Web Site Designs: Influences of Designer's Experience and Design Constraints

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ABSTRACT

Nowadays, much research examines both the cognitive difficulties encountered by web site users and the development of ergonomic guidelines for designers. However, few studies examine designers' cognitive functioning while designing web sites. We defend the idea that determining the difficulties web site designers encounter is necessary to better support their design activities, especially in making web sites easier to use. We present an experimental study that demonstrates that the designers' levels of expertise (novice and professional) as well as the design constraints that clients prescribe influences both the number and the nature of constraints designers articulate and respect in their web site designs. Based on our study findings, we suggest ways to better support web site designers.

Keywords

Web site design, designer expertise, constraints, web user, client

1. INTRODUCTION

There continues to be steady and rapid growth in the number of web sites (Internet Software Consortium, 2001). However, web sites are frequently difficult to use and do not fit users' needs (Davis, 1999; Nielsen, 2000; Nogier, 2001). Researchers have examined several ways to improve web site usability, including:

- Improving access to and navigation within web sites (e.g., McCrickard, 2001; Smith, Newman and Parks, 1997; Vora and Helander, 1997).
- Developing web design guidelines and ergonomic criteria (e.g., Nielsen, 2000; Scapin, Leulier, Vanderdonckt, Mariage, Bastien, Farence, Palanque and Bastide, 2000; Schneiderman, 1997; Thimbleby, 1997; Van Duyne, Landay, and Hong, 2002).
- Developing automated evaluation tools (e.g., Adaptive Technology Research Center, 2002; CAST, 2002; Ivory and Hearst, 2002a; Scholtz and Laskowski, 1998; Usable Net, 2000) that can assess whether sites conform to design guidelines and ergonomic criteria and, in some cases (e.g., Adaptive Technology Research Center, 2002; Usable Net, 2000), assist designers with modifying sites accordingly.

Although there is considerable interest in improving web site usability, there has been little research on the cognitive activities of web site designers. We assert that understanding designers' activities and identifying difficulties they encounter are essential to improving web site quality. Toward this end, we conducted an experimental study of web site designers with different levels of expertise. In this first study, we examine the effects of the designers' expertise (novice or professional) and of the design condition (with or without prescribed constraints) on: (1) the designers' ability to articulate constraints during the design process, and (2) the degree to which their designs (sketches) respect articulated constraints. Study results provide insight about designers' cognitive activities during the design process and illustrate that there is a wide gap between designers' articulation of constraints and designers' effective implementation of them.

The following section provides an overview of the web site design process and the role of constraints in it; it also describes related work. Section 3 provides details about our experimental study, while Sections 4 and 5 discuss study results. Based on our results, we suggest ways to support and improve web designers' activities in Section 6. Finally, we conclude this article and describe future work.

2. BACKGROUND AND RELATED WORK

We provide background information on the web site design process and contrast how designers working in small and large companies are supported throughout this process. We then summarize empirical findings on the role of constraints in the design process. Finally, we describe related studies of designers' activities.

2.1 Web Site Design Process

Numerous HTML authoring tools are available and their use, after a short training time, may be straightforward, especially for creating basic web site features with WYSIWIG (What You See Is What You Get) tools, such as Netscape Composer®, Adobe GoLive®, and Macromedia Dreamweaver®. Hence, web site design is not reserved to technology specialists; more and more people working individually or possibly within small companies are creating web sites. Although technical aspects of web site design are relatively easy to manage, designers working in small companies encounter other difficulties. Typically, they have to develop skills in many areas: database design, graphic design, user interface design, communications, public relations, etc. Designers working in large companies may not need such a broad skill set, because they often work with other specialists.

Although the web site design can appear as if the designer created it in isolation, it actually requires the intervention of at least two other actors (Bonnardel and Chevalier, 1999):

- The site's clients (i.e., persons who fund the web site)
- The site's future users (i.e., future customers of the site's clients)

These actors may not be accessible throughout the entire design process, especially for designers working within small companies, so designers have to anticipate these actors' expectations while working in individual design situations. Designers' consideration of these actors' potential and/or actual expectations is reflected by their conformance to different kinds of constraints during the design process (Chevalier and Bonnardel, in press). So, we distinguish the following kinds of constraints for this article (for more discussion, see Chevalier and Bonnardel, in press).

- *Client constraints*: constraints that clients explicitly prescribe or the designers infer from prior interactions with other clients.
- *User constraints*: constraints that designers infer from their prior experiences as web site users. Such constraints may address aspects of general interest to users (e.g., aesthetics), or they may address aspects related to usability (e.g., ease of navigation). We refer to the latter class of constraints as ergonomic constraints and to the former as non-ergonomic constraints.

2.2 Role of Constraints in Design Activities

Design activities are considered *situations of problem solving* in cognitive psychology (Malhotra, Thomas, Carroll and Miller, 1980), because designers have to produce a product that fits a specific function, while satisfying different requirements. These parameters define, to some extent, the *goal* to be reached, but designers cannot directly apply pre-defined procedures to reach this goal.

Design problems are also considered *ill defined* (Eastman, 1969; Simon, 1973; Simon 1995), because designers have, at least initially, only an incomplete and imprecise mental representation of the design goal and specifications. It is only through the problem-solving process itself that designers can complete their mental representations by choosing design options. Therefore, design activities have been described as being based on an iterative dialectic between *problem framing* and *problem solving* (Schön, 1983; Simon, 1995). To solve the problem, designers have to improve their mental representations so that they can satisfy a constraint condition, effectively transforming an ill-defined problem into a better-defined one. Designers can apply numerous cognitive processes toward this end. Détienne (2001a) and Darses (2001) state that to solve any design problem, designers have to generate and introduce new constraints to satisfy the original constraint condition.

When we surveyed the scientific literature, we found studies showing that constraints are extremely important for understanding and for solving a design problem (Bonnardel, 2000; Darses, 1994; Darses, 1997; Martin 2001; …), although we did not find a homogenous definition of this notion. Darses (1994, 1997) defines a constraint with respect to the *management of constraints paradigm*. A constraint in this paradigm is considered as a constructed relationship (i.e., a function) among variables pertaining to the product to be developed; thus, it is possible to apply specific operations to this function. According to Martin (2001), constraints are cognitive invariants, which play an essential role in the design process. Constraints research converges toward other research on the use of inspiration sources to solve the problem, the generation and the evaluation of proposed solutions (i.e., defining and examining characteristics of the web site), and the use of constraints to guide design activities (Bonnardel, 2000; Darses, 1994). Moreover, designers describe their design process as a set of constraints to satisfy (Darses, 1997). Therefore, constraints can be considered as elements of the solution, which contribute to designers' problem-solving processes to produce acceptable solutions.

Jansen, Jégou, Vilarem and Nougier (1989) showed that constraints do not have the same statute. Jansen et al. (1989) distinguish *validity constraints* from *preference constraints*. Validity constraints correspond to problem requirements that affect the validity of the product. They are inevitable and as such, designers have to respect them. On the other hand, designers may "get around to" preference constraints.

