Kansei Information Processing in Design

Carole Bouchard*, Jieun Kim*, Améziane Aoussat*

**Product Design and Innovation Laboratory (LCPI), Arts et Métiers ParisTech, Paris, France*
bouchard@paris.ensam.fr

Abstract: This paper aims at exploring the information phase of the early design process in the perspective of defining and developing new computer support tools dedicated to this phase. Our research was structured according two main steps, first the formalization of the cognitive processes, and then a computation of some routine parts which can be improved by computers. After a presentation of the theoretical background, some experimental results are proposed and an application is shown. Considering the fuzzy and affective nature of the information involved in the earliest steps of design, and the link the designers are used to apply which are often processed in an intuitive way, new formalisms will be presented that fit with the natural activity of the designers and that were developed into the TRENDS software.

Key words: Early Design phases, Information processes, Cognitive processes, Design rules.

1. Introduction

Nowadays, even if computer aided design tools are well spread out into the detailed design phases, the early phases of design are not well covered. However, these phases of the design process are of growing interest for the researchers in design science, in psychology and in artificial intelligence. One major difficulty is to make explicit the informational processes which are very implicit by nature, and also ill defined in the earliest phases.

With this in mind, the research reported in this paper was structured towards two main goals:

- formalisation of the cognitive processes in early design, and more precisely the nature and structure of information with the related expert rules.
- partial computation of some steps of the activity, where computers can bring a real support and a certain added value to the designers. This means to put the information in a format that can be implemented by algorithms in order to develop computer support tools.

This paper is organised into the following sections: in *Section 2* the design process is considered. The design process is presented through a cognitive model based on the following phases: information, generation, evaluation-decision and materialisation. In *Section 3* the design information phase is described. In *Section 4* the Kansei information is defined and argued with concrete examples extracted from design projects. In *Section 5* a computer-based support is presented which includes an image retrieval and analysis facility for designers (the TRENDS system). Finally, in *Section 6* conclusions relating to designers' information processes are drawn.

2. Early design process

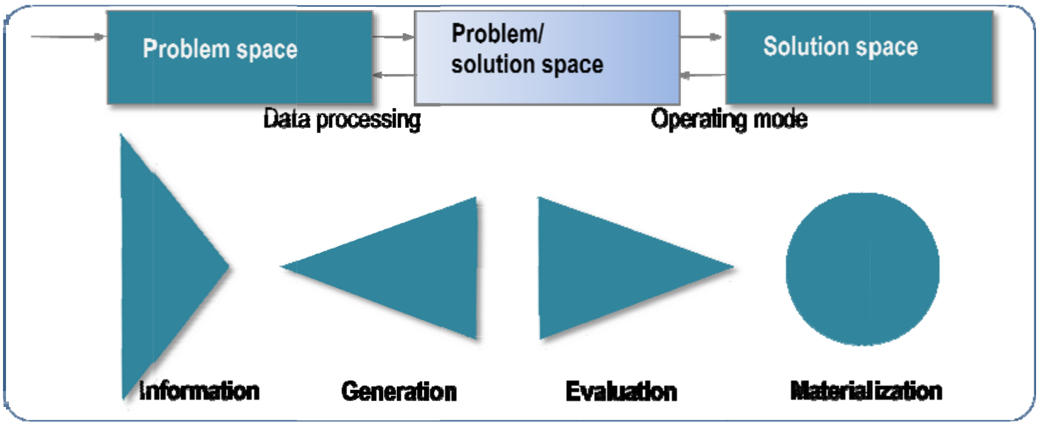

Figure1 Early design process [Bouchard 2003]

Design can be seen as a process in which the problem space (initially the design brief) is gradually transformed into the solution space (eventually the final product) (see Figure 1). This can be achieved in a series of iterations that progressively realise the design solution. Indeed, a main characteristic of design activities is that the initial state is "ill structured" [10][18]. Thus, the designer's mental representation is, initially, incomplete and imprecise. It is only through the problem-solving process itself that designers can complete their mental representations by choosing design options. Design problem-solving results from a co-evolution of problem and solution spaces [9]. This mental representation evolves until the designer reaches a design solution that is considered satisfying. In the case of a *creative* design solution, it has both to be new and to respect certain constraints and criteria. Information demands evolve throughout this process. For each cycle a problem space is described and a solution space identified [5]. Intangible information is transformed step-by-step into tangible information by way of mental and physical representations. The solution space is made explicit by external representations, progressing from first sketches to final product. As the design process progresses abstraction is reduced through successive representations each integrating numerous design constraints. Wang [24] characterised such a process of “conceptualization”, that involves mental solutions to a given problem, where (1) the selection of a solution or partial solutions enables the limitation of uncertainty, while keeping in mind the necessary level of vagueness in modifications during subsequent phases [13], (2) addition of new constraints that preserve shape and initial ideas; and (3) the display of a new physical representation generating new ideas and new solutions. Lloyd and Scott [13] describe the design process as generating deductive and evaluative statements in the activity of design. Each design cycle requires that designers are able to assimilate and deal with a large volume of information without losing sight of objectives. Computer-based support can supply external representation and storage for this process, modifying the problems of perception and memory in a decisive way.

