nuances (from left to right).

4.4.3.2 PROTOCOL

The participants followed one by one the protocol described in Figure 4.19. It allowed them to create multi-sensory representations related to their image of NGH, to describe each of them in terms of perceived kansei qualities, to compare their different creations, and finally to identify interaction-related design information fitting their overall image of NGH.

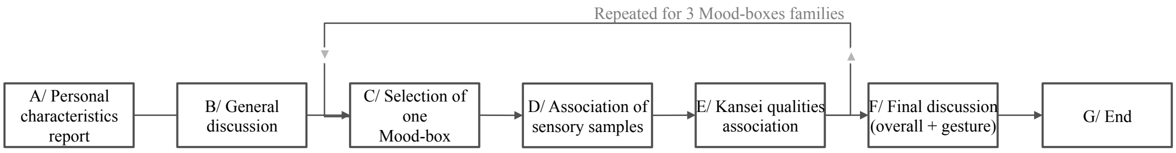


Figure 4.19: Protocol of EXP 3 – second iteration

A/ PERSONAL CHARACTERISTICS REPORT

The initial section of the protocol is meant to gather demographic information. The participant was asked to report his/her age, gender, nationality, function, and current car. He/she was then introduced to the topic of the experiment (i.e. NGH) and the 12 Mood-boxes were presented to him/her.

B/ GENERAL DISCUSSION

The four nuances of each Mood-box family were organised in groups (Picture 4.7). In this section the participant took the necessary time to explore the Mood-boxes. He/she looked at them and touched them. The moderator then discussed with him/her the three families. At the end of the discussion the participant had to emit an overall judgement about the families (e.g., say if one fitted particularly well with their image of NGH or if one was more distant from it).

Picture 4.7: Main layout of EXP 3, second iteration

C/ SELECTION OF ONE MOOD-BOX PER FAMILY

In this section of the protocol, the participant was asked to select for each Mood-box family the nuance that he/she preferred (three Mood-boxes). Each selected direction was the starting point of a generation activity for which he/she had to go through section D and E in order to create a multi-sensory kansei representation of his/her image of NGH. This iterative process is presented in Figure 4.19.

D/ ASSOCIATION OF SENSORY SAMPLES

The section corresponding to the association of sensory samples is divided into three stations: the touch, sound, and smell stations (Picture 4.8).

Picture 4.8: The three types of sensory samples

The touch station has been created using the "Sensotact" tool. It is a haptic tool developed by the FEMTO-ST institute (University of Franche-Comté, France) in order to standardise and rationalise the description of touch in the same way colour-matching systems such as "Pantone" do for colours. The tool describes nine touch attributes with scales (from 0 to 100). These scales are exemplified with five to ten touch samples per attribute. Four of the nine touch attributes were selected: thermal touch (3 samples: warm, lukewarm and cold), orthogonal hardness touch (4 samples from very soft to hard), tangential relief touch (4 samples: scattered grain, low, medium and high grain density) and tangential fibrous touch (4 samples: slick, rough, soft, and very soft fibres). The 15 corresponding samples were organised in a booth that allowed participants to touch them without seeing them (Picture 4.8). After blind-touching the 15 samples, the participant had to associate each of them to the selected Mood-box according to a 3-point scale (*not at all*, *moderately*, or *extremely*).

The sound station is composed of 14 different samples selected from a library of inspirational sounds created by a sound designer (Clos, 2009). Two sounds were selected for each kansei direction identified during the first iteration (represented in Figure 4.18). The association process was the same as for the touch station: after listening to all the samples, the participant had to associate each of them (*not at all*, *moderately* or *extremely*) with the three Mood-boxes.

Finally, the smell station was composed of seven different samples. They were created with the support of "Cinquième sens," a Parisian scent design agency. The seven kansei directions identified in the first iteration were used as briefs for the creation of the scents. The association process was similar to the two other stations.

E/ Kansei qualities association

In the section E, the participant was asked to express the kansei qualities he/she associated with the multi-sensory atmosphere that had just been created (Mood-box + sensory samples). For that purpose, he/she was asked to associate it with a selection of semantic keywords and emotions using a 3-point SD scale labelled *not at all*, *moderately* and *extremely*. The keyword selection was extracted from the corresponding kansei card families. The section D of the first iteration's protocol permitted the refinement of the lists originally used for the first iteration. 23 semantic keywords and 18 emotions were finally retained.

F/ Final discussion – Overall discussion of the three representations and NGH related gestures

After going through the sections C, D, and E three times, the participant moved to section F. At this stage he/she was asked to discuss the three representations of NGH he/she had just created. The moderator discussed with him/her the three representations in a semi-directed interview. At the end of the discussion the participants had to rate their creations using a 5-point scale.

An activity involving kansei cards was finally conducted regarding interaction. This activity did not refer to any particular kansei representation but to the participant's overall image of inspirational gestures related to NGH. For that purpose three families of kansei cards were presented to the participant: *localised gestures*, *arm gestures* and *body gestures* (Picture 4.9). For each family of kansei cards, the participant was asked to select the three samples which best fit his/her image of NGH and discuss his/her choices.

Picture 4.9: Gesture oriented kansei cards

4.4.3.3 ANALYSIS FOR EUROPEAN PARTICIPANTS

4.4.3.3.1 INTRODUCTION

The analysis of the results of this experiment is divided into two sub-sections. The first one (section 4.4.3.3) details the construction of kansei representations of NGH for European users. The second one (section 4.4.3.4) compares selection and association activities of European and Japanese users.

4.4.3.3.2 DEMOGRAPHIC INFORMATION

For the first part of the analysis the participants considered were logically all European. Similarly to the first iteration, they all were TME employees and can be considered as potential users because they were driving hybrid cars. The participant pool was composed of 41 participants from 18 European nationalities. One third of them were women.

4.4.3.3.3 ANALYSIS OF THE DISCUSSION AND SELECTION ACTIVITIES

Along the protocol of the second iteration, participants had multiple opportunities to express their preferences regarding the Mood-boxes, the concrete-oriented directions (their families), and the abstract-oriented directions (their nuances). This was done through the rating and selection activities. In this respect, four interesting measurements could be identified. They will be presented here.

The first one appeared in section C of the protocol: the participants were asked to emit an overall judgement about the families. By looking at the resulting data, the “smooth/fluid” family was on average preferred to the other ones. Differences can be observed between male and female participants for the two other families: while males tend to reject the “organic/natural” family and appreciate “technological/innovative,” the opposite can be observed for females.

The second input identified corresponds to the nuances of Mood-boxes that participants selected. It fact, when selecting 3 Mood-boxes they expressed their opinions about the different nuances. An analysis of the results of this input shows a clear preference for the “refinement” nuance. For the other nuances, differences can be observed between groups of participants such as for instance between male and female (female participants preferred “energy” and “different/unexpected” to “serene/peace of mind,” whereas the contrary was observed for males).

The third measurement corresponds to the selection ratio associated to each of the 12 Mood-boxes. For this parameter, the analysis of the results showed that the most selected Mood-box is the one corresponding to “organic/natural” & “refinement” (3B, 51%), the second one is the “technological/innovative” & “refinement” (1B, 41%) and the third is a tie between the “technological/ innovative” & “serene” and “smooth/fluid” & “energy” ones (1A and 2C, both 29%). Notably, all the Mood-boxes were selected at least 4 times (10%).

After having created the three representations, the participants had to discuss and rate them (section F). This permitted participants to summarise all positive and negative feedback related to the Mood-boxes and to the sensory samples associated to them. The fourth measurement point comes from the rating associated to each Mood-box. On average the highest-rated ones were the “technological/innovative” and “different/unexpected” (1D, 1st) as well as the nuances “energy” (2C, 2nd ex-aequo), “different/unexpected” (2D, 2nd ex-aequo), and “serene/peace of mind” (2A, 4th) of the “smooth/fluid” family.

4.4.3.3.4 ANALYSIS OF THE ASSOCIATION ACTIVITIES

The association activities (association of sensory samples, association of kansei qualities) allowed the creation of a structured database linking up for each participant the selected Mood-boxes with sensory and keyword-based samples. These associations were materialised with ordinal values: 0 for *not at all*, 1 for *moderately*, and 2 for *extremely*. In total 123 MB were described that way (41 participants * 3 MBs)

ANOVA (analysis of variance) highlighted significant differences regarding the way samples were associated to Mood-boxes in 52% of the cases (for 40 of the 77 samples). This ratio drops to an average of 14% between Mood-boxes with similar families or nuances (see Table 4.12). This expected difference shows that Mood-boxes created with similar intentions are understood in similar ways. This tends to confirm that they are effective ways to communicate concrete and abstract design information.

Table 4.12: Association significant differences (confidence interval: 95%)

	Concrete-oriented directions			*Abstract-oriented directions*				***All***
Direction	*1-TEC*	*2-SMO*	*3-ORG*	*A-SER*	*B-REF*	*C-ENE*	*D-DIF*	
Sign diff (%)	15%	14%	5%	9%	23%	18%	13%	**52%**

In the same way that it was done for the first iteration, PCA and HCA were performed to analyse the database obtained from the experiment.

A Hierarchical Cluster Analysis (HCA) of the sensory and keyword samples was made according to the 123 MB descriptions made by the participants. The dissimilarity was measured with Euclidian distance and the agglomeration method used was *Ward’s method* because it is the one creating the most homogeneous clusters. The truncation was done manually. Different numbers of classes were tested in order to identify the maximum number for which all the clusters were still composed of at least 10% of all the samples. The number of classes finally retained is 6.

The PCA method (Pearson) is here conducted with ordinary data with three categories (i.e. 0, 1, and 2). It was indeed not possible to collect continuous data. The type of data used affects negatively the variability in the data captured by the principal components. Nevertheless the percentage of variability represented by the first two principal components (i.e. used for the output graph) represented 57% of the variability in the data. This percentage was considered high enough to proceed to interpretations using it. The resulting graph discussed here is presented in Figure 4.20.

The six clusters resulting from the HCA were then represented on the PCA-graph. The directions corresponding to the Mood-boxes codes can be found on page 119. The name of the six clusters as well as the ones of the axes' anchors was interpreted from the design information conveyed by the samples and Mood-boxes located nearby on the graph (e.g., *Zen*, *Innovative and high-tech*, or *relaxation* vs. *active*).

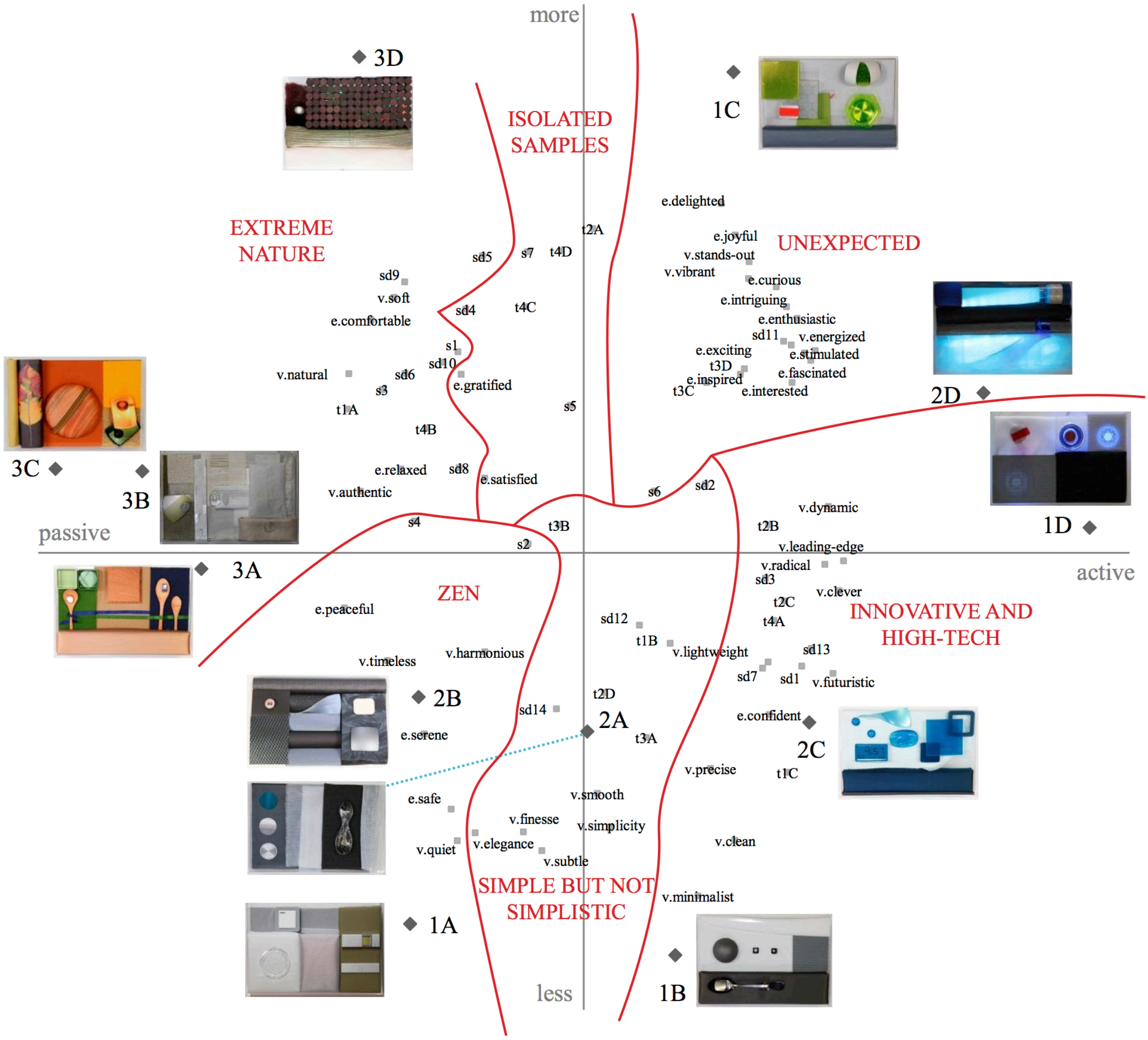


Figure 4.20: Kansei mapping representing 57% of the variability in the data (PCA) and clusters (HCA)

The other association activity involved gesture-related kansei cards (section F of the protocol). It highlighted the most relevant influential gestures of the three families (*localised gestures*, *arm gestures,* and *body gestures*). For some of them, important differences could be noticed between male and female users. This activity permitted the collection of insights related to concrete design information referring to interaction. This is particularly interesting because this category of design information had not been tackled previously in EXP 3.

4.4.3.3.5 INTERPRETATION OF THREE KANSEI DIRECTIONS

In this section, the results obtained from selection and association activities will be combined in a single output. The aim is to better define the interrelations between the different clusters obtained with the hierarchical cluster analysis, and thereby identify fewer and stronger kansei-related European directions for NGH.

The association rates of the samples (sensory and keyword) showed that the *isolated* samples cluster was less relevant than the other ones. Figure 4.20 shows also that only the Mood-box 3D (i.e. “organic/natural” and “different/unexpected”) is partially related to it. The five other clusters will now be organised according to the results of the selection activities.

It was shown previously that the most appreciated abstract-oriented direction (i.e. nuance) was the “refinement” one. The related Mood-boxes are covered by three clusters of sensory samples and kansei qualities located in the left-hand side and at the bottom of the kansei mapping (i.e. *Extreme nature*, *Zen*, and *Simple but not simplistic*). The first final kansei direction was created based on these clusters as well as on the influential Mood-boxes they contained: 3B, 1B, and 2A (top ranked in terms of rating and selection ratio). It was named “Light and organic refinement” (Figure 4.21).

The aforementioned results also showed that the preferred concrete-oriented direction (i.e. family) was the “smooth/fluid” one. It was also the only one finding a consensus between male and female participants. The corresponding Mood-boxes are mainly present in the bottom part of the mapping (towards the *subtle & minimalist* direction), covering the *Zen*, *Simple but not simplistic*, and *Innovative and high-tech* clusters. On this basis, the second final kansei direction was created. It was named “Minimal and smooth aquatic life” (Figure 4.21).

The Mood-boxes arousing the most active emotions (i.e. 1C, 1D, 2C, and 2D in the top right hand corner of Figure 4.20) are also among the ones with the highest score (all in the top 5, see also section 4.4.3.3.3). Therefore, the third final kansei direction - “Intelligent and surprising high-technology” - was created based on the clusters *Unexpected* and *Innovative and high-tech* (Figure 4.21).

Figure 4.21: Area covered by the final kansei directions

The final kansei directions merge the different results identified previously. The process followed for their identification was integrative and combined intuitive and analytical thinking. The three directions identified were then translated into different types of kansei representations such as mood-boards, Mood-boxes or inspirational sample compositions in order to communicate them to decision makers as well as to internal or external design teams (e.g., engineering development, material suppliers). Picture 4.10 shows an example of kansei representation created from one of the kansei direction identified. The type of representation influences the level of abstraction of the design information conveyed. This way, the communication of kansei directions related to next generation of hybrid cars (NGH) can be adjusted depending on the audience.

Picture 4.10: Mood-box and sensory samples composition for the "light and organic refinement" direction

4.4.3.4 Comparison between Japanese and European participants

The first part of the analysis of the second iteration of EXP 3 helped identify a European kansei image of the next generation of hybrid cars. In this section the influence of the personal characteristics of the participants will be examined. It will for instance be investigated if Japanese participants would identify similar directions. In order to do this, the selection and association done by sub-groups based on nationality (Japanese [JP]) vs. European [EU]) and gender (Female [F] vs. Male [M]) will be compared.

4.4.3.4.1 Demographic information

For this part of the analysis, the participant pool was composed of 66 persons (instead of 41 previously). 25 Japanese participants were added the experiment pool (originally focused on Europe). For both nationality groups, one third of the participants (respectively 13 and 8) were women.

4.4.3.4.2 Differences in the selection activities

From the four types of selection activities identified in section 4.4.3.3.3, two were selected for this comparison analysis: *Mood-box selection* and *abstract-oriented directions selection* (i.e. MB nuance selection).

Table 4.13 shows both types of results for the Japanese and European sub-groups. In case of important (>12%) distance (Δ) in terms of selection ratio the related cell is highlighted in grey. Regarding *Mood-box selection*, 9 important differences can be observed. The most selected Mood-boxes are also very different. Whereas the most selected Mood-boxes for Europeans are 3B (51%), 1B (41%), 1A, and 2C (29%), the ones for the Japanese are 2C (44%), 1D (44%), 3A and 2A (32%). Except for 2A, important differences in selection ratio can be observed for all for them (Table 4.13).

Regarding *abstract-oriented directions,* important differences can also be observed (Table 4.13). The relative importance of the *abstract-oriented directions* as well as their individual selection ratio are very different for the two nationality sub-groups.

Table 4.13: Selection ratios of the different MB and important differences (JP/EU comparison)

		Abstract-oriented directions			
		A-SER	*B-REF*	*C-ENE*	*D-DIF*
Concrete-oriented directions	*1-TEC*	JP: 4% **EU: 29%**	JP: 24% **EU: 41%**	**JP: 24%** EU: 12%	**JP: 44%** EU: 17%
	2-SMO	JP: 32% EU: 27%	JP: 16% EU: 20%	**JP: 44%** EU: 29%	JP: 8% **EU: 24%**
	3-ORG	**JP: 32%** EU: 17%	JP: 12% **EU: 51%**	**JP: 24%** EU: 12%	JP: 16% EU: 17%
Abstract-oriented directions (average)		JP: 23% EU: 24%	JP: 17% **EU: 37%**	**JP: 31%** EU: 18%	JP: 23% EU: 20%

The influence of participants' nationality on the selection activities (discussed previously) will now be compared to the influence of another personal characteristic sub-group: gender.

Table 4.14 shows the selection ratios for the female and male sub-groups and highlights the MB for which important distances (Δ) between these two ratios can be observed (grey cells).

Table 4.14: Selection ratios of the different MB and important differences (F/M comparison)

		Abstract-oriented directions			
		A-SER	*B-REF*	*C-ENE*	*D-DIF*
Concrete-oriented directions	*1-TEC*	F: 19% M: 20%	F: 38% M: 33%	F: 14% M: 18%	F: 29% M: 27%
	2-SMO	F: 19% **M: 33%**	F: 19% M: 18%	**F: 52%** M: 27%	F: 5% **M: 24%**
	3-ORG	F: 10% **M: 29%**	F: 43% M: 33%	F: 19% M: 16%	F: 24% M: 13%
Abstract-oriented directions (average)		F: 16% M: 27%	F: 33% M: 28%	F: 29% M: 20%	F: 19% M: 21%

When comparing Table 4.13 and Table 4.14 it is striking that far less important differences are observed between gender sub-groups than between nationality sub-groups: 4 instead of 9 for *Mood-box selection,* and 0 instead of 2 for *abstract-oriented directions selection*.

We will now look more into details at the differences in terms of distances observed between the nationality sub-groups and the gender sub-groups. The mean of the distances (Δ) between European and Japanese as well as between female and male MB selection ratio were calculated. The distance corresponds to the absolute value of the difference between the sub-groups selection ratios. The standard deviation was also calculated (Table 4.15).

Table 4.15: Comparison of selection ratio distances

	Mean (%)	*Standard deviation (%)*	*Effect size (Cohen's d)*
$MB\Delta_{JP/EU}$	15.7	10.2	0.61
$MB\Delta_{F/M}$	9.5	7.8	

Cohen's d was then used to measure effect sizes. It is here used in order to be able to judge the strength of the distance between the means related to nationality and gender differences (i.e. the strength of the effect). It is commonly accepted that d=0.2 implies that the effect is weak, d=0.5 implies that it is mild, and d=0.8 implies that is it strong. In our case the strength on the effect is between mild and strong. This confirms that the distance in terms of selection ratio tends to be more important between participants having different nationality than between participants having a different gender.

In the next paragraph the influence of the participants' personal characteristics on the sensory samples and kansei keywords associations will be discussed.

4.4.3.4.3 DIFFERENCES IN THE ASSOCIATION ACTIVITIES

For each direction (abstract and concrete), an analysis of variance (ANOVA) was conducted in order to discuss differences in the way sensory samples and kansei keywords were associated with them. Again, nationality and gender sub-groups were compared. Table 4.16 shows the percentage of samples (sensory or kansei keywords) for which significant differences could be observed (confidence interval: 95%). "18%" in the top left-hand corner of the table for instance indicates that significant differences could be observed for 14 samples out of the 77 (18%) between Japanese and European participants for Mood-boxes representing the "1-TEC" direction. An overall comparison also shows that differences of nationality are more likely to provoke differences of sensory samples and kansei keyword associations than differences of gender. Indeed, except for the direction "C-ENE," more significant differences are observed between nationality sub-groups than between gender sub-groups.

Table 4.16: Significant differences ratios in terms of sample associations

	Concrete-oriented directions				*Abstract-oriented directions*					*All*
	1-TEC	*2-SMO*	*3-ORG*	***All***	*A-SER*	*B-REF*	*C-ENE*	*D-DIF*	***All***	
JP/EU	18%	16%	17%	**17%**	12%	12%	4%	30%	**14%**	**16%**
F/M	8%	3%	9%	**6%**	4%	5%	5%	8%	**6%**	**6%**

Table 4.17 exemplifies these significant differences between Japanese and European participants for the "1-TEC," "2-SMO" and "3-ORG" directions (concrete-oriented directions).

Table 4.17: Significant differences for the concrete oriented directions

		1-TEC	*2-SMO*	*3-ORG*
Touch	*JP*	very soft, low grain density		very soft, soft, scattered grain
	EU	cold, hard	mildly hard, hard	hard
Sound	*JP*			
	EU			nature rhythm
Smell	*JP*	woody powdery scent	woody powdery scent	
	EU			
Semantic	*JP*			minimalist, subtle
	EU	clean, elegance, harmonious, minimalist, precise, subtle	dynamic, energised, lightweight, radical, soft, subtle	finesse, natural
Emotion	*JP*			gratified, serene
	EU	confident, enthusiastic, safe	enthusiastic, joyful, stimulated	confident, enthusiastic

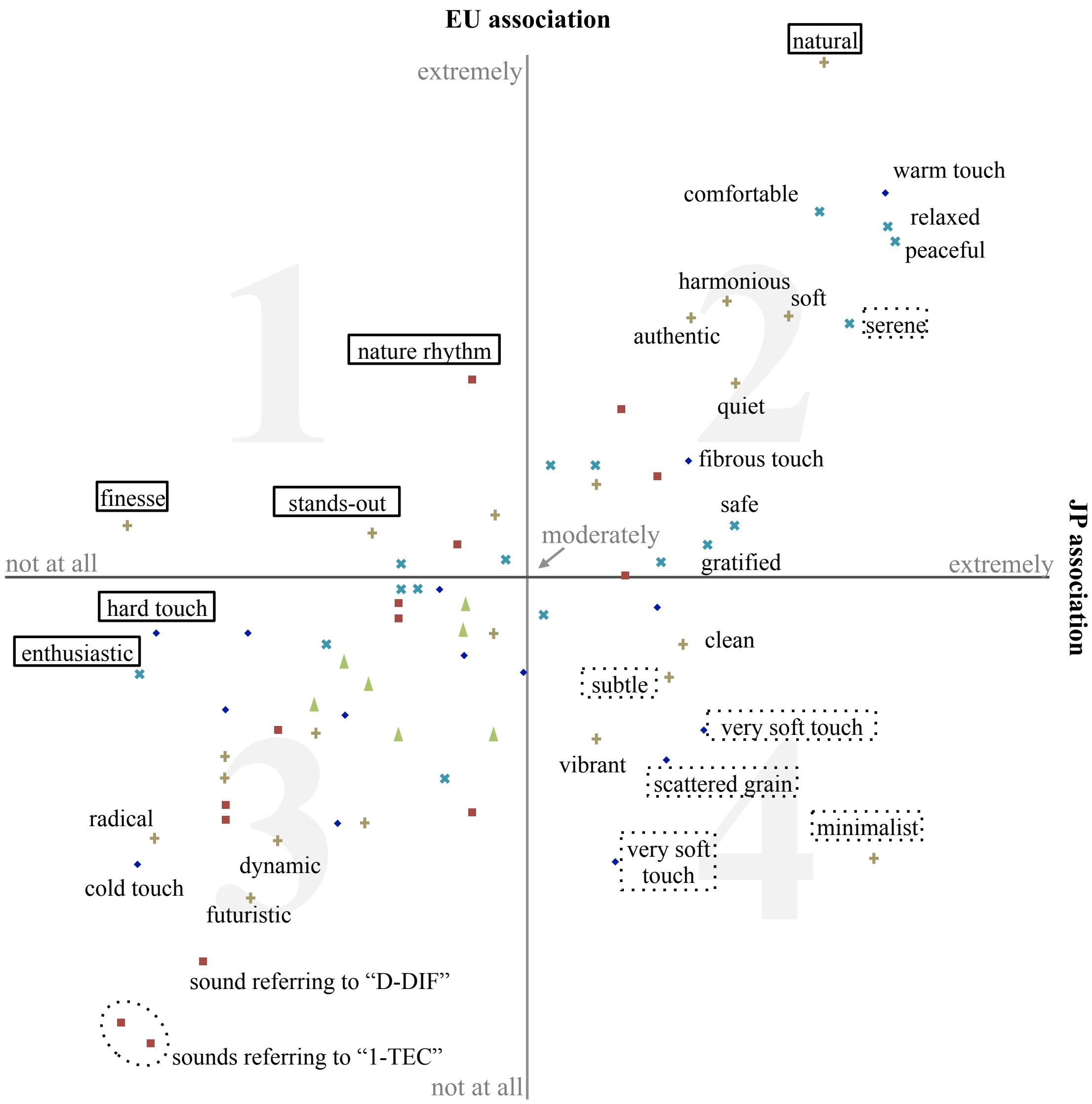
The respective 15, 12 and 13 significant differences are reported. The line in which the sample descriptions are positioned indicates their type (touch, sound, smell, semantic or emotion) and the sub-group that associated the most with the corresponding sample. Some samples tend to be generally more associated by a sub-group (e.g., hard touch, enthusiastic emotion for European, and very soft, woody powdery scent for Japanese). This shows that in some cases, preferences for some kansei means (sensory stimulation) and results (perceived kansei qualities) might be more influenced by the participants' nationality than by the direction the participant explored.

Finally, graphic representations of the association made by Japanese (JP) and European (EU) participants were also created. Figure 4.22 is shown as an example and refers to the direction "3-ORG."

Both axes are scaled to represent the average level of association of the samples (*not at all, moderately, extremely*) to the "3-ORG" Mood-boxes for the JP (X-axis) and for EU (Y-axis). By making the axes cross at *moderately* the figure is divided into 4 quadrants corresponding to samples globally associated both by JP and EU participants (area 2), samples associated by EU and not by JP participants (area 1), samples associate by JP and not by EU participants (area 4), and the ones that are on average associated by neither EU nor by JP participants (area 3). In order to improve the readability of the figure note that only key samples have been labelled.

The layout used based on four quadrants is particularly interesting because it allows the viewer to very quickly understand the position of the different samples relatively to the different areas details above and therefore the similarity and differences in terms of association. It also permits to visualise the position of the samples associated with significant differences.

The samples associated similarly are located on the y=x line. A look at Figure 4.22 shows that this description still corresponds to a large number of samples. The ones located in area 2 can be considered as samples understood by JP and EU participants as related to "3-ORG." They could therefore by used as a starting point for the creation of NGH concepts having similar perceived kansei qualities in both regions of the world.



Significant difference in terms of association:

sample EU>JP

sample JP>EU

Samples:

Touch

Sound

Smell

Semantic

Emotion

Figure 4.22: JP/EU sample associations to the "3-ORG" direction

4.4.3.5 DISCUSSIONS

In the second iteration of EXP 2, three kansei directions relevant for the next generation of hybrid vehicle in Europe were identified. For each of them, multi-sensory kansei representations could be created involving inputs from designers (creation of the Mood-boxes, of the samples) and from users (selection and association process). These representations are also composed of abstract and concrete design information.

The comparison with selections and associations done by Japanese participants showed the relevance of considering one's nationality as a major factor influencing his/her decisions during creation activities. It appeared that one's nationality influences his/her selection and association processes far more than one's gender.

These results show that, if the scope of the research would not have been NGH for Europe, the three kansei directions identified in the first part of the analysis would have been different (one kansei representation relevant for Europe is available as an example in Picture 4.10 [p. 130]). It also confirms that the final kansei directions contain design information related to the personal characteristics of the targeted users (i.e. gender, nationality). This piece of design information comes directly from the personal characteristics of the users involved in the kansei representation creation process.

To further elaborate on this, Figure 4.22 shows that common kansei associations between European and Japanese participants exist. If there was a need to harmonise the kansei qualities perceived by European and Japanese customers, this type of result could be used as a starting point for the creation process of such a vehicle.

4.4.4 CONCLUSION OF EXP 3

EXP 3 is composed of two iterations. Both of them investigated the use of participatory design sessions to create kansei representations able to communicate concrete and abstract design information related to an experience and to the future user's kansei process. Two new tools, helping the discussion of design information, have also been introduced in this experiment: "Kansei cards" and "Mood-boxes." For each iteration, the creation process involved inputs from designers (creation of the Kansei cards, Mood-boxes, of other samples) and participatory design sessions with users (selection and association process). Abductive and scientific reasoning were also both used. In that sense, the methodologies presented belong to the Kansei Design approach.

The first iteration focused on the visual medium to discuss kansei-related intentions and to represent design information. The abstract design information covered in this case was related to the intended product attributes and their perceived kansei qualities (e.g., emotion, semantic descriptor, style, sector/object), whereas the concrete design information was related to the product to be designed (e.g., shape, colour, harmonies…) and to the targeted user (culture) (summarised in Table 4.11 [p. 121]).

The second iteration took four senses into consideration (multi-sensory medium) and permitted the creation of kansei representations composed of abstract to concrete design information related to the three UX entities (Table 4.18). Some of it came from the brief (physical context) and from the people involved in the participatory design sessions (personal characteristics). This last notion was exemplified when comparing the differences of input provided by two populations (European and Japanese) during the participatory design sessions (section 4.4.3.4 [p. 130]).

Table 4.18: Design information conveyed by the kansei representations from EXP 3, iteration 2

Design information	*Related UX entity*	*Level of abstraction*
Semantic descriptor	Perceived kansei qualities	High
Emotion	Perceived kansei qualities	High
Style	Product attributes	High
Interface characteristic	Interaction attributes	Middle
Sector/objet	Product attributes	Middle
Product characteristic	Product attributes	Middle
Physical context	Context attributes	Middle
Culture (demographics)	User's personal characteristics	Low
Gesture	Interaction attributes	Low
Feedback	Interaction attributes	Low
Visual attribute	Product attributes	Low
Tactile attribute	Product attributes	Low
Auditory attribute	Product attributes	Low
Olfactory attribute	Product attributes	Low

Globally, EXP 3 contributed to exploring and discuss hypothesis H2 ("Early representations of the intended user experience of a future product can convey design information related to all the entities of an experience."). EXP 3 is complementary to EXP 2 because the methodology leading to the representations in fundamentally different (as well as the tools used). In this experiment users are treated as partners of the design team and a dialogue could be observed between them (in EXP 2 they were treated as subjects with the inputs from the UX harmonics and information related to the project's target user). In the conclusion of the first iteration (section 4.4.2.4 [p. 121]), we discussed that the kansei representations created there did not include important attributes from the environment (i.e. interaction attributes). This permitted the nuancing of H2. The second iteration expanded the amount of design information covered by the kansei representation. It also permitted to show the internal validity of H2 with another methodology: the presence of personal characteristics in the final representation has been validated (JP/EU comparison), whereas design information related to product, interaction, and context attributes is present by construction in the final representation.

4.5 EXP 4: KANSEI REPRESENTATION – CO-CREATION WITHIN A DESIGN TEAM

4.5.1 INTRODUCTION

Experiment 4 (EXP 4) has in common with EXP 2 and EXP 3 the fact that it focuses on the creation of early phase representations of UX-related intentions (i.e. kansei representations).

The kansei representations presented in EXP 2 were created by designers and the ones in EXP 3 were the result of participatory design sessions involving designers and users. In this experiment (EXP 4) the creation of kansei representations during co-design sessions occurring within a design team will be investigated. Professional designers and engineers will represent the design teams. The kansei cards (i.e. families of pictures and of keywords) introduced in EXP 3 (p. 115) will be used again.

Design teams will use them to discuss and investigate design challenges (i.e. the context of study) and represent relevant kansei-related design information. The influence that the co-creation of kansei representation has on the qualities of the idea generated from it during concept creation sessions (brainstorming) will be investigated. In order to do this, the ideas created by the groups following this process will be compared with the ones of control groups.

4.5.2 PROTOCOLS

Two protocols were created: one for the *control group* and one for the *test group* (Figure 4.23). The groups both represented multi-cultural design teams (multi-nationality, multi-gender, multi-functional). Only section B of the protocol was different for the two groups: the *test group* participated in a co-design activity involving the kansei cards whereas the *control group* did not.

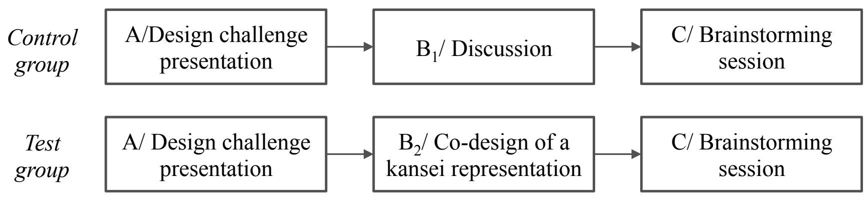


Figure 4.23: Protocols of EXP 4

A/ DESIGN CHALLENGE PRESENTATION

Both groups started with the "design challenge presentation" section. It consisted in a presentation of the project's background and of the findings of research previously undertaken (technology, context). It took a total of approximately 15 minutes. A design challenge related to the urban mobility topic was then presented to the design team. The two design challenges used in this experiment were "Give more flexibility to people using their car as a working tool (e.g., nurses, salespeople)" and "Give elderly people easier access to their favourite places." Note that the design challenges have been created for the purpose of this experiment. They are not related to any project currently investigated by TME-KD.

B_1/ DISCUSSION

For the *control group*, section B consisted of a free discussion about the topic and the design challenge among the members of the group. This section lasted on average about 15 minutes.

B_2/ CO-DESIGN OF A KANSEI REPRESENTATION

For the *test group*, the presentation of the design challenge was followed by a “kansei representation co-design” activity. During this activity, the participants were asked to position cards from different families of Kansei cards on a table. Two axes representative of the context of study and prepared before the experiment structured the space. The participants selected cards they believed to be relevant and discussed the position of the cards on the axes among themselves. This allowed them to co-create a common kansei representation of the field studied. The mapping activity ended with the participants individually rating the cards on the mapping. They marked the most relevant ones with a given amount of stickers. This section was moderated in order to last 45 minutes.

C/ BRAINSTORMING SESSION

For both control groups and test groups, the final section was a brainstorming session (section C). The participants were given 25 minutes to generate ideas and represent then on A5 pieces of paper. Before that, the activity was presented to them including the typical 11 brainstorming “rules” (e.g., “Encourage wild ideas,” “Build on the ideas of others,” “Stay focused on the topic,” “Respect everyone and let everyone speak”).

4.5.3 CONTENT OF THE EXPERIMENT

Two design challenges were tested in this experiment. For each of them, a *control group* (CG) and a *test group* (TG) followed the protocols detailed previously (four groups in total). The groups representing the design teams were multi-cultural. They were always composed of two professional engineers and two professional designers. For each of them the gender and nationality distribution of the participants was the same: two males and two females, and two European and two Japanese. All of them were Toyota Motor Europe employees and the moderator was always the author of this Ph.D. research. The groups were nevertheless not real design teams as the participants were selected on a voluntary basis. Some of the participants knew each other but none of them were used to working together.

For both design challenges, the context of the experiment was presented to the participants under the following title: “Future urban mobility: enhance usability and user experience provided by the car in urban areas.” After presenting the context of the experiment, a 15-minute-long presentation was made to the participants. It presented a short user research and a benchmark of current innovative solutions related to car (interior) space management. The two design challenges (DC1 and DC2) were the following ones:

- DC1 - “Give more flexibility to people using their car as a working tool (e.g., nurses, salespeople).”
- DC2 - “Give elderly people easier access to their favourite places.”

The protocols were followed twice each, which led to four brainstorming sessions: DC1_CG, DC1_TG, DC2_CG, and DC2_TG.

The two TG (*test groups*) both used five families of kansei cards for the kansei representation co-design session: “animals,” “sports,” “music instruments,” “semantic keywords,” and “emotions.” Examples of cards are visible in Table 4.10 (p. 115). These families were selected because they appeared to be complementary and relevant to the topic of the experiment. In both cases, the anchors of the axes used for the “kansei representation co-design” activities were labelled “city centre” and ”suburbs” (horizontal axes), and “efficient” and “comfortable” (vertical axes) (Picture 4.11).

Picture 4.11: Result of the co-design activity before rating the cards

As mentioned earlier, the brainstorming sessions were 25 minutes long. As one of the tasks of the moderator is to stimulate the participants, he also proposed concept ideas during the sessions. In order to influence the sessions in a consistent fashion, he proposed the same concepts in the same order. They were later not assessed by the group of experts.

It took approximately 1 hour for the control groups and 1 hour and 30 minutes for the test groups to complete all the tasks.

4.5.4 RESULTS

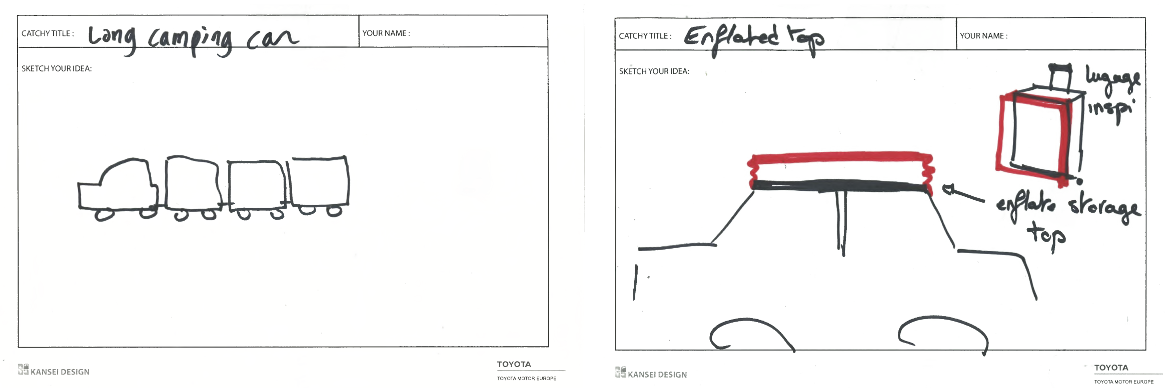
The "kansei representation co-design" activity was new to all the TG participants. The tasks (including discussing, positioning, and rating the cards) seemed rather easy for them to accomplish. They all reacted positively and contributed with interest to the different tasks. This activity enabled the groups involved in both design challenges (DC1_TG, DC2_TG) to define together the kansei states (user's values, emotions felt, possible semantic-related needs, etc) that a potential user would have in several situations. The cards also facilitated discussions related to the artefact to be designed (e.g., style intention, sensory characteristics) and its context (e.g., road infrastructure, issues related to period of the day and transportation behaviours).

Table 4.19: Evaluation grid

		Kansei qualities (presence, relevance)		
		low	*middle*	*high*
Rational qualities (quality of the features, novelty)	*low*	1 star (*)	2 stars (**)	2 stars (**)
	middle	1 star (*)	2 stars (**)	3 stars (***)
	high	2 stars (**)	2 stars (**)	3 stars (***)

The participants (TG and CG) created together a total of 66 concept ideas (33 for both design challenges). These ideas were given to three user experience experts (professional or academic), who were asked to assess them according to two criteria: their kansei qualities and rational qualities. Using the guidelines described in Table 4.19, the experts individually assigned a number of stars to each concept idea (from 1 to 3). If a consensus was not reached for specific concepts, it was reached after discussion between the three experts.

Picture 4.12 presents two concept ideas related to the first design challenge (both created by members of the TG). The idea on the left has been rated 1 star by the expert panel, whereas the one of the right has been rated 3 stars.



Picture 4.12: Concepts created from for DC1 and rated with 1 star (left) and 3 stars (right)

For each of the conditions (*test group* and *control group*), this experiment permitted to gather two measures (related to the quality and quantity concept created). Due to thing low amount of measures (2), I will not be able to draw statistically significant conclusions about the impact of co-design sessions on concept generation activities (e.g. t-test). It will nevertheless be possible to interpret a trend/ tendency.

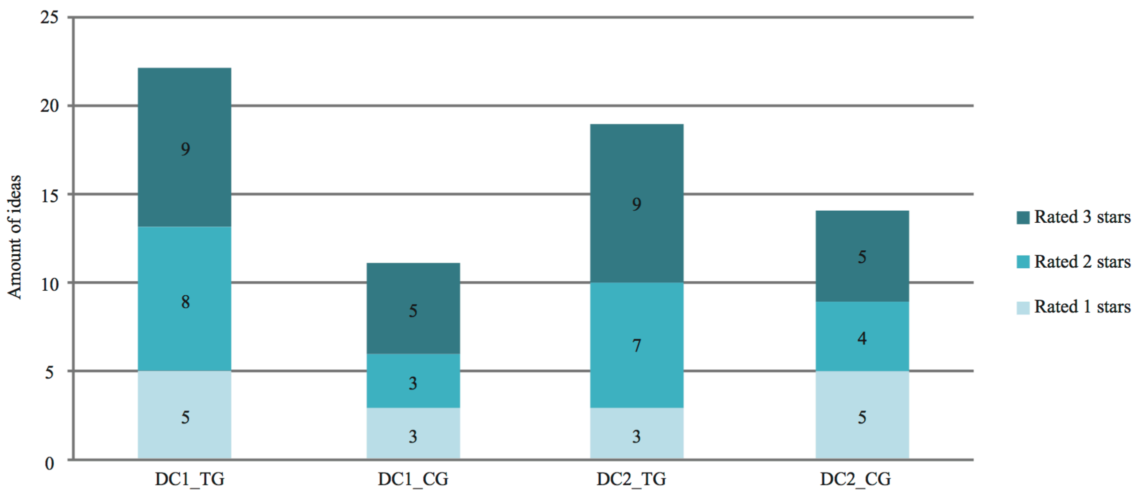


Figure 4.24: Concept ideas created: quantity and quality

When interpreting the results of the *test group* and the *control group* it appeared that the concept created by the TG surpasses the ones from the CG in terms of both quality and quantity (Figure 4.24). On average, the brainstorming preceded by a co-design activity produced 66% more concepts and had a higher ratio of valuable concepts: 80% of them were rated 2 or 3 stars for the *test group* instead of 68% for the *control group*. It appeared therefore that the co-design of kansei representation have a positive influence on the brainstorming performance of multi-cultural design teams. General descriptive statistics (Table 4.20) tend to support this trend interpretation. It should be verified with further measurements.

Table 4.20: General statistics related to EXP4

Quantity Amount of concepts created

	TG	CG
DC1	22	11
DC2	19	14
Mean	20.5	12.5
Standard Deviation	1.5	1.5

Quality Amount of 2 and 3 stars concepts created

	TG	CG
DC1	17	8
DC2	16	9
Mean	16.5	8.5
Standard Deviation	0.5	0.5

4.5.5 CONCLUSION OF EXP 4

EXP 4 presents an additional Kansei Design methodology enabling the construction of kansei representations in early phases of NCD projects. The kansei representations created appear to improve the output of brainstorming sessions likely to occur at that time of the design process. For the purpose of the experiment an artificial project context was created including background research, design challenges, and multi-cultural design teams. The function, nationality, and gender distribution was the same for the four groups that participated to the experiment. After being introduced to the context of the research the *test group* participated to a “kansei representation co-design” session and the *control group* discussed the design challenge informally. The co-creation tasks enabled the TG to discuss design information related to the three entities of experience (Table 4.21). The resulting kansei representation was a weighted mapping of kansei cards.

