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A STUDY OF DESIGNERS' COGNITIVE ACTIVITY IN DESIGN INFORMATIONAL PHASE

Céline MOUGENOT, Carole BOUCHARD, Améziane AOUSSAT
LCPI (Product Design & Innovation Lab) – ENSAM École Nationale Supérieure d'Arts et Métiers, Paris, France

ABSTRACT
In the purpose of developping better design-support tools and improving design education, design cognition studies describe designers' mental strategies for solving design problems. So far, the first steps toward a description of designers' strategies have shown that analogies are widely used in the ideas generation phases of design process. But the very early stages of design, in the transition from brief reception to idea generation, still remain uncompletely understood and described; our study aims at exploring the way designers handle visual information beforing reaching the *Eureka* moment. Experiments were carried out with four professional designers from car-design European companies. The participants were invited to browse two media, printed magazines and Internet, in order to retrieve 'inspirational' images and to associate lexical descriptions to the selected images. Then in a later task, the participants had to illustrate an assigned design brief with pictures they found through online picture-search engines. The main findings deal with designers' creativity and designers' *kansei*:
(1) In the early phases of design, the activity of browsing information sources is a combination of a generic process, shared by all designers, and individual strategies involving the designer's subjectivity.
(2) New media, such as the Internet, surely impact the information phase of the early stages of design projects. Designers modify their creative strategies to adapt to the media capabilities.

Keywords: Creativity. Design cognition. Inspirational media. Design Information Watch. Kansei.

1 INTRODUCTION

Literature review: design early stages and cognitive studies
Research in creativity is crucial for supporting innovation into product design activities. Design thinking has been attracting more and more attention from researchers since Donald Schön [1] and his contribution to the understanding of what practitioners do and think and the apparition of "reflection-in-action" and "reflection-on-action" notions. Lawson's work was more specifically focused on architectural activities; in an attempt to "demystify the design process", Lawson observed architects activities and demonstrated the importance of sketching within the design process [2]. In 1995, the Delft protocol laid the foundation stones for research dedicated to **design thinking** [3] and research community got aware that creativity in design was a research issue in itself, with particular features. Dorst *et al.* [4] showed that the design process is a continuous conversation of the designer with him/herself to have several round trips between problem and solution.
To get understanding of the **creative process** (review by Nagai *et al.* [6]), "exceptional designers" work was observed [7] and the inspirational process was studied by Eckert *et al.* [8], who stressed on the fact that designers need to devote some of their working time to browse inspirational materials, and by Ansburg *et al.* [9] who showed that creative designers are open to a wide range of inspiration and use their attentional resources to cover a wide scope of sources of information.
Creativity in design also involves a specific cognitive feature: **analogical reasoning**; many studies demonstrated that designers make an intensive use of analogies in order to adapt design features from other fields to their own design problem. From a more descriptive point of view, Leclercq *et al.* [10] described the way designers use analogies. Bonnardel *et al.* [11] showed that the most creative analogies are those made between the most distant domains and that analogies can be performed at

various levels (functional, structural, affective…). Analogical thinking is often triggered by visual stimulation, it has been shown that **pictures** and images are a major way of stimulating designers creativity [12],[13]. Besides visual materials, the importance of **words** was emphasized by Dong [14]; to him, "language serves as representations of ideas and concepts through linguistic behaviors that represent the structure of thought during the design process". Today, visual materials and linguistics materials have been identified major vectors of design creativity. We still lack an acute description of the roles of pictures, words and pictures-and-words relationships within the designers' cognitive process.

Some studies attempt to create links between products visual characteristics and descriptive words, in the frame of design, by building design precedents classification, "**ontologies**" [15], [16]; we notice that **subjectivity**, either designers' one or product users' one is taken into account [17] and that design characteristics can be linked to abstract notions, such as feelings or emotions.

Kansei studies [18] aim at describing the role of designers' subjectivity in product development (see Levy *et al.* [19] for a state-of-the-art about *kansei*); but so far, these studies are mainly focused on the idea generation phase or in the design evaluation phase. Focusing on early phases of design (informational phases) would be extremely useful for developping computational tools that efficiently support designers' creativity [20], [21].

