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Designing web sites:
The cognitive processes of lay-designers

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Over the past few years, the World Web Wide (web) has become a ubiquitous infrastructure, supporting a wide range of services offered by large organizations as well as small and medium-sized enterprises. One of the most striking characteristics of the web is how it can enable individuals to design and "self-publish" their own sites, towards personal or professional aims. Indeed, many web sites are designed and created by lay-designers: people with little or no formal training in either web site design specifically or its attendant skills (e.g., graphic design or user interface design). Little is known about the design processes of lay-designers and the difficulties they encounter during web site design. In order to better understand the cognitive processes of lay-designers, we conducted an empirical study where we asked ten participants to design and construct a small web site using a WYSYWIG web authoring tool. Verbal protocols and reaction times were collected and analyzed. The obtained results allow us to characterize the planning that designers develop, the different points of view they adopt as the design evolves and the cognitive efforts their activities require. Based on these results, we examine how design tools and short training courses might better support the specific needs of web site lay-designers.

Keywords: Design, Design cognition, Design tools, World Wide Web, Design processes, Lay-designers, Planning, Viewpoints.

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1. Introduction

The World Web Wide (web) now supports a wide range of business, government and social services, offered by large organizations as well as small and medium-sized enterprises. The Web is also an important medium of expression and communication for individuals from all walks of life. Indeed, everyone can design and "self-publish" his or her own site, without requiring big up front investments in either equipment or technical expertise.

The web sites of large organizations are typically designed by interdisciplinary teams composed of specialists in database design and implementation, graphic design, user interface design and evaluation, communications and public relations, etc., with each team member contributing their particular disciplinary skill and perspective into the overall interdisciplinary design process. Indeed, much of the theoretical and empirical work in hypermedia and web site design is focused on understanding and supporting the design and maintenance needs of such large-scale sites; such as the Relationship Management Data Model (Isakowitz, Diza, Maiorana & Gilabert, 1994), or the Structured Hypermedia Design Technic (Bichler & Nusser). While these large sites are a vital component of global ebusiness, many web sites — perhaps the majority — are designed by lay-designers. "Lay-designers" are people with little or no formal training in either web design specifically or its attendant skills (e.g., database design, graphic design, user interface design, etc.).

Lay-designers may be creating web sites to support either personal and professional aims. In the personal arena, it is becoming increasingly common for families and friends to use web sites as a means for communication and announcements about important life events, such as births, marriages, graduations, deaths, etc. (Hofmeester, 1999 ; Konrad, 2000) Many individuals design and maintain web sites to showcase and support their special interest groups and hobbiest activities. In the professional arena, many organizations request, and sometimes require, employees to maintain homepages or project pages to support organizational awareness and communication. It is also not uncommon for lay-designers to find themselves in webmaster positions, i.e., responsible for designing and maintaining the organizational website in small and medium-sized enterprises. The 1998 GVU Web Survey data suggests that there are many organizations that depend on both full and part time webmasters that have little prior webmaster experience (GVU, 1998).

Many lay-designers are self-taught and some attend short training courses. The majority of such courses (and many training materials) focus on teaching the syntax of HTML or the specifics of a particular web authoring tool, but not on theoretically or empirically-grounded methods that could facilitate the design of usable web sites. In this article, we will argue that the complexity of web site design is not due, especially, to the cognitive challenges of authoring in HTML. Indeed, there are numerous WYSIWIG (what-you-see-is-what-you-get) authoring tools (such as Netscape Composer™, Dreamweaver™ or GoLive™) which hide the syntax of HTML, and thus using these packages is somewhat similar to using a word processing package. The cognitive challenges of web site design are mainly linked to certain general characteristics of design activities, as well as to certain specific characteristics of web site design. That is, lay-designers must grapple with issues related to information design and consider what information elements they wish to present, how best to present them, and how best to provide navigation and access to these elements.