As we discussed in the preceding section, in the web site design process, designers have to consider the expectations of other actors (i.e., expectations of clients and of site users). Designers' consideration of these expectations is often reflected in their conformance to different design constraints (Chevalier and Bonnardel, 2001). The type and quantity of constraints that designers respect can vary according to (Chevalier and Martinez, 2001):

- The designer's level of expertise
- The designer's personal preferences
- The design problem specifics

These variability sources explain, at least in part, why different designers dealing with the same design problem produce different solutions (Bisseret, Figeac-Letang, and Falzon, 1988). This is because the constraints designers consider come from at least two different sources:

- *From their personal knowledge*: Designers have contextual knowledge acquired from experience (Brézillon and Pomerol, 1999; Brézillon, Pomerol, and Saker, 1998). Designers activate this knowledge to solve the problem.
- *From an external source*: Designers may receive contextual information from an external source, for instance, from the problem description or from explicit design constraints. This source represents constraints prescribed by the client. Designers activate knowledge relevant to these constraints to solve the problem.

According to Brézillon et al. (1998), when designers are confronted with tasks to solve, they activate knowledge that has some similarities to the current design task. Designers' instantiation of this knowledge allows them to consider different constraints. More importantly, the number and the nature of constraints that designers consider depend on their levels of expertise and the specifics of the problem to solve (Chevalier and Martinez, 2001).

For our experimental study, we examined: (1) the number and the nature of constraints that designers articulated during the design process; and (2) whether designers respected articulated constraints in their designs. We studied designers with different levels of expertise—novice and professional web designers.

2.3. RELATED STUDIES OF DESIGNERS' ACTIVITIES

There have been few cognitive psychology studies exploring the role of constraints in the design process. The few existing studies attempt to classify the type of constraints that designers employ (Bonnardel, 1992; Darses, 1994; Savage, Miles, Moore and Miles, 1998). For instance, Savage, Miles, Moore and Miles (1998) distinguished three kinds of constraints that designers use:

1. *External constraints:* economic aspects, such as the time and the cost to develop a product.

2. *Internal constraints:* knowledge from the design domain, the designer's experience, and the designer's intellect.

3. *Inherent constraints from the design task:* physical characteristics, such as the size of the product.

Other cognitive psychology studies have examined how designers and problem solvers in general manage constraints (Darses, 1994; Richard, Poitrenaud and Tijus, 1993). Darses (1994) showed that constraints are extremely important in the software design process. More precisely, she showed that there are significant differences in how designers respect, eliminate, or report constraints, depending on the constraints' levels of abstraction and the constraints' statutes (see discussion of preference and validity constraints in Section 2.2). Similarly, Richard, Poitrenaud and Tijus (1993) suggested a model of how subjects eliminate constraints in problem solving. In this model, the subject initially compiles a set of constraints related to the problem. However, if constraints contradict each other during problem solving or otherwise impede the subject's ability to produce a solution, then the subject is confronted with a cognitive impasse**.** In this case, the constraint elimination process comes into play; this process allows the designer to reject a constraint to reach a solution. Nevertheless, depending on the design domain, this process can be very cumbersome. The aerospace domain is one example, because the designer cannot eliminate constraints without introducing major problems, such as potential security breaches.

Bonnardel (2000) published a study that examines the role of constraints during the design process, specifically on the kind of constraints needed for designers. Bonnardel provided evidence that the designer has to produce a *constraint cognitive environment*—mental representation of constraints—during design activities. Bonnardel claims that the constraint cognitive environment allows designers to reduce the search space for producing a solution. Designers produce this environment from three cognitive processes:

- *Mobilizing and managing constraints*: Designers consider different constraints to solve the problem, but certain constraints may not be satisfied immediately. Instead, they are reported or eliminated.
- *Considering various viewpoints*: Designers consider the end user, product, and client viewpoints during the design process.
- *Reasoning by analogy*: Designers refer to prior problem solutions to resolve the current problem.

Chevalier and Bonnardel (2001) found that web site designers mobilize constraints while considering the user and the client viewpoints. More precisely, designers activate certain constraints from their prior design knowledge. Therefore, the construction of this constraint cognitive environment is very important for our study, since it guides web site designers' activities.

There have been several studies of designers' activities within the HCI domain. For example, several studies have shown that designers experience difficulties following design constraints (Borges, Morales and Rodriguez, 1996; de Souza and Bevan, 1990; Lowgren and Nordqvist, 1992; Smith 1986). One study demonstrated that designers are biased toward aesthetically pleasing interfaces, regardless of their inefficiency (Sears, 1995). These studies did not examine the effects of design expertise and of the presence or absence of design constraints on interface designs.

Newman and Landay (2001) conducted an ethnographic study to examine web designers' work practices, in particular the role of sketching during the design process. The authors observed and interviewed eleven professional web designers and found that designers viewed web site design as being comprised of three main activities—information, navigation, and graphic design—and that designers design sites at multiple levels of abstraction, from high-level sitemaps to low-level page details. The study did not examine designers' use of constraints, but it did inform the design of DENIM, a sketch-based web design tool.

3. EXPERIMENTAL STUDY

We begin this section with a brief discussion of a pilot study we conducted to gain insight about constraints that clients provide designers and then describe how the pilot study informed the experimental factors for this study. The remainder of this section presents our study hypotheses, describes study participants, and discusses the experimental task and subsequent analysis.

3.1. Pilot Study and Experimental Factors

Before conducting the experimental study described in this article, we conducted a pilot study to characterize factors influencing designers who work individually in small companies. During the pilot study, we observed and interviewed four professional designers over a ten-week period as follows (Bonnardel and Chevalier, 1999):

- We recorded and analyzed interactions between real clients and the designers.
- We identified and analyzed the set of constraints that clients gave the designers; the objective of this analysis was to determine the number and the nature of constraints that such designers receive.
- We recorded and analyzed individual design activities to determine which constraints were considered during the web site design process.

Two analysts analyzed the pilot study data. Results showed major differences in clients' expectations, and more precisely, in the set of constraints they give to designers. Clients were on a continuum: Some of them had a concrete idea about their future web sites, whereas others had only an approximate idea. To reproduce this continuum, we asked participants in our experimental study to design a web site for a car dealer in one of two constraint conditions (see Appendix A):

- A condition with eleven constraints the client prescribed
- A condition without constraints

To determine specific client constraints for our experimental study, we identified a subset of the constraints that clients mentioned frequently during the pilot study. We then adapted these constraints for our experimental study. Table 1 depicts the constraints along with our categorization.

Client constraint	Type
To integrate the X presentation	content
To indicate the mailing address and directions to the dealer	content
To present the 3 new cars: 106, 206 & 306 (and special models)	content
The logo must appear on overall pages	structure and content
The design time must be quick, because the car dealer wants his site on the Web before two months	temporal
The web site must be short: 10—15 pages maximum	structure
The site's colours must be well matched with the X logo's colours	aesthetics
In the future, this site will be able to be improved	structure
The on-line services must be presented: to arrange an appointment, to ask questions, etc.	content
To present X's services for buying a new car	content
The budget is 3 600 €	financial

Table 1: Description and nature of prescribed constraints given to designers in our experimental study.

Study participants represented two levels of design expertise: (1) professional designers who had worked in small companies for about three years, and (2) novice designers who had just completed a training course on web site design. Both professional and novice designers created web sites in this study.