Table 4.21: Design information conveyed by the kansei representations created in EXP4

Design information	*Related UX entity*	*Level of abstraction*
Values	User’s personal characteristics	High
Semantic descriptor	Perceived kansei qualities	High
Emotion	Perceived kansei qualities	High
Style	Product attributes	High
Interaction characteristic	Interaction attributes	Middle
Sector/objet	Product attributes	Middle
Gesture	Interaction attributes	Low
Feedback	Interaction attributes	Low
Visual attribute	Product attributes	Low

Complementary to EXP 2 and 3, EXP 4 also contributes to discuss H2 (“Early representations of the intended user experience of a future product can convey design information related to all the entities of an experience”).

EXP 4 exemplifies some of the possible added values of such kansei representations when they precede creativity sessions. In such cases, a significant increase of the quantity and quality of concept ideas created could be observed. On the one hand, the higher quality of the concepts created might originate from a better understanding and an improved awareness of kansei quality related notions, as well as from the inspirational qualities of the co-designed kansei representation. On the other hand, the higher quantity of concepts created might be related to the fact that the members were more daring and more in confidence. This could be because kansei representations increase reciprocal understanding and cross-functional communication (see conclusion of EXP 2 [p. 112]). Indeed, according to Douglas and Sturtton (2009) these aspects are necessary to build trust within a cross-functional team.

4.6 EXP 5: USE OF KANSEI REPRESENTATION IN AN INDUSTRIAL CONTEXT

4.6.1 INTRODUCTION

In EXP 5, the different uses of kansei representation in the industrial process will be investigated. In order to do so, 27 design projects leading to the creation of kansei representation were analysed. They can be characterised as experience design-driven NCD projects. They took place between 2008 and 2013 and were coordinated by the TME-KD team. The author of this Ph.D. thesis was involved in more than 60% of them. Some of them directly used the approaches detailed in experiments 2, 3, and 4.

4.6.2 PROTOCOL

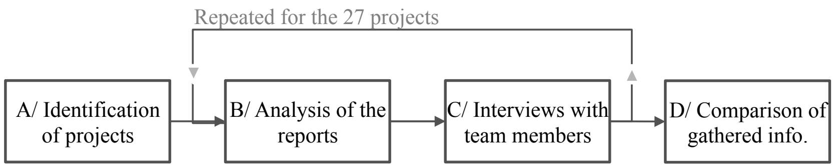


Figure 4.25: Protocol of EXP 5

A/ IDENTIFICATION OF PROJECTS

The first step of the data gathering protocol was to identify the projects leading to the creation of kansei representations. Their outputs had to describe a user experience intention. In total 27 projects were identified.

B/ ANALYSIS OF THE REPORTS

For each of them, the projects' material (e.g., design process description, final reports) was analysed and used as an input (Picture 4.13). The type of data analysed is detailed in section 4.6.3.

Picture 4.13: Analysis of the reports

C/ INTERVIEWS WITH TEAM MEMBERS

Interviews related to each project were conducted with at least one member of the original project team (Picture 4.14). The interviews were semi-directed. Approximately 30 minutes were spent for each project. Similar questions were asked each time to clarify the context of the projects. Discussions focusing on the output material (early representations) were then initiated. This part of the interview permitted the gathering of additional information related to the category of design information on which the resulting early representations were focusing.

Picture 4.14: Example of an interview with a team member

D/ COMPARISON OF GATHERED INFORMATION

The information collected from each projects was compared. Coding it enabled to identify relevant criteria related to the projects' context, the design activities, and the design information conveyed by the projects' outputs (detailed in section 4.6.3).

4.6.3 DATA ANALYSIS

The interviews and the document analysis provided different types of data related to the context of the projects, to the design activities undertaken, and to the design information conveyed by the kansei representations created. These different aspects will now be detailed.

THREE TYPES OF PROJECTS

The projects were structured according to their position on the overall operation procedure of the company. These different positions also correspond to differences in terms of purpose. Three types were identified from the 27 design-driven NCD projects analysed (they have already been briefly introduced in section 1.2.2 in order to present TME-KD's activity [p. 20]). They led to the creation of exploratory concepts, product lining strategies, and pre-development directions. This gave the names of the project-types. During the interviews, the context of the project was discussed (in regards to one of the three types below as well as to the composition of the design team and the audience addressed) and specific attention was paid to the composition of the design team (culture and affiliation of the members) and to the purpose of the project.

The “exploratory concept” group is composed of design-driven NCD projects that intend to explore innovative possibilities able to provide new pleasurable experiences including new meanings (Verganti, 2009). These projects intend to influence the development of *breakthrough products* as defined by Wheelwright and Clark (1992) (Figure 2.16 [p. 56]).

“Product lining strategy” projects are NCD projects meant to impact upcoming *platform product* development projects (e.g., hybrid vehicle NPD projects). Their outputs highlight kansei directions and related design strategies. They provide material related to user experience that enriches downstream NPD information activities.

Finally the purpose of “pre-development direction” projects is to prepare upcoming *incremental product* NPD projects. Similar to “product lining strategy” projects, they intend to communicate kansei directions and related design strategies. As the focus here is on user experience and not on style, these strategies are centred on the kansei qualities that can be expressed by different variations (or grades) of a vehicle update.

DESIGN ACTIVITIES

The information gathered about the projects also covered the different design activities that were undertaken. The reasoning approach of the *information*, *generation*, and *evaluation & decision* activities was particularly interesting. The projects analysed were usually based on integrative thinking and touched both scientific (i.e. inductive and deductive) reasoning and abductive reasoning. Depending on the project and on the design activity, it appeared that one type of thinking was more dominant. The tools and methodologies reviewed in the state of the art of this dissertation were also used as references (see section 2.4.4 [p. 78]).

Regarding the *communication* activity, the analysis focused on the nature of kansei representation used for intermediate and final outputs. Four different types of representation were identified: visual, multi-sensory, narrative, and interactive. The audience to which to projects were presented corresponded to the other type of data collected regarding the communication activity.

DESIGN INFORMATION CONVEYED

In order to classify the design information conveyed by the kansei representations created in the projects, categories were created based on those proposed by Bouchard et al. (2009) and Kim et al. (2009). In order to better fit to the experience design focus of the projects, some of the original categories have been adjusted (i.e., extended, divided, or combined). New categories have also been added. Some of the new entries have already been covered by the previous experiments (EXP 2, EXP 3, EXP 4). Table 4.22 presents the 19 categories of UX-related design information used for the analysis.

The *Action enabled*, *Product characteristics*, *Interface characteristics*, *Engagement required*, *Gesture*, and *Feedback* categories have been extracted from the original *Functionality* category. This was done in order to better identify the nuances of the latter category in terms of design information in regard to related UX entity and level of abstraction. Notably, Kim (2011) identified that this category of design information was the most used during design activities. The new categories should therefore permit refined observations.

The original *Context* category was extended into *Physical* and *Temporal context* and the *Texture* category was extended to *Tactile attribute*. The extensions permitted better coverage of these two attributes of the environment of an experience.

Some original categories were also grouped. This reduced the unnecessary complexity and eliminated notions that were not the focus of this research. *Form* and *Colour* were combined into *Visual attribute*, and finally the *Analogy* and *Semantic word* categories was integrated into *Semantic descriptor*.

Finally, several categories were also added. They correspond to the design information that was observed during the data gathering and the previous experiments but was not originally described. The categories were created in order the fit to the user experience framework introduced in the state of the art and used in the previous experiments detailed in this dissertation. The new categories are *Emotion*, *Lifestyle*, *Culture*, *Morphology*, *Auditory attribute*, and *Olfactory attribute*.

Table 4.22: Categories of UX-related design information

Category name	*Description*	*Example*	*Related UX entity*
Value [O] (H)	These words represent final or behavioural values.	Ambitious, open-minded	User's personal characteristics
Semantic descriptor [C] (H)	Adjectives related to the meaning and characteristics.	Playful, romantic, traditional	User's perceived kansei quality
Emotion [N] (H)	Targeted emotion to be felt by the user	Joy, surprise, interest	User's perceived kansei quality
Style [O] (H)	Characterization of all levels together through a specific style.	Edge design	Product attributes
Lifestyle [N] (M)	Combination of values of the user	"Work hard, play hard" lifestyle	User's personal characteristics
Interface characteristic [E] (M)	Underlying logics, engagement required	Mental engagement, physical and direct interface	Interaction attributes
Action enabled [E] (M)	Function, usage	Create, relax, communicate	Interaction attributes
Product characteristic [E] (M)	Components, ways of functioning, spatial organisation	Mechanical handle, roominess	Product attributes
Sector/object [O] (M)	Object or sector being representative for expressing a particular trend	Tennis, wearable computing	Product attributes
Physical context [X] (M)	Physical elements surrounding the product	In a modern living room	Context attributes
Temporal context [X] (M)	Notion of time in the interaction	Narrative description of an interaction	Context attributes
Culture (demographics) [N] (L)	The culture of a user covers his/her age, gender, nationality, function, and organisational affiliation	Young (20-29) Europeans	User's personal characteristics
Morphology [N] (L)	Related to the outward appearance of the user	Body shape, structure, handicap	User's personal characteristics
Gesture [E] (L)	Movement of a part of the user's body used as input	Hand and body movements	Interaction attributes
Feedback [E] (L)	Communication to the users (might be influenced by prior inputs)	Blinking light and sound	Interaction attributes
Visual attribute [C] (e.g., form and colour) (L)	Overall shape of component, shape size, and chromatic properties	Square, long and thin, Light blue, Pantone 17-5641 Emerald	Product attributes
Tactile attribute [X] (L)	Material, temperature, texture	Plastic, stripped surface, rough	Product attributes
Auditory attribute [N] (L)	Rhythm, timbre, etc	Irregular, high pitch	Product attributes
Olfactory attribute [N] (L)	Scent families and facets	Citrus, woody, floral	Product attributes

(H): High-level of abstraction
(M): Middle-level of abstraction
(L): Low-level of abstraction

[O]: Category originally presented by Kim et al. (2009)
[E]: Extracted from original category
[C]: Combination of original categories
[X]: Extension of an original category
[N]: New category

4.6.4 Results

The analysis permitted me to organise the projects into three groups: "Exploratory concept," "Product lining strategy," and "Pre-development direction" NCD projects. The results of the analysis regarding the three types of project will now be presented one by one. They touch on the three aforementioned aspects: context, design activities, and design information conveyed. They will be discussed together in the following section (section 4.6.5 [p. 150]).

4.6.4.1 EXPLORATORY CONCEPT (EC) PROJECTS

Eleven of the 27 projects analysed were described as "*Exploratory concept*" NCD projects. These include, for instance, the "Window to the World" project. Some outputs of this project, also available in the public domain, are presented in section 1.2.2 (p. 20).

CONTEXT OF EC PROJECTS

The outputs of the EC projects presented were concepts offering new experiences of mobility. Their focus was on mobility itself or on the interactions between a human and its environment (including other humans) supported by a mobility device. As mentioned previously, they can be regarded as NCD projects providing experience design-driven outputs for future *breakthrough products*. For all these projects, the design teams involved were rather small (around five people) and varied a lot from one project to another. They were always multi-cultural (multi-nationality, multi-gender, multi-function). The functions covered included design, business and engineering as well as complementary ones such as social sciences and computing. Most of the projects (73%) involved design team members external to TME. These external members were affiliated with organisations such as consultancy firms or universities.

DESIGN ACTIVITIES

The *information*, *generation* and *evolution & decision* activities of these experience design-driven NCD projects were dominantly based on abductive approaches. They were mostly based on qualitative data and relied in some part on intuition and experience. The potential users were treated as subjects (directly or indirectly) except for information activities, which could also involve participatory design sessions.

- *Information:* The most used tools and methodologies were desk research, field observation, discussions with "users," longitudinal studies, brainstorming, and bodystorming. The latter two tools included in some cases participatory design sessions. In some other cases, they used the "kansei card" tool. Generally speaking, these tools and methodologies were mostly used to gather insights and inspire the design teams.
- *Generation:* Using the information and insights gathered various creativity tools were used to generate concepts.
- *Evaluation & Decision:* In order to evaluate concepts the design teams mainly relied on expert panels (discussions, voting sessions). For this type of projects, many iterative cycles occurred between generation and evaluation & decision activities.
- *Communication:* For every project analysed, part of the final audience was unknown at the start. The audience finally reached was nevertheless much wider than that of the other types of projects. The audience reached depended on the topic tackled but also on the advice and recommendations received during the communication process. It was generally high up in the organisational scale. The educational dimension of the communication material was therefore reinforced. Narration was used 82% of the time. It was done with the help of storyboards, digital animations or videos. Interactive representations were also used 27% of the time. They are meant to provide "explicit innovative new experiences and give a more tangible context for an audience that is often focused on short term concerns" (extracted from the interview of project #4).

DESIGN INFORMATION CONVEYED

The main design information categories conveyed by final outputs of "exploratory concept" projects are presented in Table 4.23. The table organises categories according to their abstraction level (vertically) and to the experience entity to which they refer (horizontally).

As shown in this table, it appears that the kansei representations created mostly cover abstract design information. Most of the categories corresponding to the high and middle level of abstraction are covered (all except *style* and *product characteristics*). Notably, no concrete design information categories related to the product to be designed are covered. The narrative and interactive outputs relied on concrete elements (e.g., the visual and tactile attributes of the "Window to the World" prototype) in order to communicate the experience intention, but these characteristics did not belong to the main design information that was intended to be communicated.

Table 4.23: Categories of design information conveyed by outputs of "exploratory concept" projects

Abstraction level	*User's personal characteristics*	*User's perceived kansei qualities*	*Interaction attributes*	*Product and context attributes*
High	- Value	- Semantic descriptor - Emotion		
Middle	- Lifestyle		- Interface characteristic - Action enabled	- Sector/object - Physical context - Temporal context
Low	- Culture		- Gesture [EM] - Feedback [EM]	

[EM]: Emerging category

4.6.4.2 PRODUCT LINING STRATEGY (PLS) PROJECTS

Ten of the 27 projects analysed fit in the "*Product lining strategy"* project type. These projects include, for instance, methodologies and outputs similar to the ones presented in the experiments EXP 2 (3 projects) and EXP 3 (3 projects).

CONTEXT OF PLS PROJECTS

"Product lining strategy" projects are meant to impact specific upcoming *platform product* development projects (e.g., hybrid vehicle NPD projects). Their outputs highlight kansei directions and related design strategies. They provide material related to user experience meant to be used by different functions during downstream NPD stages.

Compared to EC projects, the profiles of the multi-cultural design teams were much more structured. Only product planners, designers, and engineers were involved in PLS projects. They also involved fewer members affiliated with external organisations (30% of them, and only as support).

DESIGN ACTIVITIES

In the case of PLS projects, the balance between scientific and abductive reasoning was more even than for EC projects. Most of the time, users were treated as subjects (directly involved or not) but they could also be involved as partners. This happened mostly for generation activities and sometimes for information activities.

- *Information:* For PLS projects, this activity combined quantitative and qualitative research. The ones presented in EXP 2 (respectively, results from EXP 1 and image search) were for instance used in two projects. The most used tools and methodologies were desk research, interviews, and exploration activities (including participatory design sessions).
- *Generation:* Four projects out of ten (40%) involved participatory design sessions with potential future users. For instance, the methodology developed in EXP 3 (p. 114) was used. In this case, "users" were guided in their generation activity with sensory stimuli (low abstraction level) and keywords related to kansei qualities (high abstraction level). As was shown in EXP 3, this type of methodology permitted a combination of abductive and scientific reasoning for generation activities. The other tools and methodologies used were abductive creativity tools.
- *Evaluation & Decision:* The concepts were either evaluated by a panel of potential users or by decision makers from the organisation (expert panel). In cases where potential users were

involved, quantitative evaluations were used. Additionally to psychological measurements (self reported questionnaires), behavioural measurements were done in some cases (eye-tracking).

- *Communication:* The kansei representations created were meant to be used by upcoming NPD teams (internal or supplier R&D teams). The audience was composed of both managerial (as for EC projects) and working-level Toyota employees. The interviewees expressed therefore the importance of having the experience directions and strategies conveying information that could be used directly by engineering, business, and design departments. In 80% of the cases, multi-sensory representations were used (e.g., Mood-boxes). They made it possible to convey concrete UX-related design information. Narration started to be used for some projects dealing with interactions (20%). For all the projects, visual-only versions of the output representations also existed and were used for distant communications (e.g., video conference). The visual material typically included keywords, pictures and/or figures. An example of such kansei representations (including keywords and pictures) is presented in EXP 2 (p. 105).

DESIGN INFORMATION CONVEYED

The main design information categories conveyed by the kansei representations resulting from PLS projects are presented in Table 4.24. The scope of information covered is wide. Four entities out of five (all except the context) of the intended user experience are covered with low to high abstraction categories (when a category exists). The kansei representations contained information to guide and inspire styling (e.g., *semantic descriptor, emotion, style, visual attribute, tactile attribute, other sensory attributes*) and interaction design activities (e.g., *semantic descriptor, emotion, gesture, feedback*). They could also be used by product planners interested in information about markets (e.g., *value, culture*) and product package (e.g., *sector/objec*t), as well as by engineers working on topics such as material developments (e.g., *emotion, semantic, style, visual attribute,* and *tactile attribute*).

Notably, many categories of design information have only recently emerged in PLS projects (noted as EM in Table 4.24). This was made possible through the creation of new methodologies and new kansei representations such as the ones presented in the previous experiments (EXP 1, 2, 3, and 4).

Table 4.24: Categories of design information conveyed by outputs of "product lining strategy" projects

Abstraction level	*User's personal characteristics*	*User's perceived kansei qualities*	*Interaction attributes*	*Product and context attributes*
High	- Value [EM]	- Semantic descriptor - Emotion		- Style
Middle			- Action enabled [EM]	- Sector/Object - Product characteristic [EM]
Low	- Culture - Morphology [EM]		- Gesture [EM] - Feedback [EM]	- Visual attribute - Tactile attribute - Auditory attribute - Olfactory attribute [EM]

[EM]: Emerging category

4.6.4.3 PRE-DEVELOPMENT DIRECTION (PDD) PROJECTS

Six projects could be described as PDD projects (out of 27). They will be described in terms of context, design activities, and design information conveyed.

CONTEXT OF PDD PROJECTS

The UX-related design information that these projects provide was very relevant for preparing upcoming (short-term) NPD projects. The kansei representations were aimed at a very specific audience such as styling designers (e.g., for wheel development) or material engineers (e.g., for material development). These representations expressed directions and strategies focused on the kansei qualities that could be expressed by different grade variations of future vehicle updates. Fifty percent of the projects involved methodologies similar to the one presented in EXP 4. They used outputs from benchmarks, fields, and desk researches in addition to the activities involving kansei cards.

The particularity of "pre-development direction" projects is that each of them was directly related to a new *incremental product* development project (NPD). Similarly to the other types of projects, the design teams involved were multi-cultural. In the teams' composition, a stronger accent was usually put on the function that would later be the most involved in the NPD projects (e.g., more styling designers were involved when preparing styling oriented projects). Notably, this typology of projects only involved members working at TME.

DESIGN ACTIVITIES

- *Information:* Quantitative data from market research (user involved as subject) appeared to be crucial at this stage. Information related to potential customers (i.e. target users) was studied and could lead to further *analytical reasoning* activities in order to translate it into high-level design information (Boisseau, 2013). Previous style-related NCD concepts could be used as starting points (e.g., concept cars). Finally, inspirational desk research was also used in order to put together design information from the different abstraction levels.
- *Generation:* The creation of *character* directions followed an iterative process. Refinement occurred cycle after cycle. The generation activity was in most of the cases led by styling designers sensitive to UX. Co-creation tools involving the entire design team could also be used (such as in EXP 4).
- *Evaluation & Decision:* Team members evaluated initial ideas and concepts using their expertise. Questionnaires and votes could also be used to assist the evaluation activity. Final decisions concerning directions and strategies occurred at specific milestones and involved the project's top management.
- *Communication:* As mentioned in the context, the audience of "pre-development direction" projects was very specific. It covered managerial and working-level Toyota employees. The kansei representations always took the form of visual mood boards. They included multi-sensory samples when they were related to upcoming parts or material development projects (33% of the time). Narrative and interaction types of representations were never used. Their audiences were composed of specific function-oriented (styling, product planning, engineering) NPD project teams, as well as development teams from part or material suppliers.

DESIGN INFORMATION CONVEYED

The main design information categories conveyed by the kansei representations resulting from PDD projects are presented in Table 4.25. It can be observed that whereas all product attributes are covered, no design information categories related to interaction attributes are tackled. This can be put in perspective by the fact that the original role of TME-KD was related to sensory quality perception (see also section 1.2.2 [p. 20]). The experience resulting from static perception appears to remain the domain of activity of the most established division for the projects that are the closest to the NPD phase.

The kansei representations resulting from PDD projects link intended kansei qualities of given "users" (defined with personal characteristics) to guidelines and inspiration materials related to product attributes.

Table 4.25: Categories of design information conveyed by outputs of "pre-development direction" projects

Abstraction level	*User's personal characteristics*	*User's perceived kansei qualities*	*Interaction attributes*	*Product and context attributes*
High	- Value	- Semantic descriptor - Emotion		- Style
Middle	- Lifestyle [EM]			- Sector/Object - Product characteristic
Low	- Culture			- Visual attribute - Tactile attribute

[EM]: Emerging category

4.6.5 DISCUSSIONS

The three types of projects will now be discussed together. Table 4.26 summarises this discussion.

CONTEXT

By construction, the purposes of the three types of projects are different (this is the definition of EC, PLS, and PDD projects). Similarities could nevertheless be observed regarding the nature of the design teams involved. It appeared that they were all composed of a similar number of members. Five seemed to be the average number, regardless of the project type. The different design teams also had in common the fact that they were multi-cultural. Functions that are traditionally less related to the industrial context (e.g., human sciences, computing) could only be found in EC projects. The involvement of people outside the company in the design team was the highest for projects related to long-term innovations (EC projects). Their involvement decreased progressively for PLS and PDD projects (as the commercialisation date becomes more and more clear).

DESIGN ACTIVITIES

All projects combined *abductive reasoning* and *scientific reasoning*. EC projects used the most *abductive reasoning* approaches in comparison with *scientific reasoning* approaches. It is justified by the ambiguity of their context: for this type of project there were no clear and definitive context *("you don't know what you don't know")*. The fuzziness of the context also led to very different types of representations. For EC projects, narrative and interactive representations were mostly used for final outputs. They seemed to better communicate concepts conveying a radical change in experience. These types of representation were very rarely used in PLS projects and never used in PDD projects. For these projects, the design teams relied mostly on visual and multi-sensory representations. These types of representations conveyed design information using material more established in the organisation (e.g., keywords, pictures, figures, material samples). They also communicated more information of direct use to the working-level employees involved in other NCD or NPD projects. Indeed, whereas EC projects mainly targeted managers dealing with vision and strategies, PLS and PDD projects' audience covered both managerial and working level employees. The clearer link between PLS or PDD projects and new industrial development projects (i.e. upcoming platforms and incremental development processes) is also reflected in the approach taken. Scientific reasoning is more used during the design activities. These approaches are meant to create knowledge about UX that is more explicit and that is proven with quantitative data *("you know what you know")*. This type of output appeared necessary in order to convince an audience to take decisions related to the implementation of new concepts in NPD projects.

In Table 4.26, the summary figures located in the design activities section graphically present the different uses of abductive and scientific reasoning for the information, generation, and evaluation activities of the three types of projects. The size and fuzziness of the audience reached by the communication activity are also represented.

DESIGN INFORMATION CONVEYED

The kansei representations resulting from the different types of projects had in common the fact that they effectively covered abstract design information categories and that they related these categories to design information with a lower level of abstraction. All the types of projects indeed expressed an intention regarding kansei qualities. They also referred to the abstract design information related to the potential user (*value*) and to the product to be designed (*style*).

Outputs from EC projects were nevertheless the only ones to convey design information related to all five UX entities and sub-entities (personal characteristics, kansei qualities, product, interaction, and context attributes). PLS and PDD projects lacked information about intentional contexts of use (temporal, physical) and PLS projects did not covey any intentions related to interaction attributes.

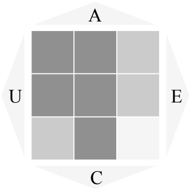
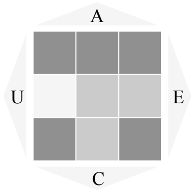
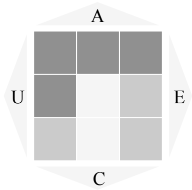
For EC projects, the design information related to the product to be designed remained abstract. Even if the narrative and interactive outputs relied on concrete elements (e.g., the visual, touch, and interaction attributes of the window to the world prototype), these characteristics did not belong to the main design information intended to be communicated. On the contrary, this type of design information was very present for PLS and PDD projects. This is indeed the experience entity that appeared to be the most directly impacted by the NPD projects that follow. This might be because it is where new meanings and experiences are traditionally created in the automotive industry (e.g., interior layout, materials, features).

EC projects and, increasingly, PLS projects conveyed design information related to interaction attributes. They covered categories such as *gesture*, *feedback, interface characteristic,* and *action enabled* (*action enabled* only for EC). The reasons for this were nevertheless different. On the one hand, EC projects proposed concepts with radically new UX (in the sense of Verganti [2009]) that included new interaction propositions, and on the other hand PLS projects increasingly sought to investigate the influence that different interfaces (e.g., button vs. touchscreen) have on the perceived kansei qualities in conventional vehicle environments. In the latter case, the interaction-related design information enriched the recommendations provided by the resulting kansei representations.

As highlighted previously, the outputs of PLS and PDD projects did not express any specific intentions related to the contexts of the intended experiences. One reason for this is that the temporal and physical contexts of new *platform* and *incremental products* resemble that of current vehicles. This aspect is therefore not the centre of attention of these project types.

In Table 4.26, the summary figures related to the design information section give an overview of the categories typically covered by each type of project. The darkness of the box is proportional to the precision with which the area is covered. The vertical axis corresponds to the abstraction level (low, middle, high). The anchors of the horizontal axis are labelled “user” and “environment.” The left column corresponds therefore to design information describing the targeted user (i.e., personal characteristics) and the right column to design information describing static aspects of the environment (i.e., intentional product attributes and physical context). Finally, the centre column contains the categories of design information specific to the intended user-product interaction (kansei qualities, interaction attributes, temporal context). These categories cannot be related to the targeted user, nor to the intended product and environment of use.

Table 4.26: Summary of EXP 5

		Exploratory concept	*Product lining strategy*	*Pre-development direction*
Context of the projects	*Purpose*	Propose new experience concepts for future *breakthrough products*	Identify user experience logics and directions for future *platform products*	Prepare grade and character strategies of future *incremental products*
	Design team	- Multi-cultural - Members from inside and outside the company	- Multi-cultural - Mostly members from inside the company	- Multi-cultural - Only members from inside the company
Design activities	*Type of reasoning*	Mainly abductive reasoning Scientific reasoning mainly used for information activity	Combination of abductive reasoning and scientific reasoning	Combination of abductive reasoning and scientific reasoning
	Type of representation	*Visual* – For intermediate output (co-creation session) *Multi sensory* – No use *Narrative* – For intermediate and final output *Interactive* – For final output	*Visual* – For intermediate and final output *Multi sensory* – For intermediate and final output *Narrative* – Limited use *Interactive* – No use	*Visual* – For intermediate and final output *Multi sensory* – For final output *Narrative* – No use *Interactive* – No use
	Audience	Wide but fuzzy – depending on recommendations Managerial level	Clear – large variety within upcoming NPD projects Managerial and working level	Specific – focused teams of upcoming NPD projects Managerial and working level
	Summary			
Design information conveyed	*High level*	PC: Value KQ: Semantic word, emotion	PC: Value KQ: Semantic word, emotion PA: Style	PC: Value KQ: Semantic word, emotion PA: Style
	Middle level	PC: Lifestyle IA: Interface characteristic, Action enabled PA: Sector/object CA: Situational context, temporal context	IA: Action enabled PA: Sector/object, Product characteristic	PC: Lifestyle PA: Sector/object, product characteristic
	Low level	PC: Culture IA: Gesture, feedback	PC: Culture, morphology IA: Gesture, feedback PA: Visual, tactile, auditory, olfactory att.	PC: Culture PA: Visual, tactile att.
	Summary			

Design activities
A.R.: abductive reasoning
S.R.: scientific reasoning

Design information conveyed
PC: Personal characteristics
KQ: Kansei qualities
IA: Interaction attributes
PA: Product attributes
CA: Context attributes

A: Abstract
C: Concrete
U: User
E: Environment

4.6.6 Conclusion of EXP 5

It this experiment, 27 industrial NCD projects, conveying an intention in terms of user experience, were analysed. Their outputs can be referred to as kansei representations as they link intended kansei qualities to personal characteristics of targeted users and attributes of the design environment.

The three types of project identified ("exploratory concept," "product lining strategy," and "pre-development direction") were described and compared in terms of context, design activities, and design information categories conveyed by their outputs. It could also be observed that these projects all combined *abductive reasoning* and *scientific reasoning*.

The experiment permitted me to characterise and present the context of use of the Kansei Design approach in an industrial context. It notably also identified the practical context of use of the tools, methodologies, and early representations created in the previous experiments.

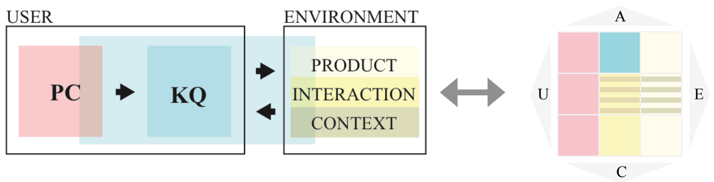
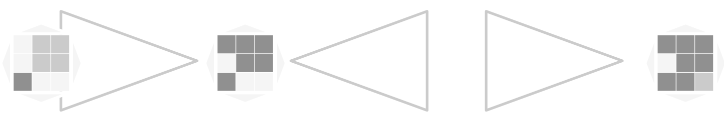
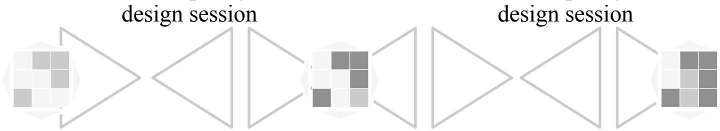
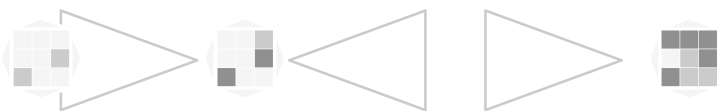
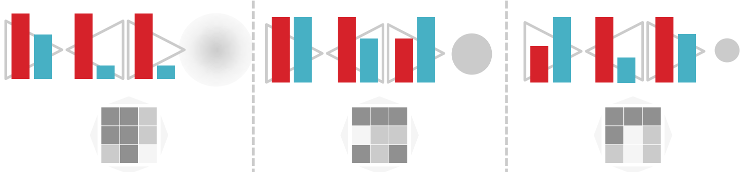
This experiment allowed me to better understand the different types of input that approaches focused on kansei can provide in the early phases of the design process. It detailed the nature of the design activities undertaken and the design information provided by these approaches as well as their strengths and weaknesses.

Hypothesis H3 stated that "the developed Kansei Design tools and methodologies can be integrated into an industrial design process." The present experiment permits us to validate this hypothesis as it identifies their use in design practice (external validity). It shows the different purpose and context of the NCD projects they can be applied to. The methodologies appear for instance to be more adapted to "product lining strategy" and "pre-development direction" projects than to "exploratory concept" projects: EC projects only made use of kansei cards (during their information activities).

4.7 Synthesis

As explained in the overall presentation of the experiments (see section 4.1 [p. 89]), EXP 1 addressed H1, EXP 2, EXP 3, and EXP 4 addressed H2, and finally EXP 5 addressed H3. Together they also covered and expanded on the four key notions of the state of the art (i.e. user experience and kansei process, industrial design process, experience-centred design activities, and cultural environment).

Table 4.27: Design activities and design information in the five experiments

EXP 1: *User experience as a composition of components and influencing factors*	 Correspondences between the kansei-experience framework and design information
EXP 2: *Kansei representation – Ux harmonics translated by designers*	 Selection of fitting Ux harmonics; Iterative process of pictures and music association
EXP 3: *Kansei representation – involving participatory design sessions*	Participatory design session; Participatory design session  Kansei cards selection; Analysis; Creation of MB and sensory samples; Analysis
EXP 4: *Kansei representation – co-creation within a multi-cultural design team*	 Research and design challenges preparation; Kansei cards mappings
EXP 5: *Use of kansei representations in the industrial context*	 In "Exploratory concept" projects; In "Product lining strategy" projects; In "Pre-development direction" projects

EXP 1 is based on the kansei-experience framework presented as one of the conclusions of the state of the art (Figure 2.13 [p. 47]). It investigated the correlations between the UX entities (personal characteristics, perceived kansei qualities and attributes of the environment) represented by arrows on this figure. Correlations and significant differences could quantify the interrelations existing between kansei qualities and experience influencing factors. Fifteen UX macro-trends (aka UX harmonics) could also be identified. They are keyword-based kansei representations describing with product examples related to this UX, as well as associated and dissociated keywords related to each of the UX entities. This experiment serves therefore to validate H1 (internal and external validity). This hypothesis states that "experiences provided by products can be compared and clustered according to the kansei qualities that users perceive from them, the user's personal characteristics, and the attributes from the environment (product, interaction, context)." Correspondences between the kansei-experience framework and design information used in early design activities could be identified. In Table 4.27, they are shown using the visual representation introduced in section 4.6.5 (p. 152). Because of the nature of the measurements made, limits can nevertheless be identified. Only self-reported personal characteristics and perceived kansei qualities could be used as input data and only a certain number of attributes of the environment have been taken into account: for example, only a finite number of the interaction attributes covered by the categories *action enabled*, *interface* and *engagement required*. More specific interaction attributes (e.g., *empower*, *raise awareness*, *search information*, *assist in case of emergency* [*action enabled* category]) and additional categories (e.g. *pace*, *movement*, *directness* [Lim et al., 2007]) could have been taken into account.

EXP 2, EXP 3, and EXP 4 presented Kansei Design tools and methodologies enabling the construction of kansei representations. They are supposed to be used in early phases of NCD projects. Different methodologies are used in each experiment. The tools used are the UX harmonics resulting from EXP 1 (EXP 2), kansei cards (EXP 3 and EXP 4), sensory stimuli (EXP 3), and Mood-boxes (EXP 3). Table 4.27 summarises the design activities of the methodologies employed in the different experiments, as well as the evolution of the UX-related design information conveyed by early representations at different moments in the process. The 3x3 tables used to represent it are the same as the ones used in the discussions related to EXP 5 (see section 4.6.5 [p. 152]): the vertical axis represents the abstraction level of the design information conveyed, and the horizontal axis corresponds to what it is describing (user on the left, and product and context on the right). The 3x3 tables on the left-hand side in Table 4.27 transcribe the design information conveyed by the initial briefs, whereas the ones on the right-hand side summarise the design information communicated by the kansei representations resulting from the three experiments. EXP 2, 3, and 4 considered respectively the user as a subject (directly involved), as a partner, and as a subject (not directly involved). EXP 3 also exemplified the influence of the culture of the users involved in participatory design sessions. Observations made there justify the presence of user-related design information in the resulting kansei representations.

The kansei representations created and evaluated in these experiments all contribute to validating H2 (Early representations of the intended user experience of a future product can convey design information related to all the entities of an experience.). The creation process of early representations could be tackled from various angles and both internal and external validity were addressed. It could nevertheless also be seen that the Kansei Design approach does not necessarily cover all entities of an experience (e.g., EXP 3, first iteration). EXP 2, EXP 3, and EXP 4 investigated different kansei representation creation methodologies all used in real projects (due to the fact that this research is taking an action research approach). They analysed these creation methodologies from different point of views (e.g. with different measures, looking at different variables) and led to similar conclusions regarding the design information conveyed by their resulting representations (see above). Together these three experiments therefore also tend to confirm the construct validity of H2.

EXP 2 showed that the kansei representations enable high (but not perfect) reciprocal understanding related to UX intentions among multi-cultural design teams. According to Graff et al. (2009), they should therefore contribute to open “functional walls” and to increase “team effectiveness.” It also was shown that the richness of the representation had a positive impact on their intrinsic chisei (e.g., understanding) and kansei (e.g., appeal) qualities perceived by the readers. EXP 4 then highlighted the benefits of this reciprocal understanding within the design team on the following generation activities (both in terms of quantity and quality of the concepts created).

EXP 5 investigated the use of the Kansei Design approach in industrial NCD projects. It reviewed and analysed 27 past projects coordinated by TME-KD. This permitted a better understanding of the scope of the tools and methodologies created in EXP 2, EXP 3, and EXP 4 and of the Kansei Design approach in general.

Three types of projects were identified (“exploratory concept,” “product lining strategy,” and “pre-development direction”). Their context, design activities and the design information conveyed by their outputs were described and compared. Only the last two involved the tools and methodologies discussed above in their core. Regarding “exploratory concept” projects, only a few of them used kansei cards and the mapping methodology presented in EXP 4 for brief inputs during the information activity. This is why this experiment served to explore and validate (external validity) H3 (“The developed Kansei Design tools and methodologies can be integrated into an industrial design process”).

5 CONTRIBUTIONS

Both academic and industrial contributions of this Ph.D. research will now be discussed.

5.1 ACADEMIC CONTRIBUTIONS

Two main aspects identified and developed during the experimental phases of this project can be regarded as academic contributions. The first aspect is related to the nature of the design information that can be used to convey UX-related intentions. The second aspect touches the added value of rich (i.e. multi-sensory) kansei representations for multi-functional design teams.

5.1.1 MODEL OF KANSEI-RELATED DESIGN INFORMATION

As could be seen previously, one of the characteristics of kansei representations is that they communicate design information related to an extended picture of user experience. This picture includes information related to the characteristics of targeted users, intended kansei qualities, and attributes of the to-be-designed product and interaction, as well as attributes of the context of use. These UX entities correspond to the kansei process' causes (attributes of the environment [product, interaction, context]), internal influencing factors (user's personal characteristics) and consequences (perceived kansei qualities) described by Lévy et al. (2007). The experiments showed that kansei-related design information used in early stages of the design process could be characterised by two dimensions. The first one, the *abstraction dimension* (concrete-abstract axis), corresponds to the one described by Bouchard et al. (2009).

The second one is the *experience entity dimension* (user-environment axis). It corresponds to the entities of the UX to which the design information categories are referring. The design information exchanged by design teams can be organised according to three different levels representative of the experience entity dimensions. A first one covers design information intrinsic to the targeted user (his/her personal characteristics) and a second one is related to what is intrinsic to the environment of design (product characteristics, physical context). Finally, the central level refers to that which depends on the interaction between a user and this environment (perceived kansei qualities, interaction attributes, temporal context). Notably, there is no causal relationship between the abstraction level (*abstraction dimension*) of a category of design information and the experience entity to which it is referring (*experience entity dimension*): design information related to every possible combination does exist.

Figure 5.1 represents a model of kansei-related design information integrating the two dimensions. It can be seen as an iteration of the model presented by Bouchard et al. (2009). The vertical axis corresponds to the *abstraction dimension*, whereas the horizontal axis corresponds to the *experience entity dimension*. The model references several categories of design information along the two dimensions. They are organised in six groups. Five groups are composed of categories covered by the experiments presented in this dissertation. They correspond either to categories originally described by Kim et al. (2009), to subfamilies extracted from original categories, to a combination of original categories, or to an extension of either the original or newly identified categories.

The *action enabled*, *product characteristics*, *interface characteristics*, *engagement required*, *gesture*, and *feedback* categories have been extracted from the original *functionality* category. It was done in order to better identify its nuances in terms of design information: related UX entity, level of abstraction. The original *context* category was extended into *physical* and *temporal context* and the *texture* category was extended to *touch*. The extensions allowed more accurate coverage of these two attributes of the environment of an experience. Some original categories were also combined in order to reduce unnecessary complexity and to eliminate notions that were not the focus of this research. *Form* and *colour* were combined into *vision* and *analogy* was integrated into *Semantic descriptor*. Several categories corresponding to design information identified during five experiments but originally not described were also added. The new categories are *emotion*, *lifestyle*, *culture*, *morphology*, *sound*, and *smell*. The last group in composed of other categories of kansei-related design information not covered by the experiments (*personality*, *past experience*, *skill*, *taste*).

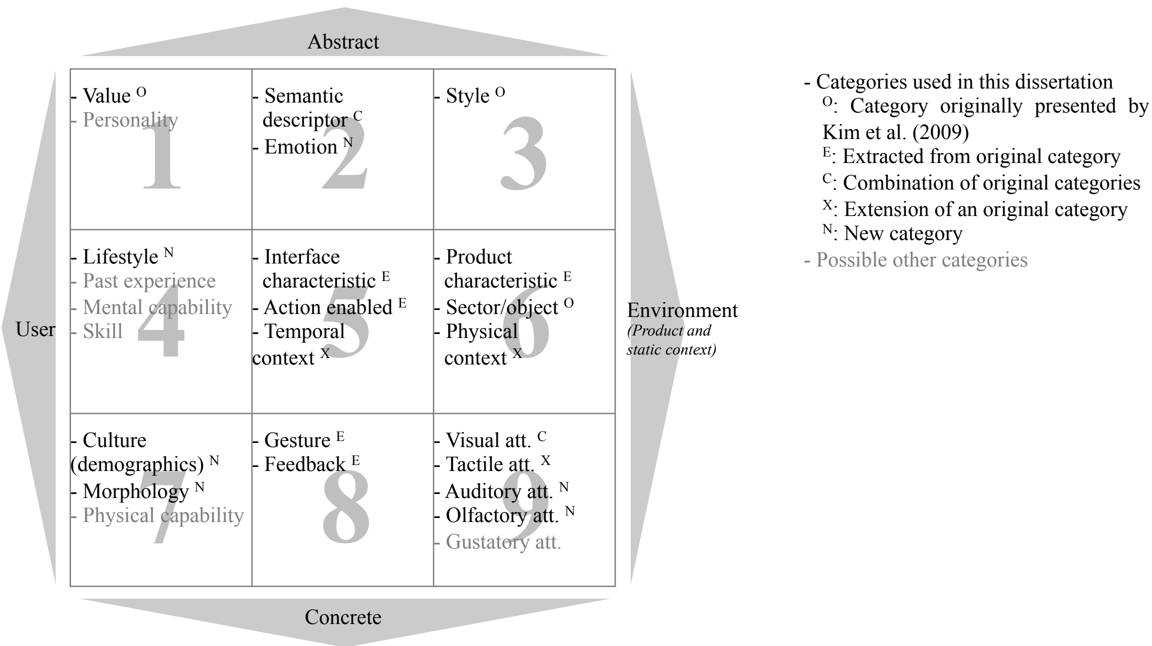


Figure 5.1: Model of kansei-related design information

Description of the categories and examples of design information, already detailed in EXP 5 can be found in Table 5.1.

Table 5.1: Description of the design information categories

Position on the model	*Category name*	*Description*	*Example*
Cell 1	Value	These words represent final or behavioural values.	Ambitious, open-minded
Cell 2	Semantic descriptor	Adjectives related to meaning and characteristics.	Playful, romantic, traditional
Cell 2	Emotion	Targeted emotion to be felt by the user	Joy, surprise, interest
Cell 3	Style	Characterization of all levels together through a specific style.	Edge design
Cell 4	Lifestyle	Combination of values of the user	"Work hard, play hard" lifestyle
Cell 5	Interface characteristic	Underlying logics, engagement required	Mental engagement, physical and direct interface
Cell 5	Action enabled	Function, usage	Create, relax, communicate
Cell 5	Temporal context	Notion of time in the interaction	Narrative description of an interaction
Cell 6	Product characteristic	Components, ways of functioning, spatial organisation	Mechanical handle, roominess
Cell 6	Sector/object	Object or sector being representative for expressing a particular trend	Tennis, wearable computing
Cell 6	Physical context	Physical elements surrounding the product	In a modern living room
Cell 7	Culture (demographics)	The culture of a user covers his/her age, gender, nationality, function, and organisational affiliation	Young (20-29) Europeans
Cell 7	Morphology	Related to the outward appearance of the user	Body shape, structure, handicap
Cell 8	Gesture	Movement of a part of the user's body used as input	Hand and body movements
Cell 8	Feedback	Communication to the users and influenced by prior inputs	Blinking light and sound
Cell 9	Visual attribute	Overall shape of component, shape size and well as chromatic properties	Square, long and thin, Light blue, Pantone 17-5641 Emerald
Cell 9	Tactile attribute	Material, temperature, texture	Plastic, stripped surface, rough
Cell 9	Auditory attribute	Rhythm, timbre, etc	Irregular, high pitch
Cell 9	Olfactory attribute	Scent families and facets	Citrus, woody, floral

The kansei representations created in this Ph.D. research cover well the two dimensions of design information of the model. Table 4.27 (p. 154) presented a summary of the areas covered by the kansei representations discussed in each experiment (also reported in tables at the end of each experiment). The ones of the second iteration of EXP 3 cover for instance seven cells, and the ones of EXP 2 and EXP 4 cover eight cells. EC, PLS, and PDD projects discussed in EXP 5 covered seven or eight cells (Table 5.2). More details can also be found in the conclusion section from the five experiments.

Table 5.2: Kansei-related design information conveyed by early representations

	EXP 2	*EXP 3, it. 1*	*EXP 3, it. 2*	*EXP 4*	*EXP 5, EC*	*EXP 5, PLS*	*EXP 5, PDD*	*Design brief*	*Mood board*	*Visual theme board*	*Scenarios*
Cells of the model covered	8	5	7	8	8	8	7	5	4	4	5

Other experience-centred early representations described in the state of the art cover generally a more narrow scope of design information (Table 5.2). The *design briefs* encountered during the course of the Ph.D. research covered up to five cells. *Mood boards* and *visual theme boards* each focus mainly on four cells. Indeed, the former was defined by Baxter (1995) as "try[ing] to identify a single expression of values for the product" (p. 222), whereas the latter was described as representing a style direction focused on visual aesthetics. Finally, *storyboard scenarios* cover generally up to five cells (no references to most of the environment-related and to some of the user-related design information). The design information coverage of these early representations has been visualised using the model presented above (Figure 5.2).