Despite the cognitive complexity of design activities (Bonnardel, 1999, in press, Bonnardel & Gaden, 2000, Bonnardel & Sumner, 1996) and the specific challenges of web site design, little research is being conducted on the cognitive activities of designers who exploit the creative facilities offered by the web environment. Indeed, much research has focused on access to and navigation within web and/or hypermedia documents (see, for instance, Smith, Newman & Parks, 1997; Vora & Helander, 1997) or the elaboration of guidelines for designing such documents (see Nielsen, 1995; Schneiderman, 1997; Thimbleby, 1997; Leulier, Bastien & Scapin, 1998). Given the pervasiveness of web site design, we argue that it is increasingly important to know more about the cognitive processes of web site designers and, particularly, lay-designers in order to create better design tools and better training materials and courses. Indeed, previous research showed that differences in the cognitive processes of beginning and experienced designers have important, and sometimes surprising, implications for design support tools; i.e. features deemed most appropriate for beginners proved to be better for experienced designers (Bonnardel & Sumner, 1996; Sumner, Bonnardel & Kallag-Harstad, 1997).

Thus, we consider it especially important to analyze lay-designers' "intuitive" or "spontaneous" design activities, in order to gain insight into their cognitive functioning and, on this basis, to identify difficulties they may encounter. Towards this end, we will first analyze characteristics of design activities and, especially, of the design of web sites in order to identify and characterize the cognitive processes to be studied. Then, we will present an exploratory study conducted with lay-designers who recently completed a short training course on web site design. In this study, we asked ten participants to design and construct a small web site using a WYSYWIG web authoring tool. We analyzed their verbal protocols and reaction times to characterize their mental representations and planning processes, their cognitive effort at various stages of design problem-solving, and the points of view they adopted during design construction and analysis. Based on these results, we discuss how design tools and training courses might better support the specific needs of web site lay-designers.

2. General Characteristics of Design

From the perspective of theoretical cognitive psychology, the design of web sites belongs to the field of design problem-solving: designers have to define a product which should fit a specific function and satisfy different requirements (this defines to some extent the "goal" to reach) but the designers cannot directly apply pre-defined procedures to reach this goal (cf. Malhotra, Thomas, Carroll & Miller, 1980). For this reason, design problems are complex because they are both ill-structured and open-ended.

Design problems are "ill-structured" or "wicked" since each designer has to construct his or her own mental representation or mental model of the product to be designed (e.g., a web site) though he or she is provided with only a small set of requirements (Eastman, 1969; Simon, 1973). Mental representations can be defined as transitory constructions elaborated in a particular context towards specific goals (Clement & Richard, 1997). Contrary to knowledge elements stored in long term memory, which need to be activated in order to be efficient, mental representations are immediately available since they are elaborated and maintained in working memory. Mental representations support the designer to deal with the task at hand or the problem-solving in progress; conversely, it is only through the problem-solving process itself that the designer can complete her or his mental representation by choosing design options.

Given this, design activities have been characterized as an iterative dialectic between problem-framing and problem-solving (Rittel, 1984; Simon, 1995). During problem-framing, designers refine design goals and specifications and, thus, refine their mental representation of the problem. During problem-solving, designers elaborate solutions and evaluate these solutions with respect to various criteria and constraints, which guide the designers in performing subsequent stages of design problem-solving (Bonnardel, 1999). The iterative dialectic between problem-framing and problem-solving allows the designer to transform the ill-structured problem into a better defined problem supported by the progressive elaboration of his or her own mental representation of the problem.

In terms of cognitive processes, this dialectic process can be viewed as opportunistic planning. Observations of planning activities are typically used to indirectly examine the evolving mental representation of designers. For instance, in the past, design actions were believed to be based on hierarchical planning; i.e., designers decompose the problem into sub-problems in order to reach sub-solutions, which would later be grouped through a process of composition (Eastman, 1969). However, the seminal study of Hayes-Roth & Hayes-Roth (1979) and later research (see Guindon, 1990; Visser, 1990) indicates that design actions are not purely hierarchical, but instead mainly consists of opportunistic activities, which include hierarchical parts but also consists of unplanned actions, throwing back into question or even giving up of previous decisions, and post-poning actions or decisions. Contradictions have been noticed between designers' descriptions of their own activities as hierarchical, and observations in real time (Visser, 1987): the designers' activities appeared to be less structured than designers stated and their actions moved away from their initial plan.