In summary, we manipulated two experimental factors:

- The level of design specification (with prescribed constraints or without prescribed constraints).
- The level of design expertise (novice designer or professional designer).

3.2. Research Problem and Objectives

One specificity of web site design is that designers are also Web users, which is not the case for most design situations (e.g., the design of aerospace products). We hypothesized that this circumstance should influence designers' design activities; specifically, they should be able to easily anticipate the needs of the future site users, irrespective of their levels of expertise. Nevertheless, the reality is that many web sites are considered difficult to navigate (e.g., David, 1999; Nielsen, 2000). Therefore, how can we explain why designers, who are also web users, develop sites that are difficult to use? This experimental study provides some answers to this question.

In addition to anticipating users' expectations, designers have to consider and to satisfy clients who fund Web sites. Our pilot study provided evidence that clients differ with respect to the degree of constraint specification: Some clients give designers detailed constraints about their future sites, whereas others provide no information. We hypothesized that this characteristic would influence the designers' cognitive activities. We expected to observe differences in designers' consideration and satisfaction (respect) of clients' constraints based on both the designers' levels of expertise and the constraint conditions (i.e., with or without constraints). We expected that professional designers, who had prior experience with clients who provided them with precise constraints for their sites, would be able to infer and add new client constraints during the design process. Based on their professional experience, we hypothesized that professional designers would consider more client constraints than novice designers, who had no prior experience with clients.

During the experimental study, designers articulated constraints that they considered to make design decisions. Afterwards, separate analysts assessed whether their designs actually respected constraints the designers articulated. We argue that the constraint condition and the designers' levels of expertise influence both:

- The designers' articulation of the client's and the users' expectations
- The designers' ability to satisfy articulated constraints in the web site sketches they produced

More precisely, our experimental study examines the following based on the constraint condition and the designer's level of expertise:

1. The number and the nature of articulated constraints linked to the client's expectations (referred to as client constraints).
2. The number and the nature of articulated constraints linked to the users' expectations (referred to as user constraints).
3. The number and the nature of articulated constraints effectively respected/satisfied in the designers' sketches.

3.3. Study Participants

Fourteen web site designers participated in this study; we characterize the designers as follows.

- Six professional designers, who had created web sites within small companies for about three years: These designers had different backgrounds (e.g., architecture and arts), but they specialized in designing e-commerce sites.
- Eight novice designers, who had just attended a class to learn how to create web sites using a WYSIWYG HTML authoring tool: They had developed only one web site during their training and had not interacted with a real client.

All of the designers used an authoring tool, such as Macromedia Dreamweaver® or Adobe GoLive®, to create web pages and used Microsoft Photoshop® to create images. We conducted a between-subjects experiment wherein we randomly assigned designers to the constraint conditions (see Table 2).

Design Expertise	**Constraint Condition**		**Total**
	With constraints	Without constraints	
Novice	4	4	8
Professional	3	3	6
Total	7	7	14

Table 2: Designer assignment to the two constraint conditions.

3.4. Experimental Task and Data Analysis

Designers had about one and a half hour to create an initial web site sketch; designers were told that this sketch would be presented to an X car dealer (the client). Designers created sites based on the assigned constraint condition (see Appendix A), and we provided them with supporting paper and electronic documents (e.g., photographs of the client's store and cars, contact information for the store, etc.). While they designed their sketches, designers had to think aloud (Ericsson and Simon, 1993). Researchers often use this technique to study cognitive processes in design activities (e.g., Dorst and Cross, 2001; Gero and McNeill, 1998); this technique allowed us to identify the number and the nature of constraints that designers articulated.

We recorded designers' verbal protocols and then transcribed them for analysis. Two different analysts analysed the transcribed protocols to derive objective data (i.e., the number and nature of articulated constraints). There was 95 percent agreement between the two analyses.

We analysed the verbal protocols according to the typology of constraints proposed in Section 3.2—client constraints and user constraints. To determine if the designers' articulated constraints were liked with the client or with the users, two analysts categorized constraints as follows:

- *Client constraints:* are similar to the eleven prescribed constraints (see Table 1) or the designer inferred them from prior interactions with other clients. More precisely, these constraints typically refer to the client's branding, need to improve sales, commercial arguments, etc.
- *User constraints:* are mentally constructed during a designer's prior experiences as a web user. These constraints refer to site navigation (an ergonomic constraint), and to aesthetic aspects of the site (e.g., page layouts, colors, and photographs). We refer to the latter as non-ergonomic constraints.

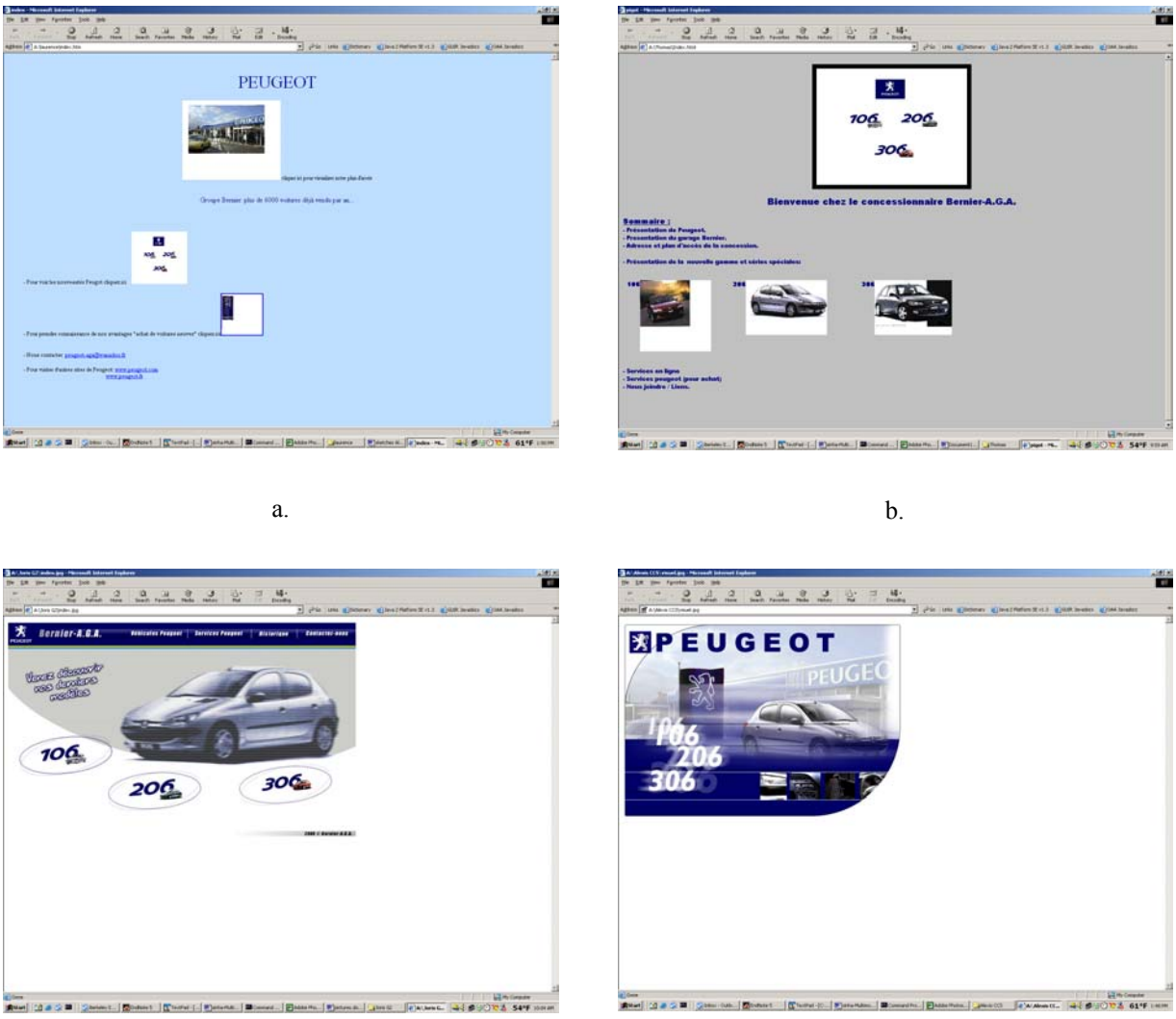
During this analysis phase, we counted each constraint that at least one designer articulated. For the final stage of analysis—to determine if designers effectively respected articulated constraints in their sketches—the same two analysts analysed the designers' final electronic productions. Specifically, analysts looked at each designer's production and noted whether the designer implemented articulated constraints in the sketch. In some cases, articulated constraints were too vague or could not be assessed (e.g., whether the sketch will improve sales); such constraints were not considered during the final analysis phase.