The model of kansei-related design information also helps to describe the content of different types of trends related to user experience. By nature, trends combine different categories of design information. They can focus on human behaviours and society (societal trends [Kornblum, 2007]) and cover in this case design information related to the cells 1, 2 and 4 of the model (people's values and lifestyles and their new drives in terms of emotions and semantics). They can also be design trends and combine in this case design information about specific design environment attributes and related kansei qualities. The mood boards and visual theme boards exemplify the differences in term of the scope that design trends can have (Baxter, 1995).

This comparison using the "model of kansei-related design information" exemplifies the discussion held previously regarding the differences between kansei representation and the other types of representation. It also highlights the nature of the differences and the specificity of each type of representation.

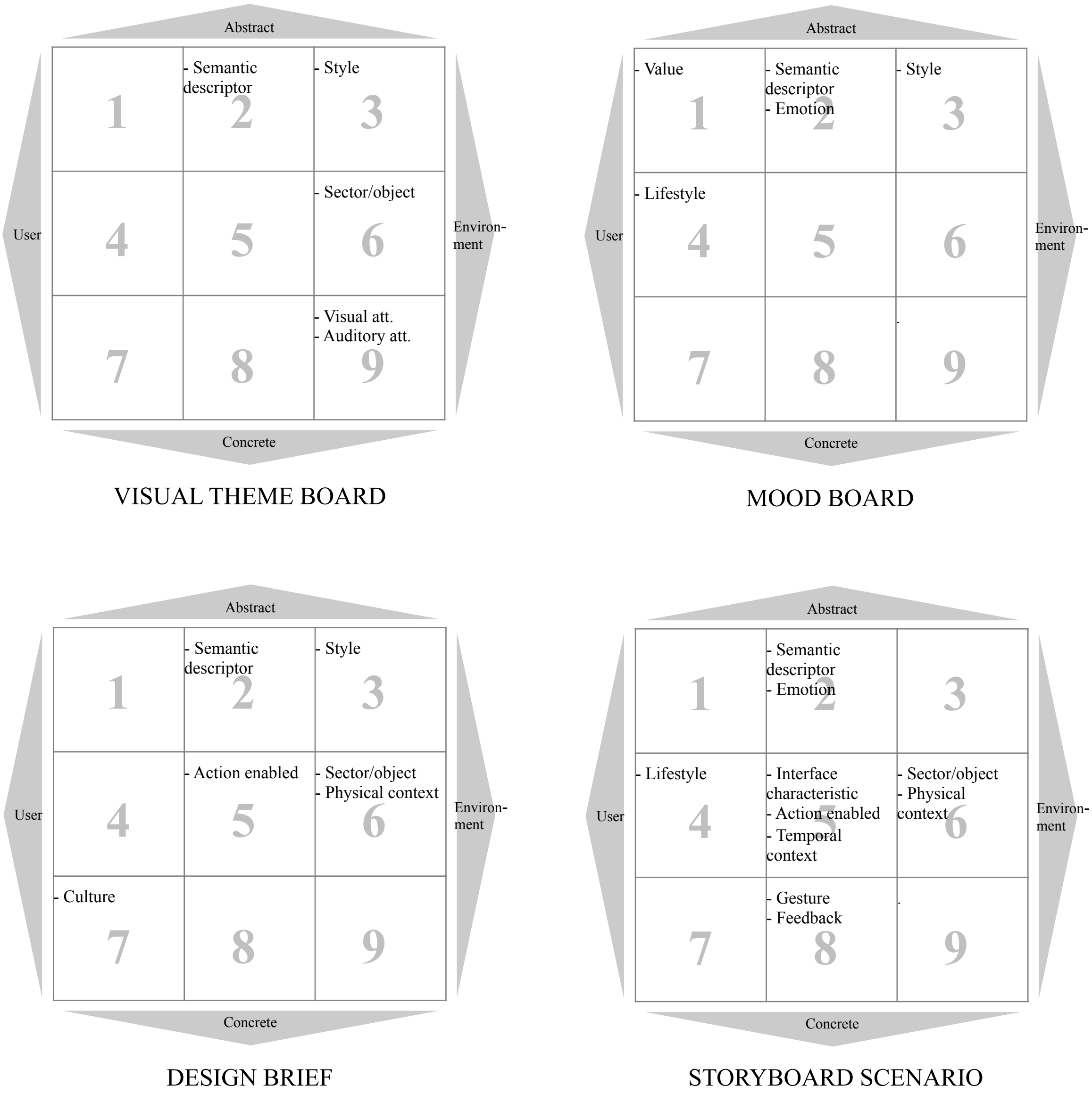


Figure 5.2: Design information conveyed by "traditional" early representations

A parallel can be drawn between the model of kansei-related design information presented in this section and Hassenzahl's (2013) *Why, What, and How levels* (Figure 2.27 [p.74]). According to Hassenzahl, these levels should be considered chronologically when designing a product experience. The *Why level* clarifies "the needs and emotions involved in an activity, the meaning, the experience" (p.83). In that sense the design information tackled at this stage of the experience design process is mainly contained in cells 1 and 2 (at an abstract level and dealing with the users' personal characteristics and intended kansei qualities). The *What level* "determines functionality that is able to provide the experience" (p.83) and seems therefore to deal mainly with design information contained in the cells 5 and 6 (e.g. action enabled, interface characteristic, product characteristic…). The last level is the *How level* which determines "the appropriate way of putting the functionality to action" (p.83). This means that the design team is at that time mainly dealing with concrete and tangible design information such as morphology, gesture, sensory properties of the product or of the feedbacks (i.e. cells 7, 8, and 9). In that sense, the model of kansei-related design information seems to cover well the scope of design information relevant for a complete experience design process. Additionally, it seems that the design information considered by the design team during that process evolves gradually from high level of abstraction towards lower levels of abstraction.

To conclude this sub-section related to the *model of kansei-related design information*, I will summarise its main characteristics. First of all, building on previous research by Bouchard et al. (2009) and Kim et al. (2009), it enhances the description of design information exchanged within a design team. In comparison with the original model, the categories have been refined and now better cover the scope of UX design. A new *experience entity dimension* (user-environment axis) has also been added.

As a result it permits a better picture of the contributions of the different experiments described in this dissertation and facilitates future studies of the subject. The model facilitates for instance the comparisons and discussions related to the different types of early representations.

5.1.2 Multi-sensory representations of user experience

In EXP 2 and EXP 3, multi-sensory kansei representations have been created (Picture 5.1). This type of representation has received very little attention in the literature. The literature review only identified the multi-sensory design (MSD) approach from Schifferstein and Desmet (2008) as being close to the ones developed (more details on p. 77). Notably, the representations developed by this approach emphasize the intention related to the "sensory" characteristics of the product to be designed. In that sense, they convey more low level design information and less high-level design information than the multi-sensory kansei representations created during this research.

Picture 5.1: Multi-sensory representations from EXP 2 (left) and EXP 3 (right)

Using the model described in the previous sub-section, Figure 5.3 shows in detail the design information conveyed by the two types of multi-sensory representations. In both cases, the design information categories were identified in the conclusion section of both experiments (Table 4.9 [p. 113] and Table 4.18 [p. 136]).

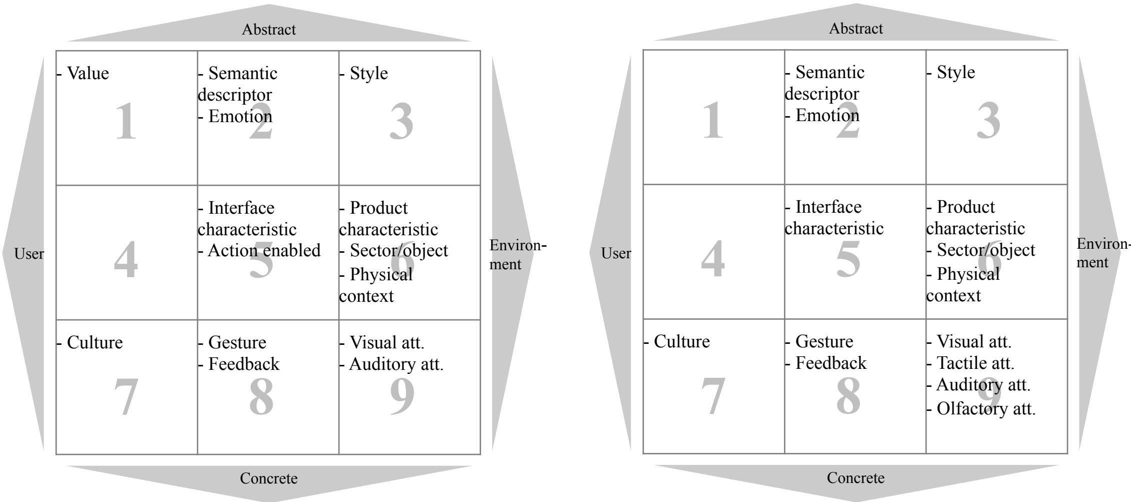


Figure 5.3: Detail of the design information conveyed by multi-sensory representations from EXP 2 (left) and EXP 3 (right)

EXP 2 showed that rich representations (communicating with several modalities such as keywords, pictures, music) are easier to understand and have more intrinsic kansei qualities than keyword-based or pictures-based representations. These observations are independent from the function of the person reading them (engineers, styling designers, product planners). It shows that the multi-sensory representations improve cross-functional communication related to UX as well as reciprocal understanding of UX-related intentions. I would like to highlight this finding, as it appears more important than the exact composition of the representations tested: more innovative multi-sensory representations with high congruity are easily achievable.

Because of these characteristics, richer kansei representations better open “functional walls” and increase “team effectiveness.” Even though they do not improve people’s competences or the quality of the design process, rich kansei representations contribute to better connecting design-driven and technology NCD projects as well as the related design teams.

5.2 INDUSTRIAL CONTRIBUTIONS

This Ph.D. research and the various side activities conducted during my stay at TME-KD contributed to creating the Kansei Design approach used in this division and to evolving it into what it is today: an approach based on abductive and scientific types of reasoning, and focusing on the integration of experience at the new concept development (NCD) stage. It also permitted the establishment of this approach within the international design research community (Lévy, 2013).

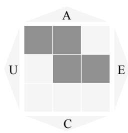
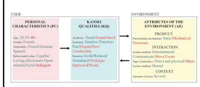
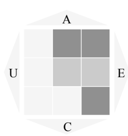
Studies presented in previous publications as well as the one presented in EXP 5 permitted a better understanding and defined the approach in an industrial design context. In addition to these theoretical contributions, three types of practical industrial contributions can be highlighted. They will be detailed in the upcoming sub-sections. The first type corresponds to new tools supporting the design activities that have been created, the second type to the creation of kansei representations, and the third type corresponds to the new design methodologies.

Since the moment they were created for the purpose of this research, they were all infused in various NCD projects. This way, they also contributed to integrating the Kansei Design approach into Toyota's industrial design process (see also EXP 5). In the last sub-section related to the industrial contribution of this dissertation, I will discuss how these new tools, kansei representations, and methodologies contributed to and should continue to support TME-KD's design activities. I will also detail the way they are integrated into "exploratory concept," "product lining strategy," and "pre-development direction" projects.

5.2.1 CREATION OF NEW TOOLS

Three new tools have been created during the course of this Ph.D. research: *UX harmonics*, *Kansei cards*, and *Mood-boxes* (Table 5.3). They all support experience-centred design activities as well as the exchange of information during the creation of early representations. The first two were created entirely for this research, whereas *Mood-boxes* already existed within TME-KD but were used for other purposes (smaller, simpler, used as stand alone concrete-oriented representations).

Table 5.3: Tools introduced in this research

Name of the tool	*Sense(s) stimulated*	*Origin*	*Design information*	*Related early representation*	*Illustration*
Ux harmonics	- Vision	- Statistical analysis of a user research (EXP 1)		- Ux harmonics keyword-based representations (EXP 1) - Multi-sensory kansei representation (EXP 2)	
Kansei cards	- Vision	- Brainstorming and iterations for each family (EXP 3)	Dependent on the card family (see Table 4.9 for some examples)	- Visual kansei directions (EXP 3) - Multi-sensory kansei representation (EXP 3) - Mapping of kansei cards (EXP 4)	
Mood-boxes	- Vision - Touch	- Translation of visual kansei directions (EXP 3)		- Multi-sensory kansei representation (EXP 3)	

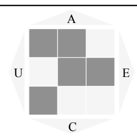
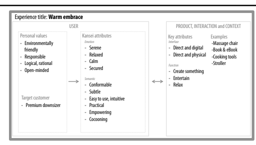
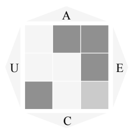
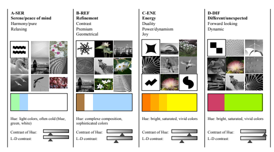
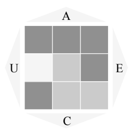
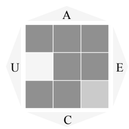
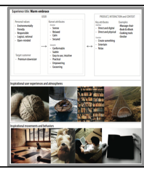
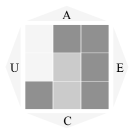
Each tool stimulates sensory channel(s) in order to convey certain categories of design information. Table 5.3 shows the specificities of each of them. In that sense, similarities can be observed between the function of these three tools and the different kansei representations presented in this dissertation. The table also explains the origin of each tool. Whereas *Kansei cards* and *Mood-boxes* involved the sensibility of designers for their creation, *UX harmonics* relied only on the statistical analysis of user research. Finally, the table also connects the tools with the early representations that they helped create. The tools are actually often embedded in the resulting early representations (e.g., *UX harmonics* in multi-sensory kansei representation [EXP 2], *Kansei cards* in Visual kansei directions [EXP 3]).

5.2.2 NEW TYPES OF EARLY REPRESENTATIONS

The new types of early representations that will be covered in this review are related to the focus of this research and have been described in EXP 1, 2, 3, and 4. The review does not cover representations created during other NCD projects I was involved in during the time of the Ph.D. (e.g., narrative and interactive representations mentioned in EXP 5).

Table 5.4 presents side-by-side visual and multi-sensory representations introduced in the literature review and representations created in this Ph.D. research. Characteristics from the latter type of representation are detailed. The large scope of design information they convey is indicated using the model of kansei-related design information introduced in section 5.1.1 (p. 158). Each type of early representation is also illustrated with the figures and pictures already used when describing their creation. In this way, Table 5.4 exemplifies the contributions to design practice (industrial contributions) of these new types of representation.

Table 5.4: New types of early representations introduced in this research

Nature of the representations	*Literature review (pp. 73-75)*	*Contributions from this Ph.D. research*		
		Name and reference	*Design information conveyed*	*Illustration*
Visual	- Mood-boards - Trend boards - Image collage	Ux harmonics keyword-based representations (EXP 1)		
		Visual kansei directions (EXP 3, 1st iteration)		
		Mapping of kansei cards (EXP 4)		
Multi-sensory	- MSD representations	Kansei representation based on Ux harmonics (keywords + pictures + music) (EXP 2)		
		Mood-boxes, Kansei cards, and multi-sensory samples composition (EXP 3, 2nd iteration)		

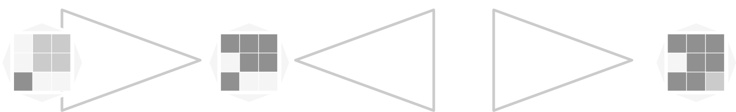
Notably, they are now used by TME-KD in NCD projects in order to convey experience-related design information. They have also been understood and adopted by styling design, engineering, and product planning divisions collaborating with TME-KD, as well as by counterpart divisions in Japan and by TME's top management. As was shown in this Ph.D. research, these new types of early representations permit increased awareness and mutual understanding among design teams and in communication with management. In this way, they contribute to the research activities (NCD phase) which precede the development of new breakthrough products, platform products, and incremental products (see also EXP 5 [p. 142]).

5.2.3 CREATION OF NEW METHODOLOGIES

Three new types of Kansei Design methodologies were detailed and discussed in the experiment section of this dissertation (section 1 [p. 89]). They will now be looked at from a design practice perspective. They will be described according to the way they treat intended users, to the activities they are composed of, and to the way they relate to the two types of reasoning involved in the Kansei Design approach (i.e. scientific and abductive reasoning) (Table 5.5, Table 5.6, Table 5.7).

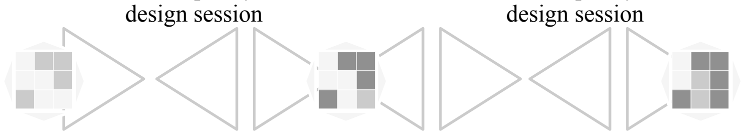
The three methodologies are very different one from another. They cover the different ways to treat potential users in design research described by Sanders and Stappers (2008): as a subject (directly or not directly involved) or as a partner.

Table 5.5: Description of the Kansei Design methodologies introduced in EXP 1 and 2

METHODOLOGY A *EXP 1 and 2:* *Kansei representation – Ux harmonics translated by designers*	 Selection of fitting Ux harmonics Pictures and music association (iterative process)
	Scientific reasoning: Statistical analysis of the user research data, Creation of Ux harmonics creation (cluster analysis) *Abductive reasoning:* Ux harmonics selection, Pictures and music association "Users" treated as subjects and directly involved in the design activities

The first methodology (A) covers experiments 1 and 2. It makes use of UX harmonics originating from user research in order to identify experience directions. It is particularly adapted to exploring the experience possibilities of a relatively detailed design brief (e.g., a marketing brief with personas describing the targeted users). This is due to the fact that the first activity of this methodology is to combine the existing brief (rather concrete design information) with the UX harmonics composed of abstract design information. In this case, the two sources of information used as entry points are complementary. They also combine a large scope of information (quantitative and qualitative) that is then used as input for the creation of multi-sensory kansei representations (pictures and music association).

Table 5.6: Description of the Kansei Design methodologies introduced in EXP 3

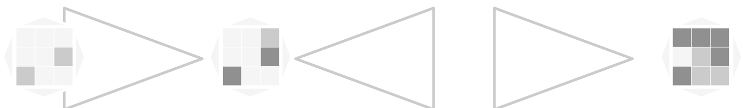
METHODOLOGY B *EXP 3:* *Kansei representation – involving participatory design sessions*	
	Scientific reasoning: Statistical analysis of the participatory design sessions (PCA, clusters) *Abductive reasoning:* Creation/selection of the samples (Mood-boxes, Kansei cards, multi sensory samples), Combination of clusters “Users” treated as partners for the design activities

The second Kansei Design methodology (B) was presented in EXP 3. It treats potential users as partners and involves two participatory design sessions in order to explore relatively open design briefs.

The first iteration relies exclusively on the use of Kansei cards and colour samples. Its main added values are that it narrows down the scope of possibilities to a finite number of directions, it requires limited time to set-up and it takes potential users' opinions and creativity into account (kansei process) while still allowing easy comparison.

The second iteration involved Mood-boxes and multi-sensory samples and allows a much more refined definition of the experience directions. It is nevertheless not suitable for direct use with open design briefs because the preparation of the multi-sensory samples necessitates some guidance. Notably, participatory design methodologies similar to the second iteration could be used in situations similar to the one of the methodology A. They would make it possible to narrow down and detail with more concrete design information the directions identified with the UX harmonics and the related multi-sensory kansei directions.

Table 5.7: Description of the Kansei Design methodologies introduced in EXP 4

METHODOLOGY C *EXP 4:* *Kansei representation – co-creation within a multi-cultural design team*	
	Scientific reasoning: Presentation outputs from desk researches *Abductive reasoning:* Creation/selection of the samples (Kansei cards), Co-creation session (involving Kansei cards) “Users” treated as subjects and not directly involved in the design activities

The third type of methodology (C) was presented in EXP 4. It involves “traditional” desk research and builds on its outputs with a co-creation session organised among a design team (kansei cards mapping session). It is the quickest to set up and directly contributes to building mutual understanding among a design team. Nevertheless, it only relies on scientific reasoning for the information gathering activities (not for the mapping) and treats the users as subjects that are not directly involved in the design activities. It can be used as a substitute to participatory design sessions in order to explore open design briefs (methodology B, 1st iteration) for topics that can take advantage of expert knowledge (e.g., concepts related to precise car parts, brand identity).

5.2.4 UPTAKE OF THE INDUSTRIAL CONTRIBUTIONS IN TME-KD'S ACTIVITIES

INTRODUCTION

In this sub-section I will present how these tools, early representations, and methodologies are supporting the different types of projects involving TME-KD within the global Toyota organisation. This discussion is based on know-how and knowledge transfer that had already happened at the time of writing this dissertation as well as a more general view on how the industrial contributions of this research could further infuse themselves into the structure of the organisation.

As this research followed an action research approach it can be described as an iterative process involving research and practice activities. The different contributions detailed previously have therefore been created having in mind both an academic relevance and an industrial utility. Methodologies A and B (EXP 2 and 3) have been organised as part of real NCD projects. For reasons of confidentiality, the focus of those cases has been put on the set-up, the tools, the methodologies, and the structure of the early representations rather than on the exact aspects and communication activities of the resulting representations. Methodology C was first tested in different NCD projects before an experiment was organised in a controlled environment (EXP 4). The experiment permitted me in this case to verify assumptions and better understand the impact of the different parameters.

UPTAKE OF THE TOOLS, EARLY REPRESENTATIONS, AND METHODOLOGIES

After having been theorised as part of the experiments, the three methodologies (A, B, and C) have all been reused in subsequent NCD projects of the Toyota and Lexus brands. This uptake in TME-KD's experience design activities also includes the reuse of the related tools and early representations. The added value of the different industrial contributions has also been recognised by design team members from other functional departments (engineering, product planning, styling), by TME's top management as well as by several chief engineers of vehicle development. Tools such as Kansei cards and UX harmonics are now even used with other methodologies than the ones they were originally created for. Table 5.8 summarises the amount of industrial projects for which the tools and methodologies developed in this research have already been used (at the time this dissertation was written). In this table, the amount of uses is also detailed by project-type.

Table 5.8: Uptake of tools and methodologies into Toyota projects by project-type

	Tools			*Methodologies*		
	Ux harmonics	*Kansei cards*	*Mood boxes*	*A*	*B*	*C*
EC projects	1	2	0	1	1	1
PLS projects	2	3	2	2	1	2
PDD projects	1	4	2	1	1	4
Total	**4**	**9**	**4**	**4**	**3**	**6**

EXP 2 showed that multi-sensory kansei representations were understood and appreciated by the different functions involved in NCD projects (styling designers, product planners). It is important to mention here that representatives of the same functions also acknowledged the added value of kansei representations during project review meetings (e.g., "the topic raised by the representation [i.e. the experience] is now something critical to take into account" [Product planning GM], "the representations are very clear, I can understand the message they are conveying" [Styling design Director]). The working-level members involved in project teams also appropriated the representations as they used them for their internal communication as well as in their own activities. Notably, product planners used them to trigger discussions during focus group interviews and styling designers displayed the early representations alongside their own sketches, inspirational boards, and mock-ups during communication activities.

Interviews were conducted with the two oldest TME-KD members: Carole Favart (General Manager) and Daniel Esquivel (Senior Kansei Engineer). This permitted to get another perspective on the uptake of some of the contributions of this research by TME-KD as well as to gather feedbacks from practitioners from the field.

During the interview, Mrs Favart mentioned that this research strongly contributed to structure and to widen the scope of activities conducted by TME-KD. It created "a structured approach that does not imprison its practitioners and that enables creativity management." She also underlined that this research permitted to build an integrative approach based on synergies between designers' sensibility and scientific reasoning (i.e. two types of approaches used independently by TME-KD prior this research).

Concerning the extension of TME-KD's field of activity, she agreed that this research permitted to integrated the notion of *interaction* (TME-KD activities were previously mostly centred on perception [see also p. 20]). She also highlighted that the tools, methodologies, and early representations created as well as the related theoretical models permitted the TME-KD division to now "apprehend [future users'] perception and interaction with physical and digital worlds without having to dissociate the two worlds." She added that the methodologies created and now implemented in development projects permit "to foster immaterial value" and therefore meet a need related to "a major societal trend."

Mrs Favart and Mr Esquivel agreed that this research also introduced the notion of "experience" within TME-KD activities as well as, more importantly, tools and methodologies able to deal with it and communicate about it with a view to translate intentions into future cars attributes.

They pointed out that the theoretical background related to *user experience* and *kansei process* as well as the connection established between these notions and the industrial design process contributed to structure the "Kansei Competency Centre". This is now one of the three cross-functional collaboration-platform of TME. It centred on kansei and sensory quality and was created in 2012 (one year after the start of this research) (more information p. 22). In that context, Mrs Favart and Mr Esquivel also stressed the fact that this research contributed to provide guidelines for the flow of activities of NCD projects as well as for the flow information between NCD projects.

They mentioned that one of the challenges to meet in the future would be to integrate such guidelines and targets into the official operational procedure of the company. Envisioning a positive perspective to this challenge, Mrs Favart observed that "whereas in the past [TME-KD] struggled to get involved in some NCD projects, [the] participation [of TME-KD] in similar projects is now requested: in a sense [TME-KD] became inescapable" (Note: this evolution is attributed to a large numbers of activities, which include this Ph.D. research).

In order to better communicate internally the different industrial contributions as well as the underlying Kansei Design approach, Toyota-specific (confidential) communication material has been created. It has been regularly presented during the research project to TME's top management as well as to selected counterparts in TMC (Japan). The creation of an overview presentation and of separate prescriptive reports related to the final contributions are currently in process.

USE OF THE TOOLS, EARLY REPRESENTATIONS, AND METHODOLOGIES ACCORDING TO THE THREE TYPES OF NCD PROJECT

When reviewing the three types of methodologies (and their related tools and early representations), situations for which they are best adapted could be identified. In this sub-section, I will discuss the types of NCD project for which these different contributions are best adapted.

EXP 5 allowed a wider overview of experience design-driven NCD projects and of the different types of kansei representations. This has been very useful for discussing the challenges of the industrial design process that can be addresses with the Kansei Design approach (in terms of project context, design activities, design information exchanged).

Table 4.26 (p. 152) summarised the characteristics of "Exploratory concept," "Product lining strategy," and "Pre-development direction" projects. Recall that their purposes are respectively to "propose new experience concepts for future breakthrough products," to "identify user experience logics and directions for future platform products," and to "prepare grade and character strategies of future incremental products."

As mentioned earlier, I will now detail the industrial contributions that are the most suitable for each project-type. This discussion combines observations from projects already conducted and speculations about future uses. It is summarised in Table 5.9. Notably this discussion only includes direct contributions from this research. They are complementary to other experience design tools, methodologies, and early representations presented in the literature review (sections 2.4.3 and 2.4.4 [pp. 73-84]).

Table 5.9: Uptake of the industrial contributions in TME-KD's projects

	Exploratory concept	*Product lining strategy*	*Pre-development direction*
Tools	- UX harmonics - Kansei cards	- UX harmonics - Kansei cards - Mood boxes	- UX harmonics - Kansei cards - Mood boxes
Methodologies	- User research (quantitative) (Methodology A) - Desk research (Methodology C) - Co-creation with Kansei cards (Methodology C)	- User research (quantitative) (Methodology A) - Selection of fitting UX harmonics (Methodology A) - Pictures and music association (Methodology A) - Participatory design session (Methodology B)	- Selection of fitting UX harmonics (Methodology A) - Participatory design session (Methodology B) - Co-creation with Kansei cards (Methodology C)
Early representation *(Communication material)*	- Multi-sensory representation based on UX harmonics (intermediate output) (EXP 2) - Kansei cards mapping (intermediate output) (EXP 4)	- Multi-sensory representation based on UX harmonics (EXP 2) - Kansei cards arrangement (EXP 3) - Multi-sensory composition (Mood box, Kansei cards, multi-sensory samples) (EXP 3) - Kansei cards mapping (intermediate output) (EXP 4)	- Kansei cards arrangement (EXP 3) - Multi-sensory composition (Mood box, Kansei cards, multi-sensory samples) (EXP 3) - Kansei cards mapping (EXP 4)

"Exploratory concept" projects aim to influence or initiate the development of future breakthrough products. EXP 5 showed that their final outputs were mainly narrative in order to be able to facilitate the understanding of the new user experience situations investigated. In that sense, the early representations' creation in the previous experiments are not per se the most suitable to be used as final communication material. Nevertheless, *kansei cards mapping* and *multi-sensory representations based on UX harmonics* can help to respectively explore a wide range of possibilities and to identify insights helping with concept creation. These two types of early representations could therefore be used to intermediate outputs for EC projects. The representations imply the use of the methodologies A and C and of the related tools (UX harmonics, Kansei cards).

“Product lining strategy” projects’ objective is to identify a relevant and consistent set of experience directions for a given context (e.g., hybrid, small car). It is probably the one which is the most in line with the methodologies A and B. Both methodologies were indeed initially developed for projects of this type. Whereas methodology A is more adapted for situations in which an initial market study has already been realised (leading to a rather defined design brief), methodology B can be deployed at the same time as this exploratory market research (for instance during focus group interviews). The kansei representations resulting from both methodologies are rich in terms of design information and can also be understood and used by managerial- and working-level employees.

“Pre-development direction” projects take place in a context where many functional divisions (e.g., product planning, engineering, and styling design) are starting their investigations related to an upcoming new product development project. The time prospect is also much shorter-term than one of the two other project types. This has as a consequence that a lot of information available from other NCD projects (e.g., market-based and technology-driven projects) and that decision-makers already have a rather defined preconception about the results. The role of experience-driven projects is not only to “prepare grade and character strategies for future development projects” but also to unite the different stakeholders around a common intention. In order to fulfil its first role, the design team should try to gather the most valuable data. Methodologies combining rich data from users (user research, participatory design sessions) with the sensibility and experience of the different team members are among the most efficient ways to do this. In that sense, the use of methodologies A and B make perfectly sense for this type of project. On the other hand, methodology C has shown that it was very appropriate in order to facilitate a multi-cultural (multi-nationality, multi-gender, multi-functional) network of stakeholders and could therefore also be used for PDD projects; especially to fulfil their second role. As can be seen, the different methodologies developed in this research are complementary when it comes to “pre-development direction” projects.

5.3 Summary of the contributions

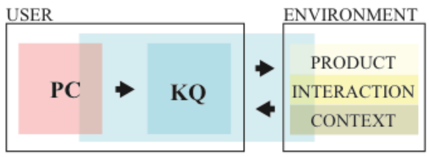
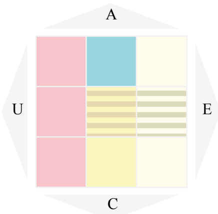
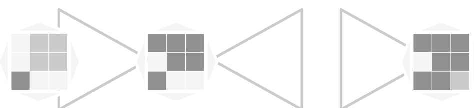
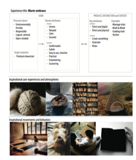
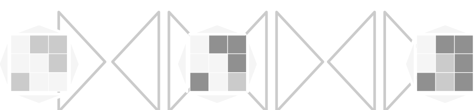
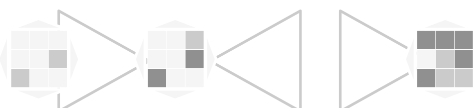
I will conclude this dissertation by presenting an overview of its different contributions. They have been organised in Table 5.10 according to their nature (the Table is spited in two parts).

The first ones are descriptive and help to detail the context of study: the experience occurring during a human-product interaction and the design information exchange in the early design phase (related to construction from the state of the art and the five experiments).

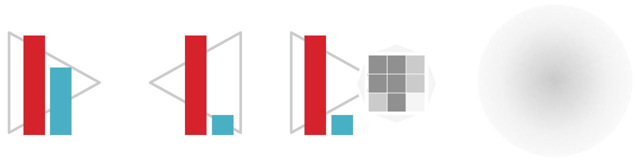
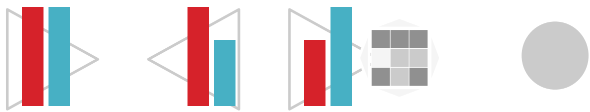
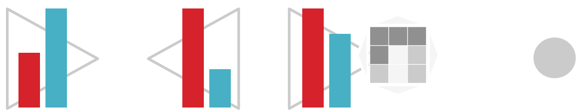
The second ones are prescriptive and introduce the Kansei Design approach including new methodologies and early representations (related to EXP 2, 3, and 4).

The last ones are mainly descriptive and present Kansei Design approaches for three types of industrial NCD projects (related to EXP 5).

Table 5.10: Summary of the main contributions of this Ph.D. research

Type of contribution	*Summary of the contributions*		
Descriptive: Context of study	Context of human-product interaction	 *Kansei-Experience framework*	
	Context of design information exchange during early design activities	 *Kansei design information model*	
Prescriptive: Kansei Design approach	Translation of user research		
	Participatory design sessions		
Design information: Not covered; Somewhat covered; Covered	Co-design within a design team	 *New methodologies*	 *New types of early representations*

<table>
<tr><th>Type of contribution</th><th colspan="2">Summary of the contributions</th></tr>
<tr><td rowspan="3">Mainly descriptive: Kansei Design approach in the industrial process

Type of reasoning used:
Abductive
Scientific</td><td>“Exploratory concept” projects</td><td></td></tr>
<tr><td>“Product lining strategy” projects</td><td></td></tr>
<tr><td>“Pre-development direction” projects</td><td></td></tr>
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6 CONCLUSION AND PERSPECTIVES

6.1 CONCLUSION

This PhD research is the fruit of the long-standing collaborations between the CPI laboratory from Arts&Métiers ParisTech and the Kansei design division from Toyota Motor Europe. It debuted in 2011 with the wish to develop an original approach for which hints could already be perceived from previous research projects (i.e. Master degree theses [Esquivel, 2006; Clos, 2009; Gentner, 2010], internal studies). The aim of this research was to create knowledge and know-how that could nourish the industrial design process in order to better take into account the future users' kansei process. The multi-cultural context of the company and of the market it addresses was already identified at that time as an area for research.

During the first months of the research, *user experience* emerged as a key notion and the related field of research became an influential area of the literature review. Until then, the scope of the activities conducted by TME-KD and of the collaboration with LPCI Arts&Métiers ParisTech was only focused on the affective process following sensory perception. As a result, the scope of the research refined itself and became centred on ways to discuss and represent user experience intentions in the early phases of the industrial design context. When defining the theoretical background of this research, a link had therefore to be created between the complementary notions of *user experience* and *kansei process*.

Based on this original field of study, the present dissertation discussed experience-centred design activities undertaken by design teams in order to nourish the much wider industrial design process. This area of research was selected because it had been observed that even though experience-centred tools and methodologies supporting design-activities existed, the uptake of experience-centred approaches in the industrial design process had only been poorly studied.

With the five experiments of this dissertation, I explored different angles. With the help of newly created tools and methodologies, I explored how the kansei process of future users of a product can be discussed during the early design phases of this product and how outcomes of these discussions can be represented in order to convey intentions related to the experience entities (e.g., attributes of the product and interaction to be designed, personal characteristics of the user groups to be targeted). I also investigated how the nature of the resulting early representations can impact reciprocal understanding within multi-cultural design teams and finally how the developed approach (Kansei Design approach) could impact different types of new concept development projects. Notably, this is one of the first times that the kansei process has been discussed in relation to the industrial process (Schütte [2005] already tackled the topic but mostly for evaluation activities).

In each of the five experiments, the multi-cultural dimension related to potential users and design teams was a major topic of discussion. The way it influences appeal for certain types of user experiences was discussed in EXP 1 (based on questionnaires) and EXP 3 (based on participatory design sessions), whereas EXP 2 and EXP 4 addressed the topic of reciprocal understanding among a multi-cultural design team. Finally EXP 5 detailed the characteristics of three types of experience-centred NCD projects occurring in a multi-cultural organisation.

This research finally led to both academic and industrial contributions. In terms of the former, it made it possible to model the kansei-related design information exchanged among design-teams as well as highlight the reciprocal understanding and kansei qualities of multi-sensory early representations resulting from experience-centred design activities.

Regarding the latter type of contribution, the different experiments permitted me to characterise the Kansei Design approach in terms of tools, methodologies, and early representations. Moreover, a link could be established between the different characteristics of this approach and three types of new concept development projects aiming to impact the development of new breakthrough, platform, and incremental products, respectively.

6.2 PERSPECTIVES

This research created ways to discuss and represent user experience intentions in the early phases of the industrial design context. It also contributed to modeling the different aspects of UX that can be discussed (i.e. the experience entities) and the ways to exchange design information related to them (i.e. kansei representations).

The kansei representations created in this dissertation have shown promising results but some of their limits could also be identified. For instance, they do not fit to every type of experience-centred project identified: outputs from NCD "exploratory concept" projects could not be communicated using them because this type of project seemed to require narrative representations. In that sense, further research should be conducted on narrative or interactive kansei representations (i.e. more engaging representations). These should also be able to take into account the temporal context of an experience and additional interaction attributes.

The industrial design process in the automotive industry is rather long. The NPD phase lasts between four and five years. The area that has been covered by this Ph.D. research is at the very front end of the process: at the transition between NCD and NPD. The kansei representations created were indeed meant to convey experience directions for the early NPD phase or for other NCD projects. In future studies it would be very interesting to investigate how the experience directions which identified and agreed with the different stakeholders evolve through the different stages of the new product development process. These studies would have to answer questions such as "How can the design information related to the experience directions be translated into technical or styling requirements?", "How much of the intended experience can be perceived in the final product?", and if a gap exists between the intentions and the results, "What are the causes of that gap?".

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1.1 INTRODUCTION

Cette recherche de doctorat est le fruit d'une longue collaboration entre le service « Kansei design » de Toyota Motor Europe (TME-KD) le « Laboratoire Conception de Produits et Innovation » (LCPI) d'Arts&Métiers ParisTech. Cette dernière a débuté en 2005 avec un premier étudiant accueilli par TME-KD pour son projet fin de cycle de Master. Depuis un total de sept étudiants en master ont contribué à enrichir cette collaboration. Un huitième était par ailleurs en acitivité au moment où ces lignes ont été écrites (année scolaire 2013-2014). Cette recherche constitue la première recherche de doctorat provenant de cette collaboration. Elle s'intéresse à la prise en compte de l'expérience utilisateur dans les phases amont du processus de conception de nouveaux produits. Des outils et des méthodologies contribuant à une meilleure prise en compte de l'expérience vont être présentés. Ces derniers seront discutés d'un point de vue industriel et académique. Au cours des prochains paragraphes, ce sont les contextes industriels et académiques qui vont tout d'abord être présentés.

1.2 CONTEXTE INDUSTRIEL

Fondé en 1937, Toyota Motor Corporation est aujourd'hui un des principaux constructeurs automobiles en termes de production, chiffre d'affaire et d'innovations. L'entreprise commercialise des véhicules avec les marques suivantes : Toyota, Lexus, Scion, Daihatsu et Hino trucks. Elle a acquit une renommée internationale avec son système de production, aussi connue sous le nom de "lean manufacturing." Centré sur la performance, ce dernier à la particularité de donner une grande importance à tous les employés dans l'amélioration du processus de fabrication. Depuis les années 80 ce système de production a été étudié de manière approfondie par l'industrie et le monde universitaire. Ballé et Ballé (2005) se sont aussi intéressés au processus de conception de nouveaux véhicules chez Toyota. Ils le décrivent comme aussi innovant et contre-intuitif que le processus de fabrication (aval). Comme le processus de conception constitue plus directement le contexte de cette recherche, les points clés de ce dernier décrits par Ballé et Ballé (2005) vont être détaillées. Ces auteurs l'ont comparé au processus de conception d'un concurrent américain. D'après ces derniers le processus de conception d'une automobile chez Toyota prend moitié moins de temps et implique seulement un quart des ressources humaines (150 au lieu de 600 ingénieurs).

Les quatre points clés du processus de conception Toyota, pris en compte dans tous les développements de nouveaux véhicules, sont les suivants :

- Toyota demande à ses ingénieurs de se soucier des attentes de leurs clients. Dans ce but, une vision forte est partagée au sein de chaque équipe de développement.
- Toyota tente de résoudre les problèmes majeurs dans les phases amont de conception et limite ainsi les changements technologiques tardifs.
- Une attention toute particulière est portée au flux des dessins techniques et à la conception de l'outillage.

- En misant sur son expertise dans le domaine du processus de fabrication, Toyota prend en compte la qualité et les coûts de production dès les phases amont du processus de conception.

Les auteurs décrivent aussi certaines activités clés permettant d'atteindre ces objectifs : le « concept paper » résultant de la « concept phase » (phase conceptuelle), l'utilisation de l'ingénierie concurrente et de l' « obeya », l'utilisation de nombreux outils et méthodologies standardisées, l'utilisation du système de production Toyota lors des phases de prototypages et de création de l'outillage, l'utilisation de plates-formes depuis le début des années 90 ou encore l'utilisation de pratiques « lean ».

En dehors du Japon, Toyota à ouvert des sièges régionaux comprenant des centres dans les régions suivantes : Amérique du Nord, Asie du Sud-Est et Europe (Figure 1.1). En Europe, le centre de recherche et développement de Toyota Motor Europe (TME) à ouvert en 1987 à Zaventem (Belgique). Il est situé à quelques kilomètres du siège Europe de Toyota centralisant ainsi pour cette région les principales activités du constructeur. Ce centre de R&D participe à la conception de la plupart des véhicules vendus en Europe et est responsable de la fabrication des véhicules assemblés en Europe.

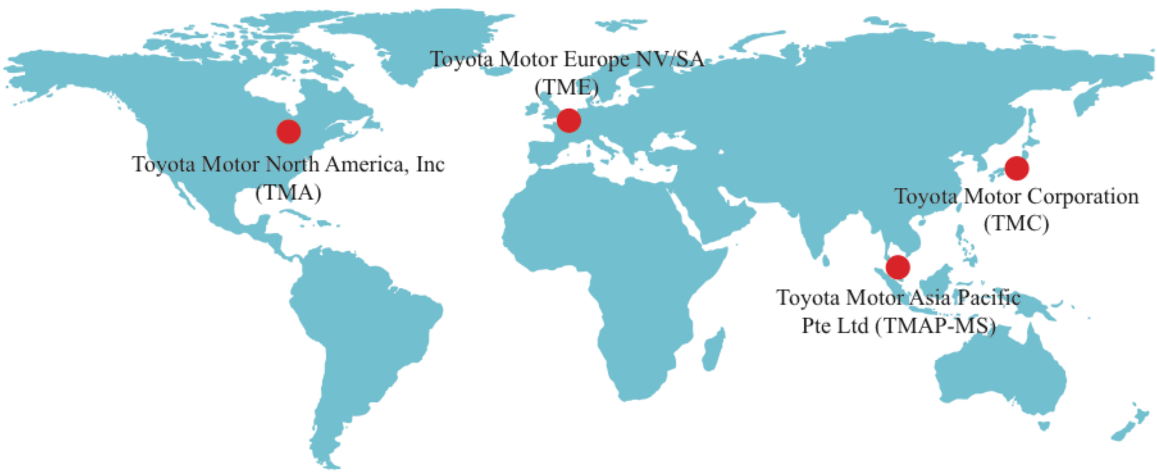


Figure 1.1: Les centres de R&D Toyota dans le monde

Tout au long de cette recherche j'ai été intégré au service « Kansei Design » de Toyota Motor Europe (TME-KD). Ce service fait partie intégrante du centre européen de recherche et développement présenté précédemment. « Kansei » est un mot Japonais décrivant un processus humain subjectif impacté (entre autre) par la perception sensorielle. Il peut être décrit comme à l'origine des émotions, des sentiments, et des impressions. Il sera plus longuement décrit dans l'état de l'art.

Le service a été créé en 2006 (approche initiée en 2003) et a la particularité de ne pas avoir de division-mère au Japon. Il s'intéresse aux aspects subjectifs liés à la perception des utilisateurs. Avec cette perspective, il mène des activités de recherche et participe au développement de nouveaux véhicules. L'analyse des activités amont de TME-KD sera le sujet de la cinquième expérimentation (EXP 5).

Au cours de sa courte histoire, l'approche et les domaines d'étude du service se sont considérablement enrichis (Figure 1.2).

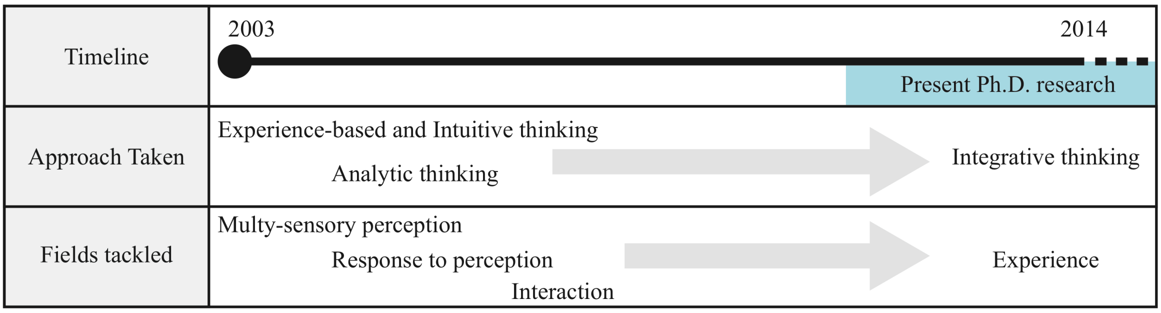


Figure 1.2: L'évolution de l'approche et des domaines d'étude de TME-KD dans le temps

L'approche initialement qualitative et basée sur la sensibilité (i.e. experience-based and intuitive thinking) a rapidement été complémentée par des raisonnements scientifiques et des données quantitatives (i.e. analytic thinking). Plus récemment ces deux approches ont été combinées et sont maintenant utilisées en synergie (i.e. integrative thinking). En terme de domaine d'application, le service était à l'origine centré sur les aspects multi sensoriels de la conception automobile. Ces considérations ont évolué pour prendre en compte la réponse des utilisateurs à la perception (émotion, sémantique et comportement). Cette prise en compte du comportement a par la suite amené l'équipe de TME-KD à aussi s'intéresser à l'interaction qu'il peut exister entre un utilisateur et un produit. Plus récemment la notion d'expérience d'utilisation a émergé. Cette dernière prend en effet en compte les différents domaines mentionnés précédemment de manière plus holistique. Dans la pratique, cette recherche de doctorat a contribué de manière substantielle aux dernières évolutions liées à l'approche et à ces domaines d'application (outils, méthodologies, représentations amont). Elle a aussi permis d'appuyer ces évolutions avec des contributions théoriques mises en lumière, par exemple, par le biais de publications académiques (modèle, framework). Sans divulguer d'informations confidentielles, cette recherche de doctorat va donc discuter ces contributions industrielles et académiques.