Since each designer constructs his or her own mental representation of the problem at hand, different designers supposedly solving the same design problem, are going to reach different solutions, all of which may be potentially acceptable (Bisseret, Figéac-Letang & Falzon, 1988). Therefore, design problems are also "open-ended": there is usually no single correct solution or direct procedure for a given problem. There are, instead, a variety of potential solutions, which satisfy different criteria or constraints to varying degrees. Moreover, the criteria and constraints used during design are also open-ended, since they are not only dependent on explicitly stated design requirements. They are also dependent on the designer's own evolving mental representation of the design problem, or his or her point of view, which reflects prior experiences with the design situation and personal preferences (Bonnardel, 1999).

Again, in terms of cognitive processes, while more and more studies in cognitive psychology are examining the adoption of points of view during problem-solving, no clear and consensual definition has been proposed. Nevertheless, in "classical" problem-solving activities (i.e. well defined problems which have an optimal solution), research suggests that changing one's viewpoint on a given situation leads to the construction of a new problem space (Clément & Richard, 1997). In the case of design, we consider that the adoption, or taking into account, of a new viewpoint allows the designer to refine his or her mental representation and, thus, to refine or revise the solution element previously elaborated. More precisely, the new viewpoint would lead to the activation or definition of new knowledge elements: criteria and constraints specific to this viewpoint, which can be situated at different levels of abstraction. Criteria can define either desirable or imperative orientations for the design solution and they can be operationalized by constraints (Bonnardel, 1991, 1993). Specifically, these criteria and constraints can:

- arise from knowledge specific to the designer, learned prior to the problem at hand ("constructed constraints");
- result from filtering and refining of provided information related to the problem at hand and presented, for instance, in a problem specification, design brief, or other form of requirements statement ("prescribed constraints");
- be defined during the design process, by analyzing the implications of already defined constraints or the implications of already defined design options or solution elements.

3. Specific Characteristics of Web Site Design

In addition to these general characteristics of design problems, other characteristics, which may underlie questions about the cognitive functioning of designers, appear to be more specifically linked to the design of web sites. For instance, contrary to other design situations, such as the repetitive design of a well understood technical artifact (e.g., commodity personal computers), owners of web sites often aspire for their sites to be "innovative" and "attractive", as well as fulfilling more functionally-oriented requirements. According to certain descriptions of creativity, this potential tension epitomizes a "constrained cognitive environment" (Bonnardel, in press) where the search for creative or artistic solutions is guided in part by other constraints. These constraints may be specified by the customer (i.e., the person ordering a specific site) in a design brief or written specification, or they may not be documented, known or even anticipated, particularly if the designer and the customer are the same individual. Therefore, it is interesting to ask what impact the level of problem specification may have on the cognitive processes of lay-designers? Particularly, is creativity favored by providing inexperienced designers with relatively complete specifications, or by giving them the freedom to define for themselves the majority of the design constraints? How did the level of problem specification influence their evolving mental representation, as revealed in their planning processes?