Therefore, our goal is to study the impact of designers' subjectivity within the informational/inspirational phase and to identify the influence of visual and lexical materials on designers' subjectivity.

Internet as an inspirational medium for designers?

Browsing magazines is seen as a usual and daily activity by designers; 32 designers who were interviewed in a previous study [22] claim that reading magazines is the traditional way of being kept informed about trends and design news, they also acknowledged that the Internet is becoming more and more used in watch activities, all of them using it on a daily basis as well.

Thus, we are interested in knowing whether Internet and Pictures Search Engines as Google Images, are used differently from the printed media in the informational phase of designers' jobs.

Our experimental protocol is aimed at observing designers' way of selecting inspirational materials and of associating words and pictures. In sum, the goal of this experimental study is twofold:

- Describing the cognitive process of designers when the latter search for images and texts in the frame of their inspirational process.
- Comparing the ways magazines on one hand and websites on the other hand contribute to supporting designers' creativity

Our hypotheses

Our study is based on the following premises:

(1) In the early phases of design, the activity of browsing information sources is a combination of a generic process, that all designers share, and individual strategies belonging to each designer and involving his/her own subjectivity.

(2) New information sources, such as Internet sites, might impact the information phase in design projects. Designers might change their working strategies to adapt to the computer tools.

2 EXPERIMENT DESCRIPTION

Experimental tasks were performed with 4 professional designers in position in European car-design companies. Each experimental session was carried out by one experimentator (design methodology researcher) interacting with one designer for 120 minutes. The sessions were video-taped in order to facilitate the post-session analysis.

In this paper, we present two of the three assignments that were performed by the participants. Both assignments were designed as to be as close as possible to a real professional activity; the experiments were performed in a lab-like room, inside the designers' usual environment (companies sites). Besides, the designers were invited to perform the experiments as if they were performing their usual activities of trends and design information watching.

2.1 Panel

The panel was made of four professional designers, in position in two car-design companies located in Italy. Nationality of designers varied (2 Italian, 1 German, 1 French). They were 4 males.
Ages of participants ranged from 27 to 33 years old (mean age: 29.8 years old).
Professional design experience ranged from 3 to 7 years (mean experience: 5.3 years).
All participants were proficient in English.
In this paper, the participants are called “designer 1”, “designer 2”, “designer 3”, “designer 4”.

2.2 Protocol

2.2.1 Assignment 1: Magazines and Websites Free Browsing

The first task consisted in browsing inspirational materials which designers were provided with, i.e.:

- Magazines (6) dealing with automotive design, fashion, interior design, art and architecture
- Websites (10) dealing with automotive design, fashion, product design

Table 1: Magazines and websites provided to the participants

Magazine Name	*Issue Reference*	*Sector*
Carl*s Car	N° 16 – July 2006 Issue (131 pages)	Automotive Design and Lifestyle
DAM	N° 7 – July / August 2006 Issue (168 pages)	Product Design, Art & Architecture
ELLE	August 2006 Issue (218 pages) – UK Edition	Fashion, Lifestyle and People
ESTETICA DESIGN	N° 6 – July 2006 Issue (102 pages)	Architecture and Interior Design
FRAME	N° 51 – July / August 2006 Issue (209 pages)	Interior Design and Product Design
VANITY FAIR	August 2006 Issue (148 pages) – UK Edition	Fashion, Lifestyle and People
Website Name	*Html Address(all websites version from July 25, 2006)*	*Sector*
Ads of the world	http://adsoftheworld.com	Advertising
Car Design News	http://www.cardesignnews.com	Automotive Design
Design Goodness	http://www.frederiksamuel.com/blog/	Design - Advertising (blog)
Design*sponge	http://www.designsponge.blogspot.com	Design (blog)
Inside-photo.com	http://www.inside-photo.com	Architecture (pictures tank)
MoCo Loco	http://www.mocoloco.com	Product Design
My Fashion Life	http://www.myfashionlife.com	Fashion and People
Style 4 Cars	http://www.style4cars.com	Automotive Design
Truc design	http://www.trucdesign.com	Product Design
Wallpaper*	http://www.wallpaper.com/architecture	Architecture & Design