1.3 CONTEXTE ACADEMIQUE

Après avoir présenté le contexte industriel de cette recherche, place maintenant au contexte académique. Les paragraphes ci-après vont détailler les courants de recherche en design centré utilisateur qui ont influencé cette recherche, le positionnement de cette recherche par rapport aux activités de recherche du laboratoire CPI, et finalement l'approche prise par cette recherche (i.e. recherche-action).

1.3.1 APPROCHES DESIGN CENTREES UTILISATEUR

Cette recherche s'inscrit dans un courant récent de la recherche en design centré sur l'utilisateur qui s'intitule « Kansei Design ». Ce dernier s'appuie sur trois courant plus établis : « kansei engineering and science », « ergonomics and cognitive psychology in design » et « emotional and experience design » (Figure 1.3).

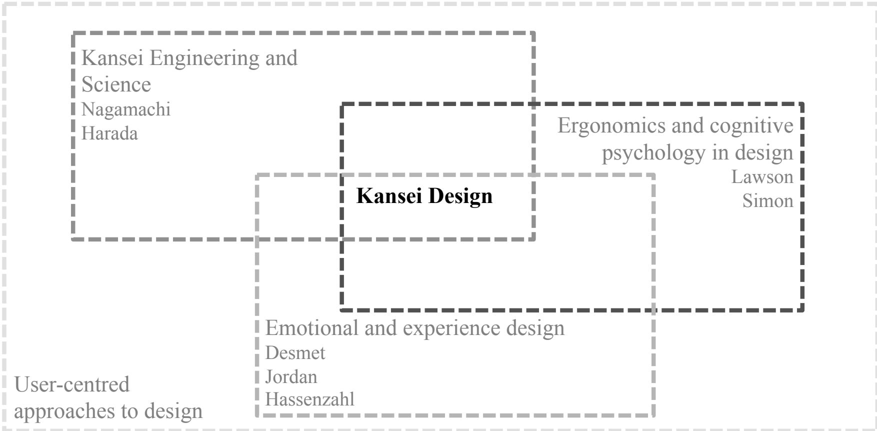


Figure 1.3: Kansei Design à l'intersection entre trois courants de design centré utilisateur

Les courants ont en commun le fait de s'intéresser à l'aspect subjectif de la perception humaine et aux implications que peut avoir cette subjectivité (de l'utilisateur ou du créateur) sur le processus de conception de nouveaux produits (ou services).

Les courants « kansei engineering and science » et « ergonomics and cognitive psychology in design » prennent tous les deux une posture scientifique. Ils sont apparus presque simultanément il y a de cela environ quatre décennies respectivement au Japon et en Occident. Le courant « emotional and experience design » est quant à lui plus récent. Il s'éloigne de considérations strictement scientifiques dans l'étude des interactions entre humains et produits (ou services). Il tend de ce fait à se baser sur la sensibilité des équipes de conceptions et des utilisateurs.

Lévy (2013) a été le premier à définir de manière approfondie la complexité du courant « kansei design ». Il a identifié deux types de recherche utilisant cette terminologie. Le premier type est basé sur des théories de perception indirecte et s'inscrit de ce point de vue dans la continuité des approches « kansei engineering and science ». Il se démarque de ces dernières par la prise en compte de la sensibilité des concepteurs afin de pouvoir être utilisé dans des situations comprenant de l'ambiguïté et l'incertitude (que des outils scientifiques seuls ne pourraient pas gérer). Cela permet ainsi à ce type de recherche de s'intéresser aux phases amont de la conception et à intégrer les différents acteurs de ce processus comme c'est le cas de cette dissertation. Le second type de recherche utilisant la terminologie « kansei design » s'intéresse quant à lui aux qualités des artefacts en termes d'interaction et est basé sur la théorie dite de la perception directe (phénoménologie).

1.3.2 POSITIONNEMENT PAR RAPPORT AUX RECHERCHES DU LABORATOIRE CPI, ARTS&METIERS PARISTECH.

Le laboratoire conception de produits et innovation d'Arts et Métiers ParisTech est un pionnier national en ce qui concerne la modelisation et l'optimisation du processus de conception de produits et l'innovation (Aoussat, 1990).

Cette recherche s'inscrit très clairement dans les thématiques du laboratoire en s'intéressant à la prise en compte du kansei de l'utilisateur final dans les phases amont de conception. Un certain nombre de rapprochements peuvent aussi être fait avec des travaux récents du laboratoire. Une des notions principales discutée dans cette recherche est « l'expérience d'utilisation ». Cette dernière a par ailleurs déjà été prise en compte dans les travaux de thèse de Ocnarescu (2013) et Bongard-Blanchy (2013).

Cette recherche a aussi la particularité de toucher les quatre activités design (i.e. design activities) décrites par Bouchard et Aoussat (2003), professeurs au laboratoire CPI (Figure 1.4). Ces dernières sont analysées dans le contexte de la création de représentations amont. Sur ce même sujet, des travaux antérieurs avaient déjà établis des liens entre le kansei de l'utilisateur final et les activités d'information (Mougenot, 2008) (i.e. information activity), de génération (Kim, 2011) (i.e. generation activity) et d'évaluation et décision (Mantelet, 2006) (i.e. evaluation and decision activity).

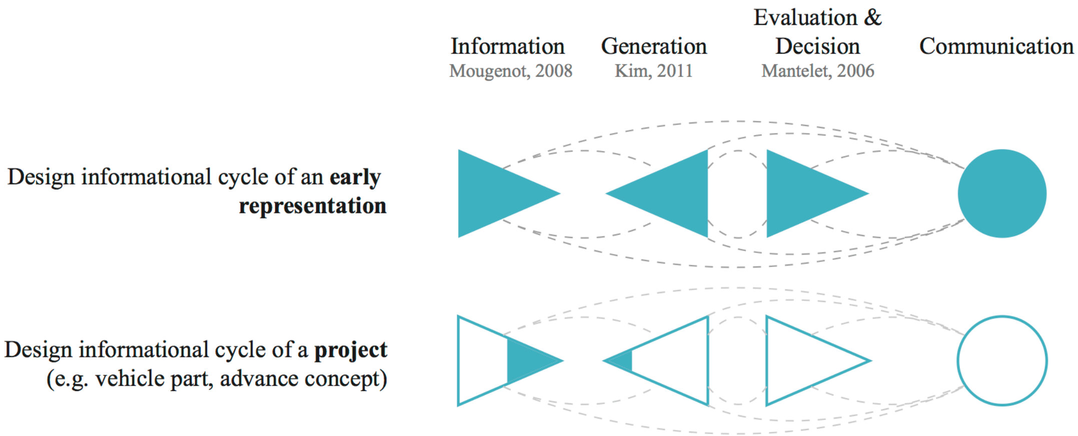


Figure 1.4: Positionnement par rapport au « design informational cycle » (Bouchard & Aoussat, 2003)

Les recherches du laboratoire visant à mesurer le processus kansei se sont appuyées sur les trois types de mesures possibles : psychologique, physiologique et comportementale. Cette recherche s'intéresse uniquement aux mesures psychologiques (Figure 1.5). L'originalité des mesures pratiquées réside néanmoins dans le fait que des stimuli multi sensoriels sont utilisés sur les échelles sémantiques en plus des traditionnels mots-clés.

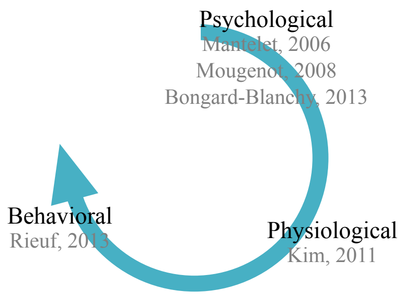


Figure 1.5: Recherches impliquant une mesure du processus kansei faites au LPCI, Arts&Métiers ParisTech

1.3.3 LA RECHERCHE ACTION COMME APPROCHE DE RECHERCHE

Durant les trois années qui ont conduit à cette thèse, j'ai eu deux perspectives sur les sujets traités : celle d'un chercheur au sens académique du terme (en temps que doctorant à Arts&Métiers ParisTech) et celle d'un praticien (en temps que membre à part entière de l'équipe TME-KD).

La Figure 1.6 illustre bien comment ces deux rôles permettent de mettre en relation les domaines de pratique et de la théorie dans une approche de recherche action (Owen, 1998). La connaissance est utilisée pour travailler dans la pratique (la conception de nouveaux produits), et est évaluée à acquérir de nouvelles connaissances et décrire de nouveaux modèles liés à la théorie de la conception. Cela conduit à un processus itératif de recherche impliquant des cycles de recherche et d'application.

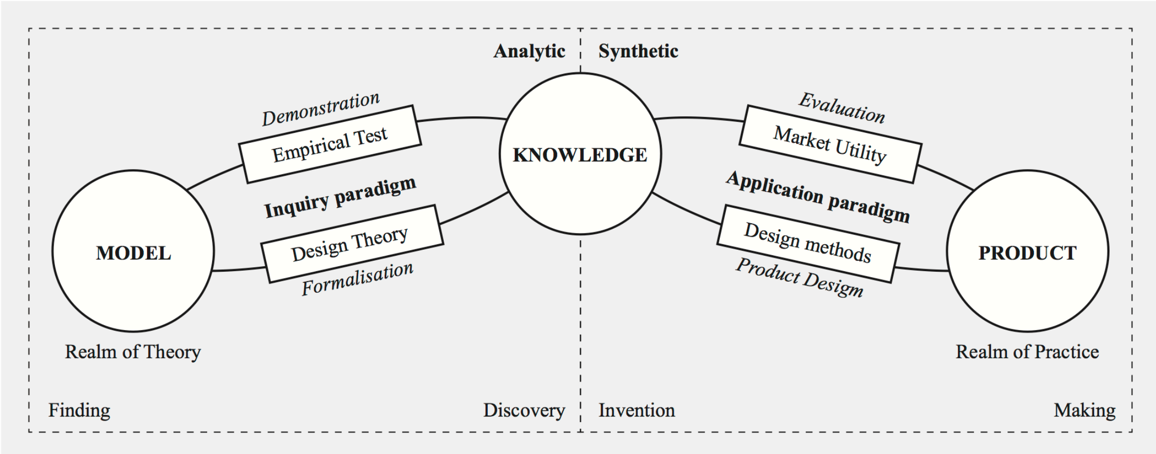


Figure 1.6: Les processus d'utilisation et de création de connaissance dans le domaine de la conception (Owen, 1998)

Selon Reason et Bradbury (2001), la recherche action est très bénéfique pour pratique, car elle permet une meilleure compréhension de certains des problèmes rencontrés et en même temps permet des changements. Lawson (2004) a également observé que beaucoup de choses qui se passent en pratique dans les processus de conception sont implicites, et en ce sens sont presque impossibles à percevoir d'un point de vue externe. Comme elle se penche sur le processus de conception d'un point de vue interne, l'approche de la recherche-action a à cet égard un avantage majeur par rapport aux «études de laboratoire» liées au processus de conception industrielle. D'autre part, les inconvénients existent aussi: une approche de recherche-action ne permet par exemple pas de réaliser d'études comparatives (entre les outils, méthodologies ...) dans un contexte identique (i.e. un même projet). Ces études ne correspondent en effet pas aux notions de rentabilité et d'efficacité présentes dans un contexte industriel.

2 ETAT DE L'ART

2.1 INTRODUCTION

La revue de la littérature de cette thèse établit une connexion entre les deux principales notions introduites dans le contexte: l'*expérience d'utilisation* qu'on peut obtenir lors de l'interaction avec un produit et le *processus industriel de conception* d'un tel produit. La Figure 2.1 représente schématiquement cette connexion. Il introduit également deux notions complémentaires qui sont elles aussi clés pour cette recherche: les *activités design centrées sur l'expérience* et *l'environnement culturel*.

L'*environnement culturel* est représenté comme englobant les autres notions car il est présent dans toutes ces dernières : la culture de l'utilisateur qui interagit un produit et la culture des membres de l'équipe de conception impliqués dans les activités design et plus globalement dans le processus de conception. L'intérêt particulier de cette thèse est la façon dont l'expérience de l'utilisateur peut être prise en compte au cours du processus de conception et en particulier dans les phases amont. C'est pourquoi l'*expérience d'utilisation* est au centre de la figure. Enfin, les *activités design centrées sur l'expérience* sont représentées entre les deux autres notions majeures comme un moyen de prendre en compte l'*expérience d'utilisation* dans le contexte industriel.

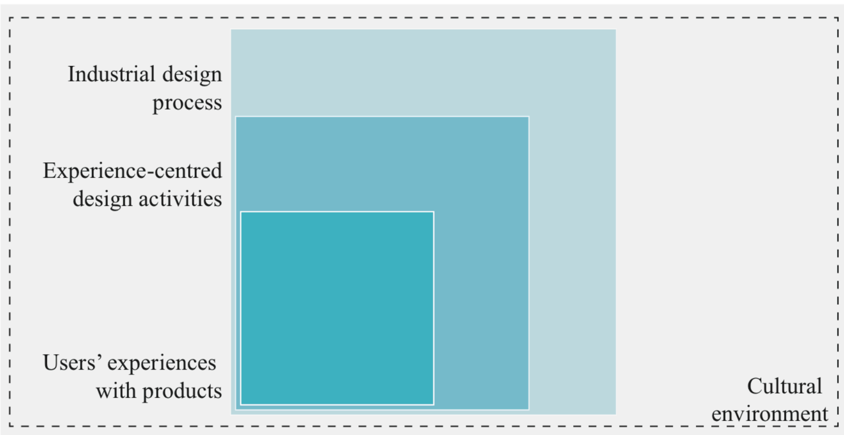


Figure 2.1: Notions couvertes par l'état de l'art

2.2 L’EXPERIENCE UTILISATEUR

Dans les sections suivantes, la description du processus de perception d'un utilisateur sera discutée à partir des points de vue de la recherche Kansei et de la recherche en design d’expérience. Un modèle (i.e. kansei-experience framework) permettant de rassembler les points de vue sera aussi présenté. Il sera ensuite utilisé comme base théorique pour le reste de cette recherche.

2.2.1 DU POINT DE VUE DES RECHERCHES KANSEI

Les études Kansei sont généralement transversales et impliquent des chercheurs de domaines tels que les sciences cognitives, la psychologie et l’ingénierie ainsi que la recherche en design ou en marketing. Bien que le mot kansei soit largement utilisé dans la littérature scientifique des sciences de la conception, il est habituellement défini brièvement comme une introduction au contexte de l'étude présentée et est interprété de diverses façons (Lee et al., 2002). Parmi les raisons mises en avant, la principale est que cette notion, étroitement liée à la culture japonaise, est impossible à traduire avec un seul mot dans des langues tel que l’anglais ou le français (Schütte, 2005).

Afin d’améliorer la compréhension réciproque lié à la notion de kansei (entre les mondes industriel vs académique et entre l’Orient et Occident) Lévy, Lee, et Yamanaka (2007) ont tenté de la définir de manière plus détaillée en prenant en compte des recherches antérieures. Ils définirent la notion de kansei en fonction de trois aspects: le *processus kansei*, le *moyen kansei* et le *résultat kansei* (i.e. kansei process, kansei mean, kansei result). Ainsi les auteurs caractérisent le kansei comme un processus (*processus kansei*) présenté dans un contexte clair comprenant des données d’entrée (*moyen kansei*) et de sortie (*résultat kansei*). Ces trois différents aspects sont définis ainsi :

• Le *processus kansei* regroupe les fonctions cérébrales liées aux émotions, à la sensibilité, aux sentiments, et à l'intuition ainsi que les interactions qu’il existe entre ces dernières.

• Les *moyens kansei* sont tous les sens (vue, ouïe, goût, odorat, le toucher, l'équilibre, la reconnaissance...) et probablement, d'autres «facteurs internes» (tels que la personnalité, l'humeur, les expériences de l’utilisateur).

• Le *résultat kansei* est le fruit du processus de kansei (i.e. des processus de ces fonctions cérébrales et de leurs interactions). Cet aspect vient du fait qu’il semble y avoir une perception unifiée offrant un sens et une valeur qualitatifs à l'environnement direct d'une personne. En d'autres termes, le résultat kansei représente ce qu’une personne perçoit de manière qualitative de son environnement. Par conséquent, le kansei est une synthèse de ses qualités sensorielles.

Comme mentionné ci-dessus, les *moyens kansei* fournissent des informations au *processus kansei* qui mène ensuite à des *résultats kansei*. Le flux entre les trois aspects n’est pas strictement linéaire car les *moyens kansei* et les *résultats kansei* s'influencent mutuellement (Figure 2.2). Notez également que la nature des *résultats kansei* est toujours mentale (ni physiologiques, ni comportementaux) mais que des conséquences kansei peuvent être observées à des niveaux psychologiques, physiologiques et comportementaux. Cela implique que les différents aspects mesurables du kansei d’un individu sont ses causes (point 1 de la Figure 2.2), les « facteurs internes » (point 2) et ses conséquences (points 3 à 5) mais pas le processus proprement dit.

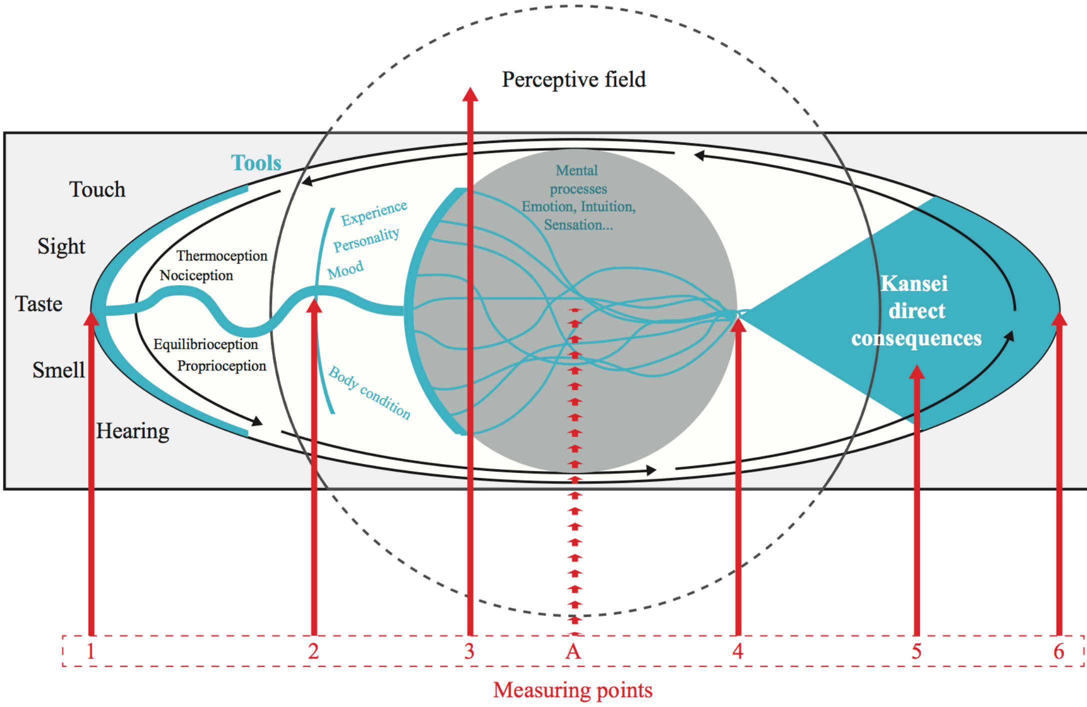


Figure 2.2: Une description visuelle du kansei et des études kansei (Lévy et al., 2007)

2.2.2 Du point de vue des recherches en design d'experience

La communauté de recherche en design a récemment commencé à aborder des sujets liés aux processus mentaux liés à une stimulation sensorielle en utilisant nouvelles approches. Il est intéressant de noter que les modèles développés mettent également l'accent sur les processus et sur les résultats de ces processus.

2.2.2.1 Experience

La notion d'expérience (employée par exemple dans les expressions ; expérience utilisateur, expérience produit, et design d'expérience) est maintenant utilisée de plus en plus dans la littérature scientifique pour décrire une interaction homme-artefact (instrumental ou non). Desmet et Hekkert (2007) ont défini l'expérience du produit comme un changement en terme de noyau affectif (i.e. core affect) qui est attribuée à l'interaction homme-produit. La notion de «noyau affectif» est ici définie comme se référant à tous les types d'expériences subjectives qui ont une valence, c'est à dire qui impliquent une perception de bonté, de méchanceté perçue, ou un sensation agréable ou désagréable.

Il est également intéressant de noter que la plupart des chercheurs différencient la notion d'expérience de celle d'utilisabilité faisant valoir que l'utilisabilité ne reflète pas un changement en terme de noyau affectif. Une relation d'interdépendance à cependant été décrite entre ces deux notions (Buxton, 2007; Desmet et Hekkert, 2007).

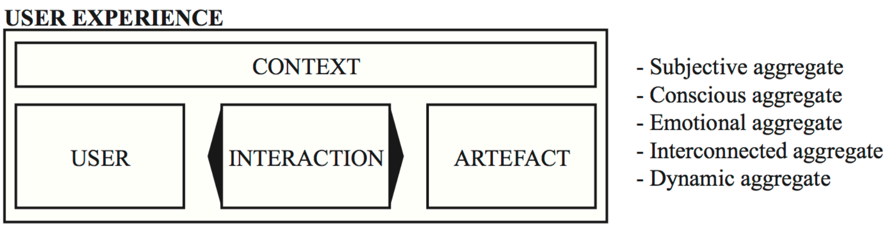


Figure 2.3: Modèle synthétique de l'expérience d'utilisation (Ortíz Nicólas & Aurisicchio, 2011)

Ortiz Nicolas et Aurisicchio (2011) ont analysé 11 modèles de la littérature liés à l'expérience d'utilisation dans le but de réunir dans une vue d'ensemble cohérente la littérature sur le sujet. La conclusion de cette recherche suggère que, même si les perspectives des 11 équipes de chercheurs sont différentes, des *constituants* et des *agrégats* communs comme l'expérience utilisateur ont été effectivement reconnus par la majorité des points de vue examinés (Figure 2.3).

Ortiz Nicolas et Aurisicchio (2011) ont repris le terme «agrégat» utilisé initialement par Varela et al. (1991: p. 64) afin de caractériser les propriétés d'une expérience utilisateur. Ils ont décrit cinq types d'agrégats ainsi :

• Agrégat subjectif: Il fait référence au fait que l'expérience est personnelle. L'expérience d'un même produit à beaucoup de chance d'être différente pour deux personnes distinctes.

• Agrégat conscient: Les chercheurs s'accordent sur le fait que l'expérience se produit lorsqu'un utilisateur interagit avec un produit dans un état conscient.

• Agrégat émotionnel: Les chercheurs s'accordent sur le fait que les émotions semblent être l'un des aspects «visibles» d'une expérience.

• Agrégat interconnecté: Cette propriété vient du fait qu'une expérience émerge de l'interaction entre des processus cognitifs et affectifs, entre l'information sensorielle perçue, le comportement, et tous les autres systèmes qui caractérisent les êtres humains. Les chercheurs affirment donc qu'une expérience doit être comprise et étudiée en faisant des références à un ensemble interconnecté (par exemple, Hassenzahl [2010]).

• Agrégat dynamique: En raison de son constituant lié à l'interaction, une expérience est en constante évolution. Cet aspect différencie l'expérience d'une situation dans laquelle le produit serait perçu de manière uniquement statique.

2.2.3 CONVERGENCE DES PERSPECTIVES KANSEI ET USER EXPERIENCE DESIGN?

Une partie de l'originalité de cette recherche est qu'elle combine des notions de la recherche en design «occidental» (i.e. lié par exemple au design émotionnel) et des notions de la recherche kansei (principalement oriental). Comme indiqué dans les sections précédentes, les deux approches ont en commun le fait qu'elles décrivent un processus humain subjectif impliquant une dimension affective faisant suite à la perception d'une construction artificielle (produit, interaction, service ...). En effet, de la même manière que l'expérience se distingue de l'utilisabilité, le kansei se distingue du chisei (conduisant à la compréhension intellectuelle) et s'oppose au risei (processus de construction mentale logique). Afin de définir un cadre clair pour les expérimentations de cette recherche, je vais utiliser cette section pour mettre les deux points de vue en perspective et construire « Kansei-Expérience framework» qui sera utilisé comme base pour les discussions suivantes.

Tout d'abord, il est intéressant de noter qu'il y a une différence en terme de point de vue entre les deux notions: «kansei» est centrée sur les processus mentaux subjectifs d'un individu, tandis que «l'expérience» est plus englobante et décrit d'un point de vue plus large un utilisateur interagissant avec un produit dans un environnement et contexte précis. Ce second point de vue est clairement exprimé par Desmet et Hekkert : «l'expérience n'est pas la propriété d'un produit, mais le résultat de l'interaction homme-produit" (2007: p. 63). Concernant l'utilisateur, cette perspective s'intéresse principalement aux expressions visibles des processus mentaux (par exemple, le plaisir, l'attrait, les émotions, les associations sémantiques). Ces expressions visibles correspondent du point de vue de la recherche kansei aux conséquences directes kansei décrites par Lévy et al. (2007).

Les deux points de vue peuvent être combinés dans un framework décrivant une interaction utilisateur-produit dans un environnement donné (le contexte d'une expérience), le processus de kansei, et le résultat de ce processus: les « qualités kansei perçus ». Ils correspondent à Kansei conséquences directes (Lévy et al., 2007), y compris les réponses des utilisateurs comme le plaisir, ce qui signifie élaboration, émotions primaires et secondaires (Colombo, 2012). Ce framework est présenté dans la Figure 2.4.

Comme expliqué précédemment, la compréhension (liée à l'intelligibilité des fonctions, facilité d'utilisation) est dissociée des *qualités kansei perçues* mais est encore représenté sur le framework comme un facteur influençant le processus de Kansei. Les autres facteurs influant représentés comprennent les caractéristiques personnelles de l'utilisateur et les attributs de l'environnement (i.e. produit, interaction, contexte).

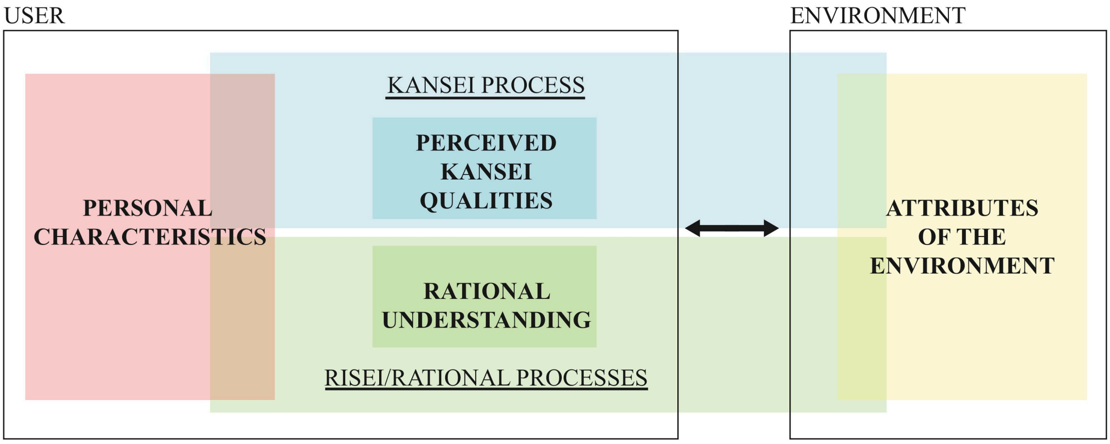


Figure 2.4: Framework générique mettant en relation les perspectives de recherche kansei et de recherche en expérience d'utilisation

Un framework simplifié est présenté ci-après: le « Kansei-Experience framework" (Figure 2.5). Il est centré sur le processus kansei qui est le cœur de cette thèse.

Le processus kansei est représenté comme le lien entre les entités de l'expérience utilisateur : les qualités kansei perçues englobent des notions telles que le plaisir, le sens, les émotions, les caractéristiques personnelles couvrant les notions de culture (e.g. l'âge, le sexe, la nationalité, la fonction, affiliation organisationnelle), les valeurs, la personnalité, mentalité, ainsi que la mémoire, et attributs liés au produit, à l'interaction et au contexte (attributs de l'environnement).

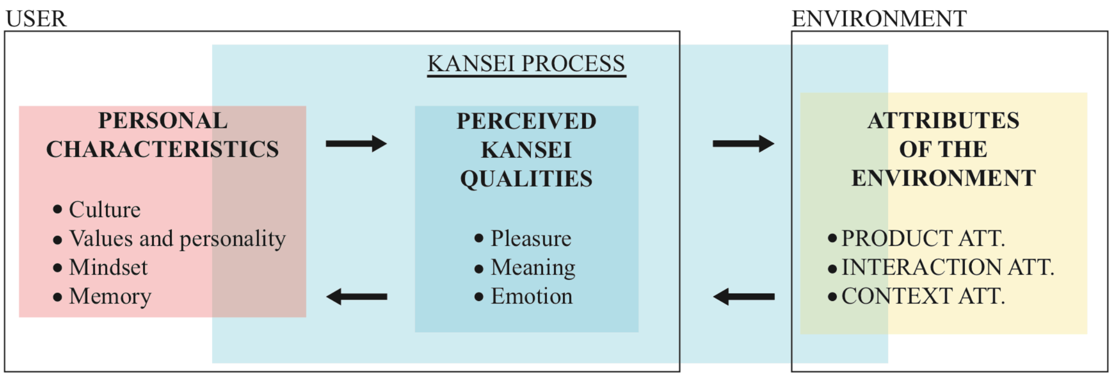


Figure 2.5: Kansei-Experience framework

Les qualités kansei perçues seront utilisées comme marqueurs du processus kansei car ils ont la particularité d'être observables directement. Dans le cas de cette thèse, ces observations indirectes du processus kansei seront effectuées sur les réactions psychologiques (questionnaires et entretiens) en utilisant les informations exprimées par les utilisateurs, tels que les associations sémantiques, les émotions, l'attrait et/ou le plaisir.

La section suivante portera sur la littérature existante relative à l'influence des caractéristiques personnelles de l'utilisateur et des attributs de l'environnement sur le processus kansei et les qualités kansei perçues.

2.2.4 Influences des caracteristiques personnelles et des attributs de l'environnement sur les qualites kansei perçues

Attributs produits – Environnement

Les influences des attributs produits sur les qualités kansei perçues ont fait l'objet de nombreuses recherches. Itten s'est par exemple intéressé à la couleur (1967) ainsi qu'aux formes et aux textures (1983). L'influence des formes, couleurs et dimensions des produits sur les qualités kansei perçues ont aussi fait l'objet de nombreuses études dans le domaine de la recherche en ingénierie kansei (e.g. Nagamachi, 1997).

Des recherches plus récentes ont étudié les influences d'autres modalités sensorielles telles que le tactile (Moussette, 2012) et l'ouïe (Özcan et Sonneveld, 2009). Zampini et al. (2003) et Schifferstein et al. (2008) ont quant à eux souligné l'importance de traiter les différentes modalités sensorielles simultanément dans ce type de recherche.

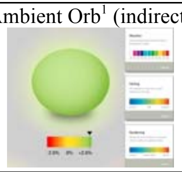
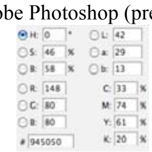
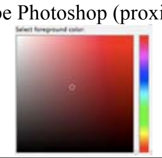
Karjalainen (2006) a étudié la marque d'un produit comme un attribut produit supplémentaire. La marque d'un produit implique en effet des qualités kansei spécifiques à ces utilisateurs. Ces dernières sont par exemple induites par l'information sensorielle perçue par les utilisateurs au cours d'une expérience produit, ainsi qu'à leurs souvenirs des expériences passées.

Attributs d'interaction - Environnement

L'interaction est ce que lie les utilisateurs et les produits. Ce lien abstrait, qui a longtemps été négligé dans la recherche en design, est maintenant considéré comme un élément essentiel de l'expérience utilisateur (Ortiz Nicolas & Aurisicchio, 2011). Les chercheurs explorent aujourd'hui ses qualités esthétiques (Hummels et Overbeeke, 2010), ainsi que sa sémantique et l'impact qu'elle peut avoir sur les émotions de l'utilisateur (Forlizzi & Batterbee, 2004).

En raison de leur caractère abstrait, les attributs d'interaction nécessitent plus d'efforts pour être décrits. Lim et al. (2007) ont élaboré un schéma taxonomique afin de décrire des logiques d'interactions (i.e. un type d'attribut d'interaction). Ils ont proposé le concept « d'interaction gestalt » composé d'une liste de onze attributs: « connectivity », « continuity », « directness », « movement », « orderliness », « pace », « proximity », « resolution », « speed », « state », and « time-depth ». Trois d'entre eux sont présentés dans le Tableau 2.1. Ils sont considérés comme un outil pour les concepteurs et les chercheurs pour comprendre et décrire les interfaces. "Normaliser" les attributs d'interaction permet d'identifier les attributs qui peuvent être manipulés et la façon de les manipuler lors du design d'interactions (Lim et al., 2011).

Tableau 2.1: Exemple de trois attributs de l'interaction gestalt (Lim et al., 2007)

Attributes	*Definition*	*Examples*	
Continuity (discrete-to-continuous)	The level of continuity of users' manipulation toward interface elements.	SanDisk Sansa (discrete) 	Apple iPod (continuous) 
Directness (indirect-to-direct)	The level of directness of what is shown through an interactive artefact or its information elements	Ambient Orb[1] (indirect) 	Weather.com[2] (direct) 
Proximity (precise-to-proximate)	The level of proximity of controlling information.	Adobe Photoshop (precise) 	Adobe Photoshop (proximate) 

[1]http://www.ambientdevices.com/technology/glanceable-information
[2]http://www.weather.com/weather/today/Paris+FRXX0076:1:FR

Le protocole d'interaction de Krippendorff (2006) peut également être utilisé en tant que schéma taxonomique. Lin Cheng (2011) l'a utilisé pour étudier et comparer les qualités kansei perçues résultant de séquences d'interactions spécifiques. Cette analyse séquentielle montre que les mouvements du produit et les gestes de l'utilisateur sont d'importants types d'attributs d'interaction qui influencent beaucoup l'expérience utilisateur. Une recherche de Klooster et Overbeeke (2005) introduisant la notion de chorégraphie de l'interaction a également souligné ces types d'attributs d'interaction.

ATTRIBUTS DU CONTEXTE – ENVIRONNEMENT

Le contexte dans lequel une interaction utilisateur-produit a lieu a également une grande influence sur la façon dont les utilisateurs perçoivent une expérience (Forlizzi & Battarbee, 2004). Ortiz Nicolas et Aurisicchio (2011) ont détaillé quatre types de contextes pour une expérience. Chacun d'eux a fait l'objet de recherches approfondies : contextes physique (Underhill, 2000), situationnel (Hassenzahl et al., 2002), social (Forlizzi & Battarbee, 2004 ; Battarbee & Koskinen, 2005) et temporel (Karapanos et al., 2009 ; Fenko et al., 2010).

CARACTERISTIQUES PERSONNELLES

Je vais maintenant détailler les recherches portant sur l'influence des caractéristiques personnelles de l'utilisateur.

La culture d'un individu peut être définie par des caractéristiques telles que son sexe, sa nationalité, son âge, ou sa fonction. En ce sens, la notion de culture est très similaire à celle de démographie. Les études empiriques dans les domaines de la science cognitive, du kansei, et la recherche en design d'expérience ont étudié de manière extensive les influences que la culture d'un individu peut avoir sur la façon dont il perçoit et interagit avec les produits.

Par exemple, Medeiros et al. (2008) ont observé l'influence de l'âge sur la perception de l'expérience et Schroeder (2010) les différences entre les femmes et les hommes. Les différences de perception des qualités kansei ont également été observées entre orientaux et occidentaux tels que par exemple dans la recherche de Haring et al. (Japonais/Européen) (2012), Lee et Ho (Orient/Occident) (2008) et Tomico et al. (Néerlandais/Japonais) (2009). En ce qui concerne les études portant sur plus d'une région linguistique la phase d'évaluation doit être traité avec soin. Lors de l'utilisation d'évaluation par mot-clé, Fenko et al. (2010) ont observé des différences de sens littéral et métaphorique entre les différentes traductions des mots-clés. Laurens et Desmet (2012) ont également observé des différences de compréhension des outils de mesure non-verbale (par le biais des émotions représentées avec les pictogrammes animés de l'outil PrEmo).

Avec le Rokeach Value Survey (RVS), Rokeach (1973) a proposé deux listes pour deux types de valeurs différentes. Les valeurs terminales (i.e. terminal values) correspondent à des buts/objectifs existentiels: des objectifs que l'on souhaite atteindre dans sa vie (par exemple, une vie confortable, un sentiment d'accomplissement). Les valeurs instrumentales (i.e. instrumental values) font référence à des types de comportement préférés: la manière par laquelle un individu tente d'atteindre ses valeurs terminales (par exemple, l'ambition, l'ouverture d'esprit). Les valeurs du RVS ont été utilisées par différents chercheurs dans les recherches portant sur l'influence des valeurs des utilisateurs sur les qualités kansei perçues (Desmet et al, 2004; Bouchard et al, 2009.).

2.3 PROCESSUS INDUSTRIEL DE CONCEPTION

2.3.1 VUE D'ENSEMBLE

Le contexte industriel donne un cadre, ainsi que d'un ensemble d'objectifs et de contraintes à la pratique de la conception. Au sein d'une organisation une équipe de personnes, appelée équipe de conception, est responsable du processus de conception d'un produit. Elle est composée de membres des différentes fonctions assurant l'ensemble des opérations liées à ce processus. Le processus industriel de conception d'un produit peut être divisé en plusieurs macro-phases. Une représentation de celui-ci par Buijs (2012) peut être trouvée sur la Figure 2.6. Quatre macro-étapes différentes du processus de conception peuvent être distinguées dans ce modèle: "développement de nouveaux concepts" (représenté en bleu sur la Figure 2.6), «développement de nouveaux produits» (représenté en jaune), la «commercialisation» (représentée en orange), et "l'utilisation du produit" (représenté en vert). Ces phases sont relativement consensuelle entre les chercheurs et ne sont pas spécifiques à Buijs. Elles sont aussi référencées dans les écrits de certains des chercheurs les plus influents du domaine comme Cooper (2008) et Cross (2008).

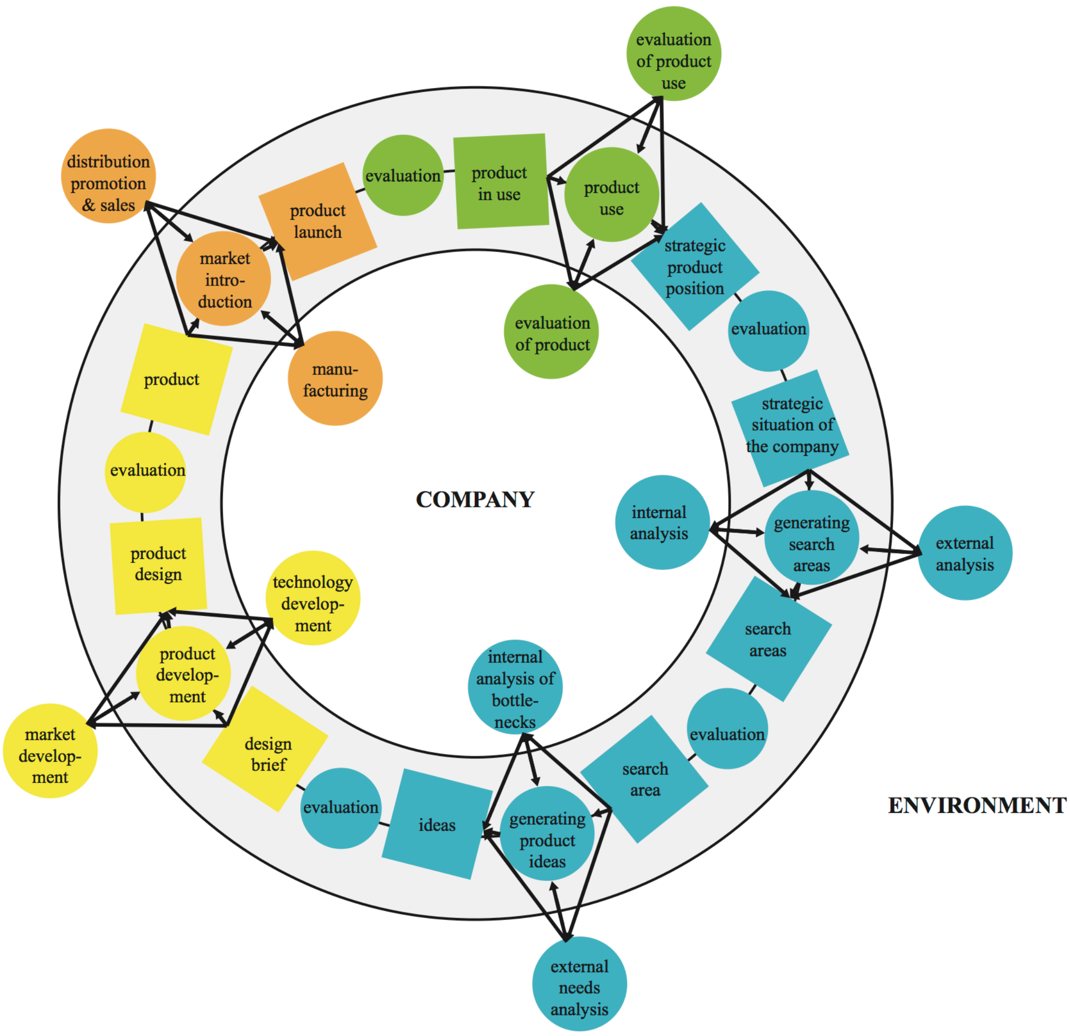


Figure 2.6: Delft Innovation model (Buijs, 2012)

Wheelwright et Clark (1992) ont distingué trois grands types de nouveaux produits: « des produits de pointe » (i.e. breakthrough products), « des produits plates-formes » (i.e. platform products) et les produits incrémentiels (i.e. incremental products). Ils caractérisent des nouveaux produits en fonction de la qualité de changement (sur le produit et le processus) induit par leur développement (Figure 2.7).

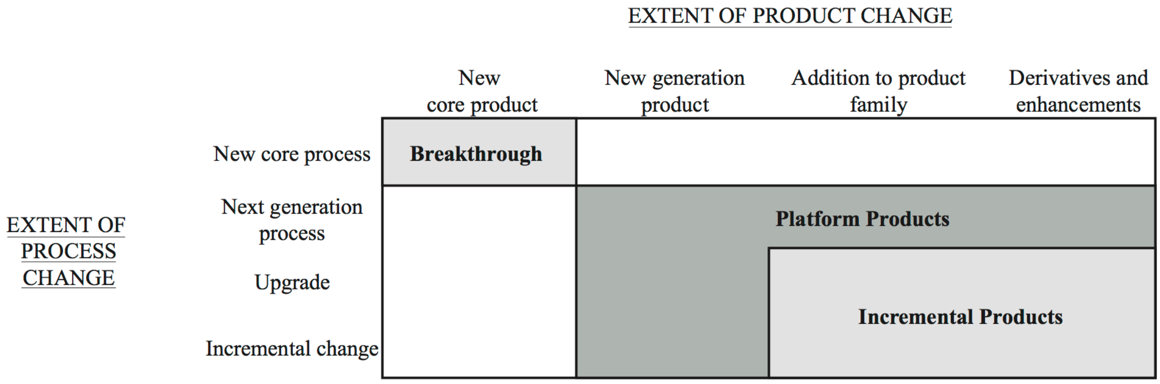


Figure 2.7: Typologies de nouveaux produits (Wheelwright & Clark, 1992)

Cette recherche touche principalement trois des quatre étapes du processus industriel de conception. La première est l'utilisation du produit (représenté en vert sur la Figure 2.6). Il correspond à l'aboutissement, mais aussi au point de départ de tout processus de développement centré sur l'utilisateur. Lorsqu'il est considéré comme le point de départ du processus il doit être considéré comme une source d'information concernant les utilisateurs actuels, leurs usages et l'expérience offerte par les produits déjà sur le marché (Buijs, 2012). Des perspectives tirées de ces observations combinées à la vision d'une société conduisent à des décisions sur les orientations de recherche (Koen et al., 2002).

Deux autres étapes seront couvertes par cette étude: le développement de nouveaux concepts (représenté en bleu sur la Figure 2.6) et le développement de nouveaux produits (représenté en jaune sur la Figure 2.6). Une attention particulière sera accordée à la transition entre le développement de nouveaux concepts (NCD) et le développement de nouveaux produits (NPD).