Similar to other design situations, designers of web sites have to take into account the viewpoints of different stakeholders, in addition to their own. Much professional design work is based on cooperation and communication between different stakeholders, such as design team members, customers, users, testers, etc., and this communication provides a forum for articulating different perspectives and viewpoints on design priorities, criteria, and constraints; i.e., potentially divergent knowledge elements which must be considered during design (Rittel, 1984; Sumner, 1995). Our previous studies (Bonnardel & Chevalier, 1999) indicate that professional web design designers consider four broad classes of criteria and constraints during design:

- *functional aspects*, which refer to navigation inside the site and to characteristics linked to the navigation (e.g., number of pages, depth and breadth of navigation structure, etc.);
- *cost aspects*, which groups together the financial cost and temporal cost necessary to design a given site;
- *technical aspects*, which refer to the knowledge designers have of design support tools they can use, including the strengths and limitations of the tools;
- *aesthetic aspects*, which refer to the look-and-feel of the site to be designed (such as the harmony of colors inside a given site).

Web site lay-designers, on the other hand, typically work individually. While interactions between lay-designers and customers may occur at certain stages in the design process, interactions between designers and web site users remain in most cases only "virtu al" or imagined. This is particularly the case in small enterprises that lack the expertise or resources to engage in user-centered requirements analysis techniques (e.g., Lewis and Rieman, 1993; Holtzblatt and Jones, 1993) or user testing. The majority of web site design, construction, and reflection activities (such as the cycle of "problem-framing" and "problem-solving" or the cycle of "generation and evaluation of design solutions") take place when the designer is by himself or herself. Design decision-making that occurs in this type of isolated situation is supported mainly by the designer's evolving mental representation and by his or her ability to formulate and consider potentially divergent knowledge elements. Therefore, it is useful to ask whether lay-designers consider multiple viewpoints during design? Do they consider similar viewpoints to professional designers (i.e., technical, functional, aesthetic, cost)? If so, how do individual lay-designers articulate these viewpoints and what are the criteria and constraints associated with different viewpoints? How do designers apply, or take into account, these knowledge elements during design problem solving?

Particularly salient to web site design is the distinction between the customer's viewpoint (i.e., the desires of the person paying for the site to be developed) and the user's viewpoint (i.e., the needs and desires of the web site user). Previous studies suggest that awareness of three types of actors comprise the superordered viewpoints of professional web designers: the designer himself or herself, the customer and the web user (Bonnardel & Chevalier, 1999). Reconciling these viewpoints is a well-known challenge in user interface design and much professional training and design methods are devoted to understanding and championing user needs (Lewis and Rieman, 1993; Holtzblatt and Jones, 1993; Greenbaum and Kyung, 1991; Schuler and Namioka, 1993). Nielsen argues that understanding user needs takes on a new urgency in web environments since, at many sites, people experience the usability of the site first, and then can optionally decide to pay or purchase later (Nielsen, 2000). In this case, poor usability can be particularly devastating for small businesses if it results in loss of revenue. Since many small businesses rely on lay-designers, it behooves us to ask specifically how lay-designers articulate, internalize, and take into account the user’s viewpoint during design problem solving?

Given our previous arguments about the ubiquity and importance of lay-designers, it is therefore also important to ask what impact the "level of expertise" has on designers' cognitive functioning and, especially, on the viewpoints and criteria they take into account and on the cognitive effort required during different stages of design?

In order to characterize the cognitive processes developed by recently trained designers of web sites, we conducted an experiment with students who just attended a class on the creation of web sites. Our objectives were to study:

1. the construction of a mental representation by designers as revealed through the planning activities designers develop,
2. the changes of viewpoints designers perform as well as the aspects of the design activity on which they focus,
3. the cognitive effort they allocate to different stages of the design.

In addition, we wished to replicate a feature of real-life design situations which may have an important impact on designers’ cognitive processes: the level of problem specification. Sometimes designers are provided with a precise schedule of conditions, whereas other times they have only a vague idea of the purpose and functionality necessary for the site being designed. Such a feature became an experimental factor, in order to determine its impact on the designers' mental representations and, consequently, on the cognitive processes they develop. Before presenting the empirical study, we will first consider some methodological issues that must be taken into account when studying designers’ cognitive processes.