4. RESULTS

We present example designs that designers produced in each experimental condition; these designs illustrate differences based on the experimental factors. We then describe constraints that designers articulated during the design process and present results after classifying constraints as being linked with the client or the users. Finally, we discuss designers' respect of articulated constraints in their sketches and the ergonomic quality of their sketches.

4.1. Example Designs

Figure 1 depicts several designs that designers produced during the experimental study. The sketches suggest that there are more differences in designs produced by novice designers in the condition without constraints than for novice designers in the condition with constraints. However, this difference is not as apparent in the sketches produced by professional designers. The sketches also highlight major differences in design quality based on the designers' expertise. We examine these hypotheses with objective data in the remainder of this section.



a. b.

c. d.

Figure 1: Designs that study participants produced: a. novice designer without constraints, b. novice designer with constraints, c. professional designer without constraints, and d. professional designer with constraints.

4.2. Designers' Articulation of Constraints

Table 3 shows that the professional designers articulated more constraints than the novice designers, irrespective of the constraint condition; this difference is significant as measured by the analysis of variance test (ANOVA). The table 3 also shows a significant difference in the number of articulated constraints for novice designers in the two constraint conditions; however, there was no significant difference in the number of articulated constraints for professional designers in the two constraint conditions. The remainder of this section provides further analysis of the

data presented in the table and elaborates on articulated constraints, specifically on their associations with the client's or users' expectations.

Design Expertise	**Constraint Condition**		**Significance**
	With constraints	Without constraints	
Novice	14.8	21.0	$F(1,6)=9.236$; **$p < .030$**
Professional	30.3	38.2	$F(1,4)=2972$; $p > .1$
Significance	$F(1,5)=23.279$; **$p < .005$**	$F(1,5)=30.964$; **$p < .003$**	$F(1,9)=.05$; $p > .100$

Table 3: Mean number of constraints that designers articulated. Significance results are from Analysis of Variance (ANOVA) tests; bold entries represent significant differences.

4.2.1. Designers' articulation of client constraints

Table 4 summarizes the mean number of client constraints designers articulated in each condition. The table 4 distinguishes between prescribed constraints (i.e., the list of client constraints experimentalists gave to designers; see Section 3.1) and constraints that the designers inferred. There were no significant differences in the number of prescribed constraints that professional and novice designers articulated in the condition with constraints. But, there was a significant difference for designers in the condition without constraints; professionals inferred more prescribed constraints than novices. Moreover, professional and novice designers in the condition without constraints inferred about the same number and nature of constraints as designers in the condition with constraints. Prescribed constraints that designers articulated typically referred to the content and to the structure of the future web site, such as the following constraints:

- "To indicate the mail [address] and the map" (content constraint)
- "The web site must be short: 10—15 pages maximum" (structure constraint)

Therefore, the professional and novice designers, irrespective of the constraint condition, articulated constraints that were identical to the client's expectations.

Design Expertise	**Constraint Condition**				**Significance**	
	With constraints		Without constraints			
	Prescribed constraints	Inferred constraints	Prescribed constraints*	Inferred constraints	Prescribed constraints	Inferred constraints
Novice	7.5	1.3	5.3	5.3	$F(1,6)=4.418$; $p > .100$	$F(1,6)=2.387$; **$p < .020$**
Professional	8.0	9.3	7.0	10.7	$F(1,4)=.375$; $p > .100$	$F(1,4)=.559$; $p > .100$
Significance	$F(1,5)=.79$; $p > .100$	$F(1,5)=28.844$; **$p < .004$**	$F(1,5)=9.545$; **$p < .030$**	$F(1,5)=22.028$; **$p < .006$**		

Table 4: Mean number of client constraints that designers articulated. Significance results are from ANOVA tests; bold entries represent significant differences.

*Designers, who were not provided with a list of constraints, inferred these constraints; inferred constraints were identical to the client-prescribed ones.

Table 4 also shows that all of the designers inferred constraints that were relevant but not prescribed by the client. Results show significant differences in the number of inferred client constraints according to the level of design expertise and the constraint condition:

- Professional designers inferred significantly more constraints than novice designers inferred in the condition with constraints (9.3 vs. 1.3 constraints on average, respectively).
- Novice designers in the condition without constraints inferred significantly more client constraints than novice designers inferred in the condition with constraints (5.3 vs. 1.3 constraints on average, respectively).
- Constraint conditions did not influence the number of constraints professional designers inferred.

Qualitative analysis of inferred constraints revealed several commonalities, thus we grouped similar constraints into the following four categories.

- *Site originality*: the car dealer's site must be original compared to sites for other car dealers. For example, "The picture of the store must show very well this car dealer."
- *Branding usage:* the site must respect characteristics of the car dealer's mark or logo. For example, "To use the same typography of the mark."
- *Sales improvement*: the site must present information to increase the number of new car purchases. For example, "We will have to work on the text with the car dealer in order [for] it [to] be more attractive and commercial."
- *Site structure and content:* refer directly to the web site's content and structure. For example, "We need a page per car."

Table 5 shows that regardless of the designers' levels of expertise and the constraint condition, designers inferred constraints predominately related to site originality, branding usage, and sales improvement.

Design Expertise	**Constraint Category**					**Significance**
	Originality	Branding	Sales	Structure and content	Other	
Novice						
with constraints	0.5	0.5	0.25	0.00	0.00	$F(3,12)=.586$; $p > .100$
without constraints	2.00	1.50	1.00	0.75	0.00	$F(3,12)=8.178$; **$p < .002$**
Professional						
with constraints	1.80	4.40	2.30	1.00	0.00	$F(2,8)=14.77$; **$p < .001$**
without constraints	3.00	4.00	2.70	0.70	0.30	$F(2,8)=7.125$; **$p < .010$**

Table 5: Classification of the mean number of client constraints that designers articulated. Significance results are from ANOVA tests; bold entries represent significant differences.