3. Design information process

Few issues until now in the discipline of *design science* were specifically centred on the design information phase. However, due to its impact on creativity, the design information phase attracts increasing attention. This is demonstrated by studies of the design process, information processing, design expertise, sources of inspiration, Kansei Engineering and trend boards. The availability of inspirational materials (e.g., images, textures) is crucial to the design process. Indeed, information processing in design has a major impact on the generative phase. The inspirational phase of design helps both in defining the context in which the future object will be used (and so the coherency of the proposed solutions), and in stimulating the creative approach which is mainly based on analogical reasoning [11] [25]. Analogical reasoning involves sectors of influences or references used by the designers in their daily life, in professional and also in private circumstances [4] [3].

Designers integrate many categories of information that will be gradually visually categorized and synthesized into design solutions. They get their inspiration in their personal life and through a more focused way in their professional life, in various sources like specialised magazines, material from exhibitions and the web, and in different sectors. They use a large variety of types of sources coming from different areas as comparable designs, other types of design, images of art, beings, objects and phenomena from nature and everyday life. Sources of inspiration are an essential base in design thinking, as definition of context, triggers for idea generation [11], and anchors for structuring designers' mental representations of designs. They help designers structuring mental representations of designs and also arguing the generation of design solutions. The designers also operate a more or less systematic watch which completes their natural inspirational process. The latter goes largely over their professional activity. All related information will be memorized and potentially further evocated in design contexts [12].

There is little understanding of the requirements for information retrieval in the context of a creative process such as industrial design. For creative tasks it is possible that, instead of highly focused searches being optimal, some diversity in retrieved material is useful [3]. This idea is supported by the results of [2], who found that creative thinkers tend to use more peripherical cues (data not directly linked to the problem). Sectors of influence are any sectors of analogy related to the reference sector (arts, nature, industrial design, etc) in which the designers are used to pick relevant information, and which integrate high-middle or low-level information (semantic adjectives, consumer values, shape, colour or texture), being potentially transferred as new references in the reference sector. Sectors of influence play a major role of filtering the information which is useful for the designers.

We launched a first experiment in 1997 with car designers [4]. This experiment aimed to make explicit the designer's watch process and their sectors of influence by studying the specialized literature/exhibitions and motor shows they are used to consider. It was also studied which elements they select in these types of sources (table 1). A more recent study achieved in 2006 enabled to verify that these sectors are long term indicators [16]. Both studies were based on interviews and observations during sketching activities.

Year	***1997***	***2006***
Designers	*40 (10 professional, 30 students)*	*30 professional*
Nationality	*French, English, German*	*Italian, German, British, French*
Sectors	1 Car design & automotive	1Car design & automotive
	2 Aircrafts, aeronautics	2 Architecture
	3 Architecture	3 Interior design & furniture
	4 Interior design & furniture	4 Fashion
	5 Hi-Fi	5 Boat
	6 Product design	6 Aircraft
	7 Fashion	7 Sport goods
	8 Animals	8 Product design
	9 Plants	9 Cinema & commercials
	10 Science Fiction	10 Nature &urban ambiances
	11 Virtual reality	11 Transportation (moto, trucks)
	12 Fine arts	12 Music
	13 Cinema	13 Fine arts
	14 Music	14 Luxury brands
	15 Travels	15 Animals
	16 Food	16 Packaging & advertising

Figure2 Sectors of influence in design

4. Kansei information and structures

In this part we will define the concept of Kansei in the framework of design activity. First we emphasize the core skills of the designers, highly linked to semantics and emotions. Then we describe the nature of information involved in Kansei processes. Then we explore the Kansei rules which are used to link the information together.