All selected magazines and websites dealt with creative sectors (car-design, architecture, interior design…) that were identified as usual sectors of reference by car-designers, both by the same panel of designers as in this very study [22] and by another panel of car-designers in a previous study [23].
In this first step, the search was not targeting any specific issue; this intended to put designers in a situation close to their usual continuous trends and design watch. Without any brief or any directions, designers were invited to browse freely magazines first, and then websites.

- Pictures Selection: All retrieved images were recorded, as well as the search terms that participants use, using sticky notes.
- Inspirational Value Evaluation : In the mean time, participants were asked to explain why they chose such or such images, why they considered them as inspirational and to classify them as to whether they would include them in a trends board or not.

Participants were asked to identify which components of each image led to their decision on inspirational content. Assessments were prompted according to shape, color, texture or semantics.
It was requested from the designers to write down this information on sticky notes that were associated with the selected pictures.

When the pictures collecting task was over, designers were invited to categorize the pictures and to choose words for naming the categories.

2.2.2 Assignment 2: Image-search constrained by a design brief

Secondly, participants completed a focused image-search; the search was so-called "focused" because somewhat constrained by a design brief (cf. Table 2) which gave clues about sociological and emotional values, subjective elements, to integrate into the targeted design.

Table 2: Brief provided in the assignment 2

Target car-maker:	European car-maker
Type of vehicle:	"Zinedine Zidane" Roadster
Target customers:	Young male driver in his 20's
Based on the sport vehicles segment, this new roadster should embody the spirit and the values of the soccer idol, Zinedine Zidane.	

Participants were invited to browse a selection of pictures tanks websites, most of them being designed for professional users. Large-audience-targeting engine, GOOGLE Images, was integrated in the websites list, since it is also the most popular image-search engine by the designers' community [22].

Table 3: Pictures tanks provided to the participants

Website Name	*Html Address(all websites version from July 25, 2006)*	*Sector*
CORBIS	http://pro.corbis.com	Generalist Pictures Tank
FOTOLIA	http://www.fotolia.co.uk	Generalist Pictures Tank
GETTY	http://creative.gettyimages.com	Generalist Pictures Tank
GOOGLE Images	http://www.google.com	Generalist Pictures Tank
INSIDE	http://www.inside-photo.com	Generalist Pictures Tank
MASTERFILE	http://www.masterfile.com	Generalist Pictures Tank

While browsing these websites, participants selected pictures in order to illustrate the best the design brief which was provided by the experimentators, as if they would use these pictures for a trend board illustrating a design proposal. The selected pictures were saved by the participants on the PC hard-disk. During the picture selection, participants verbally explained their choice; notes were taken by the experimentator.

3 EXPERIMENTAL RESULTS

3.1 Magazines and Websites Free Browsing

Type of images in selection

In the magazines browsing tasks, 55 pictures were retrieved by the four participants.

Most of the selected pictures were A4-magazine page format in their globality (cf. Table 4); the selected pages showed a very clear focus on a specific subject, without any text most of the time. Pages full of small details were not popular: only 5 images (/55) were a selection within a page full of details (selection of graphical details or shapes details).

6 selected images were A3-format (magazine double-pages), all selected by the same designer, who also created many categories linked with feelings and atmospheres topics. An explanation for this selection could be that large-format images better involve the watcher in the picture atmosphere.

Table 4: Format types for images selected by the participants (over 55 selected pictures)

Format	A4-format picture	A4-format page full of details	A3-format picture
Visual information	One single subject	Many subjects / sub-images	One single subject
Lexical information	No text	Full of text	No text
Number of items in overall selection (55 items)	44	5	6

Example given			

Commonalities between sets of selected pictures

In Table 5 is shown the only picture which was part of more than one selection. 2 participants picked this picture; they both described it with the concept of "simplicity» and they both decided to classify it in a "shape"-related category. Designer 1 used his picture description to name a whole category.