4.2.2. Designers' articulation of user constraints

Recall from Section 3.4 that experimentalists did not provide designers with a list of user constraints in either condition; however, designers were able to infer user constraints, as hypothesized due to their prior experiences as web users. Table 6 shows significant differences in the number of user constraints articulated based on the designers' levels of expertise and the constraint condition:

- Professional designers inferred significantly more non-ergonomic user constraints than novice designers inferred in both conditions.
- Professional designers in the condition without constraints inferred significantly more non-ergonomic user constraints than professional designers inferred in the condition with constraints.
- Professional designers articulated the same number of ergonomic constraints in both conditions.
- Novice designers in the condition without constraints inferred significantly more ergonomic and non-ergonomic user constraints than novice designers inferred in the condition with constraints.

Results show that all of the designers spontaneously articulated ergonomic constraints related to web site usability (i.e., ergonomic constraints), without the experimentalist indicating usability guidelines. We classified ergonomic constraints that designers articulated using the ergonomic guidelines elaborated by Scapin et al. (2000). Designers articulated ergonomic constraints that refer mainly to two ergonomic criteria (defined by Scapin et al., ibid.):

- *Guidance*: these constraints concern providing specific information to the web user about where he/she is (e.g., "to indicate a title on each web page" and "to put a link at the bottom of each page to enable the user to return to the home page"). Ergonomic constraints related to this criterion represented 44.4 percent of the articulated ergonomic constraints.
- *Cognitive Workload*: these constraints concern perceptive and memory aspects (e.g., "to minimize scrolling for web pages"). Constraints related to this criterion represented 22.2 percent of the articulated ergonomic constraints.

Therefore, constraints related to these two ergonomic criteria represent 66.6% of the articulated constraints.

Design Expertise	**Constraint Condition**				**Significance**	
	With constraints		Without constraints			
	Non-ergonomic constraints*	Ergonomic constraints	Non-ergonomic constraints*	Ergonomic constraints	Non-ergonomic constraints*	Ergonomic constraints
Novice	0.0	6.0	2.3	8.3	$F(1,6)=22.091$; **$p < .004$**	$F(1,6)=18.356$; **$p < .006$**
Professional	5.4	7.6	13.2	7.3	$F(1,4)= 38.4$; **$p < .004$**	$F(1,4)=0.667$; **$p < .040$**
Significance	$F(1,5)=26.786$; $p < .004$	$F(1,5)=.591$; $p > .100$	$F(1,5)=208.534$; **$p < .000$**	$F(1,5)=2.539$; $p > .100$		

Table 6: Mean number of user constraints that designers articulated. Significance results are from ANOVA tests; bold entries represent significant differences.

* Non-ergonomic constraints are of general interest to future site users (e.g., page layouts, colors, and photographs), but are not necessarily related to usability or ergonomic criteria.

The remaining user constraints refer to aspects of general interest to web site users. We grouped them into two categories:

- A*esthetic*s: these constraints relate to the look and feel of the site; for example, the photographs or colours used. Example constraints that designers articulated include: "the colours of the web site must be attractive" and "to group harmoniously the documents on the interface."
- *Attractive content*: these constraints refer to the kind of information to put on web pages. Example constraints that designers articulated include: "to not design a web site too technical," "to forward [users] toward [X].com or [X].fr," "to put a part 'news and more,'" and "to give technical advice."

We observed differences in designers' articulation of constraints based on the designers' levels of expertise. Recall from Table 6 that professional designers inferred significantly more non-ergonomic user constraints than the novice

designers inferred. However, Table 7 shows that attractive content constraints represented the majority of non-ergonomic constraints that novice and professional designers articulated in both constraint conditions.

Design Expertise	**Constraint Category**		**Significance**
	Aesthetics	Content	
Novice			
with constraints	0.00	0.00	—
without constraints	0.50	1.75	$F(1,3)= 12.36$; **$p < .050$**
Professional			
with constraints	1.33	3.67	$F(1,2)= 7.303$; $p > .100$
without constraints	4.33	8.67	$F(1,2)= 197.908$; **$p < .006$**

Table 7: Classification of the mean number of non-ergonomic user constraints designers articulated. Significance results are from ANOVA tests; bold entries represent significant differences.

4.3. Designers' Respect of Articulated Constraints

Two analysts inspected the designers' web site sketches to determine whether their sketches respected constraints the designers articulated. Analysis of articulated constraints revealed that some of them could not be respected in sketches, because they were too vague, subjective, or could not be implemented (e.g., "the web site must improve the sales" or "the web site must have very nice colors"). Table 8 shows the mean number of articulated constraints that could be assessed as well as the mean number and percentage of respected constraints. Section 4.2 showed that there was a significant difference in the number of articulated constraints for novice and professional designers; however, Table 8 shows that novice and professional designers did not respect equal percentages of their articulated constraints. The remainder of this section elaborates on designers' respect of articulated constraints, specifically on their associations with client's or users' expectations.

Design Expertise	Constraint Condition		Significance
	With constraints	Without constraints	
Novice			
Articulated	14.5	17.25	$F(1,4)=63.567$;
Respected	9.5	7.5	$\mathbf{p < .001}$
Percentage	65.5%	43.5%	
Professional			
Articulated	22.9	25.7	$F(1,4)=19.78$;
Respected	17.1	15.0	$\mathbf{p < .001}$
Percentage	74.7%	58.4%	
Significance	$F(1,5)=7.744$; $\mathbf{p < .050}$	$F(1,5)=69.073$; $\mathbf{p < .001}$	

Table 8: Mean number of constraints designers articulated and respected. Articulated constraints that were too vague or could not be implemented are not included in the table. Each percentage reflects the ratio of respected and articulated constraints. Significance results are from ANOVA tests; bold entries represent significant differences.

4.3.1. Designers' respect of articulated client constraints

Table 9 summarizes the percentage of client constraints that designers articulated and respected in their sketches. Regardless of the designers' levels of expertise, designers in both constraint conditions respected almost all of the prescribed constraints that they articulated.

In addition to the prescribed constraints, designers inferred twenty-nine other client constraints. Among the twenty-nine constraints, fifteen of them were precise enough to be discerned in their sketches. Table 9 shows that 85—100% of these inferred constraints were respected in the designers' sketches that were produced in the two constraint conditions. Therefore, designers were more effective at respecting inferred client constraints than prescribed ones.

Design Expertise	Constraint Condition				Significance	
	With constraints		Without constraints			
	Prescribed constraints	Inferred constraints	Prescribed constraints*	Inferred constraints	Prescribed constraints	Inferred constraints
Novice						
Articulated	7.5	1.0	5.25	2.5	$F(1,6)=2.091$; $p > .100$	$F(1,6)=3$; $p > .100$
Respected	7	1.0	5.25	2.0		
Percentage	93.3%	100.0%	100.0%	80.0%		
Professional						
Articulated	7.3	6.0	7.0	5.7	$F(1,4)=1$; $p > .100$	$F(1,5)=3.857$; $p > .100$
Respected	7.0	6.0	7.0	4.7		
Percentage	95.9%	100.0%	100.0%	85.0%		
Significance	$F(1,5)=.15$; $p > .100$	—	—	$F(1,5)=.055$; $p > .100$		

Table 9: Mean number of client constraints articulated and respected by designers. Articulated constraints that were too vague or could not be implemented were not included in the table. Each percentage reflects the ratio of respected and articulated constraints. Significance results are from ANOVA tests; there are no significant differences.