4.1 Kansei information

Kansei information characterizes the very specific information the designers deal with. This Japanese word has a meaning which includes together different notions such as semantics, feelings, emotions, style, that can also be expressed under the term of affectivity. Designers recognize that their activity deals with emotional content, although the process is not necessarily explicit. This idea was confirmed by the results of a survey we addressed to 40 professional car designers (see figure 3). According to those, the main dimensions the car designers deal with in their activity are *emotion*s and *personality*.

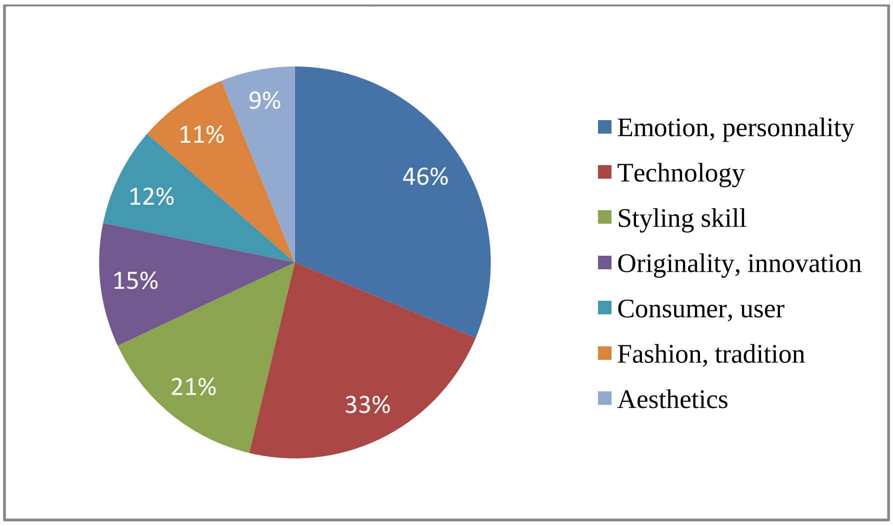

Figure3 Dimensions treated, perceived in car design, modality of the formal answer

When designers are searching for inspiration sources, pictures they select explicitly or implicitly often have a high *emotional impact*. This expertise transpires in the whole early design stages. Indeed, when designers generate new design solutions, they also provide high *emotional effects* in their new design solutions. In addition, the core skill of a designer is to link *semantic descriptors* with *design parameters* and *vice-versa*. This occurs both when selecting inspirational materials (this activity is very specific and could be compared to a hybrid search on both text and images in reciprocal ways) and also when generating or evaluating new design solutions.

4.2 Kansei structures

Designer's expertise refers to a particular knowledge which is called emotional design in Europe, and more Kansei Engineering in Asia. More precisely *Kansei* oriented methods include various approaches for translating semantic words (*Kansei words*) into design parameters, by measuring semantics and showing the correlation with some design properties [18]. The Kansei words mainly include semantic descriptors, objects names and low-level descriptors (see figure 4). The level of information can be seen as the position of the considered information on an axis going from abstract to concrete.

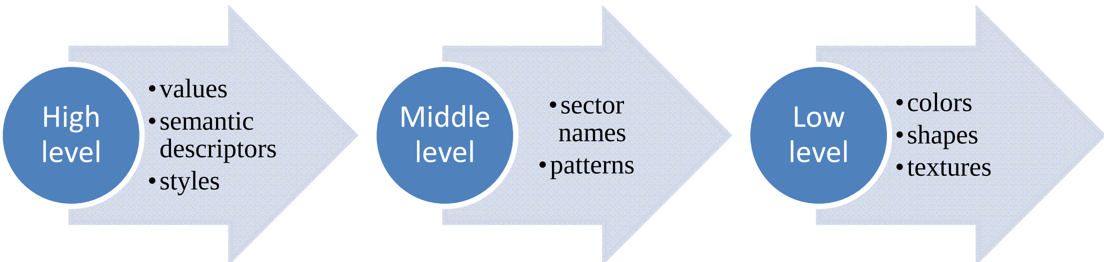

Figure4 Kansei coverage

So, Kansei is a subjective process [1] able to link high-level information, namely semantics which is quite abstract, with low-level information such as shape, colour and texture related data. Kansei also involves a high emotional impact which occurs during design activity. This emotional impact is due to aesthetic dimensions, also to the freshness of the design solutions, and finally to the intrinsic coherency of the solutions. This coherency takes place between high-level (semantics, sociological values) and low-level dimensions [7] [8], and between these low-level dimensions themselves. For instance aesthetics entails harmony rules that are applied between several colours, or several textures, or between colour, texture and shape. From previous design projects, we extracted some keywords which are representative of Kansei information as a whole (see figure 5). The notion of level of information comes from the field of artificial intelligence where it was necessary to categorise the nature of information in order to develop specific algorithms to perform content based images retrieval.