Table 5: Descriptions for the only picture that was selected by 2 participants

	Designer	*Description*	*Category*
	Designer 1	Shape simplicity	Shapes simplicity
	Designer 2	Shape cleanliness Simplicity Freshness	Objects and shapes

Sectors of influence

Among the 6 magazines proposed by the experimentators, the participants selected between 3 and 5 magazines to be browsed during a limited time (30 min). The participants selected inspirational pictures in quite similar sets of magazines among the proposed magazines: FRAME and DAM were the most popular magazines for the pictures selection, while ELLE and VANITY FAIR were the most often left aside magazine.

The four participants selected a total amount of 55 pictures. The overall selection of pictures is broken down as described in Figure 1, with respect to each browsed magazine.

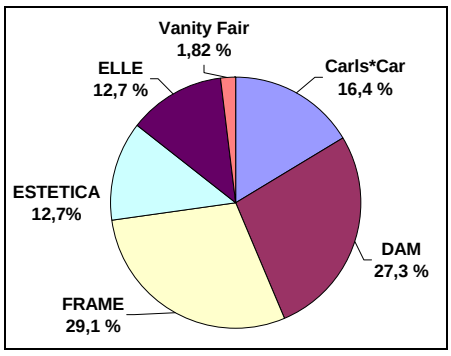

Figure 1: Distribution of the amount of selected pictures with respect to the source magazines

Since each of the proposed magazines is linked to a creative sector (car design, product design, architecture, lifestyle…), the pictures selection can be visualized with respect to the distance to the participants sector of activity (car-design). It is noticeable that the shortest selection of pictures are both made in the very same domain of car-design and the most remote domains (fashion, lifestyle and people), while the most important pictures selection (88.1%) is made in sectors different from own specialty field (car-design) but close to it, i.e. product design, interior design and architecture, as shown in Figure 2.

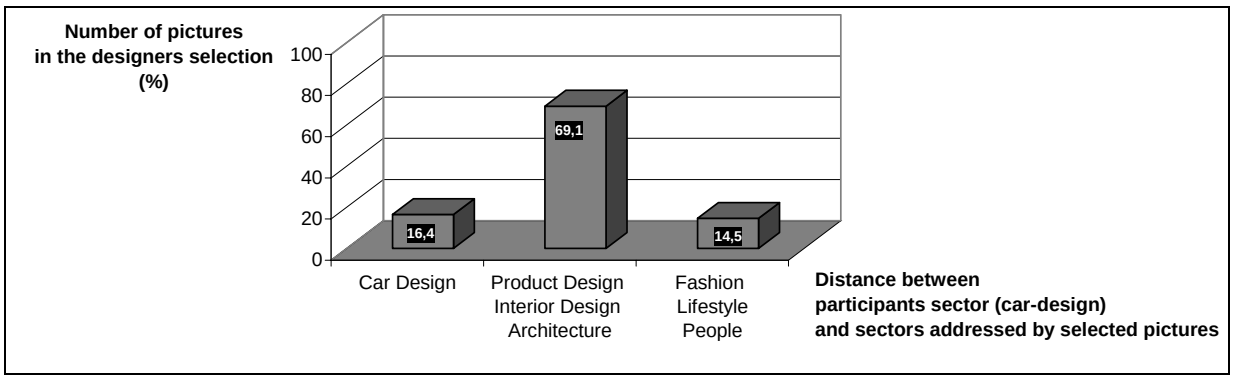

Figure 2: Representation of the magazines inspirational value with respect to the inter-sector distance

Categories created by designers for pictures classification

While browsing magazines and websites, participants selected pictures; they had then to classify the pictures and to give names to the created categories[1]. The categories names given by all four designers can be found in Table 6.

The first observation is about the total number of pictures retrieved either from printed medium, i.e. 56 pictures, or in online medium, i.e. 31 pictures. While the participants were given the same time allocation for both browsing tasks (30 min for magazines and 30 min for websites), it is obvious that they found a higher quantity of inspirational materials through the magazines than on websites.