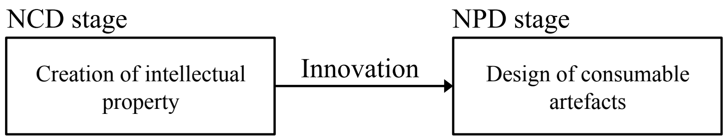


Figure 2.8: Interactions entre création de propriété intellectuelle, conception de produit et innovation (adapté de Gero [2010])

Je vais utiliser le vocabulaire introduit par Gero (2010) pour expliquer les distinctions en terme d'objectif entre les phases de NCD et de NPD. D'une part, le NCD a pour but de créer de la propriété intellectuelle, tandis que d'autre part, la phase de NPD est sur la conception d'objets consommables (Figure 2.8). Gero décrit l'innovation comme étant la mise en place ou l'absorption de la propriété intellectuelle (créé lors de l'étape NCD) dans le développement de nouveaux produits (NPD). Comme indiqué précédemment, ces innovations peuvent être liées à des produits et/ou à des processus. Cela signifie aussi que les deux étapes (NCD et NPD) sont nécessaires pour observer des innovations. Selon les changements qu'ils impliquent, les innovations sont décrites différemment (d'innovation incrémentale à innovation radicale). Leur nature a également des répercussions de la typologie des produits associés (Figure 2.7) (Wheelwright & Clark, 1992). De ce fait, la nature de la propriété intellectuelle créée détermine aussi la stratégie de développement de produits qui sera adoptée par les chefs de projet (Verworn & Herstatt, 1999).

2.3.2 L'ETAPE DE NEW CONCEPTS DEVELOPMENT (NCD)

Alors que l'étape NPD est plutôt structurée et organisée, l'étape NCD est décrit comme beaucoup plus chaotique et avec des sorties incertaines (Koen et al, 2002; Kim & Wilemon, 2002; Sandmeier et al, 2004). C'est pourquoi il est aussi appelé le « fuzzy front-end » du développement de nouveaux produits. En raison des différences fondamentales, la structure du NPD ne peut pas nécessairement être transposée aux activités amont. Koen (2004) a montré que cela est particulièrement vrai dans le cas de nouveaux produits appartenant aux catégories « produit plate-forme » (i.e. platform product) et « produit de pointe » (i.e. breakthrough product). L'étape de NCD peut apporter des avantages compétitifs majeurs, mais est en même temps reconnue comme étant la partie la plus difficile du processus d'innovation en raison de son incertitude (Kim & Wilemon, 2002; Verworn, 2009). Cette incertitude est visible à plusieurs niveaux tels que le travail, la date de commercialisation, le financement, les recettes attente, l'activité et la mesure des progrès accomplis.

Même si les chercheurs s'accordent sur certaines caractéristiques et propriétés des projets NCD, les modèles qu'ils utilisent pour décrire ce stade du processus de conception industrielle sont en fait très différents. Cinq d'entre eux sont résumés dans le Tableau 2.2. Les cinq modèles différents peuvent être divisés en deux groupes décrivant soit un «processus structuré» ou un «processus chaotique."

Les modèles appartenant à la première catégorie couvrent le processus NCD avec une création processus très structuré et des activités d'évaluation. C'est le cas des modèles de Cooper (2008) et de Buijs (2012) qui couvrent les étapes NCD et NPD dans la même logique linéaire. Les auteurs de modèles NCD spécifiques font valoir que ces processus linéaires sont incapables de transcrire la nature spécifique des projets NCD (e.g. Koen et al. [2004]). Kurkkio (2011) a également observé que ces descriptions sont principalement axées sur le développement de produits assemblés et ne sont pas particulièrement adaptés pour faire face à l'innovation dans des domaines fortement liés à l'expérience de l'utilisateur, telles que les services, l'informatique ou encore d'autres domaines très liés à l'interaction.

Les modèles axés spécifiquement sur l'étape de NCD tentent de fournir une représentation plus précise des activités de cette étape du processus de conception. Les trois modèles appartenant à ce groupe sont celles de Koen et al. (2002), Sandmeier et al. (2004), et Wormald (2010). Parce qu'ils essaient de permettre une représentation plus précise des activités, ils sont plus complexes et ne suivent pas un schéma linéaire (il est à noter que le Tableau 2.2 ne représente que des versions simplifiées de ces modèles). Sandmeier et al. (2004) admettent néanmoins qu'en raison de leur complexité, les praticiens éprouvent plus de difficultés à transposer ces modèles à la pratique et à appliquer leurs prescriptions.

Tableau 2.2: Comparaison de cinq modèles NCD

References	*NCD stage*	*NPD stage*
Koen et al. (2002)	- Engine (*leadership, culture and business strategy*) - Controllable activity elements (*Idea generation and enrichment, Opportunity identification Opportunity analysis, Idea selection, Concept definition*) - Influencing factors (e.g. *Competitive environment, enabling sciences, organizational capability*) →	
Sandmeier et al. (2004)	Market and Technology opportunities ↔ Product and Business Ideas ↔ Draft Concept of Product and Business Plan →	
Wormald (2010)	Context analysis: - User research - PEEST research - Brand research → Context representation: - Persona boards - Experience boards (scenarios) - Insight/Opportunity boards - Brand boards → Value proposition: - Combine information from different context researches - Creativity involved → Design brief formulation: - Expression of a value proposition →	
Cooper (2008) *partial*	Idea → Gate 1: Idea screen → Scoping → Gate 2: Second screen → Build business case → Gate 3: Go to development →	
Buijs (2012) *partial*	User research: - Evaluation of strategic situation of the company → Strategy formulation: - External/Internal analysis - Identify search areas → Design brief formulation: - Use of information gathered internally and externally - Idea generation →	

2.3.3 LES EQUIPES DE CONCEPTION MULTI-CULTURELLES

Il a déjà été démontré qu'il existe une culture commune entre les personnes qui partagent la même nationalité, appartenance à une organisation, la fonction ou le sexe. De nos jours, la plupart des équipes de conception de travail sont multifonctionnelles (Dahlin et al., 2005). Cela signifie que les membres d'une équipe de conception ont des profils divers comme celui de designers (style), ingénieurs (technologie), marketeur (cible marketing). Liés au phénomène de la mondialisation, les équipes de design sont maintenant souvent composées de personnes de différentes nationalités et même de différentes affiliations organisationnelles. Cela est particulièrement vrai dans l'industrie automobile, qui est organisé au niveau international dans un réseau composé de constructeurs, de fournisseurs et de sous-traitants (Miller, 1993). Pour toutes ces raisons, de nombreuses équipes de conception actuelles peuvent être décrites comme multiculturelles.

La fonction dominante d'une personne lui donne d'un point de vue fonctionnel qui influe sur la façon dont ils pensent, agissent et se comportent. Les différences en termes de perspectives fonctionnelles entre les membres de l'équipe créent des «murs fonctionnels» qui entourent les personnes et entravent l'interaction entre les membres d'une équipe (Bunderson & Sutcliffe, 2002). À ce sujet, Graff et al. (2011) ont montré que la présence de la compréhension réciproque et la communication inter-fonctionnelle dans une équipe ouvrent les "murs fonctionnels" et augmentent l'efficacité de l'équipe. En plus de la notion de «mur fonctionnel», des chercheurs ont observé d'autres opportunités et défis liés aux équipes de conception multiculturelles. Le Tableau 2.3 résume les forces et les faiblesses des équipes de conception multiculturelles et mono-culturelles identifiées par Gibson (2004) et par Graff et al. (2009).

Tableau 2.3: Équipes multiculturelles: forces et faiblesses (adapté de Gibson [2004] et Graff et al. [2009])

	Strengths	*Weaknesses*
Multi-cultural teams	- Improved decision quality[1] - More innovative [1,2] - Higher adaptability[1] - Inter-group and inter-organization coordination[1] - Personal growth[1]	- Lower cohesiveness, increased conflict[1,2] - Less positive mood[1] - Decreased communication[1] - Turnover[1] - Lower performance[2] - Lower competitive response[2]
Mono-cultural teams	- Cohesiveness[1] - Warmth and acceptance[1] - Strong communication[1] - Stability[1] - Higher performance[2]	- Less creative[1] - Less stimulating[1] - Less personal growth[1]

[1] Gibson (2004)
[2] Graff et al. (2009)

2.3.4 Integration d'approches design dans les phases amont du processus de conception

Comme on peut le voir dans les paragraphes précédents, les innovations prennent source dans le NCD. Verganti (2009) a identifié deux caractéristiques des produits et services innovants: l'innovation liée à des changements dans la technologie et les innovations liées à des changements de sens donné à l'artefact. Ce dernier peut être assimilé à ce qui a été défini dans cette thèse comme les qualités kansei perçues. Ces deux dimensions ajoutent un nouveau niveau d'information par rapport aux trois typologies de nouveaux produits de Wheelwright et Clark (1992) (« produit de pointe », « produit plate-forme », « produit incrémental »).

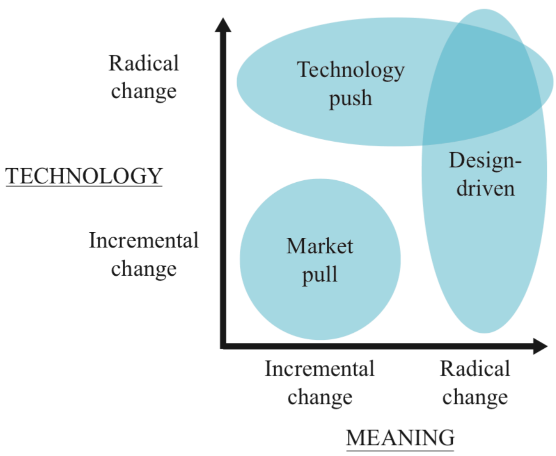


Figure 2.9: Différentes sources d'innovation (Verganti, 2009)

À partir de ces deux dimensions Verganti (2009) a identifié trois types d'innovation: tirée par le marché, poussée par la technologie et orientée par le design. Les innovations tirées par le marché correspondent essentiellement à des produits incrémentaux et sont basées sur les besoins exprimés par les clients. Les critiques formulées par les chercheurs concernant ce type d'innovation sont que les clients (le marché) ont une vision court terme et que leurs exigences ne sont ni totalement explicites ni stables (Sandmeier et al, 2004; Norman, 2010). C'est pourquoi les innovations tirées par le marché seul ne peuvent pas induire les changements et la propriété intellectuelle nécessaires pour le développement de nouveaux « produits plates-formes » et « produits de pointe ».

Au cours des dernières années, les nouveaux produits (et service) « plates-formes » et « de pointe » des expériences mettant l’accès à la fois sur la technologie et l’expérience d’utilisateur (comprenant le sens perçu) ont gagné en importance (par exemple, Nintendo Wii, écosystème Apple avec médias et applications) (Verganti, 2009). Cela confirme que les entreprises concevant des produits de consommation tendent en effet à passer d’approches basées sur l’innovation technologique seule (les deux exemples donnés n’ont pas nécessairement les spécifications techniques les plus avancées) à une combinaison d'activités amont centrées sur l'expérience utilisateur et combinant de la technologique et centrée utilisateur (design-driven). Cette dernière approche permet aux entreprises de mieux gérer l'expérience d’utilisation de leurs futurs produits et facilite la création de nouveaux concepts qui influencent radicalement le sens du produit pour l’utilisateur. Des académiques ont mis en évidence à la fois le non-sens de processus NCD portés uniquement sur les utilisateurs et leurs besoins, et l'importance de considérer l'expérience d’utilisation en phase amont du processus de conception (Norman, 2010; McCullagh, 2010; Karapanos et Martens, 2009).

2.4 ACTIVITES DESIGN CENTREES SUR L'EXPERIENCE

La section 2.3 a souligné le fait que le développement de produits innovants implique de plus en plus d'activités centrées sur l'expérience utilisateur (UX), en plus de recherches axées sur la technologie. Dans cette troisième partie de l'état de l'art, je vais discuter des activités design centrées sur l'expérience. La particularité de ces activités est qu'elles couvrent les différents constituants d'une expérience: l'utilisateur, l'interaction, le produit, le contexte (et ne sont donc pas seulement centrées sur l'utilisateur). Elles permettent aussi de formuler des intentions concernant le processus kansei des utilisateurs finaux (et ne sont donc pas uniquement centrées sur l'utilisabilité).

2.4.1 ACTIVITES DESIGN

Le modèle de base de l'activité de design souvent utilisé dans la littérature contemporaine est représentée sur la Figure 2.10 (Bouchard et Aoussat, 2003; Cross, 2008). Il est composé de quatre activités symbiotiques: *information*, *génération*, *évaluation et décision* et *communication*. Il est aussi appelé le cycle d'information design car il décrit la façon dont l'information design est utilisée par l'équipe de conception (collectée, transformée et générée, communiquée).

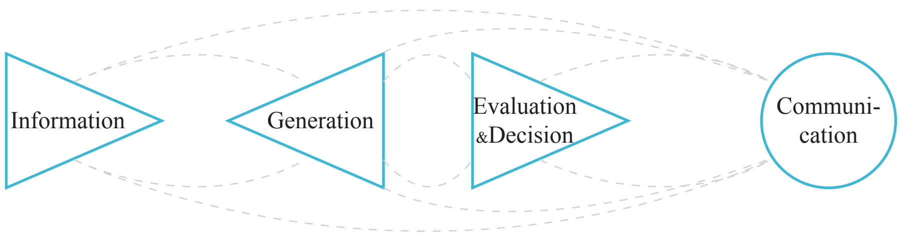


Figure 2.10: Activités design – Cycle d'information design (adapté de Bouchard & Aoussat [2003], et Cross [2008])

Les différentes activités design peuvent être définies comme suit (Bouchard et Aoussat, 2003) :

- **Information:** Les membres de l'équipe de conception rassemblent différents types d'informations afin de renforcer leurs connaissances liées au contexte du projet. L'activité consiste à questionner les intentions initiales de différents points de vue (utilisateur cible, politique, économique, environnemental, social, technologique, marque) par la collecte et l'organisation des données. La connaissance acquise et mutuellement partagée peut ensuite également être utilisée comme source d'inspiration.
- **Génération:** Cette activité correspond à la génération de nouvelles idées et de nouveaux concepts. Ils sont réalisés en utilisant les données recueillies dans la phase information, des images mentales et d'autres informations contenues dans la mémoire des personnes impliquées. Les membres de l'équipe de conception génèrent durant ce type d'activité des représentations (intermédiaires) physiques et/ou numériques.
- **Evaluation et décision:** Durant cette activité les concepts proposés sont évalués. Elle comprend aussi une phase de décision qui valide (ou non) la continuation du développement du concept et/ou du projet. Selon le contexte, cette décision peut être prise par les personnes impliquées dans le processus de conception ou par des décideurs qui lui sont extérieurs.
- **Communication:** Cette activité consiste à présenter les données de sortie des précédentes activités design et/ou à préparer du matériel à utiliser pour les cycles à venir. L'équipe de conception peut adapter le type de représentation utilisé et d'informations design transmis en fonction de son audience.

2.4.2 DESIGN INFORMATION

Il a été vu précédemment que les activités design correspondent également à un cycle d'information design. Cela signifie que les équipes de conception identifient (activité d'information), génèrent (activité de génération), discutent et d'évaluent (activité d'évaluation et de décision) et finalement communiquent (activité de communication) de l'information design. Dans cette partie, une ontologie de l'information design, ainsi que des moyens de la représenter dans les phases amont de développement (avant représentations 2D et 3D) seront discutés.

2.4.2.1 CATEGORIES D'INFORMATION DESIGN

Bouchard et al. (2009) ont étudié les informations design échangées par les membres d'une équipe de conception lors des activités design ayant lieu en phase amont. Les auteurs ont recueilli des informations design à partir d'études empiriques. Ils les ont organisées en différentes catégories d'information design, qu'ils ont structuré en trois groupes différents en fonction de leur niveau d'abstraction. Les trois groupes identifiés correspondent à des niveaux d'abstraction bas, moyen et haut.

- **L'information design de bas niveau (Low-level)** correspond à de l'information concrète et liée aux attributs sensoriels principalement concernant l'artefact en cours de conception (couleur, forme, texture).
- **L'information design de moyen niveau (Middle-level)** relie les informations design abstraites et concrètes. Elle couvre notamment le domaine de la fonctionnalité ainsi que le contexte et les secteurs de référence.
- **L'information design de haut niveau (High-level)** correspond à de l'information abstraite traitant des caractéristiques personnelles de l'utilisateur, des qualités kansei intentionnelles, et des attributs produits désirés (valeur personnelle des utilisateurs, mots sémantiques décrivant l'expérience, et style relatif au produit en développement).

Tableau 2.4: Détail des différentes catégories d'information design (adapté de Kim et al. [2009])

Category name	*Description*	*Examples*	*Related UX entity*
Value (H)	These words represent final or behavioural values.	Security, Wellbeing	User's personal characteristics
Semantic word (H)	Adjectives related to the meaning and characteristics.	Playful, Romantic, Aggressive	Perceived kansei qualities
Analogy (H)	Objects in other sectors with features to integrate in the reference sector	Comparison with a rabbit to convey "speed"	Perceived kansei qualities
Style (H)	Characterization of all levels together through a specific style.	Edge Design, Classic	Product attributes
Context (M)	User social context	Leisure with Family	Context attributes
Functionality (M)	Function, usage, component, operation	Modularity	Product attributes
Sector/object (M)	Object or sector being representative for expressing a particular trend	Tennis, wearable computing	Product attributes
Form (L)	Overall shape or component, shape size	Square, long and thin	Product attributes
Colour (L)	Qualitative or quantitative chromatic properties	Light blue, Emerald	Product attributes
Texture (L)	Patterns and texture and materials	Plastic, striped surface	Product attributes

(H): Haut niveau d'abstraction
(M): Moyen niveau d'abstraction
(L): Bas niveau d'abstraction

Notez que les différentes catégories d'informations design identifiées par Bouchard et al. (2009) se rapportent à des entités spécifiques de l'expérience d'utilisation prévue (caractéristiques personnelles de l'utilisateur, qualités kansei perçues, attributs produits et de contexte). Les entités d'expérience correspondant à chaque catégorie ont été ajoutées au tableau de synthèse détaillant les différentes catégories d'information design (Tableau 2.4). Il a initialement été présenté par Kim et al. (2009).

2.4.2.2 REPRESENTATIONS AMONT D'INFORMATION DESIGN

Les représentations intermédiaires permettent la communication d'informations au sein d'une équipe ou avec les intervenants du projet dès les phases amont d'un nouveau développement. Cette notion est apparue dans les années 1920. Ces représentations ont d'abord été utilisées dans le domaine de la conception technique pour communiquer au sujet de nouvelles technologies étudiées lors de projets NCD. Durant les années 1950, ils ont été adoptés par les designers industriels afin de communiquer des études de style relatives à l'information design concrète (par exemple, le design extérieur de la voiture). Une utilisation de plus en plus précoce des représentations peut être aujourd'hui observé (Sanders, 2005). Par conséquent, ils ne sont pas nécessairement liés à une solution design mais peuvent également exprimer une intention (par exemple, l'utilisation d'images d'inspiration) (Mougenot, 2008). Les catégories d'information design qu'elles véhiculent ont également évolué. Elles en couvrent à présent un spectre large et combinent les niveaux d'abstraction haut et bas, se référant aux différentes entités de l'expérience utilisateur (et pas seulement de l'information design concrète liée aux attributs produits).

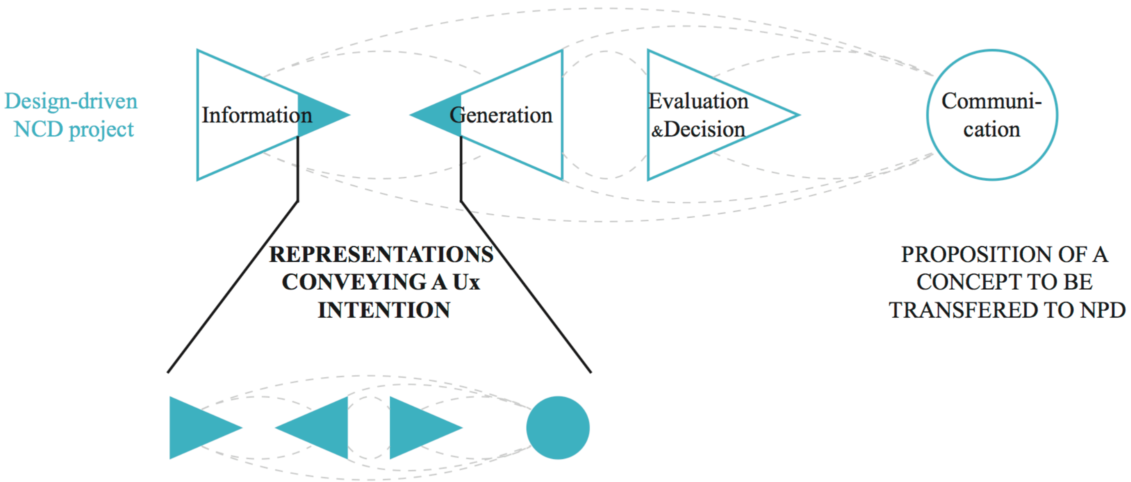


Figure 2.11: Positionnement des représentations amonts par rapport aux activités d'un projet NCD entier

Je vais maintenant passer en revue la littérature décrivant les différents types de représentations utilisées pour diffuser et discuter des intentions design en phase amont d'un développement. Lorsque l'on regarde les activités design d'un projet NCD entier (au niveau macro), elles sont situées à la transition entre les activités d'information et de génération. Comme le montre la Figure 2.11, la création de ces représentations peut être décrite par une autre couche d'activités design (ceci est dû à la nature fractale du cycle d'information design). Eckert et Stacey (2000) ont observé que peu de recherches ont été effectuées sur cette transition. Cinq types de représentations ont néanmoins été identifiées.

• **Brief design et personas (représentations à base de texte)** - Le brief design définit une intention en ce qui concerne le produit qui va être conçu (comprenant de l'information design de haut, moyen et bas niveau lié à l'information aux attributs produits), les utilisateurs cibles, et le contexte d'utilisation (Buijs, 2012). La représentation des utilisateurs cibles peut aussi se faire par le biais de personas. Ce sont des «représentations fictives, spécifiques et concrètes» (Pruitt et Adlin, 2006: p.11).

• **Planches tendances et mood boards (représentations visuelles) -** Baxter (1995) a identifié plusieurs types de représentations basées sur des images, créées par les designers et utilisées par les équipes de conception au cours des activités de recherche et développement. Ces représentations sont soit axées sur les utilisateurs cibles et représentent de l'information design abstraite liée à ces utilisateurs (les «lifestyle boards») ou sur le produit à développer («mood boards» et «visual theme boards»). Alors que les «mood boards» communiquent de l'information design de haut niveau tels que les catégories ; analogie, descripteur sémantique, et style, les «visual theme boards» véhiculent de l'information design haute et basse cette fois-ci uniquement en rapport avec les attributs du produit en cours de conception (style, secteur/objet, forme, couleur).

• **Représentations multi sensorielles (représentations multi sensorielles)** – Schifferstein et Desmet (2008) ont développé une approche design multi-sensorielle dans laquelle les concepteurs explorent différentes modalités sensorielles et créent un concept d'expression sensorielle intégré représentant leurs intentions avant les activités liées à la mise en forme du produit. Cette approche leur permet de mieux prendre en compte dès les premiers stades de la conception les différentes modalités que le produit utilise pour influencer l'expérience de l'utilisateur.

• **Scenarios (représentations narratives)** - Selon Sanders (2006), les scénarios sont un moyen très efficace de communiquer des intentions liées à l'expérience lors des premiers stades de la conception d'un produit. Ces derniers se concentrent sur l'interaction qu'il permettra et transcrivent les parcours idéaux que les utilisateurs auront avec lui. Ils sont souvent représentés de façon narrative, en utilisant des storyboards, des graphiques ou des vidéos (Sanders, 2006). Les représentations basées sur des scénarios permettent principalement aux concepteurs de transmettre des informations design liées aux qualités kansei intentionnelles (sémantique perçue, émotions ressenties) et aux modes d'interaction possibles avec le produit en cours de conception (attributs d'interaction) (Buxton, 2007; Sears & Jacko, 2007).

• **Prototypes (représentations interactives)** - L'utilisation de prototypes a récemment été introduite dans les étapes amont de l'élaboration de nouveaux concepts (Sanders, 2005). Les prototypes sont utilisés pour explorer diverses directions et sont très différents en terme d'information design abstraite qu'ils véhiculent (valeur, descripteur sémantique, style) (Koskinen & Lee, 2009). En raison de leur faible niveau de fidélité, ils ne contiennent souvent pas beaucoup d'information design concrète. Ils permettent finalement aussi d'obtenir un retour constructif de la part de personnes extérieures à l'équipe de conception (Buchenau et al., 2000).

2.4.3 OUTILS ET METHODOLOGIES DESIGN

Des outils et méthodologies centrés sur l'expérience ont été créés pour soutenir les différentes activités design. Ils peuvent être utilisés pour des activités menant à la création des premières représentations, telles que celles présentées dans la section précédente, ou plus largement pour des activités liées aux développement de nouveaux concepts proprement dit (Abras et al., 2004). Les outils peuvent être basés sur un raisonnement scientifique ou abductif. Les uns sont basés sur des analyses quantitatives des données (et des raisonnements logiques), tandis que les autres sont basés sur des données qualitatives (et des raisonnements abductifs). Certains d'entre eux combinent également les deux et peut être désigné comme provenant d'approches intégratives (Martin, 2009). Tous les outils et méthodologies qui seront présentés ont des caractéristiques communes comme le fait qu'ils contribuent à l'amélioration de l'expérience utilisateur (par le biais d'activités d'information, de génération ou d'évaluation et décision), mais ils diffèrent dans leur façon de traiter l'utilisateur. Selon l'outil ou méthodologie, il peut soit être considéré comme un partenaire (design participatif) ou comme un sujet (observé et interrogé). Quand ils sont traités comme sujets, les utilisateurs peuvent être soit directement (e.g. entretiens) ou indirectement (e.g. observations de terrain) impliqués dans les activités design (Sanders & Stappers, 2008). Dans les sous-sections suivantes un large panel d'outils et méthodologies sont classifiés et listés. Compte tenu de leur diversité, il est néanmoins impossible d'être exhaustif. Ceux qui sont présentées doivent donc être considérés comme une sélection d'exemples illustrant les principaux types d'approche. Certains d'entre eux ont été recueillis dans des publications répertoriant des outils et méthodologies centrés sur l'expérience (Byttebier & Vullings, 2009; Forlizzi, 2008; IDEO, 2003; Vredenburg et al, 2002.).

2.4.3.1 OUTILS ET METHODOLOGIES SUPPORTANT LES ACTIVITIES D'INFORMATION

À ce stade précoce du processus de design l'équipe de conception a pour but de recueillir des informations et de trouver de l'inspiration pour préparer les activités ultérieures (Sanders, 2005). Les outils et les méthodes listés ci-après portent sur au moins un de ces deux aspects.

RECHERCHE DOCUMENTAIRE – RAISONNEMENT ABDUCTIF/SCIENTIFIQUE

La recherche documentaire permet la capture des tendances actuelles et permet d'accéder à un large éventail d'informations dans divers domaines (e.g. la recherche PEEST). Elle peut conduire à des rapports et des présentations, ainsi que des représentations visuelles (Wormald, 2010). Lors de la recherche documentaire, les équipes de conception utilise l'Internet ainsi que d'autres médias (e.g. revues) pour recueillir des informations et de l'inspiration (Bouchard, 1997).

- *Design-specific libraries* (e.g., matériauthèque [Amaral Da Silva et al., 2012], taxonomie de gestes [Solinski, 2011]).
- *Benchmarks*
- C*onjoint trend analysis method* (Bouchard et al., 1999 ; Kim et al., 2012).
- *Cross-cultural comparisons, long-range forecasts* (IDEO, 2003).

RECHERCHE DE TERRAIN – RAISONNEMENT ABDUCTIF/SCIENTIFIQUE

Les observations de terrain sont similaires à la recherche documentaire dans leur but, mais ils utilisent le monde réel comme source d'information (Vredenburg et al., 2002). Elles peuvent être combinées avec des discussions ou des interviews (voir ci-dessous). Elles peuvent toucher les potentiels «utilisateurs» et leur environnement ainsi que les organisations impliquées dans le processus de création et de leur procédure de fonctionnement.

- *A day in a life, behavioural mapping, guided tours*, e*rror analysis, flow & activity analysis* (IDEO, 2003).

IMPLICATION DES UTILISATEURS: INTERVIEWS – RAISONNEMENT ABDUCTIF/SCIENTIFIQUE

Des interviews avec des utilisateurs et des experts sont des outils de collecte d'information communs. Elles peuvent être non structurées (discussion), semi-dirigées ou dirigées. Elles peuvent également contenir des activités spécifiques (e.g. card sorting). Dans les deux derniers cas, les questions sont préparées et les réponses peuvent être suggérées en utilisant par exemple des échelles différentielles sémantiques (Osgood, 1969). Celles-ci peuvent ensuite être analysées suivant un raisonnement scientifique. Différents types d'interviews sont listées ci-dessous.

- *Macro-level kansei engineering investigations* (Schütte et al. 2008a)
- *Mutual design approach with image-icons* (Lee et al., 2002)
- *Laddering interviews* (Wansink, 2003)
- *Repertory grid technique* (Tomico, 2007)
- *iScale (outil d'évaluation)* (Karapanos, 2010)
- C*ard sorting sessions* (Rugg & McGeorge, 2005)

IMPLICATION DES UTILISATEURS: AUTRE – RAISONNEMENT ABDUCTIF

Les utilisateurs peuvent être impliqués dans les activités design d'information. Ceci peut être en qualité de sujet ou de partenaire (design participatif). Leurs participations aide l'équipe de conception à saisir de nouvelles idées et à identifier des besoins ou des lacunes.

- *Brainstorming session, bodystorming session*
- *Rapid ethnography sessions* (Bødkur & Buur, 2000).
- *Diary* and *longitudinal studies* (Battarbee et al., 2002; Forlizzi, 2007)
- *Probes* (Gaver et al., 1999)
- *Camera journal, unfocus group* (IDEO, 2003)
- *Collage* (Sanders, 2006).

ACTIVITES EXPLORATOIRES – RAISONNEMENT ABDUCTIF

Les activités exploratoires aident les membres de l'équipe de conception à explorer et comprendre l'expérience utilisateur qu'ils voudraient réaliser.

- *Brainstorming* (Boess, 2006)
- *Quick prototyping*, *experience prototyping*, *bodystorming* (Boess, 2006; IDEO, 2003)

2.4.3.2 OUTILS ET METHODOLOGIES SUPPORTANT LES ACTIVITIES DE GENERATION

Les activités de génération suivent généralement les activités d'information. Elles sont des phases divergentes pendant lesquels les idées sont conceptualisées. Trois catégories d'outils et de méthodologies seront présentées ci-après.

OUTILS ET METHODOLOGIES DE SUPPORT POUR LA CREATIVITE – RAISONNEMENT ABDUCTIF

Différents outils et méthodologies abductifs soutiennent la créativité. Ils améliorent la qualité et/ou la quantité d'idées générées par les individus ou les groupes qui les utilisent (Byttebier & Vullings, 2009).

- *Biomimicry*, *Osborn checklist*, *Harvey cards, lotus blossom technique*, *random input* (Byttebier & Vullings, 2009)
- *Brainstorming, brainwriting, reverse brainstorming* (Byttebier & Vullings, 2009)
- *Early representations* (Goldschmidt & Smolkov, 2006)
- Iterative creation of low-tech prototypes (Hummels & Overbeeke, 2010)

OUTILS DE SUPPORT POUR LA CREATIVITE – RAISONNEMENT SCIENTIFIQUE

En plus des approches abductives, des outils basés sur des raisonnements scientifiques soutenant les activités de génération existent également.

- *Principles of good user experience design* (Von Saucken et al., 2013)
- Skippi (*computer-aided tool)* (Bongard-Blanchy, 2013)

SESSIONS DE DESIGN PARTICIPATIF – RAISONNEMENT ABDUCTIF

Les outils et méthodologies de création participatives permettent aux équipes de conception de collaborer avec des utilisateurs pour les activités de génération d'idées. Ces derniers facilitent la compréhension mutuelle et améliorent la façon dont les groupes multiculturels (composé de membres de l'équipe de conception et d'utilisateurs) travaillent ensemble (Muller, 2003).

- *Scenarios* and *projections* (Fulton Suri, 2003; Sanders, 2006)
- *Storyboarding* (Chung et al., 2010)

- *Bodystorming*, and *role-playing* (Larssen et al., 2007)
- *Collages* (Sanders, 2006)
- *Low-tech prototyping* (Buchenau & Fulton Suri, 2000)

2.4.3.3 OUTILS ET METHODOLOGIES SUPPORTANT LES ACTIVITIES D'EVALUATION ET DE DECISION

Il a été vu précédemment que la génération d'idées et de leur évaluation suivent souvent un chemin itératif. Les compléments directs des activités de génération mentionnées ci-dessus sont donc des activités d'évaluation et de prise de décision. Par le biais de l'évaluation, la combinaison, le raffinement et la sélection de directions, elles permettent la convergence vers une/un corpus de proposition(s) (Byttebier & Vullings, 2009). Des outils et des méthodologies permettent par exemple l'évaluation des qualités kansei expérimentées en percevant ou en interagissant avec le concept généré. Ils sont basés sur les différents types de représentations intermédiaires des concepts qui résultent des activités de génération (prototypes, croquis, story-boards, vidéos ...).

Dans le cas des activités d'évaluation liées à un projet NCD complet, les activités centrées sur l'expérience sont complémentaires à d'autres types d'évaluation liées à des préoccupations telles que la facilité d'utilisation, le coût, la durée de vie, et la valeur marchande. Tous ces aspects doivent être pris en compte dans la décision de faire passer un concept dans le processus de développement de nouveaux produits (Buijs, 2012).

OUTILS AND METHODOLOGIES DE SUPPORT A LA CONVERGENCE – RAISONNEMENT ABDUCTIF/SCIENTIFIQUE

Ces outils et méthodes permettent la combinaison et l'affinage des concepts au cours d'activités de groupe. Ils s'appuient à la fois sur le raisonnement abductif et scientifique.

- E*nhancement checklist* (Byttebier & Vullings, 2009).
- *Hundred euros test*, *idea advocate, six thinking hats* (Byttebier & Vullings, 2009).

PANEL D'EXPERTS – RAISONNEMENT ABDUCTIF/SCIENTIFIQUE

L'évaluation d'idées et de concepts peut également être faite par un panel d'experts (Adams et al., 2011). Même avec les différentes activités détaillées ci-après, ce type d'activité d'évaluation et de décision reste très subjectif. (Vredenburg et al., 2002; Lawson, 2005).

- *Formal heuristic evaluation* (Adams et al., 2011)

MESURES PSYCHOLOGIQUES – RAISONNEMENT SCIENTIFIQUE

Les mesures psychologiques évaluent les qualités kansei perçues que les utilisateurs peuvent exprimer après avoir interagi avec un artefact. Cet artefact peut être un prototype plus ou moins avancé, l'image d'un produit ou même un scénario sous la forme de story-board (Bongard-Blanchy, 2013). Les qualités kansei perçues sont habituellement collectées en utilisant des échelles sémantiques (Osgood, 1969), des tests de personnalité (Eysenck & Keane, 2005), ou des questions ouvertes. L'évaluation peut avoir lieu dans un laboratoire ou dans un contexte proche de la réalité. Ce dernier type de contexte améliore la précision de l'évaluation (Mäkelä et al., 2000).

- *Kansei engineering methodologies* (Nagamachi, 1997)
- *Repertory grid technique* (Tomico, 2007).
- *iScale* (evaluation tool) (Karapanos, 2010).
- *Self-Assessment Manikin* (*Lang, 1980*)
- *International Affective Pictures System*, *International Affective Digitalized Sound System*, *International Affective Lexicon of English Words* (Lang et al., 1999)

- *Geneva Wheel of Emotions* (Scherer, 2005)
- *PrEmo software* (Desmet, 2002)

MESURES PHYSIOLOGIQUES – RAISONNEMENT SCIENTIFIQUE

Contrairement aux mesures psychologiques, les mesures physiologiques peuvent identifier les qualités kansei d'un environnement qui sont perçues mais non exprimées. En ce sens, elles permettent l'observation des conséquences kansei directes. Au Japon, un champ de recherche couvrant cette zone a émergé dans les années 1990. Il est nommé Kansei science (Harada, 2003).

- *Electromyography*, *heart rate*, *electroencephalography*, *event-related potential*, *functional magnetic resonance imaging* (Lévy et al., 2007)

MESURES COMPORTENMENTALES – RAISONNEMENT ABDUCTIF/SCIENTIFIQUE

Les mesures comportementales sont une autre façon d'observer les conséquences kansei directes. Différents types de comportements peuvent être observés et mesurés comme les mouvements des yeux, du corps ou les expressions corporelles et faciales. Ce type d'activités d'évaluation permet aux chercheurs de recueillir de nombreux renseignements sur l'expérience donnée par un produit en l'utilisant. Il exige cependant des prototypes fonctionnels avec un niveau relativement élevé de fidélité.

- C*amera*, *eye-tracking* (Kim, 2011; Lagadec, 2012)
- *Motion sensors* (Rieuf, 2013)
- *Testing activities* (Sanders, 2006)

2.5 RESUME ET OBSERVATIONS

La revue de la littérature a permis d'établir des connexions entre le processus kansei des utilisateurs lorsqu'ils interagissent avec des produits (ainsi que leur expérience d'utilisation) et le contexte de la conception industrielle. Les deux notions supplémentaires décrites dans cette revue de la littérature sont les activités design et de l'environnement culturel. La section relative aux activités design centrées sur l'expérience d'utilisation a permis de comprendre la façon dont l'expérience peut être prise en compte dans les projets NCD ainsi que des notions connexes importantes (e.g. l'information design conception, les représentation amont, les outils et les méthodologies liées). En ce sens cette section a montré des indices sur la façon dont des liens peuvent être établis entre l'expérience des utilisateurs et les processus de développement des organisations. Comme toutes ces notions sont dépendantes de personnes, la notion d'environnement culturel se reflète dans chaque section de cette revue de la littérature. La culture des utilisateurs et des membres de l'équipe de conception (démographie, fonction, organisation) a été identifiée comme une des caractéristiques principales qui influent sur le processus de conception industrielle, les activités design centrées sur l'expérience ainsi que les expériences des utilisateurs.

La Figure 2.12 résume les points majeurs tirés de chacune de ces grandes parties de l'état de l'art. Elle reprend la structure de la Figure 2.1 (p. 205), déjà utilisée dans l'introduction qui montre la façon dont elles sont interconnectées.

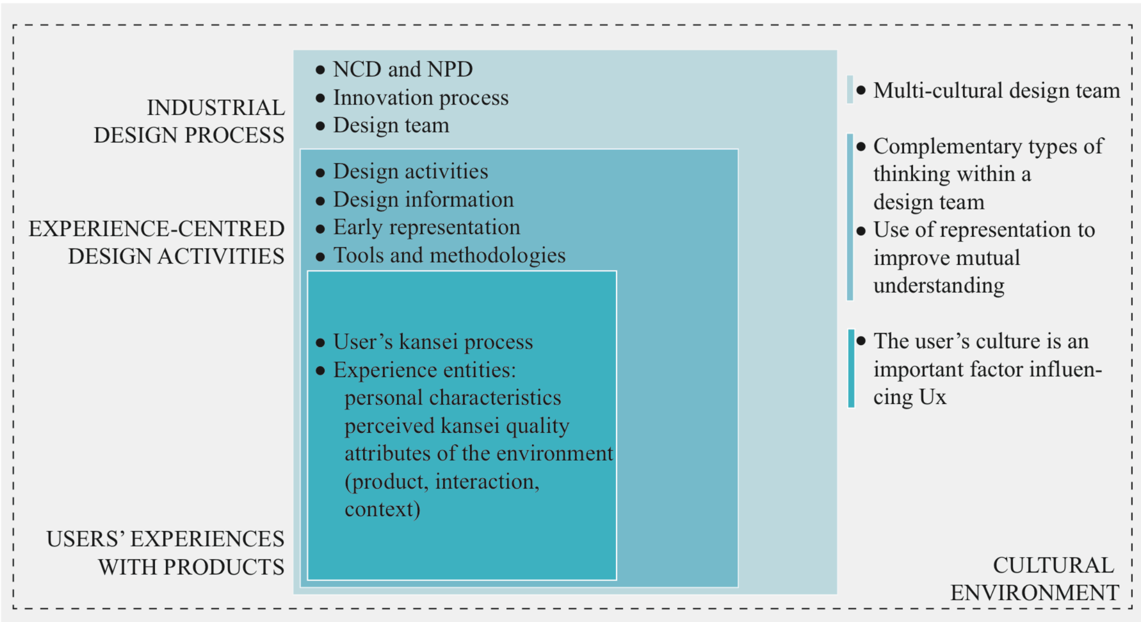


Figure 2.12: Résumé de l'état de l'art

Les observations suivantes ont guidé l'élaboration de la question de recherche et des hypothèses de recherche qui seront présentées dans la section suivante.

EXPERIENCE UTILISATEUR ET PROCESSUS KANSEI

- L'état de l'art relatif à l'expérience utilisateur et celui lié au processus kansei ont pu être examinés parallèlement. Des points de jonctions ont pu être identifiés.
- Les interrelations entre les entités de l'expérience de l'utilisateur sont souvent étudiées une à une. Les qualités kansei perçues sont la plupart du temps considérées comme des variables

dépendantes, alors que les caractéristiques personnelles de l'utilisateur et les attributs de l'environnement sont traités comme des variables indépendantes.
- Seules quelques études empiriques couvrent toutes les entités de l'expérience. Cette approche reflète néanmoins le mieux la nature holistique d'une expérience utilisateur.

ACTIVITIES DESIGN CENTREES SUR L'EXPERIENCE D'UTILISATION
- Les outils et méthodologies favorisant les activités design centrées sur l'expérience sont soit basés sur un raisonnement abductif soit sur le raisonnement scientifique. Ils ne combinent que rarement les deux types de raisonnement. La plupart du temps ils sont adressés à un public spécifique (type particulier de fonction au sein d'une équipe de conception).
- Les représentations amont facilitent la communication lié aux intentions en terme d'expérience utilisateur dans les premiers stades de la conception. Les recherches existantes traitant de ce type de représentations sont rares.
- Seuls peu de types de représentation permettent de transmettre des informations design liées à toutes les entités de l'expérience (caractéristiques personnelles de l'utilisateur, qualités kansei, attributs de l'environnement [produits, d'interaction, du contexte]).

PHASE DE DEVELOPPEMENT DE NOUVEAU CONCEPT (NCD)
- L'innovation produit peut s'appuyer sur des nouvelles technologies et/ou sur de nouvelles qualités kansei pour le produit.
- La recherche couvrant les nouvelles qualités kansei est moins mature et moins bien établie que celle portant sur les nouvelles technologies. Seuls quelques chercheurs ont décrit les outils et méthodologies facilitant son intégration dans les projets NCD.
- La communication au sein d'une équipe de conception et entre l'équipe de conception et son environnement est un facteur déterminant en ce qui concerne le développement de nouveaux concepts.

3 QUESTION DE RECHERCHE ET HYPOTHESES

Cette recherche examine la définition et la représentation de l'expérience dans les phases amont du développement de nouveaux produits. Elle s'intéresse aussi plus particulièrement au processus kansei. La question de recherche ainsi que les hypothèses qui vont guider les cinq expérimentations vont être présentées ci-après.

3.1 QUESTION DE RECHERCHE

La question de recherche est la suivante.

Comment des approches centrées sur le processus kansei peuvent-elles enrichir les activités de design?

3.2 Hypotheses

H1 – Kansei-Experience framework

La première hypothèse se fonde sur la section de la revue de la littérature traitant de la notion d '«expérience». Elle est basée sur le cadre mis en place dans cette section (Figure 2.5 [p. 210]). Ce qui sous-tend cette hypothèse est le fait d'être en mesure de traiter les variables liées à toutes les entités de l'expérience comme indépendant et de ne pas distinguer les variables dépendantes et indépendantes.

H1: ***Les expériences venant de produits peuvent être comparées et regroupées selon les qualités kansei que les utilisateurs perçoivent d'eux, les caractéristiques personnelles des utilisateurs et les attributs de leurs environnements (produit, interaction, contexte).***

H2 – Approche Kansei Design

La seconde hypothèse est liée à la nature des représentations amont: ce qui résulte des outils et méthodologies Kansei Design qui seront créés et expérimentés au cours de certaines expérimentations. Elle vise à explorer un domaine qui est mal couvert dans l'état de l'art: les représentations amont transmettant des informations design relatives à toutes les entités de l'expérience.

H2: ***Les représentations amont[1] d'intentions en terme d'expérience utilisateur peuvent contenir de l'information design se rapportant à toutes les entités [2] d'une expérience.***

H3 – NCD dans un contexte multiculturel

La troisième hypothèse est liée à la manière dont les représentations d'intentions d'expérience peuvent être utilisées dans la pratique dans les étapes de développement de nouveaux concepts. Elle examine également les caractéristiques des activités design menant à leur création en mettant l'accent particulier sur la communication (identifié comme un aspect crucial dans l'état de l'art).

H3: Les outils et méthodologies développés peuvent être intégrés dans un processus industriel de conception.

[1] Les représentations amont précèdent la définition de caractéristiques concrètes (en termes de technologie, de style) du produit/service en cours de conception.

[2] Les entités d'une expérience sont les caractéristiques personnelles de l'utilisateur, les qualités kansei perçues et les attributs de l'environnement (attributs produits, d'interaction et de contexte)

4 EXPERIMENTATIONS

4.1 INTRODUCTION

Cette recherche comporte cinq expérimentations. Elles sont notées EXP 1, EXP 2, EXP 3, EXP 4 et EXP 5. Comme représenté sur la Figure 4.1 elle couvrent les trois sections de l'état de l'art et explorent les trois hypothèses présentées dans la section précédente.