*Designers, who were not provided with a list of constraints, inferred these constraints; inferred constraints were identical to the client-prescribed ones.

4.3.2. Designers' respect of articulated user constraints

Table 10 summarizes the percentage of user constraints that designers articulated and respected in their sketches. Results provide evidence that very few articulated ergonomic constraints (0—40.8%) were respected in designers' sketches. In addition to the ergonomic constraints, designers articulated nineteen non-ergonomic constraints. Among these nineteen constraints, ten of them were precise enough to be discerned in their sketches (e.g., "the paper about the decrease of the sales must not be integrated"). Results show that very few of the non-ergonomic constraints (33.3—50%) were respected in the designers' sketches that were produced in both constraint conditions. Therefore, very few user constraints, regardless of the constraint condition, were respected in designers' sketches.

Design Expertise	**Constraint Condition**				**Significance**	
	With constraints		Without constraints			
	Non-ergonomic constraints*	Ergonomic constraints	Non-ergonomic constraints*	Ergonomic constraints	Non-ergonomic constraints*	Ergonomic constraints
Novice						
Articulated	0.0	6.0	0.8	8.3	—	$F(1,6)=150$; **$p < .000$**
Respected	—	1.5	0.3	0.0		
Percentage	—	25.0%	33.3%	0.0%		
Professional						
Articulated	2.0	7.6	5.7	7.3	$F(1,4)=.13$; $p > .100$	$F(1,4)=81.785$; **$p < .001$**
Respected	1.0	3.1	2.0	1.3		
Percentage	50.0%	40.8%	35.1%	17.8%		
Significance	—	$F(1,5)=38.745$ **$p <.002$**	$F(1,5)=.055$ $p >.100$	$F(1,5)=465.029$ **$p < .000$**		

Table 10: Mean number of user constraints designers articulated and respected. Articulated constraints that were too vague or could not be implemented are not included in the table. Each percentage reflects the ratio of respected and articulated constraints. Significance results are from ANOVA tests; bold entries represent significant differences.

* Non-ergonomic constraints are of general interest to future site users (e.g., page layouts, colors, and photographs), but are not necessarily related to usability or ergonomic criteria.

4.4. Ergonomic Quality of Designers' Sketches

Two analysts used the ergonomic criteria defined by Scapin et al. (2000) and Nielsen (2000) to inspect the designers' web site sketches. The purpose of each inspection was to assess their ergonomic quality by quantifying the number of constraint violations. Table 11 shows that the ergonomic quality of sketches, as measured by the number of constraint violations, was not good; analysts identified a large number of ergonomic problems (an average of 12.7 to19.7), irrespective of the designers' levels of expertise and the constraint condition. More precisely, designers in the condition without constraints violated fewer ergonomic constraints than designers violated in the condition with client-prescribed constraints.

Design Expertise	**Constraint Condition**		**Significance**
	With constraints	Without constraints	
Novice	17.0	15.3	$F(1,6)=1.485$; $p>.1$
Professional	19.7	12.7	$F(1,4)=88.2$; **$p<.001$**
Significance	$F(1,5)=2.949$; $p>.100$	$F(1,5)=7.713$; **$p<.040$**	

Table 11: Mean number of ergonomic violations found in designers' sketches. Significance results are from ANOVA tests; bold entries represent significant differences.

5. DISCUSSION

We discuss findings on both designers' articulation and designers' respect of constraints in this section.

5.1. Designers' Articulation of Constraints

Study results showed that, regardless of the designers' levels of expertise, designers dealing with constraints articulated roughly the same number of client-prescribed constraints. On the contrary, professional designers in the condition without constraints articulated more client-prescribed constraints than novice designers. In accordance with our hypothesis—professional designers, who had prior experience with clients whom provided precise constraints for their sites, would be able to infer and to add new client constraints during the design process—professional designers in the condition without constraints were able to infer client constraints, because they had contextual knowledge acquired through experience (stored as mental schemata) (Hunt, 1989; Minsky, 1975; Reed, 1996; Richard, 1995; Schank & Abelson, 1977). These mental schemata are important for designers' activities, because they find similarities between the design problem to solve and one or several problems solved previously (Bonnardel & Marmèche, 2001; Détienne, 1991; Détienne 2001b; Kolodner, 1983; Schank & Riesbeck, 1989; Visser, 1995). When designers identify one or several adapted schemata, they can instantiate and modify them according to the specific design problem. In our experimental study, designers' instantiation of mental schemata could have allowed them to infer and to add new constraints in the assigned constraint condition, to anticipate

necessary information/constraints to solve the given problem, and to achieve an acceptable solution (Brézillon & Pomerol, 1999). The following verbal protocol illustrates a professional designer (in the condition without constraints) referring to a similar design problem solved previously and adding a new client constraint in the process.

Verbal Protocol Extract (Professional Designer in the Condition Without Constraints)	**Inferred Constraint (in bold letters)**
"For instance, in the web site of X to present his painting gallery, he wanted that the web users could see his different paintings on the Web and the possibility to directly buy them. For this car dealer, I have to make about the same, by adapting to the car sale."	**I have to make about the same**, by adapting to the car sale.

Results from the novice designers' activities in the condition without constraints were more surprising, because they were able to infer the same constraints prescribed by the client, even though they had not worked with real clients. Novice designers' inference activities can be explained, because they are also web users, as hypothesized. Their prior use of web sites allowed them to identify structures and information often presented on web sites. Hence, they could use reproduce what they had experienced in prior visits to web sites to infer and to add new necessary constraints to their web site designs. The following verbal protocol extract shows a novice designer (in the condition without constraints) referring to web sites visited previously and adding a new client constraint (a prescribed constraint) in the process.

Verbal Protocol Extract (Novice Designer in the Condition Without Constraints)	**Inferred Constraint (in bold letters)**
"Very often, we see on web sites an history, so we must put them on this site even if nobody reads them, in modelling and in changing them a little."	we see on web sites an history, so **we must put them on this site.**

Our interpretation also explains the inference activities of professional designers, because they are also web users. Nevertheless, their interactions with real clients allowed them to develop procedures and mental schemata linked more specifically with their design activities (i.e., linked with clients' expectations encountered previously in their professional activities).

Moreover, results showed that novice designers in the condition without constraints inferred more client constraints than novice designers inferred in the condition with constraints. First, we can explain these results by referring to the study Ward, Smith, and Schumacher (1993) conducted, in which participants had to draw a specific picture. When Ward et al. (1993) gave participants example drawings, they observed that participants used the main characteristics of the supplied examples at the onset of their drawing efforts. In our study, we observed the same tendency—novice designers in the condition with constraints relied heavily on the prescribed constraints, and then they inferred/added fewer client constraints than the novice designers inferred/added in the condition without constraints. Therefore, providing novice designers with an important number of client constraints limited their inference activities; however, we expected an opposite effect—giving novice designers explicit constraints would help them to deduce and to infer other client constraints.