Table 6: Categories created by the designers and number of pictures allocated to each category

Categories for the pictures selected in printed magazines		*Categories for the pictures selected on websites*		
Impressions	2	Provocation	2	*> Affective / semantic level*
(Shapes) harmonies dynamics	10	Atmosphere	4+1	
(Shapes) simplicity	4	Cool	1	
Ambiences atmospheres emotions	3			
Cool	2			
Atmosphere	4			
Style	4			
Objects and shapes	2	Objects	3	*> Products / Sectors*
Product design	4	Products	1	
Garage	3	Car	1	
Architecture	2	Furniture/Interior Design	6	
		Graphics	8	
Graphics	8	Sketches	1	*> Low-level descriptors*
Textures	2	Backgrounds	3	
Colors	2			
Shapes (harmonies dynamics)	10			
Shapes (simplicity)	4			
Miscellaneous	4			*> Undefined level*

All retrieved information can be classified into various levels of abstraction. Design information starts from low-level descriptors, such as colors, shapes… Design information can also be described in a subjective way, and thus linked to designer interpretation, up to an affective and semantic level.

In this case study, the participants classified their selected pictures into "low-level descriptors" categories, e.g. *Colors*, *Shapes*, into "product/sectors" mid-level categories, such as *Architecture* or *Products*, and into "affective and semantic level" categories, entitled *Cool*, *Provocation* or *Impressions*…

As analyzed from Figure 3, the content of the retrieved images is different whether they were found in magazines or on websites; in our attempt to evaluate the level of abstraction for each categories created by the designers, it appeared that 41.4 % of the pictures found in the magazines were classified in "high-level categories", i.e. linked to an affective or a semantic description, while only 25 % of the pictures found on the Internet fell into this category level. The high-level categories often refer to an atmosphere triggered by the visual information.

[1] 14 pictures from the magazines were classified into "Shapes Harmonies Dynamics" and "Shapes Simplicity"; they are counted twice: in both affective/semantic level and low-level categories (total of 70 printed pictures in tab.6 and fig.3)

Actually, the Internet seems to provide pictures that are very often categorized at a mid-level of abstraction, more than 60 %, linked to a product or to a creative sector (*Car*, *Furniture*).

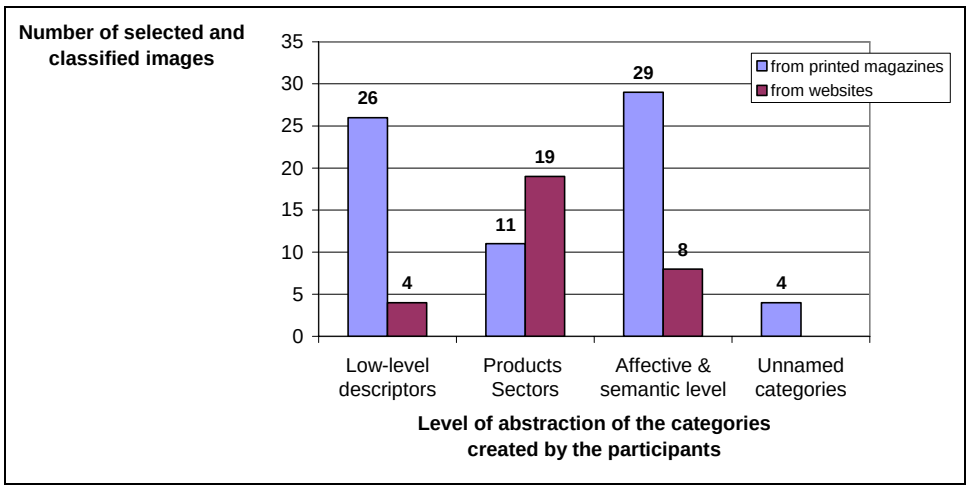

Figure 3: Representation of the number of pictures for each category abstraction level

3.2 Image-search constrained by a design brief

Sector of reference: car-design

After having received the design brief, all designers started their search task with a very clear idea of a car-model that would fit the brief requirements.