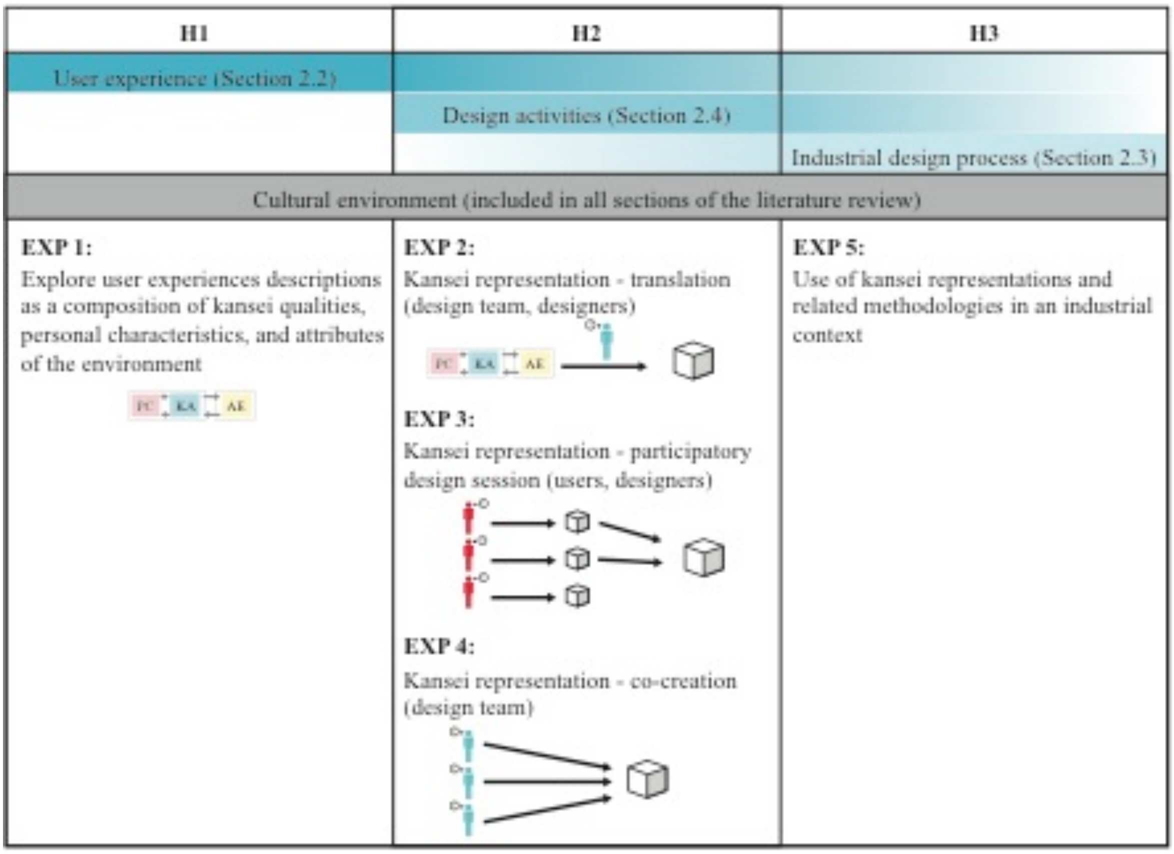


Figure 4.1: Vue d'ensemble des expérimentations

4.2 EXP 1: EXPERIENCE UTILISATEUR ET PROCESSUS KANSEI – UNE COMPOSITION DE COMPOSANTS ET DE FACTEURS INFLUENTS

4.2.1 PRESENTATION

La première expérimentation (EXP 1) est une étude empirique. Elle a pour but de mieux comprendre les différentes typologies d'expérience qui peuvent exister en investiguant les interrelations pouvant exister entre les entités d'une expérience (i.e. les caractéristiques personnelles de l'utilisateur [PC], les qualités kansei intentionnelles [KQ], et les différents attributs de l'environnement [AE]).

4.2.2 PROTOCOLE

Le format du questionnaire en ligne a été sélectionné afin de permettre à des participants de différents pays de pouvoir participer plus facilement. Il a été créé en cinq langues. Chaque version a fait l'objet d'une vérification par un locuteur natif (anglais, japonais, français, allemand et espagnol).

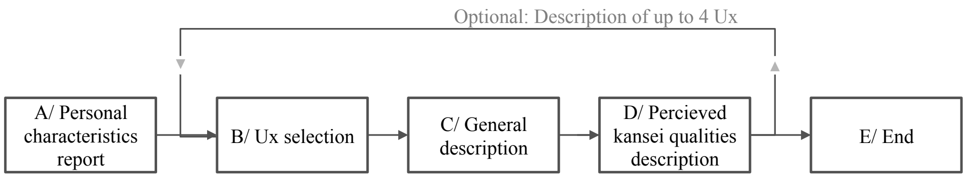


Figure 4.2: EXP 1 – Protocole suivi par les participants

La Figure 4.2 présente une vue d'ensemble du protocole de questionnaire. Les différentes étapes peuvent être décrites ainsi :

- A/ renseignement des caractéristiques personnes : le participant renseigne son âge, sexe, nationalité et ses valeurs instrumentales (dans ce dernier cas par l'intermédiaire d'échelles différentielles sémantiques marquées « not at all » et « extremely »).

- B/ Sélection d'une expérience utilisateur : après avoir informé simplement sur ce qu'est une expérience utilisateur, le participant est invité à sélectionné librement un produit ou service avec lequel il a eu par le passé une expérience plaisante.

- C/ Description générale : le participant est invité à décrire en quelques phases le produit/service et l'expérience associé. Cette entrée sera ensuite structurée et codée afin de pouvoir décrire et comparer les attributs de l'environnement des expériences décrites par tous les participants.

- D/ Description des qualités kansei : le participant décrit les qualités kansei qu'il associe à l'expérience à partir des mots-clés proposés (descripteurs sémantiques, émotions, canaux sensoriels provoquant du plaisir). Pour ce faire il évalue les mots-clés à l'air d'échelles différentielles sémantiques à 5 points marquées « not at all » et « extremely ».

- E/ Fin : Le participant à la possibilité de décrire jusqu'à quatre expériences (à l'aide des étapes B/, C/ et D/). Quand il décide de finir le questionnaire, il est invité à laisser un commentaire puis est remercié.

4.2.3 RESULTATS

4.2.3.1 DESCRIPTION DES DONNEES COLLECTEES

Au total 189 participants ont rempli des questionnaires entièrement. Ils ont permis de collecter 211 descriptions d'expérience utilisateur. La distribution de ces participants en terme de nationalité, de sexe et d'âge est renseignée sur le Figure 4.3.

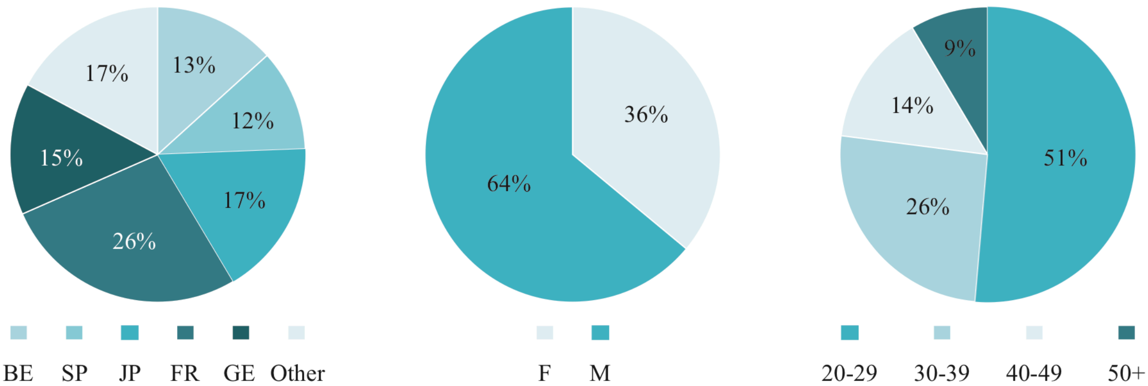
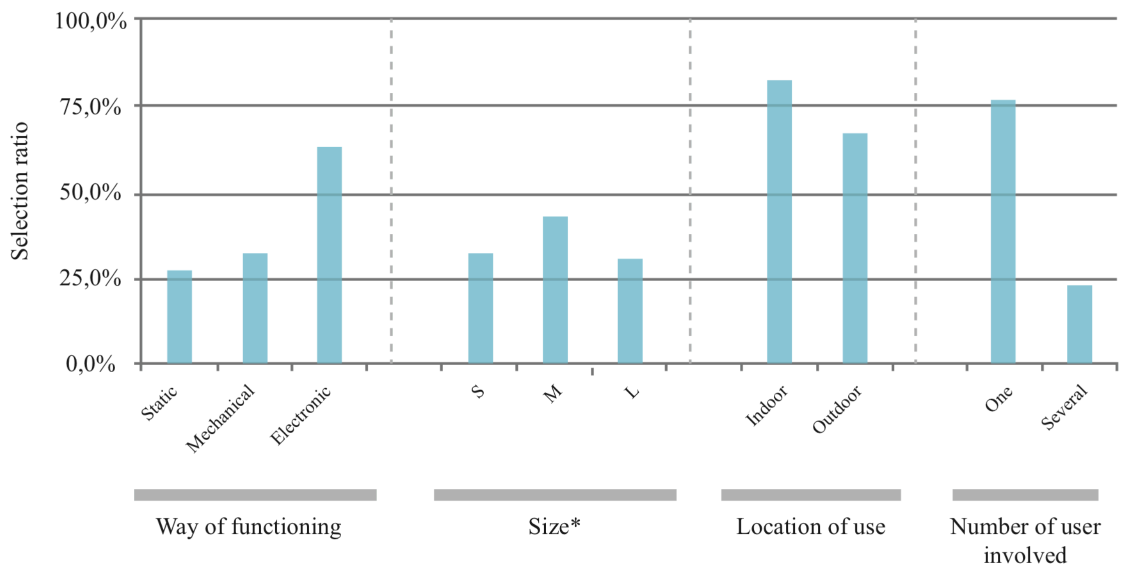


Figure 4.3: Distribution des participants en terme de nationalité (5 plus représentées), de sexe et d'âge

Comme indiqué précédemment, l'étape C/ du protocole à permis de collecter des informations par rapport aux attributs d'environnement des différentes expériences. Les entrées des participants ont été codées et associées à différents attributs produits, d'interaction et de contexte. Les ratios de sélection pour les attributs produits et de contexte sont représentés sur la Figure 4.4 et ceux concernant les attributs d'interaction sur visible sur la Figure 4.5.



*les tailles de produits sont définies ainsi : S = rentre dans une poche, M = rentre dans un sac-à-dos, and L= rentre dans une pièce.

Figure 4.4: Ratio de sélection pour les différents attributs produits et de contexte identifiés

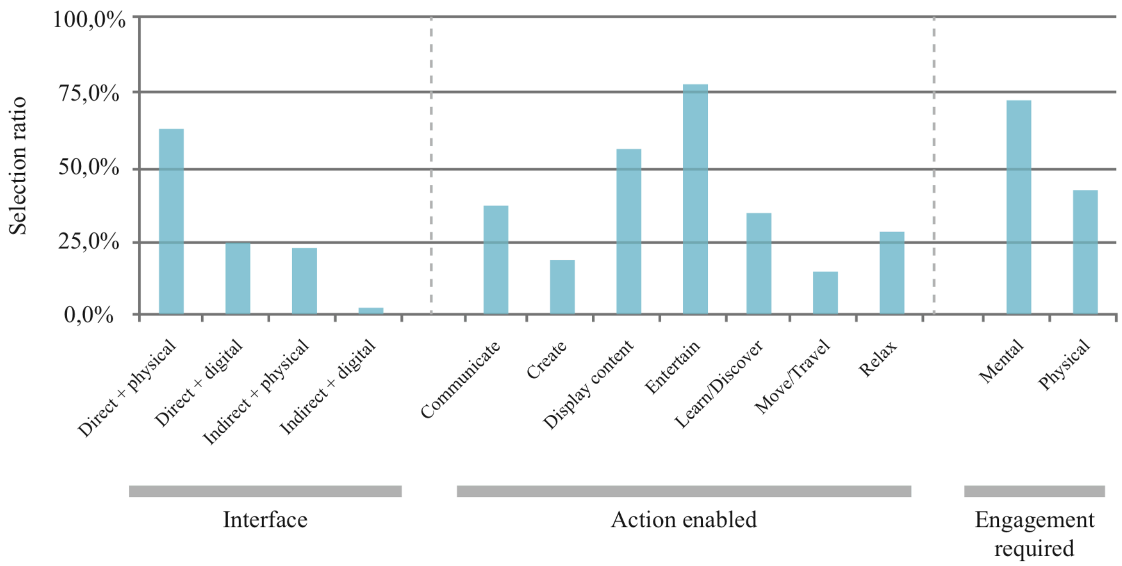


Figure 4.5: Ratio de sélection pour les différents attributs d'interaction identifiés

4.2.3.2 ANALYSE DES DONNEES

La base de donnée obtenue est représentée schématiquement sur le Tableau 4.1. Les 211 descriptions d'expérience utilisateurs sont toutes décrites quantitativement en termes de caractéristiques personnelles des utilisateurs (PC), de qualités kansei associées (KQ) et d'attributs de l'environnement (AE). Ces descriptions sont faites soit par des échelles sémantiques 5 points, soit de manière binaire (oui/non).

Tableau 4.1: Représentation schématique de la base de donnée obtenue

	PC			*KQ*			*AE*		
	$Gender_A$	*$Nationality_A$*	*$Value_A$*	*KQ_A*	*KQ_B*	*KQ_N*	*AE_A*	*AE_B*	*AE_N*
UX_1	0	0	2	1	2	3	0	0	0
UX_2	1	1	4	3	3	0	0	1	0
…	…	…	…	…	…	…	…	…	…
UX_{211}	1	0	3	4	4	4	0	0	1

CORRELATIONS ENTRE ENTITES DE L'EXPERIENCE

À la manière de recherches décrites dans l'état de l'art cette base de donnée permet d'identifier des corrélations entre les différentes entités de l'expérience utilisateur. La version française n'étant qu'un résumé je ne vais décrire qu'un seul type de corrélation analysé : les corrélations entre PC et KQ pour des attributs de l'environnement donnés (AE fixé).

Je vais utiliser deux attributs produits à titre d'exemples: produits statiques et électroniques. Pour ces attributs produits, des matrices de corrélation ont été créées et des analyses de la variance ont été réalisées. En résumé, les différences significatives en termes de KQ perçues entre les différents groupes PC ont été rapportés dans le Tableau 4.2 et le Tableau 4.3 (intervalle de confiance: 95%). Ces différences significatives ont été observées entre le groupe ayant le score le plus élevé et le groupe ayant le score le plus bas. Par exemple, "Stimulated 50+ > 40-49" doit être compris comme suit: le groupe des 50+ ans se sentait plus stimulé que tous les autres groupes d'âge et significativement plus que celui des 40-49 (qui est celui qui s'est senti le moins stimulé).

Pour les **produits statiques**, on peut observer qu'il n'y a presque pas de différences significatives entre les différents groupes de caractéristiques personnelles en termes de plaisirs sensoriels perçus (Tableau 4.2: colonne de gauche). Ils sont tous relativement proches de la tendance générale observée pour les produits statiques. Pour le sexe, la différence la plus forte a lieu pour le toucher, ce qui est une modalité majeure liée au plaisir pour les femmes mais pas chez les hommes (significativement moins). Quant aux autres KQ, le Tableau 4.2 illustre que les émotions déclenchées par des produits statiques sont particulièrement sensibles à l'âge (3 diff. sign.) et que les associations sémantiques qu'ils véhiculent sont particulièrement sensibles à la nationalité (5 diff. sign.)

Tableau 4.2: Différences significatives en terme de KQ pour différentes PC lors d'interaction avec des produits statiques

	Sensory pleasure (KQ)	*Semantic (KQ)*	*Emotion (KQ)*	*Total*
Age (PC)			Stimulated 50+>40-49 Satisfied 30-39>40-49 Inspired 50+>20-29	3
Gender (PC)	Touch F>M	Fun, amusing F>M Modern M>F		3
Nationality (PC)		Comfortable JP>GE In fashion JP>GE Subtle SP>BE, SP>GE, SP>FR	Calm JP>GE	6
Total	1	7	4	

Les résultats de la même analyse concernant les **produits électroniques** peuvent être observés dans le Tableau 4.3. Lorsque l'on compare avec le Tableau 4.3 avec Tableau 4.2 on peut remarquer qu'il existe des différences plus significatives entre les groupes de PC pour les produits électroniques que pour les produits statiques. Cela est particulièrement vrai entre les sous-groupes de nationalité pour laquelle de nombreuses différences peuvent être observées pour tous les types de KQ (plaisir sensoriel, association sémantique, et l'émotion). Le Tableau 4.3 montre par exemple que le plaisir sensoriel issu de l'interaction est beaucoup moins perçu par les utilisateurs japonais que par les utilisateurs européens et que le sous-groupe espagnol est celui qui attribue des significations fortes pour les produits électroniques (par exemple : in fashion, subtle, social, at ease).

Tableau 4.3: Différences significatives en terme de KQ pour différentes PC lors d'interaction avec des produits électroniques

	Sensory pleasure (KQ)	*Semantic (KQ)*	*Emotion (KQ)*	*Total*
Age (PC)	Sound *40-49>50+*	Harmonious *20-29>50+*	Amused *30-39>50+* At ease *20-29>30-39*	4
Gender (PC)		Social *F>M* In fashion *F>M* Chic, elegant *F>M*	Curious *F>M*	4
Nationality (PC)	Smell *FR>SP, JP>SP, BE>SP* Interaction *FR>JP, SP>JP, GE>JP, BE>JP*	In fashion *SP>GE* Subtle *SP>GE* Social *SP>GE, SP>JP, SP>BE, SP>FR* At ease *SP>JP, FR>JP*	Passionate *GE>SP, FR>SP, BE>SP* Satisfied *FR>GE, FR>JP, FR>BE* Surprised *SP>GE, SP>FR, BE>GE*	24
Total	8	12	12	

4.2.3.3 INTERPRETATION DES DONNEES

Cette section décrit la création d'UX harmonics (harmoniques d'expérience d'utilisation). Une UX harmonics est une composition de critères liés aux caractéristiques personnelles de l'utilisateur [PC], aux différents attributs de l'environnement [AE] et aux qualités kansei intentionnelles [KQ] qui ensemble décrivent une direction d'expérience pertinente.

Afin de créer ces harmoniques UX, une analyse de classification hiérarchique des 211 UX décrite par les participants a été effectuée en fonction de leurs KQ perçues renseignées. La dissemblance a été mesurée avec la distance euclidienne et la méthode d'agglomération utilisée était la méthode de Ward car elle permet la création de classes (ou clusters) les plus homogènes. La troncature a été effectuée manuellement. Différents nombres de classes ont été testés afin de déterminer le nombre maximum pour lequel tous les groupes étaient encore composés de plusieurs descriptions d'expérience. Le nombre de classes retenues est de 15. La Figure 4.6 affiche le dendrogramme et la répartition des 15 clusters (nommées C1 à C15). La Figure 4.7 représente une exemple de cluster : le cluster C6 (correspondant à des expériences provenant de livres, jeux de société et tentes de camping).

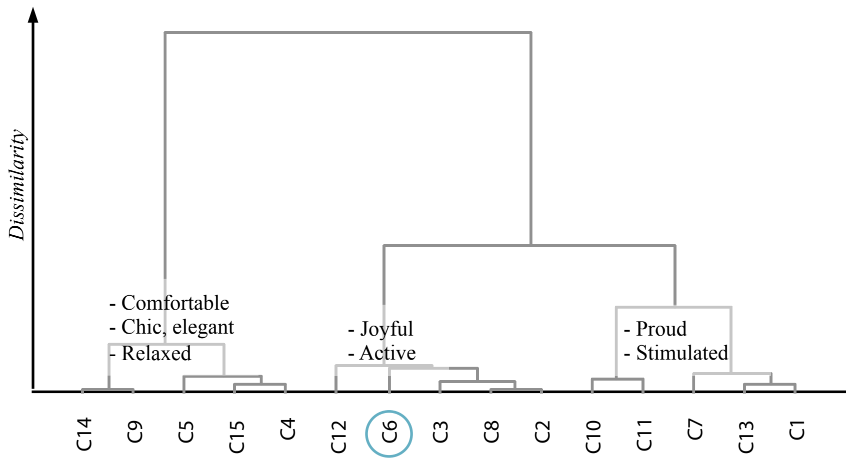


Figure 4.6: Dendrogramme représentant les 15 clusters

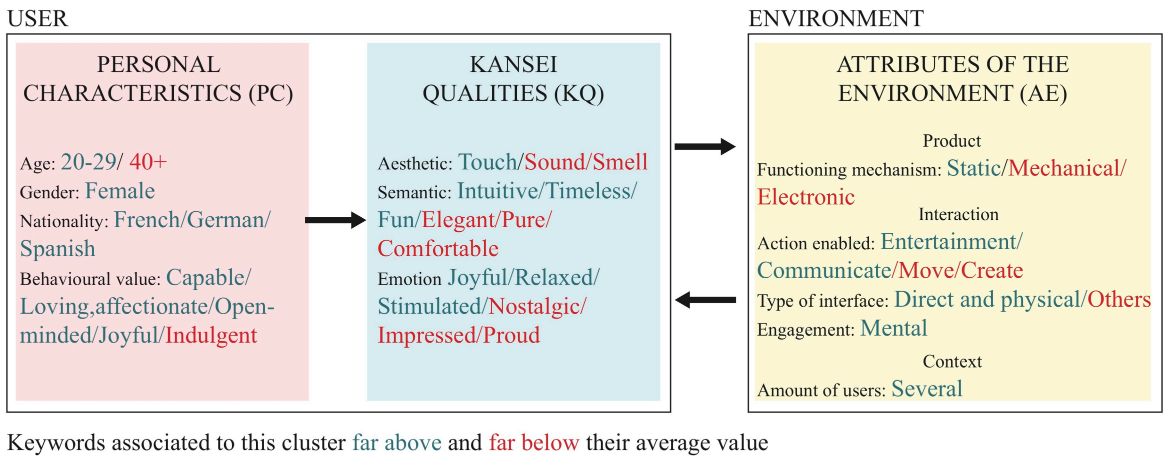


Figure 4.7: Exemple d'une UX harmonic (C6)

Les UX harmonics résument 15 directions d'expérience utilisateur attrayantes. Elles ont la particularité d'être relativement clairement définies en termes de PC, KQ, et AE ainsi que par des produits réels (ceux décrits par les participants). Cette liste de 15 directions n'est cependant pas exhaustive.

Les UX harmonics semblent donc être des points de départ intéressants pour être utilisés en temps que design brief/persona dans le cadre de projet de conception encore relativement ouverts. Les partager au sein d'une équipe de conception peut amener la discussion à des thèmes liés à l'UX et pourrait également aider l'équipe à identifier les directions UX les plus appropriées pour le projet. En effet, les UX harmonics contiennent des informations design relatives aux différents membres de l'équipe de conception.

Utiliser une sélection d'UX harmonics pourrait aussi contribuer à enrichir le design brief avec des informations design liées à l'expérience utilisateur. Dans le cas d'un intérieur de voiture, la sélection de certains UX harmonics pourrait par exemple aider à rechercher et à discuter des directions qui pourraient ensuite être traduites en termes d'attributs produits (formes, matériaux, fonctions ...) et de services associées (interaction, écosystème).

Les deux aspects décrits ici comme susceptibles d'être pertinents pour la pratique du design seront étudiées dans EXP 2.

4.2.4 CONCLUSION DE L'EXP 1

La première expérience (EXP 1) a exploré les corrélations entre les différentes entités d'UX. Une étude empirique basée sur 211 descriptions d'expérience utilisateur a permis la construction d'une base de données associant à chaque description des mots clés liés aux caractéristiques personnelles de l'utilisateur, aux qualités kansei perçues par l'utilisateur et aux attributs de l'environnement.

Les liens entre le PC, KQ et AE ont ainsi pu être quantifiés (corrélations, différences significatives). Une analyse de classification hiérarchique a permis d'identifier des macro-tendances d'expérience utilisateur. Ces 15 UX harmonics sont décrites avec des exemples de produits ainsi que des mots clés associés et dissociés liés à chacune des entités UX. Les valeurs ajoutées pour la pratique de ces différents résultats ont également été discutées.

Cette expérimentation permet aussi de discuter la validité d'H1 (« Les expériences venant de produits peuvent être comparées et regroupées selon les qualités kansei que les utilisateurs perçoivent d'eux, les caractéristiques personnelles des utilisateurs et les attributs de leurs environnements (produit, interaction, contexte). »). Les 15 clusters identifiés à partir des contributions des participants représentent 15 descriptions d'expérience utilisateur couvrant les différentes entités d'une expérience. Ils permettent de confirmer la validité interne et externe d'H1.

En raison de la nature des mesures effectuées, des limites peuvent néanmoins être identifiées. Seules les caractéristiques personnelles et les qualités kansei perçues auto-déclarées ont pu être utilisées comme données d'entrée et seulement un certain nombre d'attributs de l'environnement ont été prises en compte. Cette limitation porte sur la validité de construction de H1. Néanmoins, les mesures psychologiques utilisées sont très courantes pour ce type d'étude et sont également les seules capables de collecter une telle variété de données relatives à chaque entité de l'expérience.

Tableau 4.4: Information design contenue par les UX harmonics

Design information	*Related UX entity*	*Level of abstraction*
Value	User's personal characteristics	High
Semantic descriptor	Perceived kansei qualities	High
Emotion	Perceived kansei qualities	High
Action enabled	Interaction attributes	Middle
Interface characteristic	Interaction attributes	Middle
Sector/objet	Product attributes	Middle
Product characteristic	Product attributes	Middle
Physical context	Context attributes	Middle

Tableau 4.4 compile les informations design contenues par les UX harmonics. Les catégories sont inspirées par celles présentées par Kim et al (2009) et le niveau d'abstraction se réfère à la notion développée par Bouchard et al. (2009).

Des Tableaux similaires seront utilisés pour caractériser les catégories d'informations design couvertes par les représentations kansei utilisées dans chacune des expérimentations de ce rapport. Ils me permettront de construire un modèle décrivant les informations design utilisées dans les phases amont du processus de conception.

4.3 EXP 2: REPRESENTATIONS KANSEI – UX HARMONICS TRADUITES PAR DES DESIGNERS

4.3.1 PRESENTATION

La deuxième expérience (EXP 2) présente une méthodologie permettant la traduction des UX harmonics développées dans EXP 1 en représentations d'intentions UX liées à un contexte spécifique. Ces représentations amont peuvent être considérées comme des représentations kansei parce qu'elles transmettent des informations design liées aux qualités kansei intentionnelles du produit en développement et aux entités d'expérience qui influencent ces qualités (PC, AE).

La deuxième partie de l'expérimentation permettra d'évaluer l'influence de différents facteurs sur la compréhension des représentations kansei. Les différents facteurs étudiés sont l'expérience représentée, le contenu de la représentation (mots-clés, photos, musique), ainsi que la fonction et le sexe des lecteurs (équipe de conception).

4.3.2 GENERATION DE REPRESENTATIONS KANSEI

Les 15 UX harmonics ont été utilisées comme points de départ dans le processus de définition d'intentions en terme d'expérience dans le cadre de la phase amont du processus de développement d'un nouveau véhicule (utilisé comme une étude de cas). A ce stade du processus, le véhicule n'est décrit que par un cahier des charges contenant des intentions en terme de fonctionnalités clés, de dimensions et de clientèle cible (concept initial). Le protocole suivi pour la création de représentations kansei est représenté dans la Figure 4.8.

Figure 4.8: Protocole utilisé pour la génération de représentations

A/ SELECTION D'UX HARMONICS ADAPTEES

Les acteurs majeurs de l'équipe de conception ont été réunis pour une séance de travail. Suite à des discussions et des votes, cette séance a permis d'identifier 7 UX harmonics correspondant à ce projet véhicule.

B/ AFFINEMENT DES MOTS-CLES

Les 7 UX harmonics ont été enrichies avec des mots-clés provenant du concept initial.

C/ ASSOCIATION D'IMAGES

Une activité itérative impliquant cinq designers a permis la création de deux catégories d'images représentant chaque UX harmonic. Ces deux catégories sont : « expériences utilisateur d'inspiration » et « mouvements et comportements d'inspiration ».

D/ ASSOCIATION DE MUSIQUE

Une séance de brainstorming utilisant Youtube comme outil de recherche (2 heures, 8 participants) a été organisée afin de d'associer une musique à chaque UX harmonic sélectionnée.

.

E/ SELECTION D'UN TITRE

Les cinq designers impliqués dans la sélection des images ont finalement attribué des titres aux 7 représentations kansei crées à partir des UX harmonics.

L'Image 4.1 est un exemple de représentation kansei créée intitulé « Warm embrace ». La musique associée est le titre « Sunday Morning » des Velvet Underground.

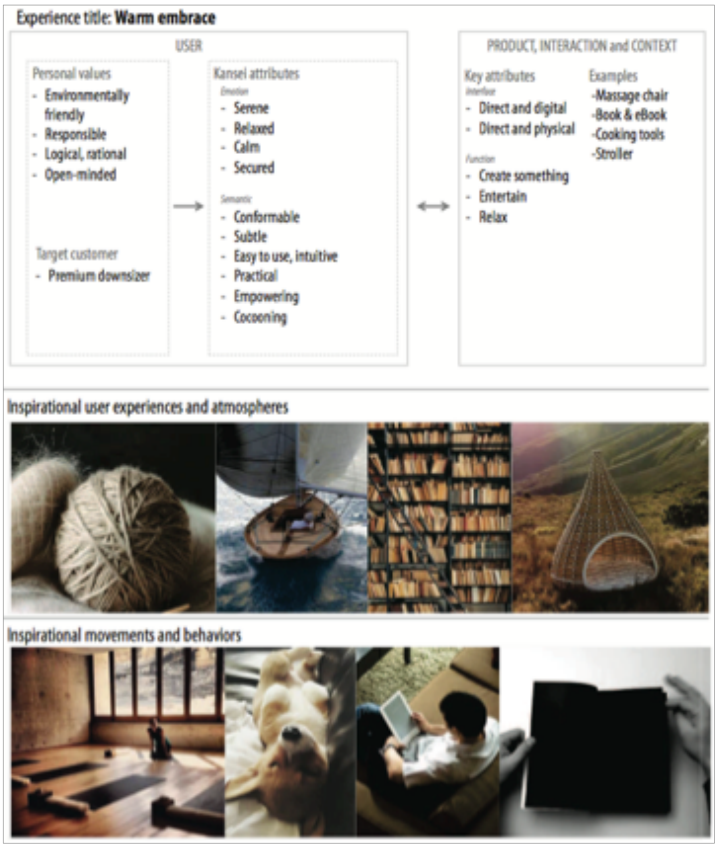


Image 4.1: Exemple (visuel) d'une représentation kansei créée

4.3.3 PERCEPTION DES KANSEI REPRESENTATION PAR UNE EQUIPE DE CONCEPTION NCD

Cette activité analyse la compréhension et les qualités kansei intrinsèques des représentations crées lorsqu'elle sont perçues par leur utilisateur principal : les différents membres d'une équipe de conception pluridisciplinaire. Elle investigue aussi l'intérêt des différentes modalités sensorielles dans la représentation d'information design liée à l'expérience d'utilisation.

4.3.3.1 PROTOCOLE DE EXPERIMENTATION

La Figure 4.9. représente le protocole de l'expérimentation. 31 professionnels, membres d'équipe de conception, l'ont suivi individuellement lors de sessions d'une heure.

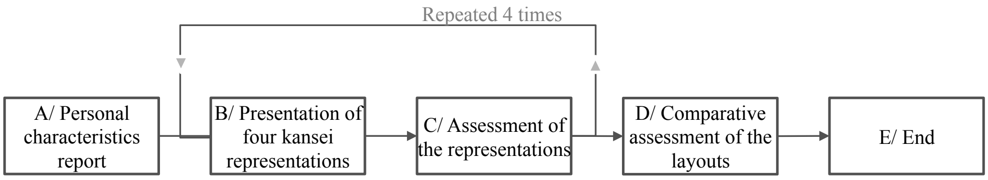


Figure 4.9: Protocole suivi par les participants afin d'évaluer les représentations kansei

A/ CARACTERISTIQUES PERSONELLES

Dans cette section, les participants ont indiqué leur sexe, et leur fonction. Afin d'isoler les deux variables inter-sujets qui seront au centre de l'expérimentation (genre, fonction), tous les participants recrutés, des professionnels impliqués dans les activités de pré-développement, étaient répartis uniformément en termes de genre (masculin, féminin) de fonction (ingénieur, designer, responsable produit). Ils étaient tous européens.

B/ PRESENTATION DE QUATRE REPRESENTATIONS KANSEI

Dans cette section, quatre représentations kansei sont présentées au participant (A, B, C, D). Pour chaque direction un type de mise en page différente a été utilisée (1: uniquement mots-clés, 2: uniquement photos, 3: mots-clés + photos, 4: mots-clés + photos + musique). L'ordre dans lequel les représentations sont présentées ainsi que la mise en page utilisée pour les représenter varie d'un participant à l'autre. Lorsque l'on prend en compte les 31 participants (et les sous-groupes de genre et de fonction), les deux paramètres (UX représentée et mise en page) sont répartis de manière homogène entre les quatre options possibles pour chacun d'eux.

C/ EVALUATION DES REPRESENTATIONS

Dans cette section les participants doivent évaluer les représentations en fonctions de critères liées aux différentes entités de l'expérience.

- Les caractéristiques personnelles perçues sont évaluées à l'aide d'échelles sémantiques différentielles (Osgood et al., 1957) représentant les traits de personnalité du Five Factor Model (Goldberg, 1990) et avec une échelle linéaire représentant six groupes d'âge.
- Une sélection de qualités kansei perçues est évaluée à l'aide d'échelles sémantiques différentielles similaires à celles utilisées dans EXP 1.
- Les attributs produits sont évalués à l'aide de six « style représentations » (Image 4.2). Les participants les associent aux représentations kansei à l'aide d'échelles sémantiques différentielles (de *not at all* à *extremely*).
- Les attributs d'interaction sont évalués à l'aide d'échelles sémantiques différentielles utilisant des paires de descripteurs d'interaction du type synonyme/antonyme (e.g. *physical interface* vs. *digital interface*, *active user* vs. *passive user*).

Image 4.2 : Exemple de quatre « style representations »

D/ EVALUATION COMPARATIVE DES QUATRE MISE EN PAGES

Les quatre mise en pages sont évaluées à l'aide d'échelle à cinq points en fonction de trois critères : *appeal*, *ease of use* et *efficiency*. Finalement les participants sont demandés de classer les mises en pages par ordre de préférence.

4.3.3.2 COMPREHENSION DES REPRESENTATIONS KANSEI

Je vais ici m'intéresser aux résultats de la section C du protocole qui traite de l'évaluation des représentations par les participants.

FACTEURS INFLUENÇANT LA COMPREHENSION RECIPROQUE

Quatre facteurs influençant la compréhension réciproque ont pu être testés : *l'expérience représentée*, la *mise en page* de la représentation kansei, le *genre* des participants, leur *fonction*. Le niveau absolu de différenciation "AL_{diff}" a pour cela été calculé pour chaque facteur. Il correspond au pourcentage de mesures pour lesquelles des différences significatives ont été observées entre leurs sous-groupes (e.g. homme et femme pour le factor *genre*). Ce niveau permet de comparer l'influence des facteurs sur la compréhension réciproque des participants. Il est représenté sur le Tableau 4.5.

Tableau 4.5: Niveau absolu de différenciation des quatre facteurs

Factor's origin	*Factor*	*Absolute differentiating level (AL_{diff})*
Representation	User experience	86.7%
	Layout	18.3%
Participant	Function	3.3%
	Gender	0.8%

Le Tableau 4.5 montre que l'*expérience représentée* et le facteur qui implique le plus de différence dans la compréhension. Il est suivi par la mise en page de la représentation kansei, puis par la fonction des participants, puis enfin par leur genre.

INFLUENCE DE LA MISE EN PAGE SUR LA DISTANCE A LA COMPREHENSION "CORRECT"

Les réponses des participants ont été comparées à la compréhension "correct" de chacune des expériences représentées. Cette dernière a été obtenue en faisant évaluer les quatre représentations par leurs créateurs. Cette évaluation a été effectuée en suivant le même protocole que les participants. Pour chaque mesure un Δ a été calculé. Il correspond a la valeur absolue de la différence entre la réponse du participant et cette des designers (exprimé en pourcentage).

L'influence de la mise en page de la représentation kansei a été calculée par chaque mesure et pour chaque expérience a l'aide d'ANOVA (comparant les Δ des différentes mise en page). Le niveau relatif de distance "RL_{diff}" a ainsi été calculé pour chaque type de mise en page. Il correspond au pourcentage de mesures pour lesquelles le layout appartient au groupe ayant une valeur Δ significativement plus grande que les autres. Le Tableau 4.5 retranscrit les valeurs de "RL_{diff}" pour les différents types de mise en page. Il permet d'observer que plus la représentation est riche, plus la distance entre intention et perception (distance à la compréhension "correct") est faible.

Tableau 4.5: Niveau relatif de distance pour les différentes mise en pages de représentation kansei

Type of layout	*Relative distance level (RL_{diff})*			
	PC	*KQ*	*AE*	***Overall***
1/Keywords only	7.1%	8.3%	2.3%	**5.8%**
2/Pictures only	7.1%	4.2%	0.0%	**3.3%**
3/Keywords + Pictures	3.6%	4.2%	2.3%	**3.3%**
4/Keywords + Pictures + Music	0.0%	2.1%	2.3%	**1.7%**

4.3.3.3 QUALITES KANSEI INSTINSEQUES DES REPRESENTATIONS KANSEI

Dans la section D du protocole, il a été demandé aux participants d'exprimer leur opinion concernant les différentes mises en pages. Le Tableau 4.6 montre pour chaque mise en page la moyenne et l'erreur standard (SE) de l'attractivité perçue, de la facilite d'utilisation perçue et de l'efficacité perçue (note de 1 a 5), ainsi que du classement relatif aux autres (de 4 a 1). Ces points représentent les qualités kansei intrinsèques des différentes mises en pages.

Tableau 4.6: Evaluation affective des quatre types de mise en page

Type of layout	*Average rating (sign. diff. group(s))*						*Average ranking (sign. diff. group)*	
	Appeal		*Ease of use*		*Efficiency*			
	Mean (Group)	*SE*	*Mean (Group)*	*SE*	*Mean (Group)*	*SE*	*Mean (Group)*	*SE*
1/Keywords only	2.32 (B)	0.26	2.58 (B)	0.24	2.17 (C)	0.23	3.7 (C)	0.18
2/Pictures only	3.94 (A)	0.25	4.03 (A)	0.24	3.70 (B)	0.23	2.5 (B)	0.18
3/Keywords + Pictures	3.87 (A)	0.26	4.00 (A)	0.25	4.17 (A, B)	0.24	2.2 (B)	0.18
4/Keywords + Pictures + Music	4.39 (A)	0.26	4.26 (A)	0.25	4.61 (A)	0.25	1.7 (A)	0.19

L'analyse de la variance a permis d'observer des différences significatives entre les qualités kansei intrinsèques des mises en pages (Tableau 4.6). Pour tous les axes de mesure il peut être observé que la mise en page de type 1 (uniquement mots-clés) possède la moyenne la plus basse et est a chaque fois significativement moins bien évaluée. Du côté opposé la meilleure moyenne est toujours obtenue par la mise en page de type 4 (mots-clés + photos + musique): pour certains critères la différence avec les deux types de mise en page restants est significative (c.f. Tableau 4.7). Les évaluations de ces deux derniers types de mise en page (2: uniquement photos, 3: mots-clés + photos) sont quant a eux assez proches (le type 3 a globalement une moyenne légèrement meilleure au type 2). Ces résultats montrent que la richesse sensorielle de la mise en page des représentations tend à augmenter leurs qualités kansei intrinsèques.

4.3.3.4 UTILISATION DANS LES PHASES AMONTS DE DEVELOPEMENT

Les représentations kansei proviennent d'un projet de pré-développement. Celles de type 3 et 4 (en fonction de la présence d'un système audio) ont aussi été utilisées dans le cadre d'activité pluridisciplinaires. Les membres de l'équipe projet ainsi que leurs managers respectifs ont très bien accueilli cette nouvelle activité. Ils ont reconnu la portée de l'information design communiquée et la valeur ajoutée des mises en pages sensoriellement riches. Les équipes projets ont aussi su s'approprier les représentations en les utilisant dans leurs activités spécifiques.

4.3.4 CONCLUSION DE L'EXP 2

Deux activités faisaient partie de la deuxième expérimentation (EXP 2). La première était liée à la création de représentations kansei et la seconde à leur évaluation.

Au cours de la première activité, les UX harmonics ont été traduits en représentations multi-sensorielles afin de transmettre les intentions de la direction UX. La méthode utilisée combine raisonnements scientifiques (identification des UX harmonics) et le raisonnement abductif (sélection des UX harmonics, associations d'images et de musique).

La deuxième activité a consisté à évaluer la qualité des représentations kansei créées et à comprendre l'importance de leur mise en page (présence de mots clés, images, sons). Ces dernières ont été testées avec des intervenants professionnels de différentes fonctions impliqués dans les phases amont de conception (ingénierie, design, business). Il a été montré que la compréhension et l'attractivité des représentations allaient de pair avec la richesse de leur contenu.

Le Tableau 4.7 montre l'étendu des catégories d'information design communiquée par les représentations kansei multi-sensorielles discutées précédemment. Il peut être noté que de le spectre d'informations communiquées est très large : d'abstraite à concrète et couvrant toutes les entités d'une expérience. Celui-ci est aussi bien plus large que celui des représentations discutées dans l'état de l'art (scénario, persona, mood-boards..).

Tableau 4.7: Information design information communiquée par les représentations kansei créées dans l'EXP2

Design information	*Related UX entity*	*Level of abstraction*
Value	User's personal characteristics	High
Semantic descriptor	Perceived kansei qualities	High
Emotion	Perceived kansei qualities	High
Style	Product attributes	High
Action enabled	Interaction attributes	Middle
Interface characteristic	Interaction attributes	Middle
Sector/objet	Product attributes	Middle
Product characteristic	Product attributes	Middle
Physical context	Context attributes	Middle
Culture (demographics)	User's personal characteristics	Low
Gesture	Interaction attributes	Low
Feedback	Interaction attributes	Low
Visual attribute	Product attributes	Low
Auditory attribute	Product attributes	Low

La partie concernant l'évaluation des représentations a montré que les caractéristiques personnelles des lecteurs n'avaient que très peu d'influence sur leur compréhension. Elle a également montré que la compréhension de ces représentations (par rapport à l'intention) était très bonne. Cela me permet de déduire que les représentations kansei testées permettent d'améliorer la compréhension mutuelle liée à des directions UX au sein d'équipes de conception multiculturelles.

Dans ce sens, les représentations kansei présentées dans l'EXP 2 vont permettre de discuter H2.

4.4 EXP 3: REPRESENTATION KANSEI – BASEES SUR DES SESSIONS DE DESIGN PARTICIPATIF

4.4.1 INTRODUCTION

Pour cette troisième expérimentation (EXP 3), les méthodologies de création de représentations kansei utilisées incluent en plus de designers (comme vue dans EXP 2) des utilisateurs par le biais de sessions de design participatif. Le contexte de cette expérimentation est la définition de direction UX d'un point de vue européen pour la future génération de véhicules hybrides (NGH).

Le processus de création de représentations kansei dans cette expérimentation se divise en deux itérations : la première utilisant des stimuli visuels et la seconde des stimuli multi-sensoriels.

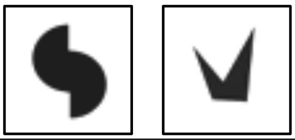
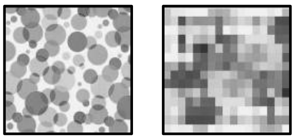
4.4.2 PREMIERE ITERATION

4.4.2.1 KANSEI CARDS

Les stimuli visuels utilisés sont des kansei cards. Ces dernières sont organisées en famille. Chaque famille a comme propriété de se focaliser principalement sur certaines catégories d'information design, les différentes cartes couvrant ensuite un spectre large de variations au sein de ces catégories. Quatorze familles ont été créées (11 d'images, 3 de mots-clefs). Certaines sont présentées en exemple dans le

Tableau 4.8.

Tableau 4.8: Description de 11 familles de kansei cards

Family topic	*Number of cards*	*Main category of design information*	*Example of pictures*
Simple shapes	59	- Semantic descriptor - Visual attribute (shape)	
Patterns	95	- Semantic descriptor - Style - Visual attribute (shape)	
Animals	47	- Value - Semantic descriptor - Emotion - Product characteristic - Gesture	
Natural landscapes	30	- Value - Semantic descriptor - Emotion	
Chairs	30	- Style - Semantic descriptor - Product characteristic	
Sports	37	- Value - Semantic descriptor - Emotion - Interface characteristic - Temporal context	
Flowers	31	- Semantic descriptor - Style - Visual attribute (shape and colour)	
Arm gestures	29	- Semantic descriptor - Emotion - Interface characteristic - Gesture	
Semantic keywords	16	- Semantic descriptor	Authentic 正真正銘、本物 Subtle さり気無い
Emotions	17	- Emotion	Amused 面白い Passionate 情熱的な
Instrumental values	18	- Values	Ambitious 野心的 Honest, Frank 正直、率直な

4.4.2.2 PROTOCOLE

Le protocole de la première itération est présenté sur la Figure 4.10.