We can also explain these results according to the statute attributed to articulated constraints. It is possible that designers had distinguished validity constraints from preference constraints (Janssen et al., 1989). Designers in the condition with constraints could have treated most of the prescribed constraints as validity constraints (i.e., these constraints were inevitable, since the client specified them). Thus, designers could not eliminate prescribed constraints without first discussing them with the client. On the contrary, designers in the condition without constraints had to infer all of the necessary information to solve the design problem. Thus, designers may have considered inferred constraints, identical or not identical to prescribed constraints, as preference constraints, and thought that they could eliminate them if they hindered the design process. On the contrary, results suggest that if professional designers eliminated some prescribed constraints at the beginning of their design activities, their inference activities were not limited by client constraints, because they articulated about the same number of constraints in both constraint conditions. Therefore, even if professional designers considered the prescribed constraints as validity constraints, they could infer an important number of non-prescribed client constraints by instantiating and modifying mental schemata relevant to their design activities. We grouped non-prescribed constraints into four categories: site originality, branding usage, sales improvement, and site structure and content. All of the designers inferred constraints linked mainly with the first three categories. The first three categories relate to the creative and constrained character of the web site design. Indeed, developed web sites have to be original and attractive to attract web users (Chevalier and Bonnardel, 2000), but they must also respect client-prescribed

constraints (and specific HTML coding rules, for instance the format for saving pictures). Designers may have thought that respecting these particularities and demonstrating originality would increase client satisfaction.

Study results showed that professional designers inferred significantly more user constraints than novice designers inferred. More precisely, professional and novice designers in the condition without constraints inferred more constraints than designers inferred in the condition with constraints. Results suggest that when designers have to consider client-prescribed constraints, they focus mainly on these constraints and experience difficulties adding user constraints or anticipating users' activities and vice versa.

We can explain these findings also by referring to the statute attributed to articulated constraints. Indeed, as we discussed previously, designers may consider client-prescribed constraints as validity constraints and therefore consider them as inevitable and unavoidable. Thus, professional designers consider them more so than they consider user constraints. On the contrary, even if the professional and novice designers in the condition without constraints inferred constraints identical to the prescribed ones, these inferred constraints could be considered as preference constraints. Therefore, the designers could consider them as less important and instead focus on the user constraints.

Among the inferred user constraints, designers articulated spontaneously ergonomic constraints. We observed differences based on the designers' levels of expertise and the constraint condition. As stated previously, novice designers in the condition with constraints experienced difficulties in detaching their attention from the client-prescribed constraints, so they inferred fewer ergonomic constraints than the novice designers inferred in the condition without constraints. On the other hand, the constraint condition did not influence the number of ergonomic constraints that professional designers inferred.

In addition to the ergonomic constraints, mainly professional designers and a few novice designers inferred non-ergonomic user constraints. More precisely, our analysis showed that these constraints could be grouped into two categories: aesthetics and attractive content. All of the designers who inferred these kinds of constraints focused mainly on the latter category. We can explain these study results by the fact that the objective of an e-commerce site is to sale the client's products. Consequently, designers have to give precedence to the site's content, specifically to commercial arguments for attracting future users and future customers more so than aesthetic aspects. Aesthetic constraints are typically considered in a later design stage (Newman and Landay, 2001). These results corroborate our other results about the nature of inferred client constraints.

5.2. Designers' Respect of Articulated Constraints

All of the designers articulated an important number of both client and user constraints; however, results showed that the designers focused more so on the client's needs than the users' needs. Indeed, irrespective of the constraint condition and the designers' levels of expertise, designers respected nearly all of the articulated client constraints in their sketches, but implemented very few articulated user constraints. How can we explain these results? We offer the following plausible hypotheses.

1. Designing is an extremely complex activity that requires designers to use important cognitive resources. Hence, to simplify the design process, designers may adopt a specific strategy wherein they initially focus on client constraints and then consider user constraints later.

2. Designers plan to respect user constraints, especially because they can anticipate web users' activities. However, they encounter difficulties applying user constraints in their sketches.

3. Although designers are also web users, they have became "super web users," so certain web site aspects that may be problematic for novice users are not problematic for them. Hence, they do not respect constraints for these potentially problematic aspects.

4. The first person to judge the web site will be the client, so designers prefer to respect the client's constraints.

5. The hour and a half allotted for designing the web site was too short, thus, the designers did not have enough time to respect all of their articulated constraints in their sketches.

We argue that the third hypothesis is the most likely one for the novice designers. Although designers are also web users, they have become expert web users through practice. Certain constraints linked with ergonomic aspects, such as web site navigation, have become automatic to these expert users; thus, such ergonomic aspects are not problematic for them now. Consequently, novice designers did not respect ergonomic constraints in their sketches, and instead focused on the client's needs. These findings suggest that being both a designer and a user is a real problem in the design domain, because designers can believe that they adequately consider users' needs, but actually introduce major ergonomic problems in their productions. This tendency does not exist for designers who are not users, as in the aerospace domain, because they have to effectively consider users' needs and as such tend to collaborate with human factors specialists.

For professional designers, we think that the first hypothesis and/or the fourth hypothesis especially may be more plausible. Newman and Landay (2001) describe how designers prepare several alternative designs initially to present to their clients for approval. Their discussion also points out that professional designers are extremely concerned about satisfying clients.

To test our hypothesis about designers who are super web users, we conducted a second study. For this follow-up study, a different set of designers had to evaluate a web site sketch and comment on its positive and negative features. The sketch used in this second study exhibited all of the ergonomic problems encountered in the sketches designers produced during the first experimental study. Similarly to the first study, professional and novice designers had to evaluate the sketch in the two constraint conditions (with or without prescribed constraints).

Results showed that all of the designers needed only a half an hour on average to evaluate the sketch. Moreover, designers articulated about the same number of constraints, except that professional designers in the condition with constraints articulated more constraints than the other designers articulated. All of the designers articulated more user constraints than client constraints, except for professional designers in the condition with constraints. Even though designers in the second study articulated more user than client constraints (in mean, 17.75 user constraints for novices and 16.75 for professionals vs. 6.25 client constraints for novices and 11.25 for professionals in the first study), designers found very few existing ergonomic problems in the sketch they evaluated; in mean, designers identified only four to ten percent of ergonomic problems.

Results from the first two studies show that professional and novice designers encounter difficulties in effectively considering users' needs during the design process, even though they focus mainly on users' needs during the evaluation process. This discrepancy raises the following two questions:

1. How can we help web site designers to apply articulated user constraints in their sketches?
2. How can we help designers to focus on user constraints more so than on client constraints and more precisely how to help them strike a balance between the two actors?