All four designers named car brands or car-models aloud, *Smart*, *Renault* and *BMW Z4* by two of them: 2 designers started the task by sketching the car model they were thinking of (inspired by *Smart* and by *Renault* brands) and 2 other designers initiated an Internet search with requests about *BMW Z4.*

Without any brief, designers tended to look for images that were not specifically related to car-design sector, while with the brief constraint, all four designers seemed to be spontaneously coming back to their domain of knowledge and skills: car-design.

Subjectivity integration into web request

The brief dealt with *Zinedine Zidane spirit*, in consequence it was expected that designers would try to find pictures to illustrate abstract elements, sociological values, emotions or personality features.

The results for this task were twofold: first the designers wrote down a list of lexical terms they spontaneously associated with the brief statement, secondly the designers launched Internet searches based on the list of words they wrote down. It is interesting to look at the gap between the first ideas that came to the participants' mind right after listening to the brief and the actual results of the Internet requests that were meant to illustrate their first ideas.

Let's take the example of 'designer 1': after listening to the brief, 'designer 1' wrote down the following words: *versatile*, *accessories*, *fun*, *2-seat car*, *city*, *zainetto*; he also sketched a *zainetto* car model. He then started a search with picture-search engines, with a strategy described in Table 7.

Table 7: "Designer 1" strategy for looking online for pictures to illustrate the design brief

Step	*Search Engine*	*Word keyed in the 'request' dialog box*	*Retrieved images*
1	CORBIS	'Zainetto'	No satisfying image
2	CORBIS	'Zainetto' + 'bag'	No satisfying images
3	CORBIS	'Zainetto' + 'back bag'	No satisfying images
4	GOOGLE Images	'Zaino seven' (bag brand)	

5	GOOGLE Images	‘bag’	
6	GOOGLE Images	‘City’	No satisfying images
7	GOOGLE Images	‘Traffic’	 
8	GETTY	‘Fun’	No satisfying images
9	GETTY	‘Versatile’	No satisfying images
10	GETTY	‘Sport’	  
11	FOTOLIA	Free browsing	No satisfying images

‘Designer 3’ found pictures with the following keywords: *BMW Z4*, *Lotus Exige*, *Zidane*, *Football*; he was satisfied with the associated findings.
To designers 1, 2 and 4, most of request results were not satisfying. The pictures they selected were found by chance, and not thanks to the keywords that were keyed in the search engine dialog box.

4 DISCUSSION

Integration of subjectivity into informational watch

41.4 % of the pictures selected in the magazines are described with subjective lexical terms, linked to a feeling or an atmosphere. A significant part of subjectivity takes part in the informational phase of design process; the designers subjectivity is possibly integrated in information searches made with traditional tools (printed media) while subjectivity is not fully expressed in surfing the Internet.
The Internet provides pictures that are mainly described by mid-level descriptors, as if the pictures provided by the Internet were neither detailed enough for providing low-level descriptors (colors, shapes) nor subjective enough for bringing feelings, emotions or a sensation for atmospheres.
From the very first results of our analysis, this might be caused by the images formats (images on the web are often of very small size) and by the images quality (images on the web might not have been taken by professional photographers and might not be displayed correctly).
Previous studies showed the importance of designers’ subjectivity (*kansei*) within the design process. Our study specifically demonstrates the importance of designers’ *kansei* in the informational phase, as designers search for inspiration and design information.

Informational phase genericity vs. individual strategies

As Visser [24], we found that the design process is made of commonalities and individual specificities; our study demonstrates this in the frame of the informational phase.
All four designers were provided with the same set of information sources (magazines and websites); within these sources, they made some common global selection, for instance, they all rejected VANITY FAIR magazine and they all spent a long time flickering through FRAME magazine.
The sectors the designers refer to, in their informational search, were quite similar; all of them were targeting product design sector and architecture sector.
While there is a common ground for the inspirational materials retrieval, i.e. common ‘sectors of reference’, only one picture over 55 selected pictures was selected out of the magazines by more than one participant.