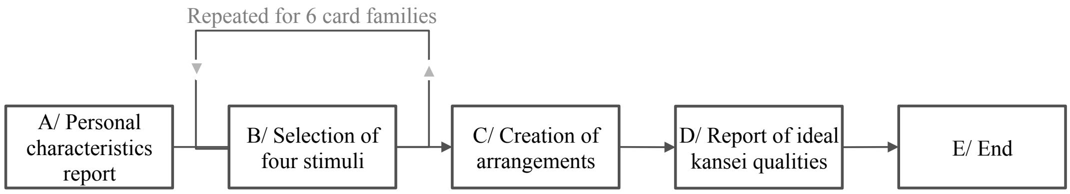


Figure 4.10: Protocole d'EXP 3 – Première itération

Durant cette expérimentation, les participants ont d'abord été priés de renseigner certaines de leurs caractéristiques personnelles (âge, sexe, nationalité) (A). Il est à noter qu'ils avaient tous une expérience avec des véhicules hybrides.

Lors de la deuxième section (B), il leur a été présenté tour à tour cinq familles de kansei cards ("animaux," "formes simples," "motifs," "fleurs," et "produits & ambiances") ainsi que des échantillons de couleur (voir comme exemple l'Image 4.3). Pour chacune des familles, il leur a été demandé de sélectionner les quatre cartes qui représentent le mieux leur idée concernant NGH.

Image 4.3: Deux familles de kansei cards ("fleurs" et "produits et ambiances") présentées sur des tableaux blancs

Lors de la section C, il a été demandé aux participants de faire des arrangements avec les kansei cards précédemment sélectionnées (voir comme exemple l'Image 4.4). Il leur a aussi été demandé de compléter la couleur sélectionnée par d'autres afin d'établir une harmonie de couleur. Pour conclure cette section, chaque arrangement devait être évalué sur des échelles différentielles sémantiques en fonction de six mots-clefs.

Image 4.4 : Exemple d'un arrangement

Lors de la section D, il a été demandé aux participants d'évaluer les qualités kansei idéales que devraient transmettre d'après eux les véhicules NGH. Pour ce faire, ils ont du associer ou non les éléments de deux familles de kansei cards basées sur des mots-clés (sémantiques, émotions).

4.4.2.3 ANALYSE AND RESULTAS

INFORMATION DEMOGRAPHIQUE

La distribution de l'âge et du sexe des 33 participants est représentée sur la Figure 4.11. Ils étaient issus de neuf pays européens différents.

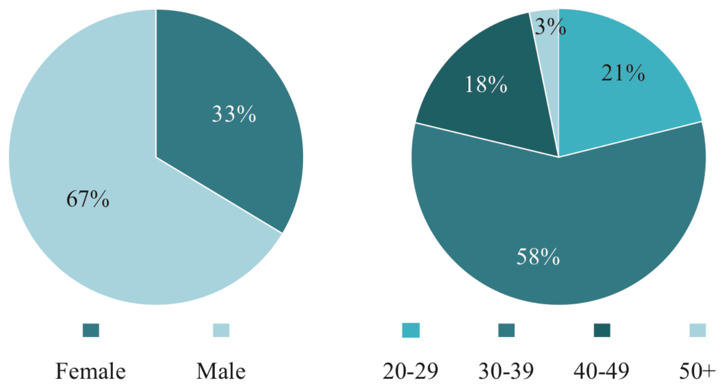


Figure 4.11: Distribution des participants en terme de sexe et d'âge

MAPPING DES STIMULI

Les 33 participants ont créé un total de 89 arrangements. Une analyse statistique par regroupement hiérarchique a permis d'identifier 7 groupes de stimuli (Figure 4.12). Ces derniers sont constitués de descripteur de qualités kansei, d'images provenant des kansei cards, de descripteur d'harmonies de couleurs et d'un exemple d'une harmonie.

Les sept directions kansei visuelles peuvent être divisées en deux catégories : celle qui comporte de l'information design de bas niveau clairement lié au monde physique ("technological/innovative" (1-TEC), "smooth/fluid" (2-SMO) et "organic/natural" (3-ORG)) et celles qui se concentrent sur de l'information design abstraite ("serene/peace of mind" (A-SER), "refinement" (B-REF), "energy" (C-ENE) et "different/unexpected" (D-DIF)).

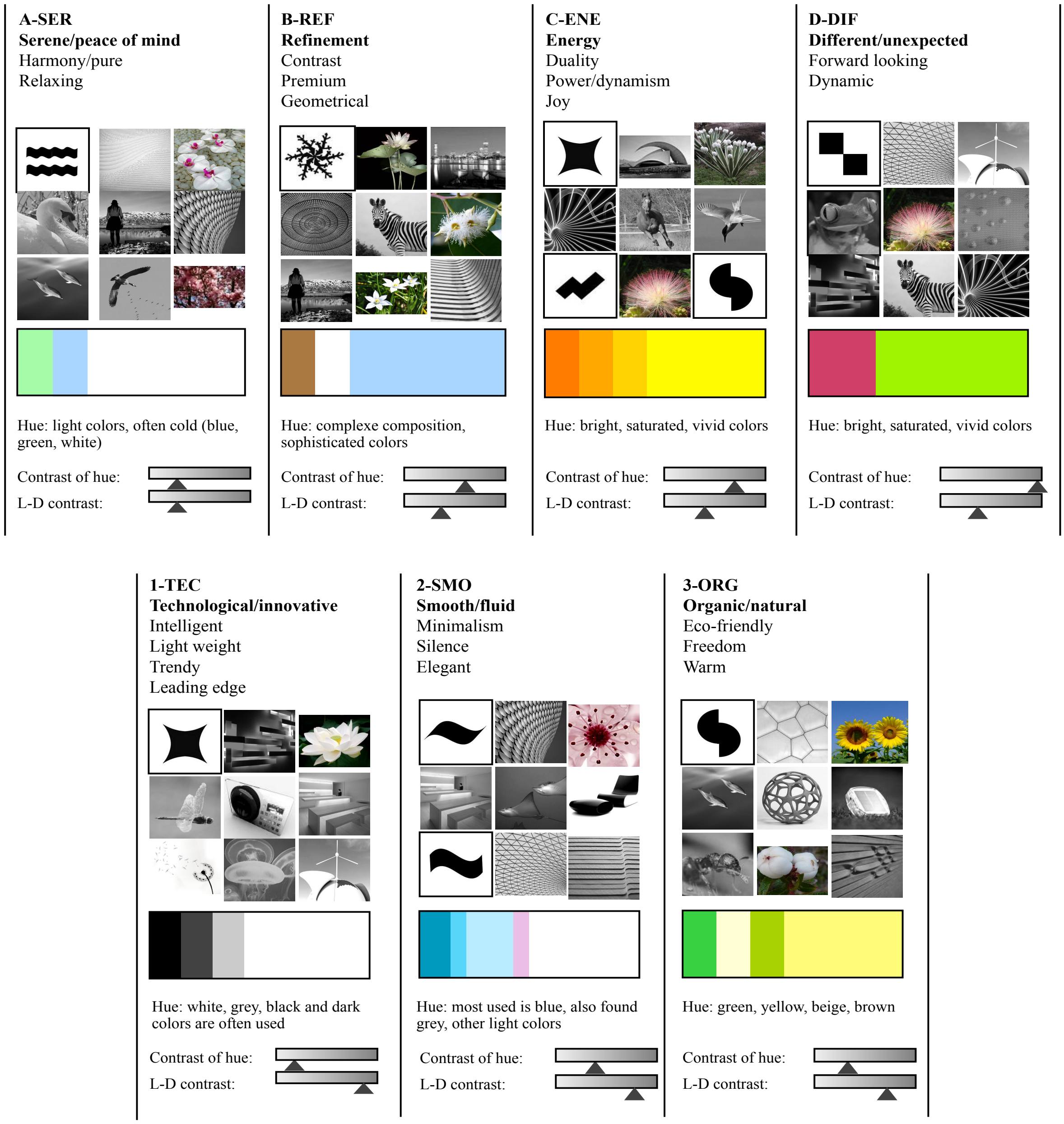


Figure 4.12: Sept directions kansei visuelles pour véhicules NGH

4.4.2.4 Conclusion

Cette première itération de l'EXP 3 peut être vue comme une méthodologie Kansei Design car elle combine des raisonnements abductifs (création et sélection des kansei cards) et scientifiques (analyse). Il est a noter que des potentiels futurs utilisateurs y prennent part à travers des sessions de design participatif. Le résultat a été sept directions kansei (Figure 4.12). L'information design qu'elles contiennent est représentée dans le Tableau 4.9.

Tableau 4.9: Information design contenue dans les représentations kansei issues de la première itération de l'EXP3

Design information	*Related UX entity*	*Level of abstraction*
Semantic descriptor	Perceived kansei qualities	High
Emotion	Perceived kansei qualities	High
Style	Product attributes	High
Sector/objet	Product attributes	Middle
Physical context	Context attributes	Middle
Culture (demographics)	User's personal characteristics	Low
Visual attribute	Product attributes	Low

4.4.3 DEUXIEME ITERATION

La deuxième itération comprend à nouveau la participation d'utilisateurs et la création de stimuli (cette fois multi-sensoriels) par une équipe de designers. Elle a pour but d'obtenir plus de précisions que la première itération en terme d'information design. Cette itération de l'EXP 3 compare aussi l'influence de la nationalité des participants (Européen/ Japonais).

4.4.3.1 MOOD-BOXES

À partir des sept directions kansei issues de la première itération des nouvelles représentations kansei ont été crées comme stimuli pour cette partie de l'expérimentation. En combinant unes à unes les directions kansei orientées sur des informations design concrètes (aussi appelées familles) avec celles orientées sur des informations design abstraites (aussi appelées nuances).

Ces nouvelles représentations créées par des designers sont appelées Mood-boxes. Elles sont composées d'un assemblage de produits et de matériaux d'inspiration ainsi que d'échantillons de métaux, plastiques et peintures disposés dans boîtes ouvertes sur le dessus (37x26x6cm). Les quatre Mood-boxes correspondants aux déclinaisons de la famille 1-TEC sont représentées sur l'Image 4.4.

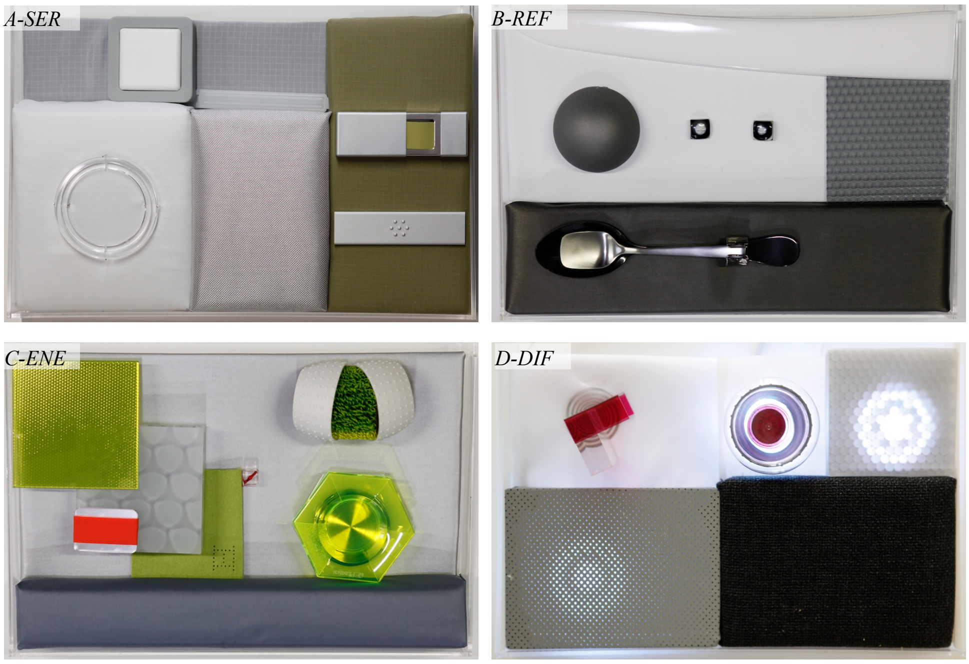


Image 4.4: Les quatre Mood-boxes provenant de la famille 1-TEC ("technological/innovative")

4.4.3.2 PROTOCOL

Le protocole de la deuxième itération est présenté sur la Figure 4.13.

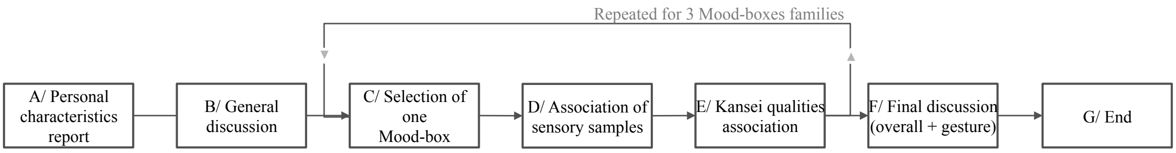


Figure 4.13: Protocole d'EXP 3 – deuxième itération

Durant cette expérimentation, les participants ont d'abord été priés de renseigner certaines de leurs caractéristiques personnelles (âge, sexe, nationalité) (A). Il est a noté qu'ils avaient tous une expérience avec des véhicules hybrides. Lors de cette section les 12 Mood-boxes leur ont aussi été présentées. Ces dernières étaient organisées par familles (voir Image 4.5).

Lors de la section B, il a été demandé aux participants d'émettre un jugement sur les familles de Mood-boxes.

Lors de la section C, les participants ont du sélectionner la Mood-box de chaque famille correspondant le plus à leur image de NGH.

Image 4.5: Organisation spatiale de l'expérimentation

Lors de la section D des stimuli tactiques, sonores et olfactifs ont été présentés aux participants (voir Image 4.6). Ils ont du associer chacun d'entre eux (*pas du tout*, *moyennement*, *extrêmement*) aux trois Mood-boxes sélectionnées dans la section C.

TACTILE SAMPLES AUDITORY SAMPLES OLFACTORY SAMPLES

Image 4.6: Trois types de stimuli sensorielles

Suivant le même principe d'association, des qualités kansei (émotions, descripteurs sémantiques) ont été associées aux Mood-boxes. Ceci s'est déroulé dans la section E de l'expérimentation.

Finalement, lors de la section F, les participants ont été priés de discuter et d'évaluer les trois univers multi sensoriels qu'ils venaient de créer à partir des Mood-boxes. Ils ont aussi été demandés d'associer à chacun des univers des kansei cards axées sur la gestuelle (voir Image 4.7).

BODY GESTURE
whole body

LOCALISED GESTURES
finger + wrist

ARM GESTURE
finger + wrist + shoulder

Image 4.7: Kansei cards axées sur la gestuelle

4.4.3.3 Analyse pour les participants Europeens

4.4.3.3.1 Informations demographique

41 participants européens ont suivi le protocole de cette deuxième itération. Ils peuvent être perçus comme des potentiels futurs utilisateurs de NGH car ils possédaient tous au moment de la recherche d'un véhicule hybride. Un tiers de ces participants étaient des femmes et ils couvraient 18 nationalités européennes.

4.4.3.3.2 ANALYSE DES ACTIVITES DE DISCUSSION ET DE SELECTION

Lors des sections B, C et F, les participants ont émis des jugements sur les familles et les nuances des Mood-boxes.

Dans la section B les familles ont été évaluées en fonction de leur représentativité de NGH. À ce niveau il a été observé que la famille 2-SMO était la plus représentative.

Lors de la sélection de trois Mood-boxes (section C), les participants ont émis des préférences par rapport aux nuances. La nuance B-REF a dans ce cas été la plus associée à la notion de NGH.

Lors de cette sélection de Mood-boxes (section C) les participants ont aussi fait une sélection par rapport aux Mood-boxes elles-mêmes (combinaison d'une famille et d'une nuance). Les Mood-boxes les plus choisies étaient celles associant "organic/natural" & "refinement" (3B, 51%), "technological/innovative" et "refinement" (1B, 41%), "technological/innovative" & "serene" (1A, 29%) ainsi que "smooth/fluid" et "energy" (2C, 29%).

Enfin lors de la section F, les participants ont discutés et évalués les ambiances liées au Mood-boxes. Dans ce cas les ambiances les mieux notées étaient celles liées aux Mood-boxes "technological/innovative" et "different/unexpected" (1D, 1st) ainsi que celles liées aux nuances "energy" (2C, 2nd ex-aequo), "different/unexpected" (2D, 2nd ex-aequo) et "serene/peace of mind" (2A, 4th) de la famille "smooth/fluid".

4.4.3.3.3 ANALYSE DE L'ACTIVITE D'ASSOCIATION

Au total 123 MB ont été associées à des stimuli sensoriels et à des qualités kansei. Une analyse en composantes principales (PCA) couplée à une analyse statistique par regroupement hiérarchique (HCA) a permis d'obtenir le mapping présenté en Figure 4.14. La proximité des points visuellement les Mood-boxes et les stimuli souvent associés (PCA). Les lignes rouges viennent renforcer les proximités conceptuelles en délimitant les différents groupes issus des regroupements hiérarchiques. Afin de faciliter leur manipulation, les différents groupes ont été nommés (indiqué en rouge sur la Figure 4.14).

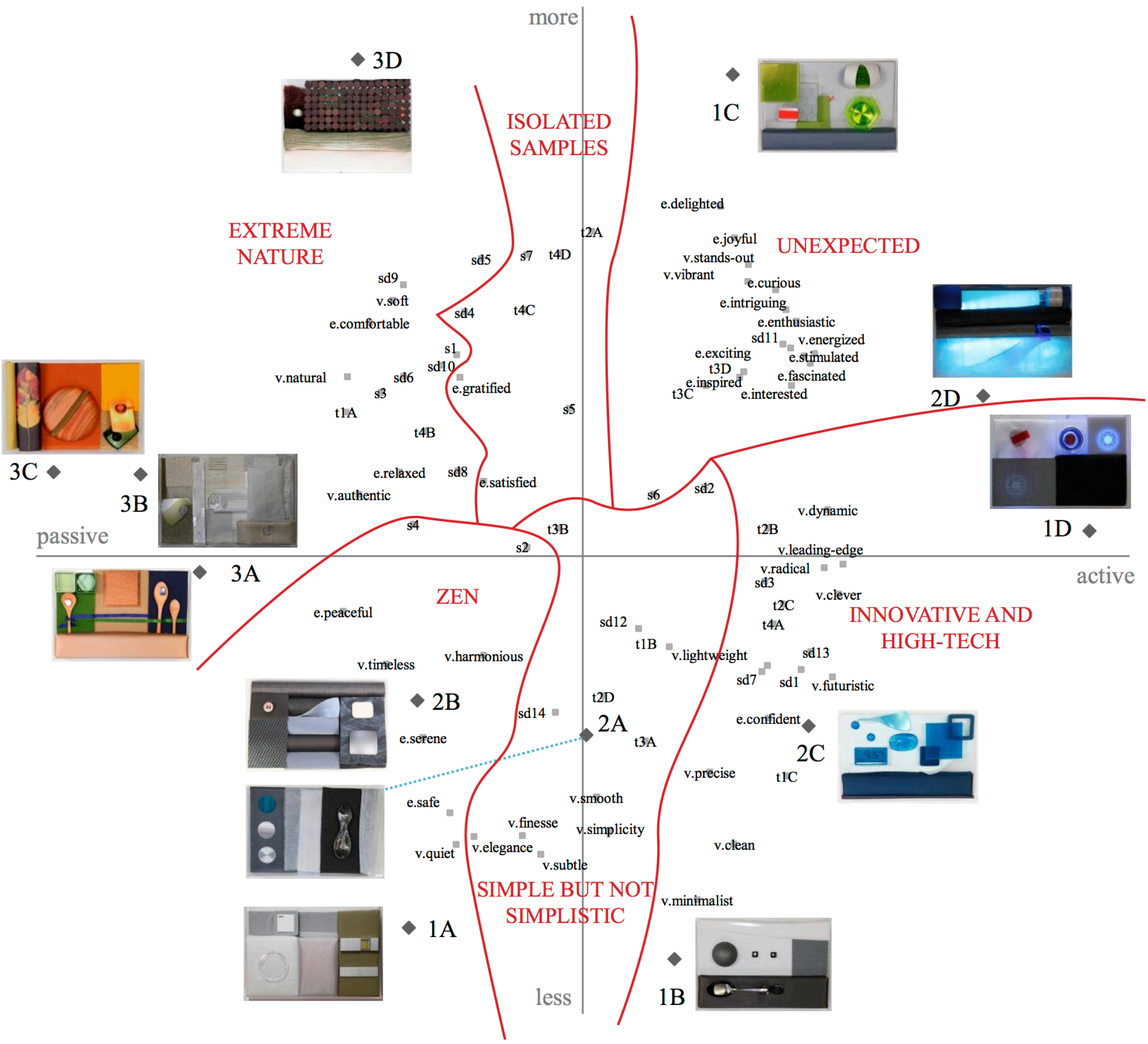


Figure 4.14: Kansei mapping et regroupement hiérarchique

4.4.3.3.4 EXTRACTION DE TROIS DIRECTIONS KANSEI

Intégrer les groupes issus du regroupement hiérarchique dans les résultats des activités de discussion et de sélection permet de faire ressortir trois directions kansei majeures (Figure 4.15).

La première direction, “Light and organic refinement”, couvre les groupes *Extreme nature*, *Zen* et *Simple but not simplistic* qui comportent les Mood-boxes les plus sélectionnées (3B, 1B et 2A).

La deuxième direction, “Minimal and smooth aquatic life”, couvre les groupes *Zen*, *Simple but not simplistic* et *Innovative and high-tech* qui comportent les Mood-boxes de la famille “smooth/fluid”. Cette dernière était la plus appréciée que ce soit pas les femmes ou les hommes.

Finalement, la troisième direction, “ *Unexpected* and *Innovative and high-tech*”, couvre les groupes *Unexpected* and *Innovative and high-tech* qui comportent les Mood-boxes les mieux évaluées (1C, 1D, 2C, and 2D). Ce sont aussi celles qui ont éveillé le plus d’émotions chez les participants.

Figure 4.15: Zones couvertes par les trois directions kansei

En utilisant la riche information design contenue par ces trois directions, ces dernières ont pu être déclinées en différents types de représentation kansei comme des nouvelles mood-boards, Mood-boxes ou des compositions d'échantillons d'inspiration (exemple sur l'Image 4.8). Ces représentations ont comme but de communiquer l'information kansei à différentes audiences comme des décideurs ou des équipes de conception internes ou externes à l'entreprise (par exemple : développement de pièces, fournisseurs de matériaux).

Image 4.8: Nouvelle Mood-box et composition d'échantillon sensorielles correspondant à la direction "light and organic refinement"

4.4.3.4 COMPARAISON ENTRE PARTICIPANTS JAPONAIS ET EUROPEENS

La première partie de l'analyse a permis d'identifier des directions kansei pour les futurs véhicules hybrides d'un point de vue européen (avec des participants européens). Cette partie de l'analyse questionne l'influence du sexe et de la nationalité des participants sur les directions kansei identifiées.

4.4.3.4.1 INFORMATIONS DEMOGRAPHIQUES

Pour ce faire, 25 participants Japonais ont suivi le protocole décrit précédemment en plus des 41 européens. Pour les deux populations, la proposition de femmes s'élevait à un tiers.

4.4.3.4.2 DIFFERENCES LORS DES ACTIVITES DE SELECTION

Deux activités de sélection vont être comparées ci-dessous : la sélection de Mood-box et la sélection de nuances.

Les tableaux ci-dessous comparent les pourcentages de sélection de Mood-box entre les sous-groupes européens (EU) et japonais (JP) (Tableau 4.10) et les sous-groupes femmes (F) et hommes (M) (Tableau 4.11). Une synthèse par nuance est indiquée en bas de chaque colonne. Les différences importantes (>12%) sont surlignées en gris. En comparant les deux tableaux il en ressort que la nationalité est une variable beaucoup plus clivante que le sexe.

Tableau 4.10: Ratio de sélection des différentes MB et différences important (comparaison JP/EU)

		Abstract-oriented directions			
		A-SER	*B-REF*	*C-ENE*	*D-DIF*
Concrete-oriented directions	*1-TEC*	JP: 4% **EU: 29%**	JP: 24% **EU: 41%**	**JP: 24%** EU: 12%	**JP: 44%** EU: 17%
	2-SMO	JP: 32% EU: 27%	JP: 16% EU: 20%	**JP: 44%** EU: 29%	JP: 8% **EU: 24%**
	3-ORG	**JP: 32%** EU: 17%	JP: 12% **EU: 51%**	**JP: 24%** EU: 12%	JP: 16% EU: 17%
Abstract-oriented directions (average)		JP: 23% EU: 24%	JP: 17% **EU: 37%**	**JP: 31%** EU: 18%	JP: 23% EU: 20%

Tableau 4.11: Ratio de sélection des différentes MB et différences important (comparaison F/M)

		Abstract-oriented directions			
		A-SER	*B-REF*	*C-ENE*	*D-DIF*
Concrete-oriented directions	*1-TEC*	F: 19% M: 20%	F: 38% M: 33%	F: 14% M: 18%	F: 29% M: 27%
	2-SMO	F: 19% **M: 33%**	F: 19% M: 18%	**F: 52%** M: 27%	F: 5% **M: 24%**
	3-ORG	F: 10% **M: 29%**	F: 43% M: 33%	F: 19% M: 16%	F: 24% M: 13%
Abstract-oriented directions (average)		F: 16% M: 27%	F: 33% M: 28%	F: 29% M: 20%	F: 19% M: 21%

Cette observation est confirmée lorsqu'on regarde en détail la moyenne et l'écart type des différences de ratio de sélection entre les sous-groupes liés à la nationalité et ceux liés au sexe. (Tableau 4.12).

Tableau 4.12: Comparaison des différences de sélection liées à la nationalité et au sexe

	Mean (%)	*Standard deviation (%)*	*Effect size (Cohen's d)*
$MB\Delta_{JP/EU}$	15.7	10.2	0.61
$MB\Delta_{F/M}$	9.5	7.8	

4.4.3.4.3 DIFFERENCES LORS DES ACTIVITES D'ASSOCIATION

Pour chaque direction de Mood-boxes (abstraite ou concrète), une analyse de la variance a été réalisée afin d'établir si des différences significatives pouvaient être observées, dans l'association de stimuli, entre les sous-groupes liés à la nationalité et au sexe. Le Tableau 4.13 retranscrit ces résultats. Il peut être observé que la nationalité est ici aussi un facteur plus différenciant que le sexe.

Tableau 4.13: Différences significatives en terme d'association de stimuli

	Concrete-oriented directions				*Abstract-oriented directions*					*All*
	1-TEC	*2-SMO*	*3-ORG*	***All***	*A-SER*	*B-REF*	*C-ENE*	*D-DIF*	***All***	
JP/EU	18%	16%	17%	**17%**	12%	12%	4%	30%	**14%**	**16%**
F/M	8%	3%	9%	**6%**	4%	5%	5%	8%	**6%**	**6%**

Le Tableau 4.14 illustre les différences d'association entre Japonais et Européens pour les trois directions concrètes. Dans les lignes liées à EU et à JP sont inscrits les références des stimuli associés significativement plus à la direction par chacune de ces populations.

Tableau 4.14: Différences significatives en terme d'association de stimuli entre Européens et Japonais pour les trois directions concrètes

		1-TEC	*2-SMO*	*3-ORG*
Touch	*JP*	very soft, low grain density		very soft, soft, scattered grain
	EU	cold, hard	mildly hard, hard	hard
Sound	*JP*			
	EU			nature rhythm
Smell	*JP*	woody powdery scent	woody powdery scent	
	EU			
Semantic	*JP*			minimalist, subtle
	EU	clean, elegance, harmonious, minimalist, precise, subtle	dynamic, energised, lightweight, radical, soft, subtle	finesse, natural
Emotion	*JP*			gratified, serene
	EU	confident, enthusiastic, safe	enthusiastic, joyful, stimulated	confident, enthusiastic

4.4.3.5 DISCUSSIONS

La seconde itération de l'EXP 2 a montré qu'il était possible de créer des représentations kansei multi-sensorielles de qualité industrielle en incluant à la fois des utilisateurs et des designers dans le processus de création.

Il a aussi été montré que les caractéristiques personnelles des utilisateurs se retranscrivent dans leurs choix en terme de sélection et d'association. Les trois directions identifiées sont donc typiquement Européennes. Différentes catégories d'information design permettant de rendre ces directions appréciées par les deux populations ou uniquement par un public Japonais ont par ailleurs aussi pu être identifiées.

4.4.4 CONCLUSION DE L'EXP 3

L'EXP 3 est composée de deux itérations. Elles explorent toutes deux les possibilités d'utiliser des sessions de design participatifs au sein de méthodologies kansei et font appel à deux types d'outils : kansei cards et Mood-boxes. Pour ce faire, les participants (de potentiels futurs utilisateurs) ont associé et sélectionné différents stimuli se référant à différentes catégories d'information design.

La première itération était basée sur des stimuli uniquement visuels. Les représentations kansei issues de cette itération contenaient des informations design de haut et bas niveau d'abstraction et couvraient toutes les entités d'une expérience d'utilisation mise à part les attributs d'interactions (détaillés dans le Tableau 4.9 [p. 251]). Les représentations kansei de la deuxième itération couvrent quant à eux quatre canaux sensoriels et des catégories encore plus larges d'information design (Tableau 4.15). Ces informations kansei proviennent principalement des stimuli utilisés mais aussi des participants (caractéristiques personnelles) et du brief (attributs de contexte).

Tableau 4.15: Information design contenue par les représentations kansei de la seconde itération de l'EXP 3

Design information	*Related UX entity*	*Level of abstraction*
Semantic descriptor	Perceived kansei qualities	High
Emotion	Perceived kansei qualities	High
Style	Product attributes	High
Interface characteristic	Interaction attributes	Middle
Sector/objet	Product attributes	Middle
Product characteristic	Product attributes	Middle
Physical context	Context attributes	Middle
Culture (demographics)	User's personal characteristics	Low
Gesture	Interaction attributes	Low
Feedback	Interaction attributes	Low
Visual attribute	Product attributes	Low
Tactile attribute	Product attributes	Low
Auditory attribute	Product attributes	Low
Olfactory attribute	Product attributes	Low

EXP 3 contribue à explorer et discuter l'hypothèse H2. Cette expérimentation est complémentaire à EXP 2 car les outils et méthodologies amenant à la création de représentations kansei sont fondamentalement différents. Dans cette expérimentation les utilisateurs sont considérés comme des partenaires et participent activement au processus de création des représentations kansei.

4.5 EXP 4: REPRESENTATION KANSEI – CO-CREATION PAR UNE EQUIPE DE CONCEPTION

4.5.1 INTRODUCTION

La quatrième expérimentation (EXP 4) s'intéresse tout comme l'EXP 2 et l 'EXP 3 à la création de représentations amont d'intention en terme d'expérience utilisateur. Cette expérimentation utilise à nouveau l'outil kansei cards présenté dans EXP 3. Cette fois-ci il est utilisé avec des groupes qui sont dans ce cas des équipes de conception (ingénieur, designer) internes à l'entreprise.

4.5.2 PROTOCOLE

Deux types de groupes vont être comparés dans ce protocole: le « control group » (CG) et le « test group » (TG) (Figure 4.16). Ces groupes de quatre personnes sont composées identiquement en terme de ratio homme-femme (50%-50%), nationalité (50% japonaise - 50% européenne) et fonction (50% ingénieur – 50% designer).

Le protocole suivi par les deux types de groupe est identique sauf pour ce qui concerne la section B de ce dernier (voir Figure 4.16).

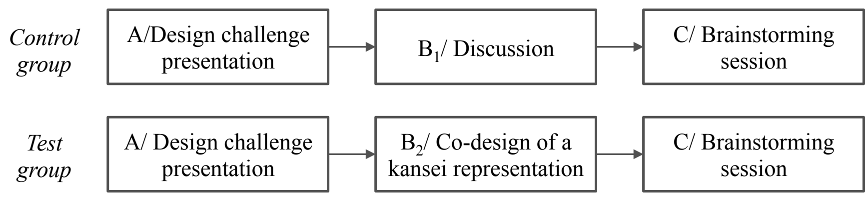


Figure 4.16: Protocole de EXP 4

Lors de la section A chaque groupe a reçu une présentation lors de laquelle ils ont pris connaissance du design challenge et d'un état de l 'art sur le futur de la mobilité. Les deux design challenges présentés à chaque groupe étaient : « Comment donner plus de flexibilité aux personnes utilisant leur voiture comme un outil de travail (infirmière, commercial,..) ? » et « Comment aider les personnes âgées à mieux accéder à leur endroits favoris ? »

Pour le control group la section B était composée d'une discussion d'une quinzaine de minutes. Pour le test group cette discussion était remplacée par une activité de co-design lors de laquelle les participants devaient placer des kansei cards de différentes familles sur un mapping à deux axes : « centre ville – banlieue » et « efficace – confortable » (voir Image 4.9). Cette activité amenait les participants à discuter le positionnement des cartes et par ce biais différents types d'information design. Elle était nouvelle pour tous les participants.

La section C était pour les deux types de groupe à nouveau identique. Elle consistait en des séances de brainstorming de 25 minutes axées sur un design challenge.

Image 4.9: Résultat de l'activité de mapping de kansei cards

4.5.3 RESULTATS

Au total 4 groupes ont pris part à cette expérimentation (1 TG et 1 CG pour chaque design challenge). Les fiches idées des participants ont ensuite été analysées par un panel d'experts suivant la table d'évaluation présentée ci-dessous (Tableau 4.16). L'Image 4.10 montre deux idées générées pour le premier design challenge : celle de gauche a été évaluée 1 étoile, celle de droite 3 étoiles.

Tableau 4.16: Table d'évaluation

		Kansei qualities (presence, relevance)		
		low	*middle*	*high*
Rational qualities (quality of the features, novelty)	*low*	1 star (*)	2 stars (**)	2 stars (**)
	middle	1 star (*)	2 stars (**)	3 stars (***)
	high	2 stars (**)	2 stars (**)	3 stars (***)

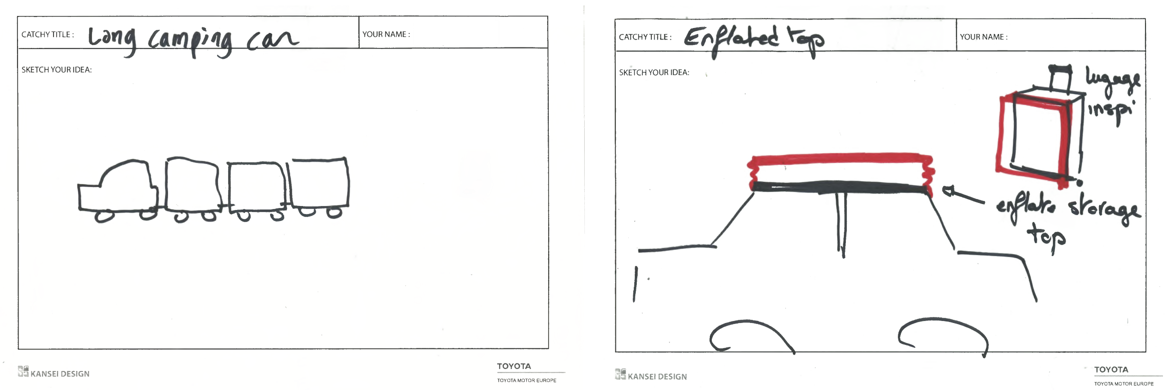


Image 4.10: Idées générées évaluées 1 étoile (gauche) et 3 étoiles (droite)

Pour chaque type de groupe, cette expérimentation permet d'obtenir deux types de mesures : le nombre d'idées générées et la qualité de ces idées. Étant donné le faible nombre de groupes testés, les résultats obtenus ne pourront néanmoins pas être considérés comme significatifs.

La Figure 4.17 montre que les groupes utilisant les kansei cards lors de la section B ont générés plus d'idées (66% plus). Le ratio d'idées générées et évaluées 2 ou 3 étoiles était aussi meilleur pour ces groupes (80% au lieu de 68%). Il semble donc que pour des groupes multiculturels, la co-création préalable de représentation kansei a une influence positive sur des sessions de génération d'idées.

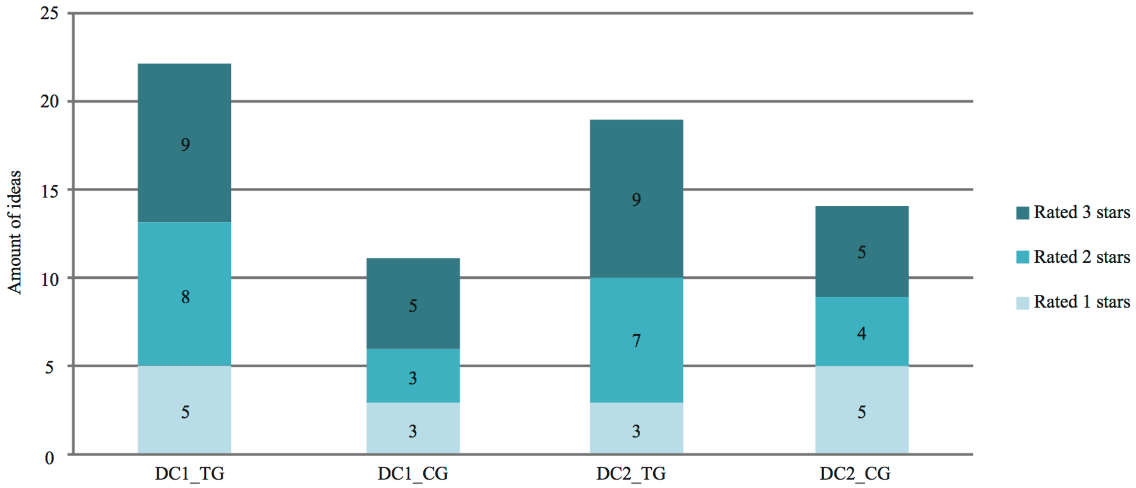


Figure 4.17: Idées générées en terme de quantité et de qualité

4.5.4 Conclusion de l'EXP 4

EXP 4 présente une autre méthodologie visant à améliorer la définition d'intentions kansei en phase amont de projet. Cette dernière permet à des équipes de conception n'aillant pas forcement le même langage (langue, language technique) de co-créer une représentation kansei à l'aide de kansei cards. Les catégories d'information design communiquées par ces représentations kansei sont indiquées sur le Tableau 4.17. Ces dernières dépendent des kansei cards utilisées : le tableau reprend celles utilisées dans le contexte de cette expérimentation.

Tableau 4.17: Information design communiquée par les représentations kansei créées dans l'EXP4

Design information	*Related UX entity*	*Level of abstraction*
Values	User's personal characteristics	High
Semantic descriptor	Perceived kansei qualities	High
Emotion	Perceived kansei qualities	High
Style	Product attributes	High
Interaction characteristic	Interaction attributes	Middle
Sector/objet	Product attributes	Middle
Gesture	Interaction attributes	Low
Feedback	Interaction attributes	Low
Visual attribute	Product attributes	Low

De manière complémentaire à l'EXP 2 et à l'EXP 3, EXP 4 contribue aussi à discuter H2. EXP 4 exemplifie l'utilité de telles représentations lorsqu'elles servent d'introduction à des séances de génération d'idées au sein d'une équipe de conception. Elles pourraient améliorer la compréhension réciproque et la communication dans des groupes multiculturels. D'après Douglas et Sturtton (2009) ces deux aspects sont nécessaires pour instaurer la confiance au sein d'équipes de conception pluridisciplinaires. Ceci pourrait expliquer les meilleurs résultats obtenus par le « test group ».

4.6 EXP 5: UTILISATION DE REPRESENTATIONS KANSEI DANS UN CONTEXTE INDUSTRIEL

4.6.1 INTRODUCTION

Cette expérimentation analyse 27 projets amont visant à créer des représentations kansei. Ces derniers peuvent tous être caractérisés comme des projets NCD orientés par le design d'expérience. Ils se sont déroulés entre 2008 et 2013 et ont été coordonnés par l'équipe Kansei Design de Toyota Motor Europe (appelé EP2 jusqu'en 2010). Certains d'entre eux utilisent les outils et méthodologies présentés dans les précédentes expérimentations.

4.6.2 PROTOCOLE

Le protocole de l'expérimentation, présenté ci-dessous se divise en quatre sections.

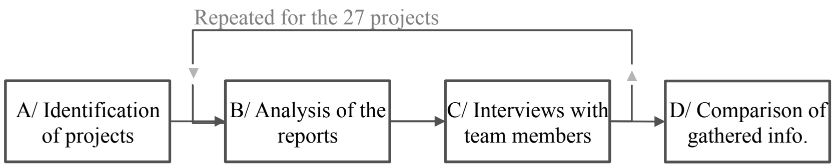


Figure 4.18: Protocole de l'EXP 5

La première section (A) correspond à l'identification de projets passés dans les archives de l'équipe TME-KD. Au total 27 projets amenant à la création de représentations kansei ont été retenus.

La section B correspond à l'analyse de ces projets utilisant les différents rendus de ces derniers (voir aussi l'Image 4.10). Cette analyse comporte trois axes : le contexte du projet, la nature de ses activités design, et le type d'information design communiqué.

Image 4.10: Analyse des rendus de projet

Pour chaque projet, une interview semi-dirigée d'environ 30 minutes a été réalisée avec un ou plusieurs membres de l'équipe projet (section C). Elle touchait aussi aux trois axes mentionnés (voir aussi l'Image 4.11).

Image 4.11: Interview avec un membre de l'équipe projet

La section D du protocole correspond à la comparaison des informations récoltées pour chaque projet. En codant et en regroupant ces dernières, il a été possible de dégager des critères en terme de contexte de projet, de nature d'activités design et d'informations design communiquées. Ces dernières vont être détaillées dans le paragraphe 4.6.3.

4.6.3 ANALYSE DES DONNEES RECOLTEES

TROIS TYPES DE PROJETS

Les 27 projets ont tout d'abord pu être organisés en fonction de leur contexte : leur position dans le processus de développement de la société. En utilisant la classification de Wheelwright and Clark (1992), présentée dans l'état de l'art, il a été possible de distinguer trois types de projets :

- les projets amenant à des « concepts exploratoires » (exporatory concept) touchant des réflexions sur des *produits de pointe* bien en amont des phases de développement de produits. Un exemple résultat de ce type de projet est le concept « Window of the world » présenté lors de différent évènements et visible sur le domaine public.
- les projets touchant à des « stratégies de gamme » (product lining strategy) visant à influencer une gamme de produits (par exemple : véhicules citadins, véhicules à motorisation hybrides) se réfèrent à ce qui a été présenté dans l'état de l'art comme *produits plates-formes*.
- les projets touchant des problématiques de définition de « directions de pré-développement » sur des *produits incrémentiels*.

ACTIVITES DESIGN

Les données récoltées concernant les activités design se concentrent sur les outils, méthodologies et approches utilisées dans les activités design d'*information*, de *génération*, *d'évaluation & décision* et de *communication* identifiées dans l'état de l'art.

INFORMATION DESIGN COMMUNIQUEES

La classification des informations design communiquées par les représentations kansei issues de ces projets sur base sur les propositions de Bouchard et al. (2009) et de Kim et al. (2009) détaillées dans l'état de l'art. Ces dernières ont été enrichies et adaptées au contexte industriel (travail sur l'expérience et dans certains cas sur l'interaction). Certaines de ces nouvelles catégories ont par ailleurs déjà pu être identifiées dans les précédentes expérimentations. La liste complète des catégories d'information design utilisées est présentée dans le Tableau 4.18.

Tableau 4.18: Catégories d'information design utilisées lors de la création d'une expérience

Category name	*Description*	*Example*	*Related UX entity*
Value ^{O} (H)	These words represent final or behavioural values.	Ambitious, open-minded	User's personal characteristics
Semantic descriptor ^{C} (H)	Adjectives related to the meaning and characteristics.	Playful, romantic, traditional	User's perceived kansei quality
Emotion ^{N} (H)	Targeted emotion to be felt by the user	Joy, surprise, interest	User's perceived kansei quality
Style ^{O} (H)	Characterization of all levels together through a specific style.	Edge design	Product attributes
Lifestyle ^{N} (M)	Combination of values of the user	"Work hard, play hard" lifestyle	User's personal characteristics
Interface characteristic ^{E} (M)	Underlying logics, engagement required	Mental engagement, physical and direct interface	Interaction attributes
Action enabled ^{E} (M)	Function, usage	Create, relax, communicate	Interaction attributes
Product characteristic ^{E} (M)	Components, ways of functioning, spatial organisation	Mechanical handle, roominess	Product attributes
Sector/object ^{O} (M)	Object or sector being representative for expressing a particular trend	Tennis, wearable computing	Product attributes
Physical context ^{X} (M)	Physical elements surrounding the product	In a modern living room	Context attributes
Temporal context ^{X} (M)	Notion of time in the interaction	Narrative description of an interaction	Context attributes
Culture (demographics) ^{N} (L)	The culture of a user covers his/her age, gender, nationality, function, and organisational affiliation	Young (20-29) Europeans	User's personal characteristics
Morphology ^{N} (L)	Related to the outward appearance of the user	Body shape, structure, handicap	User's personal characteristics
Gesture ^{E} (L)	Movement of a part of the user's body used as input	Hand and body movements	Interaction attributes
Feedback ^{E} (L)	Communication to the users (might be influenced by prior inputs)	Blinking light and sound	Interaction attributes
Visual attribute ^{C} (e.g., form and colour) (L)	Overall shape of component, shape size, and chromatic properties	Square, long and thin, Light blue, Pantone 17-5641 Emerald	Product attributes
Tactile attribute ^{X} (L)	Material, temperature, texture	Plastic, stripped surface, rough	Product attributes
Auditory attribute ^{N} (L)	Rhythm, timbre, etc	Irregular, high pitch	Product attributes
Olfactory attribute ^{N} (L)	Scent families and facets	Citrus, woody, floral	Product attributes

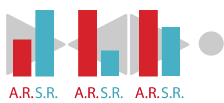
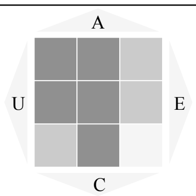
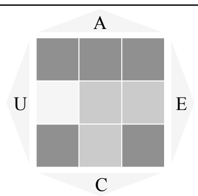
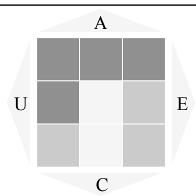
(H): High-level of abstraction
(M): Middle-level of abstraction
(L): Low-level of abstraction

^{O}: Category originally presented by Kim et al. (2009)
^{E}: Extracted from original category
^{C}: Combination of original categories
^{X}: Extension of an original category
^{N}: New category

4.6.4 RESULTATS ET DISCUSSIONS

Les trois types de projets identifiés précédemment sont comparés et détaillés en terme de contexte, d'activités design et d'informations design communiquées dans le Tableau 4.19.