- The *high-level*, corresponds to *sociological values* (freedom, ethics …), *semantic descriptors* (aggressive, romantic…), and *styling descriptors* (edge design, work wear …) and *emotional reactions* (amused, astonished, ill at ease …).
- At the *middle-level*, we can find *sector names* (sport, car design …) and *patterns* (floral, geometric …).
- The *low-level* includes specific information such as *shape* (square, like a wave …), colour (yellow, pale indigo …) and *texture* (metallic, plastic …).

		Keywords	***Low level attributes***
High-level	*Values*	These words represent final or behavioural values Examples of final values: freedom, security, ethics. Examples of behavioural values: escape, adventure, speed, tolerance.	Balance (Security) Diagonal stripes (Dynamism)
	Semantic descriptors	These words are specific semantic adjectives Examples: Muscled, fluid, robust, balanced	Similarity of shapes with analogies (symmetry for balanced)
	Style	Characterization of all levels together through a specific style Edge design, casual, active, work wear.	Cut complex volumes (Edge design)
Middle-level	*Sector names*	These words are object names describing one sector or sub sector being representative for expressing a particular trend Examples: leisure, sports, extreme sports, racing, gardening, medical sector.	
	Textures, patterns, matter	These words describe patterns (abstract or figurative) and textures Flower, geometric, metallic, plastic.	
Low-level	*Colour*	These words describe the chromatic properties using qualitative or quantitative data or are semantic descriptors related to colour. Examples: yellow, pale indigo, light green, olive green, colourful, saturated, like vitamin.	Yellow, Green, Pale indigo Degree of saturation Degree of tonality Like vitamin Colourful, Saturated
	Form, shape	Square, tight, curved, like a wave,	Square, Tight, Curved, Wavy, Tight lines, Squared, Rounded volumes

Figure5 List of Kansei words

4.3 Kansei Based Information Retrieval

Although content-based information retrieval (CBIR) is a well developed research area, there are very few information retrieval systems specifically dedicated to industrial designers. This can be attributed to the nature of the information designers deal with, i.e. visual and image information linked to particular feelings. Moreover, image retrieving tools are mainly based on visual content processing more related to low level features. More recent studies in the area concentrate on extracting semantics from images using colour features or lexical databases and adopting Kansei Engineering perspective. It is believed that future CBIR systems should support semantic and Kansei based image retrieval which reflects the way designers work. For instance, the use of harmony rules has proved to be efficient for evocation of positive emotional reactions. Even though they are not really formalized and externalized, the rules enabling to link low-level attributes with high-level dimensions are used on daily basis by the designers. This linking task is very subjective and varies from person to person. Consequently, previous systems are often based on a strong interaction between the end-users and the system itself, using images and semantic adjectives. The connection of low-level and high-level dimensions is frequently done with the intervention of the end-users through the use of neural networks or genetic algorithms. The technology enabling semantic based image retrieval is semantic based indexing and annotation.

4.4 Kansei rules

In the field of kansei engineering, the correspondance between *high-level* and *low-level* concepts is based on *design rules*. The first step to go toward Kansei based image retrieval is the extraction of contents, structures and rules of Kansei. Following the previous consideration about the corpus of Kansei knowledge and structure, it is then necessary to make explicit the expert rules involved, i. e. the logical links between the different levels of information, and to develop methods that can lead to these specific rules with respect to the information and its structure (see figure 6).