Besides, the kinds of categories the designers created to classify the pictures they found inspirational varied from low-level categories (*Colors, Textures*) to high-level categories (*Cool, Simplicity)* through sectors names (*Architecture, Garage*). We noticed that this classification was very personal, since 'designer 4' created only "sectors" categories (*Architecture, Product Design)* while 'designer 2' named 4 among his 5 categories with high-level descriptions (*Cool, Style, Impressions, Atmospheres)*; 'designer 1' and 'designer 3' provided a mixed classification.
When asked to illustrate a "Zidane roadster" with any picture of their choice, all designers first started by giving aloud a car-design reference, respectively *Smart*, *Renault*, *BMW Z4* and *BMW Z4*. Referring to car-design precedents seemed to be a shared characteristic by our participants.
However, in the following steps of the assignment 2, participants followed rather individual strategies; for instance, they either tried to illustrate high-level characteristics (*Popular, Versatile, Fun*) or launched requests about concrete elements (*Zidane, BMW Z4, Lotus Exige).* The participants performed searching sequences very dissimilar from each other.
To summarize, the participants shared common interest for specific domains (e.g. car design, architecture) and for specific media (e.g. architectural magazines, cardesignnews website) and they followed very individual strategies when they had to search for inspirational pictures (e.g. they used different keywords in the pictures search engines, they classify magazines pictures in various abstraction levels).

Designers strategies adapt to web tools' limitations

In the free browsing tasks, we observed that the designers did not retrieve the same materials whether they browse printed magazines or websites. For instance, the pictures retrieved from the magazines mainly belonged to an "affective and semantic" level (41.4%), while the pictures selected on websites mainly illustrated "Products" and "Sectors" (61.3%).
Besides, to illustrate a design brief, we observed a gap between the designers' intention (keywords) and the web request results/picture selection. 3 of the 4 designers were not satisfied with the results provided by pictures-search engine, because they felt the retrieved pictures did not correctly illustrate their ideas behind the keyword used in the requests.
We also notice that the designers adapted their searching strategies to the web limitations: for instance, to illustrate a rather abstract idea (*Competition*), a participant used other keywords that he thought would be more likely to be understood by the web engine (*Footwear*, then *Footwear + Sport*, then *Footwear + Sport + Design*).

5 CONCLUSION

Although this experimental study was performed in a car-design context, some generic elements can be extracted and be useful for all design-related activities which include information and innovation watch.
While designers engage in individual strategies when they look for inspirational materials, they share a common ground of interest, they refer to the same creative sectors; 69.1% of the selected pictures were belonging to *Product design*, *Architecture* and *Interior design,* in similar proportion by each designer.
When designers search for inspirational materials, we observed that they use the new media, such as the Internet, in a different way than the printed magazines. Designers' individual subjectivity is improperly taken into account by online search engines and designers have to alter and simplify their requests (keywords) in order to adapt to the limitations of computational tools.
Besides, when browsing pictures, some designers would rather look for atmospheres, while some others for specific colors or shapes: today's computational tools don't allow looking for inspirational materials at a specifically-chosen level of abstraction.
In consequence, we claim that designers' creativity can be fully supported by computational tools for searching images, only when these tools are able to take designers' subjectivity into account.
Future research should deal with designers' Kansei and creativity, not only in the phases of ideas generation, but in the upstream informational and inspirational phases as well. This challenging topic will impact the way computational tools for creativity support will be developed; also, the findings might help in guiding design students towards fruitful sources of information and inspiration.

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Contact: Céline MOUGENOT
École Nationale Supérieure d'Arts et Métiers
LCPI (Product Design & Innovation Lab.)
151 Bd de l'Hôpital
75013 Paris
France
Phone : +33.144.24.63.44
Fax : +33.144.24.64.02
celine.mougenot@paris.ensam.fr
http://www.paris.ensam.fr/cpi
http://www.trendsproject.org