Tableau 4.19: Détail et comparaison des trois types de projets identifiés dans l'EXP 5

		Exploratory concept	*Product lining strategy*	*Pre-development direction*
Context of the projects	*Purpose*	Propose new experience concepts for future *breakthrough products*	Identify user experience logics and directions for future *platform products*	Prepare grade and character strategies of future *incremental products*
	Design team	- Multi-cultural - Members from inside and outside the company	- Multi-cultural - Mostly members from inside the company	- Multi-cultural - Only members from inside the company
Design activities	*Type of reasoning*	Mainly abductive reasoning Scientific reasoning mainly used for information activity	Combination of abductive reasoning and scientific reasoning	Combination of abductive reasoning and scientific reasoning
	Type of representation	*Visual* – For intermediate output (co-creation session) *Multi sensory* – No use *Narrative* – For intermediate and final output *Interactive* – For final output	*Visual* – For intermediate and final output *Multi sensory* – For intermediate and final output *Narrative* – Limited use *Interactive* – No use	*Visual* – For intermediate and final output *Multi sensory* – For final output *Narrative* – No use *Interactive* – No use
	Audience	Wide but fuzzy – depending on recommendations Managerial level	Clear – large variety within upcoming NPD projects Managerial and working level	Specific – focused teams of upcoming NPD projects Managerial and working level
	Summary			
Design information conveyed	*High level*	PC: Value KQ: Semantic word, emotion	PC: Value KQ: Semantic word, emotion PA: Style	PC: Value KQ: Semantic word, emotion PA: Style
	Middle level	PC: Lifestyle IA: Interface characteristic, Action enabled PA: Sector/object CA: Situational context, temporal context	IA: Action enabled PA: Sector/object, Product characteristic	PC: Lifestyle PA: Sector/object, product characteristic
	Low level	PC: Culture IA: Gesture, feedback	PC: Culture, morphology IA: Gesture, feedback PA: Visual, tactile, auditory, olfactory att.	PC: Culture PA: Visual, tactile att.
	Summary			

Design activities
A.R.: abductive reasoning
S.R.: scientific reasoning

Design information conveyed
PC: Personal characteristics
KQ: Kansei qualities
IA: Interaction attributes
PA: Product attributes
CA: Context attributes

A: Abstract
C: Concrete
U: User
E: Environment

Dans le Tableau 4.19, la figure résumant l'information design communiquée par les projets la décrit selon deux axes. L'axe vertical correspond au niveau d'abstraction de cette information (bas, moyen et haut) tel que décrit par Kim et al. (2009). L'axe horizontal correspond aux entités de l'expérience utilisateur que ces informations décrivent. Cet axe va de l'utilisateur (U) et ses caractéristiques personnelles (colonne de gauche) aux entités exclusivement liées à l'environnent (E) (colonne de droite) : attributs produits, contexte physique. La colonne centrale contient quant à elle les catégories d'information design décrivant des intentions d'interaction utilisateur-produit (qualités kansei intentionnelles, attributs d'interaction, contexte temporel).

4.6.5 Conclusion de l'EXP 5

Lors de cette expérimentation, vingt-sept projets de développement de nouveaux concepts (NCD) portant sur des intentions en terme d'expérience utilisateur ont été analysés. Leurs délivrables peuvent être considérés comme des représentations kansei car ils mettent en relation des qualités kansei intentionnelles avec des caractéristiques personnelles d'utilisateurs ciblés et des attributs liés à l'environnement (au produit, à l'interaction, au contexte).

Trois types de projets ont été identifiés (liés à des « concepts exploratoires », « stratégies de gamme » et des « directions de pré-développement »). Ils ont chacun pu être décrit et comparé en terme de contexte, d'activité design et de catégories d'information design communiquées par les délivrables.

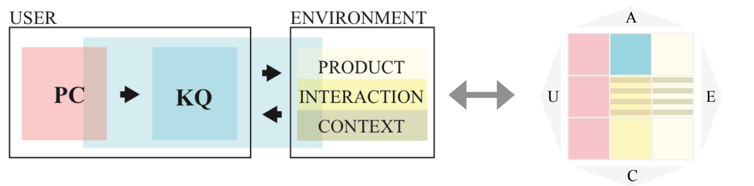
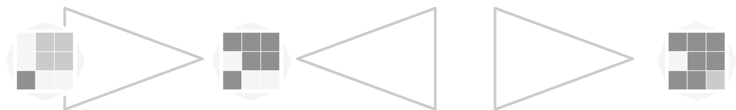
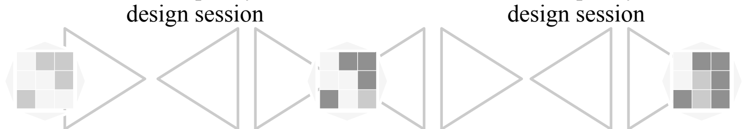
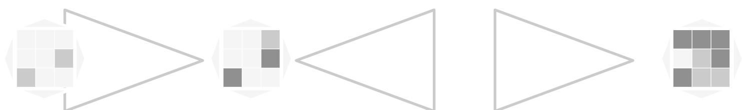
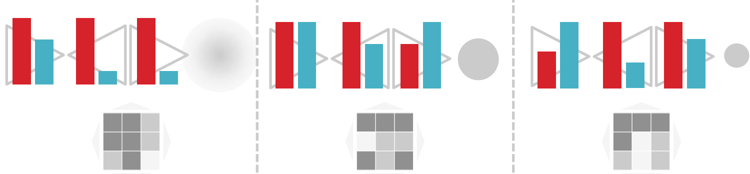
Cette expérimentation a permis de présenter et de caractériser le contexte d'utilisation de l'approche de design kansei dans un contexte industriel. Cette caractérisation a mis en lumière des différences notables en terme d'approche, d'outil et de méthodologie utilisés ainsi que dans les catégories d'information design liées à chaque type de projet.

Cette expérimentation a permis de valider l'hypothèse H3 car elle illustre l'utilisation de méthodologies et d'outils de design kansei dans tout un spectre de contextes industriels.

4.7 SYNTHESE DES EXPERIMENTATIONS

Comme expliqué dans la présentation des expérimentations (section 4.1) EXP 1 à couvert l'hypothèse H1, EXP 2, EXP 3 et EXP 4 se sont intéressées à valider H2 et EXP 5 a permis de discuter H3 (voir aussi Tableau 4.20). Ces expérimentations ont aussi permis d'explorer quatre notions clés de la recherche bibliographique : expérience d'utilisation et processus kansei, le processus de design industriel, les activités design centrées sur l'expérience d'utilisation et l'environnement culturel.

Tableau 4.20: Activités design et information design discutées au travers des cinq expérimentations

EXP 1: *User experience as a composition of components and influencing factors*	 Correspondences between the kansei-experience framework and design information
EXP 2: *Kansei representation – Ux harmonics translated by designers*	 Selection of fitting Ux harmonics Iterative process of pictures and music association
EXP 3: *Kansei representation – involving participatory design sessions*	Participatory design session Participatory design session  Kansei cards selection Analysis Creation of MB and sensory samples Analysis
EXP 4: *Kansei representation – co-creation within a multi-cultural design team*	 Research and design challenges preparation Kansei cards mappings
EXP 5: *Use of kansei representations in the industrial context*	 In "Exploratory concept" projects In "Product lining strategy" projects In "Pre-development direction" projects

Pour rappel, l'hypothèse **H1** est la suivante : « Les expériences venant de produits peuvent être comparées et regroupées selon les qualités kansei que les utilisateurs perçoivent d'eux, les caractéristiques personnelles des utilisateurs et les attributs de leurs environnements (produit, interaction, contexte). ». L'EXP 1 a permis d'identifier des corrélations entre les différentes entités d'expérience utilisateur décrites par les participants. Plus particulièrement des corrélations et différences significatives ont pu être quantifiées entre facteurs influents de l'expérience (caractéristiques personnelles de l'utilisateur et différent attributs de l'environnement) et les qualités kansei perçues par l'utilisateur. Ces rapprochements ont permis de créer des UX harmonics qui ont plus tard servi de point de départ pour des démarches design centrées sur l'expérience. Cette expérimentation a ainsi permis de valider H1.

L'hypothèse **H2** est : « Les représentations amont d'intentions en terme d'expérience utilisateur peuvent contenir de l'information design se rapportant à toutes les entités d'une expérience. ». Par le biais d'EXP 2, EXP 3 et EXP 4 cette dernière a pu être discutée et validée. Ces trois expérimentations ont présenté différents outils et méthodologies permettant la création de représentations kansei en phase amont de développement. Ces différents outils sont les UX harmonics (EXP 2), les kansei cards (EXP 3 et EXP 4), les stimuli multi-sensoriels (EXP 3) et les Mood-boxes (EXP 3). L'utilisateur a quant à lui été traité de différentes manières : en temps que sujet inclus dans l'étude (EXP 2), en temps que partenaire (EXP 3) et en temps que sujet non directement inclus dans l'étude (EXP 4).

Chaque expérimentation a permis, en suivant un cours différent, de créer des représentations kansei riches en information design. Cette dernière a couvert a plusieurs reprises toutes les entités d'une expérience utilisateur. Ces différentes observations ont permis de discuter et valider H2.

H3 s'intitule ainsi : « Les outils et méthodologies développés peuvent être intégrés dans un processus industriel de conception. ». Au cours de l'EXP 5, 27 projets industriels témoignant d'une approche centrée sur l'expérience utilisateur ont été analysés. Leurs délivrables peuvent être considérés comme des représentations kansei car ils mettent en relation des qualités kansei intentionnelles avec des caractéristiques personnelles d'utilisateurs ciblés et des attributs liés à l'environnement. Les trois types de projets ont été identifiés (liés à des « concepts exploratoires », « stratégies de gamme » et des « directions de pré-développement ») et ont été décrits et comparés en terme de contexte, d'activité design et de catégories d'information design communiquées par les délivrables ce qui a permis de vérifier la validité externe de H3.

5 CONTRIBUTIONS

5.1 CONTRIBUTIONS ACADEMIQUES

Deux aspects principaux de la phase expérimentale peuvent être considérés comme des contributions académiques. Le premier concerne la contribution à la discussion sur l'information design discuter en phase amont de conception. Le second se rapporte à l'utilisation de représentations amont multi-sensorielles et leur valeur ajoutée pour les équipes de conception pluridisciplinaires.

5.1.1 MODELE D'INFORMATION DESIGN

Au cours des expérimentations (et à chaque fois lors de leur conclusions) l'information design discutée a été décrite en fonction de son niveau d'abstraction (Bouchard et al., 2009 ; Kim et al., 2009) l'entité de l'expérience utilisation à laquelle elle se rapporte. Ces expérimentions ont permis d'identifier de nouvelles catégories d'information design permettant de définir des intentions d'expérience utilisateur en phase amont de conception. Basée sur les catégories identifiées dans l'état de l'art, une nouvelle liste a été établie au cours de l'EXP 5. Cette dernière a été reproduite dans le Tableau 5.1.

Le second critère de catégorisation de l'information design identifié (ndlr : entité de l'expérience à laquelle l'information se rapporte) à quant à lui permis d'identifier une seconde dimension descriptive. La première dimension décrite dans l'état de l'art était la dimension d'abstraction (axe concret-abstrait). À cette dernière a donc pu être rajouté une dimension reflétant l'entité de l'expérience discutée (axe utilisateur-environnement). Cet axe va de l'utilisateur (U) et ses caractéristiques personnelles (colonne de gauche) aux entités exclusivement liées à l'environnement (E) (colonne de droite) : attributs produits, contexte physique. La colonne centrale contient quant à elle les catégories d'information design décrivant des intentions d'interaction utilisateur-produit (qualités kansei intentionnelles, attributs d'interaction, contexte temporel). La Figure 5.1 représente un modèle d'information design reflétant ces deux dimensions dans lequel ont été reportées les catégories d'information design décrite dans le Tableau 5.1.

Tableau 5.1: Description des catégories d'information design

Position on the model	*Category name*	*Description*	*Example*
Cell 1	Value	These words represent final or behavioural values.	Ambitious, open-minded
Cell 2	Semantic descriptor	Adjectives related to meaning and characteristics.	Playful, romantic, traditional
Cell 2	Emotion	Targeted emotion to be felt by the user	Joy, surprise, interest
Cell 3	Style	Characterization of all levels together through a specific style.	Edge design
Cell 4	Lifestyle	Combination of values of the user	"Work hard, play hard" lifestyle
Cell 5	Interface characteristic	Underlying logics, engagement required	Mental engagement, physical and direct interface
Cell 5	Action enabled	Function, usage	Create, relax, communicate
Cell 5	Temporal context	Notion of time in the interaction	Narrative description of an interaction
Cell 6	Product characteristic	Components, ways of functioning, spatial organisation	Mechanical handle, roominess
Cell 6	Sector/object	Object or sector being representative for expressing a particular trend	Tennis, wearable computing
Cell 6	Physical context	Physical elements surrounding the product	In a modern living room
Cell 7	Culture (demographics)	The culture of a user covers his/her age, gender, nationality, function, and organisational affiliation	Young (20-29) Europeans
Cell 7	Morphology	Related to the outward appearance of the user	Body shape, structure, handicap
Cell 8	Gesture	Movement of a part of the user's body used as input	Hand and body movements
Cell 8	Feedback	Communication to the users and influenced by prior inputs	Blinking light and sound
Cell 9	Visual attribute	Overall shape of component, shape size and well as chromatic properties	Square, long and thin, Light blue, Pantone 17-5641 Emerald
Cell 9	Tactile attribute	Material, temperature, texture	Plastic, stripped surface, rough
Cell 9	Auditory attribute	Rhythm, timbre, etc	Irregular, high pitch
Cell 9	Olfactory attribute	Scent families and facets	Citrus, woody, floral

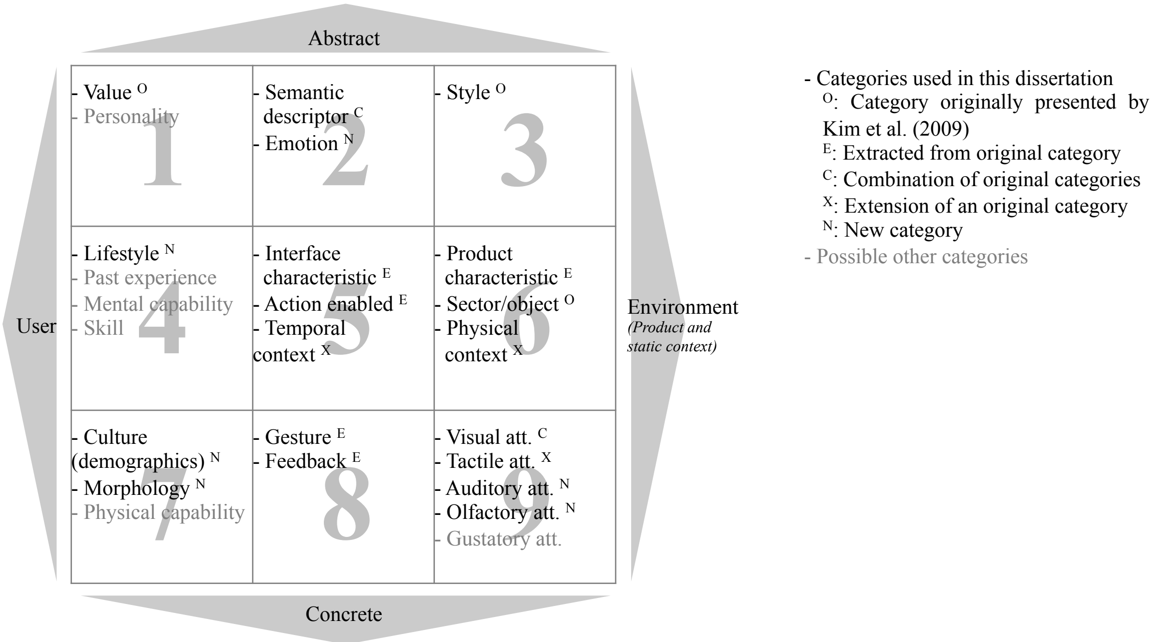


Figure 5.1: Modèle de l'information design

Le modèle peut être utilisé pour identifier et analyser l'information design renseignée par un type de représentation amont. La Figure 5.2 montre comment il peut être utilisé pour décrire certaines des représentations présentées dans l'état de l'art et utilisées usuellement dans les activités de conception (i.e. « visual theme board », « mood board », « design brief » et « storyboard scenario »).

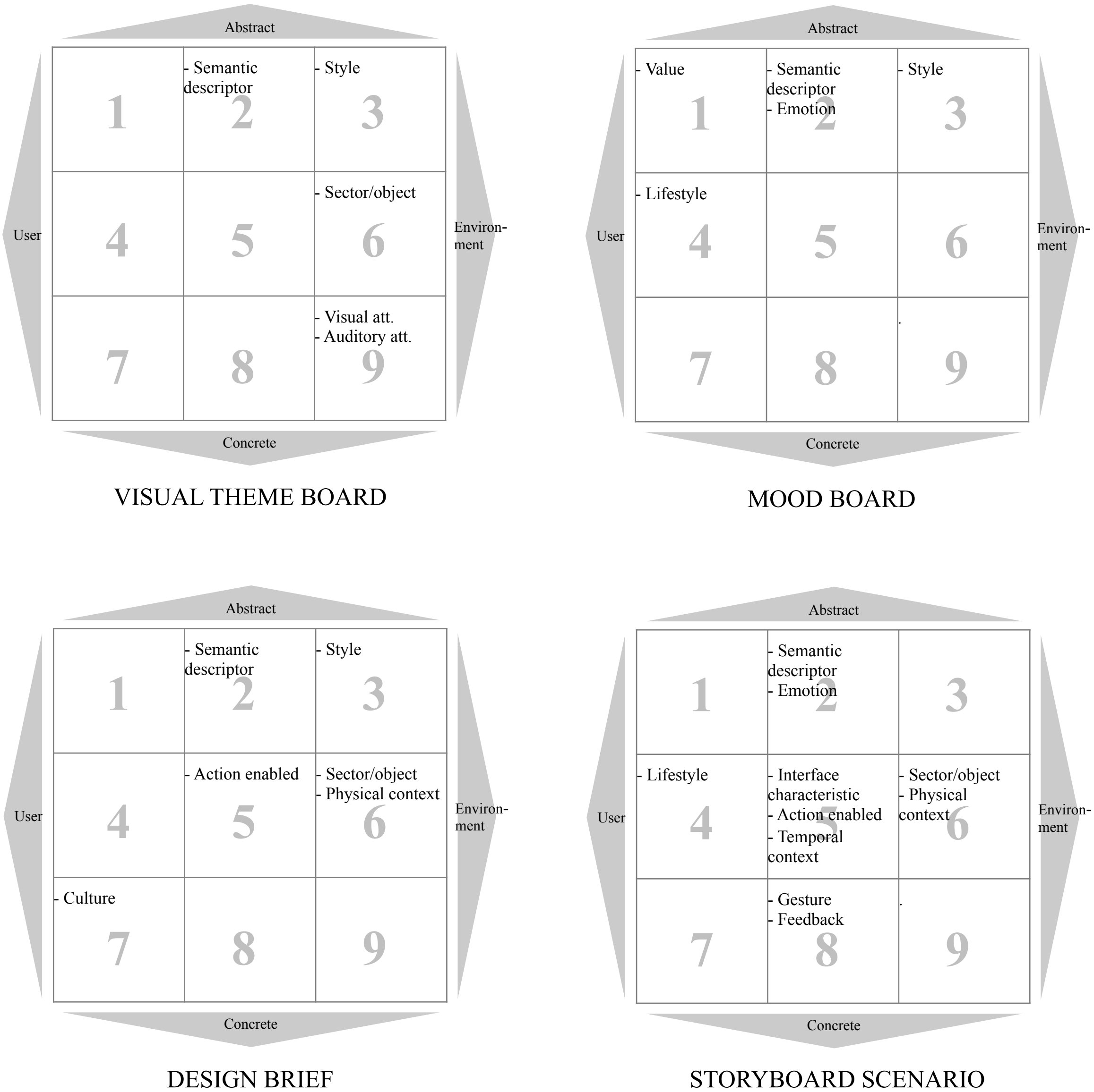


Figure 5.2: Information design communiquée par des représentations amont "traditionnelles"

En utilisant les tableaux récapitulatifs présents à la fin de chaque expérimentation, le même exercice peut être fait pour les représentations amont présentées lors de la phase expérimentale. Le Tableau 5.2 compare le spectre d'informations design communiquées (nombre de cellule du modèle couverte) de par ces différentes représentations. Il en ressort que les représentations développées lors de cette recherche sont plus riches que celles identifiées dans la littérature.

Tableau 5.2: Spectre d'information design couvert pour des représentations amont

	EXP 2	*EXP 3, it. 1*	*EXP 3, it. 2*	*EXP 4*	*EXP 5, EC*	*EXP 5, PLS*	*EXP 5, PDD*	*Design brief*	*Mood board*	*Visual theme board*	*Scenarios*
Cells of the model covered	8	5	7	8	8	8	7	5	4	4	5

5.1.2 REPRESENTATIONS MULTI-SENSORIELLES D'EXPERIENCE UTILISATEUR

Au cours des EXP 2 et 3, des représentations kansei multi-sensorielles ont été créées (Image 5.1). Ce type de représentation n'a par ailleurs été relevé qu'une seule fois dans la littérature (ndlr approche MSD par Schifferstein et Desmet (2008)). Cette dernière recherche a montré que de part leur apparence, elles permettent de mieux communiquer des intentions sensorielles concernant le produit à développer.

Au cours de la présente recherche EXP 2 a permis de montrer que des représentations multi-sensorielles permettent aussi de mieux communiquer une information design au sein d'une équipe de conception pluridisciplinaire (meilleure compréhension, qualités kansei intrinsèques plus importantes). De plus, comme en témoigne la Figure 5.3, les représentations issues des expérimentations 2 et 3 couvrent un très large spectre d'information design : le plus large observé lors de cette recherche (voir aussi Tableau 5.2).

Image 5.1: Représentations multi-sensorielles développées lors des EXP 2 (gauche) et EXP 3 (droite)

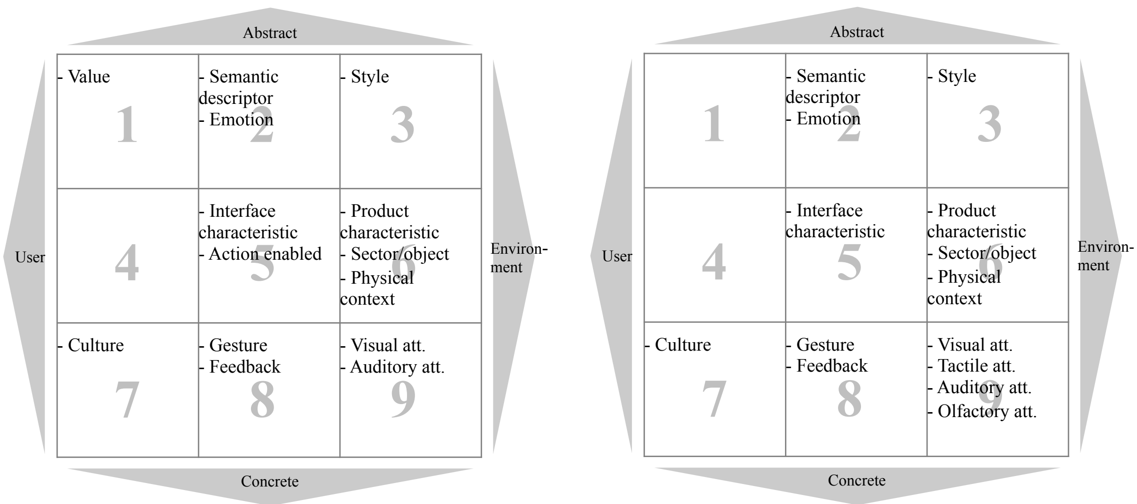


Figure 5.3: Détail de l'information design communiquée par les représentations multi-sensorielles issues des EXP 2 et EXP 3

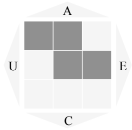
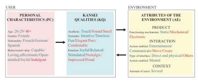
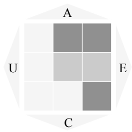
5.2 CONTRIBUTIONS INDUSTRIELLES

Tout au long de cette recherche, différents outils, représentations amont et méthodologies ont été créés. Ces derniers ont pu être testés et utilisés dans des projets industriels de TME-KD dont l'EXP 5 a permis de présenter le contexte (contexte de recherche-action de cette thèse). De plus, cette recherche a aussi permis d'affiner et de formaliser cette approche Kansei Design utilisée (mêlant des raisonnements abductifs et scientifiques et s'intéressant à l'intégration de réflexions autour de l'expérience en phase amont de la conception). Elle a aussi permis de la partager avec des communautés internationales de recherche en design (Lévy, 2013).

5.2.1 CREATION DE NOUVEAU OUTILS ET REPRESENTATIONS AMONT

Trois nouveaux outils ont été développés au cours de cette recherche. Il s'agit des *UX harmonics*, des *Kansei cards*, et des *Mood-boxes*. Ils sont tous les trois détaillés dans le Tableau 5.3. Ils ont tous pour but de faciliter des activités design centrées sur l'expérience d'utilisation et de faciliter l'échange d'information design.

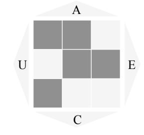
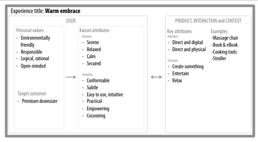
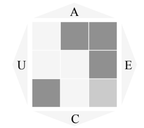
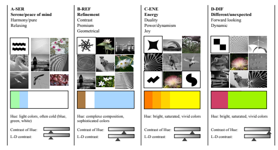
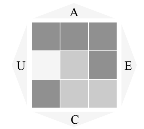
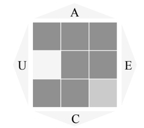
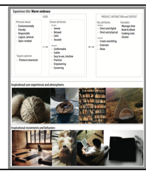
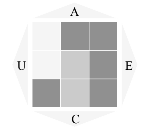
Tableau 5.3: Nouveaux outils développés au cours de cette recherche

Name of the tool	*Sense(s) stimulated*	*Origin*	*Design information*	*Related early representation*	*Illustration*
Ux harmonics	- Vision	- Statistical analysis of a user research (EXP 1)		- Ux harmonics keyword-based representations (EXP 1) - Multi-sensory kansei representation (EXP 2)	
Kansei cards	- Vision	- Brainstorming and iterations for each family (EXP 3)	Dependent on the card family (see Table 4.9 for some examples)	- Visual kansei directions (EXP 3) - Multi-sensory kansei representation (EXP 3) - Mapping of kansei cards (EXP 4)	
Mood-boxes	- Vision - Touch	- Translation of visual kansei directions (EXP 3)		- Multi-sensory kansei representation (EXP 3)	

Cinq nouveaux types de représentations amont (visuelles ou multi-sensorielles) ont été développés au cours de cette recherche. Ils sont tous les cinq détaillés dans le

Tableau 5.4. Comme cela a été relevé dans la section précédente, certains ont comme caractéristique d'être relativement riche en information design et de faciliter la compréhension mutuelle entre des populations de sexe, nationalité ou discipline différente.

Tableau 5.4: Nouveaux types de représentations amont développés au cours de cette recherche

Nature of the representations	*Literature review (pp. 73-75)*	*Contributions from this Ph.D. research*		
		Name and reference	*Design information conveyed*	*Illustration*
Visual	- Mood-boards - Trend boards - Image collage	Ux harmonics keyword-based representations (EXP 1)		
		Visual kansei directions (EXP 3, 1st iteration)		
		Mapping of kansei cards (EXP 4)		
Multi-sensory	- MSD representations	Kansei representation based on Ux harmonics (keywords + pictures + music) (EXP 2)		
		Mood-boxes, Kansei cards, and multi-sensory samples composition (EXP 3, 2nd iteration)		

5.2.2 Creation de nouvelles methodologies

Les expérimentations 1, 2, 3 et 4 ont présenté trois types de méthodologies de création de représentation amont d'intention en terme d'expérience d'utilisation. Ces trois types de méthodologies sont présentés dans les tableaux ci-dessous (Tableau 5.5, Tableau 5.6, Tableau 5.7).

Tableau 5.5: Méthodologie Kansei Design A : Développée avec EXP 1 et EXP 2

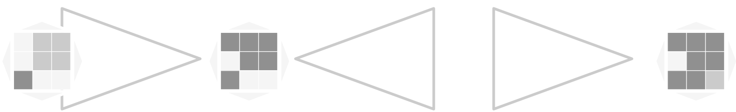
METHODOLOGY A *EXP 1 and 2:* *Kansei representation – Ux harmonics translated by designers*	 Selection of fitting Ux harmonics Pictures and music association (iterative process)
	Scientific reasoning: Statistical analysis of the user research data, Creation of Ux harmonics creation (cluster analysis) *Abductive reasoning:* Ux harmonics selection, Pictures and music association "Users" treated as subjects and directly involved in the design activities

Tableau 5.6: Méthodologie Kansei Design B : Développée avec EXP 3

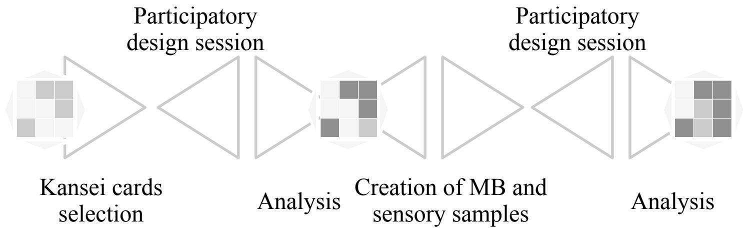
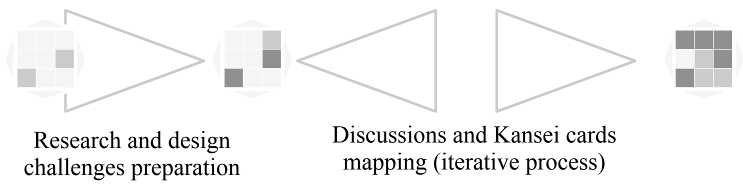
METHODOLOGY B *EXP 3:* *Kansei representation – involving participatory design sessions*	
	Scientific reasoning: Statistical analysis of the participatory design sessions (PCA, clusters) *Abductive reasoning:* Creation/selection of the samples (Mood-boxes, Kansei cards, multi sensory samples), Combination of clusters “Users” treated as partners for the design activities

Tableau 5.7: Méthodologie Kansei Design C : Développée avec EXP 4

METHODOLOGY C *EXP 4:* *Kansei representation – co-creation within a multi-cultural design team*	
	Scientific reasoning: Presentation outputs from desk researches *Abductive reasoning:* Creation/selection of the samples (Kansei cards), Co-creation session (involving Kansei cards) “Users” treated as subjects and not directly involved in the design activities

5.2.3 UTILISATION DES CONTRIBUTIONS INDUSTRIELLES DANS LES ACTIVITES DE TME-KD

Les différentes contributions industrielles présentées précédemment ont été utilisées dans différents types de projets NCD liés aux marques Toyota et Lexus. Leur utilisation est détaillée dans les tableaux Tableau 5.8 et Tableau 5.9. Ces contributions ont pu être utilisées par des équipes de conception pluridisciplinaires. En plus des retours quantifiés lorsqu’elles y participaient directement (EXP 2, EXP 4) les retours oraux ont aussi été très positifs.

Tableau 5.8: Utilisation des outils et méthodologies dans des projets industriels

	Tools			*Méthodologies*		
	Ux harmonics	*Kansei cards*	*Mood boxes*	*A*	*B*	*C*
EC projects	1	2	0	1	1	1
PLS projects	2	3	2	2	1	2
PDD projects	1	4	2	1	1	4
Total	**4**	**9**	**4**	**4**	**3**	**6**

Tableau 5.9: Détail de l'utilisation des contributions industrielles dans des projets industriels

	Exploratory concept	*Product lining strategy*	*Pre-development direction*
Tools	- UX harmonics - Kansei cards	- UX harmonics - Kansei cards - Mood boxes	- UX harmonics - Kansei cards - Mood boxes
Methodologies	- User research (quantitative) (Methodology A) - Desk research (Methodology C) - Co-creation with Kansei cards (Methodology C)	- User research (quantitative) (Methodology A) - Selection of fitting UX harmonics (Methodology A) - Pictures and music association (Methodology A) - Participatory design session (Methodology B)	- Selection of fitting UX harmonics (Methodology A) - Participatory design session (Methodology B) - Co-creation with Kansei cards (Methodology C)
Early representation *(Communication material)*	- Multi-sensory representation based on UX harmonics (intermediate output) (EXP 2) - Kansei cards mapping (intermediate output) (EXP 4)	- Multi-sensory representation based on UX harmonics (EXP 2) - Kansei cards arrangement (EXP 3) - Multi-sensory composition (Mood box, Kansei cards, multi-sensory samples) (EXP 3) - Kansei cards mapping (intermediate output) (EXP 4)	- Kansei cards arrangement (EXP 3) - Multi-sensory composition (Mood box, Kansei cards, multi-sensory samples) (EXP 3) - Kansei cards mapping (EXP 4)

5.3 RESUME DES CONTRIBUTIONS

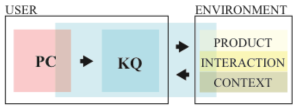
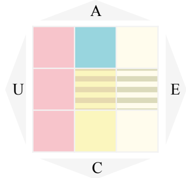
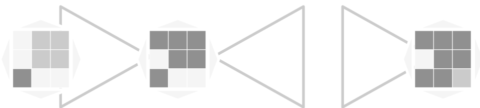
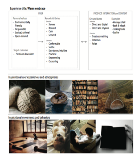
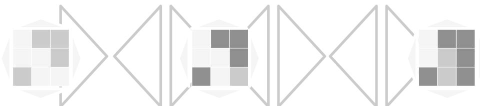
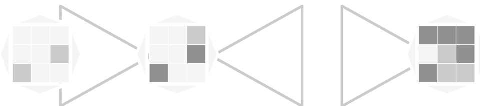
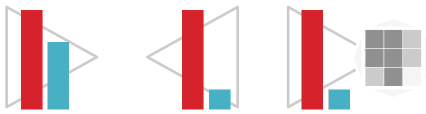
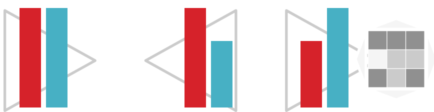
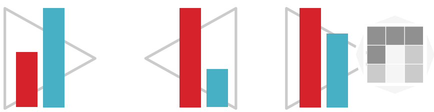
Je vais conclure cette dissertation en présentant un résumé des différentes contributions. Elles ont été organisées dans le Tableau 5.10 en fonction de leur nature.

Les premières sont descriptives et contribuent à détailler le contexte d'étude: l'expérience se produisant au cours d'une interaction homme-produit et la conception échange d'informations design dans la phase de conception (liée au framework de conclusion de l'état de l'art et aux cinq expérimentations).

Les secondes sont prescriptives et introduisent l'approche Kansei Design en terme d'outils, de méthodologies et de représentations amont (liés à EXP 2, 3 et 4).

Les dernières sont essentiellement descriptives et présentent les approches Kansei pour les trois types de projets industriels amont (liées à EXP 5).

Tableau 5.10: Résumé des contributions principales de cette recherche de thèse

Type of contribution	*Summary of the contributions*		
Descriptive: Context of study	Context of human-product interaction	 *Kansei-Experience framework*	
	Context of design information exchange during early design activities	 *Kansei design information model*	
Prescriptive: Kansei Design approach	Translation of user research		
	Participatory design sessions		
	Co-design within a design team		
Design information: Not covered Somewhat covered Covered		*New methodologies*	*New types of early representations*
Mainly descriptive: Kansei Design approach in the industrial process	"Exploratory concept" projects		
	"Product lining strategy" projects		
Type of reasoning used: Abductive Scientific	"Pre-development direction" projects		

6 CONCLUSION ET PERSPECTIVES

6.1 CONCLUSION

Cette thèse de doctorat est le fruit des collaborations de longue date entre le laboratoire CPI d' Arts & Métiers ParisTech et la division Kansei Design de Toyota Motor Europe. Il a débuté en 2011 avec la volonté de formaliser et de continuer le développement d'une approche originale qui commençait à transparaitre de certains projets (thèses de master [Esquivel, 2006; Clos, 2009; Gentner, 2010], études internes). L'objectif de cette recherche était de créer des connaissances et savoir-faire qui pourraient nourrir le processus de conception industrielle afin de mieux prendre en compte le processus de Kansei des futurs utilisateurs. Le contexte multiculturel de la société et du marché auquel elle s'adresse avait déjà été identifié à l'époque comme un domaine de recherche.

Pendant les premiers mois de la recherche, l'expérience utilisateur est apparue comme une notion clé et les champs de recherche connexes sont devenus d'une importance majeure pour la revue de la littérature. Jusque-là, la portée des activités menées par TME-KD et de la collaboration avec LCPI Arts & Métiers ParisTech avait été uniquement axée sur le processus affectif lié à la perception sensorielle. Cela a contribué à affiner le sujet de la recherche et à la centrer sur la discussion et la représentation d'intentions en terme d'expérience utilisateur en phase amont du processus de design industriel. Lors de la définition du cadre théorique de cette recherche, un lien a donc dû être créé entre les notions complémentaires de l'*expérience utilisateur* et *processus Kansei* d'un humain.

Sur la base de ce domaine d'étude original, la présente thèse a permis de discuter et d'enrichir les activités de conception centrées sur l'expérience et menées par les équipes de conception afin de nourrir le processus de conception industriel. Ce domaine de recherche a été choisi parce qu'il avait été observé que, même si des outils et des méthodologies centrées sur l'expérience existaient, l'adoption de telles approches dans le processus de conception industrielle avait été peu étudiées.

Avec les cinq expérimentations de cette thèse, différents aspects ont été étudiés. Avec l'aide d'outils et de méthodologies nouvellement créés, j'ai exploré comment le processus kansei des futurs utilisateurs d'un produit peut être discuté au cours des phases amont de conception de ce produit et comment les résultats de ces discussions peuvent être représentés afin de transmettre des intentions liées aux différentes entités de l'expérience (par exemple les attributs produits et d'interaction à concevoir, les caractéristiques personnelles des groupes d'utilisateurs à cibler). J'ai aussi étudié comment la nature de ces premières représentations peuvent avoir un impact de la compréhension réciproque au sein d'équipes de conception pluridisciplinaires et enfin comment l'approche développée (approche Kansei Design) pourrait impacter différents types de projets de développement amonts. Il est a noter que c'est l'une des premières fois que le processus kansei a été examiné dans un contexte industriel (Schütte [2005] avait déjà abordé le sujet, mais principalement dans le cadre d'activités d'évaluation).

Dans chacune des cinq expérimentations, l'aspect multiculturel des utilisateurs potentiels et des équipes de conception a été un sujet central de discussion. La manière dont il influence l'attrait d'utilisateurs pour certaines expériences a été discutée dans l'EXP 1 (basée sur un questionnaire) et dans l'EXP 3 (basée sur des sessions de design participatif). EXP 2 et EXP 4 ont quant à elles permis de discuter la compréhension réciproque d'équipe de conception pluridisciplinaires et multiculturelles. Finalement EXP 5 a permis de détailler les caractéristiques de trois types de projets centrés sur l'expérience utilisateur en phase amont de conception ayant lieu dans une entreprise internationale et multiculturelle.

Cette recherche a finalement conduit à des contributions académiques et industrielles. En ce qui concerne les premières, elle a permis de modéliser les informations design échangées entre les équipes de conception ainsi que mettre en évidence les qualités de nouvelles représentations amont en terme de compréhension réciproque de qualités kansei intrinsèques.

En ce qui concerne les contributions industrielles, les différentes expérimentations m'ont permis de caractériser l'approche Kansei Design en termes d'outils, de méthodologies, et de représentations amont. En outre, un lien a pu être établi entre les différentes caractéristiques de cette approche et trois types de projets centrés sur l'expérience utilisateur en phase amont de conception (visant à créer des « concepts exploratoires », des « stratégies de gamme » et des « directions de pré-développement ».

6.2 PERSPECTIVES

Cette recherche a établi de nouvelles manières de discuter et de représenter des intentions en terme d'expérience utilisateur en phase amont de conception. Elle a également permis de modéliser différents aspects de l'expérience qui peuvent être discutés (les entités de l'expérience) et d'identifier des moyens d'échanger des informations design qui les concernent (représentations kansei).

Les représentations kansei créés dans cette thèse ont montré des résultats prometteurs. Cependant certaines limites peuvent également être identifiées. Elles ne correspondent par exemple pas aux rendus de tous les types de projet identifiés centrés sur l'expérience: les rendus des projets visant à créer des « concepts exploratoires » ne pouvaient pas les utiliser comme délivrable final car ce type de projet semblait nécessiter des représentations narratives pour exprimer pleinement les informations design voulues. En ce sens, d'autres recherches pourraient être menées sur des représentations kansei narratives ou interactives. Celles-ci devraient également être en mesure de prendre en compte le contexte temporel d'une expérience et des attributs d'interaction supplémentaires.

Le processus de conception industrielle dans l'industrie automobile est assez long. La phase de développement d'un nouveau véhicule dure entre quatre et cinq ans. La zone qui a été couverte par cette présente recherche se situe en phase amont de ce processus (à la transition entre les phases de NCD et NPD). Dans de futures études, il serait très intéressant d'étudier la façon dont les directions d'expérience identifiées puis discutées et sélectionnées par les équipes de conception évoluent à travers les différentes étapes aval du processus de développement. Ces études devront répondre à des questions telles que «Comment les informations design liées aux directions d'expérience (faisant ici office de cahier des charges) sont-elles traduites en critères techniques ou style », « Comment peuvent-elles ensuite être suivies tout au long du projet? », « L'expérience définie initialement peut-elle être perçue dans le produit final? ». Enfin si un écart existe entre les intentions et les résultats, «Quelles sont les causes de cet écart ? ».

DEFINITION ET REPRESENTATION D'INTENTIONS LIEES A L'EXPERIENCE D'UTILISATION EN PHASE AMONT DU PROCESSUS DE CONCEPTION DE PRODUIT

RESUME: L'expérience perçue lors de l'utilisation de produits est récemment devenue un facteur différenciateur majeur entre les principaux acteurs de l'industrie. Elle influence désormais grandement le succès de nouveaux produits. En parallèle, l'intérêt de la communauté de recherche en design sur le sujet va en grandissant. La présente recherche apporte une contribution à ces deux mondes en explorant des moyens de définir et représenter des intentions d'expérience utilisateur. Une des originalités de cette recherche réside dans le fait que son assise théorique combine les notions complémentaires d'expérience utilisateur et de processus « kansei » (processus mental affectif) utilisées originellement par des communautés scientifiques différentes. Elle fait aussi partie du groupe très restreint de travaux qui investiguent les liens entre ces considérations et le monde industriel.
Au long des cinq expérimentations qui composent ce mémoire, j'explore la création d'outils et de méthodologies s'intéressant au processus kansei des futurs utilisateurs et permettant l'élaboration puis la communication d'intentions venant nourrir le processus de conception de nouveaux produits. L'influence de la nature des représentations amont sur la compréhension réciproque au sein d'équipes de conception multiculturelles (multi-nationalité et disciplinaire) ainsi que sur différentes typologies de projets prospectifs centrés sur l'expérience sont aussi mis en avant. En termes de contributions académiques, cette recherche a permis de modéliser l'information design échangée au sein d'équipes de conception visant à impacter les processus kansei des potentiels futurs utilisateurs. Elle a aussi mis en valeur les qualités et l'importance des représentations amont multi-sensorielles. Les contributions industrielles couvrent quant à elles, la création d'outils, de méthodologies et de représentations amonts permettant de caractériser l'approche dite du « Kansei Design », et d'établir des liens entre ces différents aspects et trois typologies de projets de développements de nouveaux concepts.

Mots clés: expérience utilisateur, processus kansei, phase de développement de nouveaux concepts, activité de design, information design, représentations amonts, contexte multiculturel.

DEFINITION AND REPRESENTATION OF USER EXPERIENCE INTENTIONS IN THE EARLY PHASE OF THE INDUSTRIAL DESIGN PROCESS

ABSTRACT: In the industrial context, users' experience with products recently became a major differentiation factor between competitors and can greatly influence the success of a product. In parallel, the interest from the design research community about this topic is also growing. This research intends to contribute to both contexts by investigating the definition and representation of user experience intentions. When defining the theoretical background of this research a link will be created between the complementary notions of user experience and kansei process. Based on this original field of study, this dissertation will discuss design activities undertaken by design teams in order to nourish the much wider industrial design process.
With the five experiments that will be presented in this dissertation, I will explore the creation of tools and methodologies centred on potential users' kansei process and supporting the creation of intentions related to the user experience of products to be designed. I will also investigate how the nature of the resulting early representations can impact reciprocal understanding within multi-cultural design teams, and finally how the developed approach (Kansei Design approach) can impact different typologies of new concept development projects.
In terms of academic contributions, this research enabled to model the exchange of kansei-related design information among design-teams and highlighted the added value of multi-sensory early representations resulting from experience-centred design activities. Regarding industrial contributions, the different experiments made it possible to characterise the Kansei Design approach in terms of tools, methodologies, and early representations. Moreover a link was established between the different characteristics of this approach and three typologies of new experience-centred concept development projects leading to different products development projects.

Keywords: user experience, kansei process, new concept development phase, design activity, design information, early representations, multi-cultural context.

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