Most used adjectives for image retrieval	***Related words (synonyms and related words)***	***Impacted low-level features: possibly quantified***
Balanced	*Stable*	*Shape :* symmetry
Beautiful	*Aesthetic, gorgeous*	*Shape:* use of formal harmonies *Colour:* use of chromatic harmonies
Bright	*Brilliant*	*Texture:* reflectance
Classic	*Traditional*	
Clear	*Clean, pure*	*Colours:* white, light greys
Cold	*Fresh, freezing, aqua*	*Colours:* cold colours
Dark		*Colours:* dark colours
Dynamic	*Active*	*Shape:* dissymmetry, tense lines
Elegant	*Refined*	
Exciting	*Seductive, appealing*	*Colours:* saturated colours
Freedom	*Irregular, unconventional*	*Shape :* Non regular forms / volumes
Heavy		*Shape:* dimentional ratios
Kitsch	*Loaded*	*Shape, colour, texture:* Many reference objects
Light		*Shape:* dimentional ratios *Colours:* light colours
Original	*Fresh* *Bizarre* *Funny*	*Shape, colour and texture:* Formal distance to the reference archetype
Motionless		*Shape :* symmetry
Natural	*Simple* *Authentic*	*Colours:* natural colours (green, …)
Quality	*Clean*	*Texture:* finishing, coatingwith visual and tactile effects
Relaxed	*Comfortable*	*Shape :* curves with big radius of curvature
Romantic	*Glamour*	*Colours:* unsaturated colours (pastels)
Simple	*Basic, clean*	*Shape:* elemental geometrical volumes *Colours:* plain colours
Soft	*Light*	*Shape:* curves *Colours:* pastels *Texture:* smooth matter
Warm		*Colours:* warm colours (orange, …)

Figure6 Kansei Dictionary (after Kansei rules from 47 references found in the field of Image retrieval)

After studying designer's activity in the framework of several projects, we proposed a first type of method that fits with designer's activity. This method enables to link high-level and low-level information, similarly as designers do. It is called the method of *cognitive chaining* and was established by P. Valette-Florence in the field of advertising in order to construct a message and link it to specific images. The semantic space can be determined by considering the frequency of apparition of individual items in the various types of chains, then by carrying out a multiple factor analysis dealing with the compatibility between individual items and types of chaining. A chaining is all the more coherent that the total number of links of which it is made up is limited. This method is fundamental for the translation of abstract values into tangible product attributes or vice-versa.

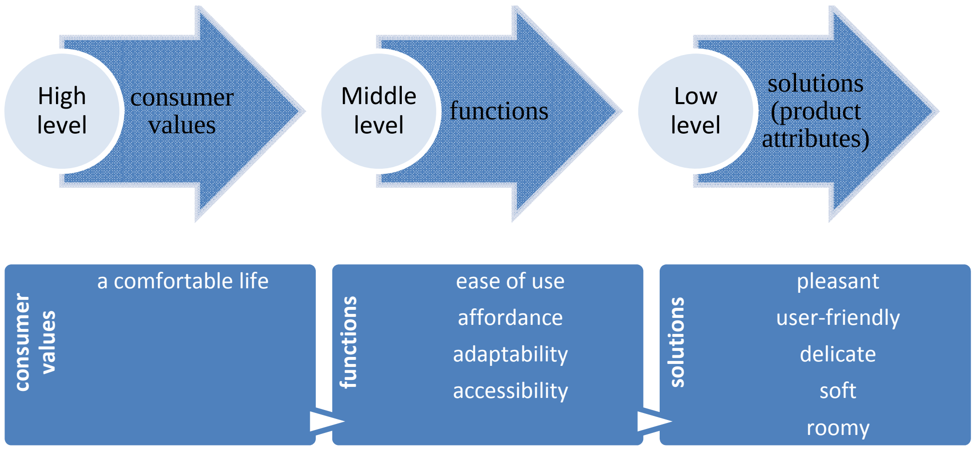

Figure7 Value-Function-Solution chain

We re-interpreted this method in the context of design, and named it the values-function-solution chaining (see figure 7). In engineering design, the cognitive chain is not established by a content analysis based on questionnaires as it is done traditionally, but it is built by the work team during the whole design process. In this context the method of cognitive chaining of means-ends [23], enables highlighting the way in which the influence of values is brought to bear on consumer behaviour. It scrutinizes the value-attribute relationship of the product through a train of hierarchical cognitive sequences graded into ascending abstraction levels. "Product attributes, both tangible (specific evaluative and descriptive features of a product such as material, colour, price, etc.) and intangible (semantic terms such as fresh, light, flowery, etc.), bring about functional and psycho-sociological consequences for the consumer helping the latter to attain their instrumental and end values". Tangible and intangible attributes are interdependent. Consequences are considered to be functional (derived from use, from main functions) or psycho-sociological (social functions produced by the functional consequences and moulds of socio-cultural standards, e.g.: a sophisticated image, high personal status). Values can be instrumental (specific behaviour modes, such as courage, honesty or romantic attitudes.) or end values (aims of life to be attained through instrumental values, such as self-fulfilment or hedonism). The sociological values related to a definite design brief provide both a strong initial orientation for the identification of sectors of influence and a creative stimulation for the generation of new design solutions. Some specific supports like advertising pages, considered as very inspirational by the designers, are extremely rich because they are able to show all these levels on the same support at the same time (values and related attributes). Following this, the identification of strong sociological values can further help in linking the three previous levels in a very relevant manner (low-level features, semantic adjectives and values words) according to the values-functions-solutions chain [23].