Our extensive review of existing evaluation methodologies (Ivory and Hearst, 2001) revealed that some methodologies might be inadequate for addressing the preceding questions. For instance, we argue that heuristic evaluation with ergonomic criteria suggested by Nielsen (2000) has not been adapted for web site designers (who have no human factors knowledge), because the ergonomic criteria are both too abstract and too numerous. Our

hypothesis is that it would be more effective to provide designers with a subset of ergonomic constraints that reflect the users' real needs. Specific constraints should be easier for designers to understand. Towards testing our hypothesis, we asked web users to evaluate the same sketch that designers evaluated during the second study. We recorded the ergonomic problems mentioned most often by web users and then transformed them into specific ergonomic constraints. To test our hypothesis, we conducted a third experimental study wherein we provided professional and novice designers with the specific ergonomic constraints and asked them to design a car dealer web site (the same design task as in the first experimental study). The main objective of this third study was to determine if designers dealing with these specific ergonomic constraints could articulate and effectively implement them in their sketches. Results supported our hypothesis. Specifically, the professional and novice designers articulated and effectively implemented the set of specific ergonomic constraints in their sketches; in mean, designers respected 90 percent of ergonomic constraints are. We also found a particularly interesting result: All of the designers were also able to infer and to respect client constraints in their sketches (in mean, 80% of client constraints were respected).

6. SUGGESTIONS FOR SUPPORTING AND IMPROVING WEB SITE DESIGNERS' ACTIVITIES

Study results were in accordance with our hypothesis—the designers' levels of expertise and the constraint condition (with or without constraints) influence designers' articulation and implementation of client and user constraints. Based on our findings, we suggest the following three ways to better support web site designers' activities.

1. Help novice designers to consider both user and client constraints
2. Help professional designers to focus more so on user than client constraints or at least help them to strike a balance between the two actors
3. Help designers, regardless of their levels of expertise, to consider and implement ergonomic constraints in their sketches

For the first two points, we suggest developing a knowledge-based system that fits the designer's level of expertise (see Fischer, Lemke, Mastaglio and Morch, 1991). Specifically:

- The system should help novice designers to identify constraints that need to be respected in the web site design.
- This system should also help novice designers to generate new constraints, through a design step oriented on the expectations of the client and the users. The system could help designers determine, based upon the current

state of the design activity, additional information the designer may need to consider. For example, the system could propose questions for novice designers to ask the client.

- The system should help professional designers deal with a client who has many expectations, in particular to help the designer consider more user constraints. For example, the system could suggest relevant constraints that the designer did not consider.

The base of knowledge for such a system could be and should be improved with complementary studies about the cognitive functioning of web site designers during different design situations and more particularly during different interaction scenarios with clients. Such studies would provide more insight for developing a design methodology geared towards considering the web site client's expectations.

To address the preceding third suggestion—to support designers in considering and implementing constraints—and more generally to help them to produce web sites that are easy to use, we suggest that designers use a questionnaire with a limited number of ergonomic constraints throughout the design process. Designers could use this questionnaire to evaluate the ergonomic quality of their work during different design stages (see a first study on this process conducted by Caro, 2000) and to possibly identify ergonomic problems introduced in their sketches. Even if designers identify ergonomic problems using such as a questionnaire, other ways for supporting them in concretely applying ergonomic constraints and in rectifying ergonomic problems might still be needed.

An alternative approach would be for designers to use validated web site evaluation tools throughout the design process. For example, researchers on the WebTango project have developed an automated methodology and tools to help web designers improve their sites (Ivory and Hearst, 2002a). The methodology entails deriving web design guidelines directly from sites that have been assessed by human judges (Internet professionals who are active web users) (Ivory, 2001). Specifically, WebTango researchers: (1) identify an exhaustive set of quantitative interface measures, (2) compute these measures for a large sample of rated interfaces, (3) derive statistical models from the measures and ratings, (4) use the models to predict ratings for new interfaces, and (5) validate model predictions via empirical studies. The researchers have demonstrated through several studies that it is possible to predict with high accuracy whether a web page or site will be rated favorably based on key measures (Ivory and Hearst, 2002b; Ivory, Sinha and Hearst 2000; Ivory, Sinha and Hearst, 2001). They have also conducted an empirical study wherein novice designers used the statistical models to assess and refine example sites and study participants—thirteen

professional and non web designers—preferred pages and sites modified based on the models over the originals (Ivory, 2001). In addition, they have demonstrated use of the statistical models in assessing existing web design guidelines (Ivory, 2001).

WebTango researchers have embedded the statistical models into a rudimentary "quality checker" tool that lets the designer iteratively assess an implemented site's quality; the models enable context-sensitive assessment (e.g., based on the page type or content type). The tool outputs the results of model predictions as well as additional information about how a design is similar to and different from highly rated designs. WebTango researchers are currently developing a viewer tool to facilitate interpreting model results. Future work entails developing an interactive evaluation tool that can suggest and implement improvements based on model predictions; the tool will support early design representations (e.g., sketches) and implemented sites. Such a tool should be very effective in supporting designers in considering and implementing constraints that can be assessed through computed measures.

7. CONCLUSIONS AND FUTURE WORK

We have presented an initial empirical study of novice and professional designers' ability to articulate and respect inferred or prescribed constraints during the design process. Study results showed that the designers' levels of expertise and the constraint condition (with or without client-prescribed constraints) affects designers' ability to articulate, and more importantly, respect constraints in their designs; this was especially the case for designers respecting user constraints. We have shown that both novice and professional designers need more support during the design process, and we suggested several ways to provide this additional support, including developing knowledge-based systems to suggest constraints to consider or using validated web site evaluation tools to assess and help designers improve the quality of their designs throughout the design process.

Future work entails additional empirical studies to gain more insight about web designer cognitive activities and work practices. For example, we will examine how novice and professional web designers evaluate the quality of their designers and how automated evaluation tools, such as WebTango, can assist them in producing better designs. We will also study their work practices to inform the design of future tools to better support web designer during all design stages. Finally, we plan to examine the influences of different styles of guidelines (e.g., ergonomic constraints, guidelines from the literature, and statistical models) on designers' activities and on the quality of their productions.

APPENDIX A: STUDY SESSION

For the two conditions, with and without constraints, the experimentalist provided designers the same instructions:

> "An X car dealer, situated at Aix-en-Provence, Bernier-A.G.A., would like to present three new car models, on the Web: 106, 206, and 306. Toward this end, he gives you documents about his business. These documents are in both electronic and paper versions. You have also paper and pen if you need to write.
>
> He asks you to elaborate a first sketch in order to present him and his business. While you design, I ask you to think aloud, i.e. all that you think, you have to say aloud."

Before they started their design activity, we allowed them to practice thinking aloud for a few minutes.

For the designers in the condition with client-prescribed constraints, we added the additional instructions:

> "To elaborate this first sketch, the client gives information about his future web site. More precisely, he wants:
>
> 1. To integrate the X presentation
> 2. To indicate the mailing address and directions to the dealer
> 3. To present the 3 new cars: 106, 206 & 306 (and special models)
> 4. The logo must appear on overall pages
> 5. The design time must be quick, because the car dealer wants his site on the Web before two months
> 6. The web site must be short: 10—15 pages maximum
> 7. The site's colours must be well matched with the X logo's colours
> 8. In the future, this site will be able to be improved
> 9. The on-line services must be presented: to arrange an appointment, to ask questions, etc.
> 10. To present X's services for buying a new car
> 11. The budget is 3 600 €

When you are ready, you can start."

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