4.5 Kansei computation

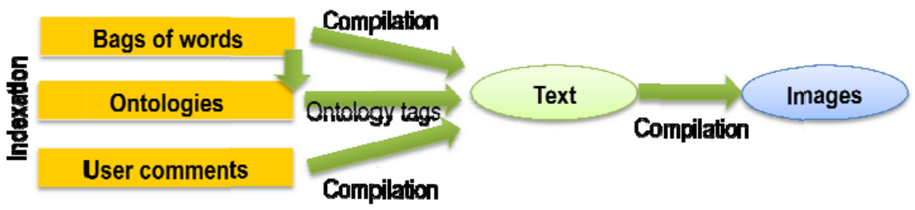

Figure8 Computational methods for Kansei rules in design [20][21].

Previous outputs were further used as specifications in order to build a computer tool for image retrieval. Methods used were a combination of design domain ontology and of expert bags of words (BoW) which provide more fuzzy relations between the Kansei words. The structures used were those of Value-Function-Solution chain (see figure 7), and more fuzzy structures involving semantic descriptors, and close semantic descriptors linked to low-level features (see figure 8).

5. Presentation of a computer-based support (TRENDS software)

This research led to the development of a software tool which is based on the applications of Kansei methods and which uses the formalisms that were mentioned before in § 4.3. This tool was elaborated in the framework of TRENDS project (www.trendsproject.org). TRENDS project aimed at introducing computer support in the inspirational and generative phases of design activity. Here we present the main functionalities included in TRENDS system, which are divided in two categories:

- Search functionalities: search functionalities include text and image search facilities with a relevance feedback module helping in refining a search by reducing the semantic gap. It is also possible to apply a search by sketch or a search by sector.

Figure9 TRENDS search functionalities (semantic search, relevance feedback)

- Advanced design functionalities: the digitization of design information made it possible to develop functions for dealing with big amounts of images and processing this information automatically. The system offers so interesting functionalities such as a categorisation of the information by applying hierarchical clustering and harmony rules, the automatic generation of harmony pallets, the semi-automatic production of a semantic mapping and the possibility to apply statistics to one word or one image in order to study its representativeness in the sectors of influence of the designers.

Figure10 TRENDS advanced functionalities (mapping, pallets)

6. Conclusion

This paper presented a research led about exploring the information phase of the early design process in the perspective of defining and developing new computer support tools dedicated to this phase. A state of the art presented related research and emphasized a lack of models and tools dedicated to this phase of the design activity. Our research was initially focused on the formalization of the cognitive processes occurring in early design, because the information and related rules are vey implicit at this level. Then we discovered that some routine parts of the early design process could be helped with the computer support tools, being able to deal with a huge quantity of images. Considering the complexity of Kansei information, some experimental results were proposed in order to explain the concept of Kansei in terms of information content, information structure and related expert rules for linking this information together. Specific structures were proposed, in order to put the information in a format that can be implemented by algorithms in order to develop computer support tools (ontologies and bags of words). Finally, an application was shown through TRENDS software. This computer tool offers very innovative functionalities turned towards information search, and the automatic processing of big sets of information. Its usefulness was validated with the end-users during the project and it is likely that this kind of tools will tend to appear in the future computer aided support tools.

Acknowledgements

The authors are grateful to TRENDS Consortium and to the European Community for funding a part of the research described in this paper.

References

[1] Bianchi-Berthouze,N., Hayashi,T. (2003). Mining Multimedia and Complex Data. in Zaiane,O., Simoff,S.J., Djeraba,C. (ed.) *Subjective Interpretation of Complex Data: Requirements for Supporting Kansei Mining Process*. Lecture Notes in Computer Science series. Springer-Verlag, 2797th edition, 1-17. ISBN: 3-540-20305-2

[2] Ansburg P, Hill K. (2003). Creative and analytic thinkers differ in their use of attentional resources, Personality and Individual Differences, 34 (7): 1141-1152.

[3] Bonnardel, N., & Marmèche, E. (2004). Evocation processes by novice and expert designers: Towards stimulating analogical thinking. *Creativity and Innovation Management, 13(3)*, 176-186.

[4] Bouchard C. (1997). Modélisation du processus de design automobile. Méthode de veille stylistique adaptée au design du composant d'aspect. Thèse de doctorat (Génie industriel). France, École Nationale Supérieure d'Arts et Métiers: 235 pages.

[5] Bouchard C, Aoussat A. (2003). Design process perceived as an information process to enhance the introduction of new tools, International Journal of Vehicle Design, Vol 32, March 2003.

[6] Bouchard, C., Lim, D., Aoussat, A., (2003), Development of a Kansei Engineering system for industrial design: identification of input data for Kansei Engineering Systems, Journal of the Asian Design International Conference, ISSN 1348-7817, (1):12.

[7] Bouchard C., Mougenot C., Omhover J. F., Mantelet F., Setchi R., Tang Q., Aoussat A., Building a domain ontology related to car design: towards a Kansei based ontology. I*PROM2007 Third Virtual International Conference on Innovative Production Machines and Systems, July 2007

[8] Bouchard, C., Omhover, J.F., Mougenot, C., Aoussat, A., et al, (2008), TRENDS: A Content-Based Information retrieval system for designers, Design Computing and Cognition DCC'08, J.S. Gero and A. Goel (eds), 593-611.

[9] Dorst, K. & Cross, N. (2001). Creativity in the design process: co-evolution of problem-solution. *Design Studies, 22*, 425-437.

[10] Eatsman, C.M. (1969). Cognitive processes and ill-defined problems: a case study from design. In *Proceedings of the First Joint International Conference on I.A.* (pp. 669-690). Washington, DC.

[11] Eckert, C.M. And Stacey, M.K. 'Sources of Inspiration: A language of design.' *Pre-Proceedings of the 4th Design Thinking Research Symposium*, MIT, Cambridge, MA, April 1999.

[12] Gero JS. (2002). Towards a theory of designing as situated acts. The Science of Design International Conference, Lyon, March 15-16, 2002.

[13] Lebahar JC (1986). Le travail de conception en architecture : contraintes et perspectives apportées par la CAO, Le Travail humain, Tome 49, N°1.

[14] Lloyd P., Scott P. (1994). Discovering the design problem, Design Studies, January Vol 15 n.2.

[15] McDonagh D., Denton H (2005). Exploring the degree to which individual students share a common perception of specific trend boards : observations relating to teaching, learning and team-based design, *Design Studies, 26* , 35-53.

[16] Mougenot C., Bouchard C., Aoussat A., Fostering innovation in early design stage: a study of inspirational process in car design companies, Wonderground 2006, Design Research Society International Conference, Lisbon, 1-5 November 2006.

[17] Mougenot, C., Thesis in Industrial Engineering, Modélisation de la phase d'exploration du processus de conception de produits, pour une créativité augmentée, 2008.

[18] Nagamachi M., Kansei Engineering: A new ergonomic consumer-oriented technology for product development. International Journal of Industrial Ergonomics 15 (1), 1995, pp 3-11.

[19] Restrepo, J., 2004, Information processing in design, Delft University Press, the Netherlands, ISBN 90-407-2552-7.

[20] Setchi R., Lagos N., Froyd D., Computational imagination: research agenda, Twentieth Australian Joint Conference on Artificial intelligence - AI07, Gold Coast, Queensland, Australia, December 2007.

[21] Setchi R., Tang Q., Bouchard C., Concept indexing of images using generic and domain-specific ontologies. KES International Conference on Knowledge-Based and Intelligent information and Engineering systems, 2010

[22] Simon, H.A. (1973). The structure of ill structured problems. *Artificial Intelligence, 4*, 181-201.

[23] Valette Florence P., Introduction à l'analyse des chaînages cognitifs, Recherche et Application en marketing, vol9 (1), 1994, pp 93-118

[24] Wang C. (1995). An approach to computer-aided styling, Design Studies Vol 16 N°1.

[25] Westerman, S.J. & Kaur, S., Supporting creative industrial design with computer-based image retrieval, Proceedings of the European Conference on Cognitive Ergonomics, Covent Garden, London, August 2007.