4. Methodological issues

Studies performed in cognitive psychology frequently refer to "cognitive effort" (also called "cognitive load" or "mental load"). We briefly define cognitive effort as attentional resources allocated to a task or needed for mobilizing a cognitive process (see Halford, 1993; Piolat & Pélissier, 1998). To date, no measure of the cognitive cost of design processes has been concretely performed. Therefore, we are going to present ways to measure cognitive efforts in an area in which such measures are frequently performed – text writing – and discuss how we adapted these methods to study design activities.

4.1 Measure of cognitive effort

Text writing appears to be one of the rare areas in which measures of cognitive efforts have been frequently performed. Several authors conducted experiments in order to measure the writers' cognitive efforts associated with specific cognitive processes (see Kellogg, 1987a&b, 1988, 1994, 1996, 1998; Kellogg & Mueller, 1993; Levy & Ransdell, 1995, 1996; Piolat, Roussey, Olive & Farioli, 1996). In this area, two main types of paradigms are used to measure cognitive effort: one proposed by Kellogg (1987b) and the other one by Levy and Ransdell (1995). These paradigms are related to the "additional task" performance model (also called "double task" or "secondary task"), which has been used for more than 25 years (see Baddeley & Hitch, 1974; Kahneman, 1973; Posner, 1978). Performance is measured on an additional task, which participants solve simultaneously with their primary task.

Humans are considered to be systems with limited capacity; therefore, attentional resources available in working memory are limited (Baddeley & Hitch, 1974). The idea underlying the paradigms of Kellogg (1987b) and Levy and Ransdell (1995) is that the residual capacity not used to perform the main task can be used to perform another task. In both Kellogg's and Levy and Ransdell's paradigms, while performing the main task (i.e. writing a text), the participants are interrupted by signals or probes and they have to react as quickly as possible to these stimuli. More precisely, reaction times of each participant are first measured independently of any other activity, in order to define a mean basic reaction time specific to each participant. This basic reaction time is then subtracted from the reaction times measured while performing the main task, in order to define "weighted reaction times" associated with cognitive processes. Therefore, the greater the weighted reaction time is, the more the cognitive process which has been interrupted is considered to require important cognitive resources.

The cognitive processes that have been interrupted by probes are identified differently according to Kellogg's paradigm and to the one of Levy and Ransdell. In Kellogg's paradigm, after each reaction, the participant has to choose among several labels the one corresponding to the cognitive process that has been interrupted (the labels used to study writing activities correspond to the three main processes described by Hayes and Flower (1980) — "planning", "translating", "reviewing" — and to the label: "other"). In Levy and Ransdell's paradigm, the participant has to think aloud (simultaneous verbalization) and several indicators are automatically logged (e.g., the activity of each participant, in order to identify precisely the beginning and the end of the writing). Thus, both Kellogg and Levy and Ransdell ask the participants to perform a *triple task:*

1. writing a text (main task),
2. reacting to probes,
3. indicating the cognitive process which has been interrupted, either by pointing out labels or through simultaneous verbalization.

Methodological concerns were expressed about the double task technique (Fisk, Derrick & Schneider, 1986-87) as well as on the functional interpretations that this technique can allow (Navon, 1984; Navon & Gopher, 1979; Pashler, 1984). However, several experiments have shown that the two additional tasks (reacting to probes and indicating the interrupted cognitive processes) do not damage the main activity (see Piolat, Olive, Roussey & Thunin, 1999; Olive, Kellogg & Piolat, in press). These experiments are based on a comparison between "natural" writing conditions (i.e. without any specific technique) and "unusual" conditions (main task associated with the two additional tasks). Specifically, these experiments showed that:

- There is no deterioration of the quality of the productions obtained. Writers can allocate enough attentional resources to preserve their writing objectives and they can define "commitments" in managing their attentional resources, which allow them both to produce a text with the same quality as in natural conditions and to perform the additional tasks (Kellogg, 1987a&b).
- Though the interruptions may slow down the task, especially when the probes are particularly frequent, the mobilization of the writing processes and the management of the task as a whole are not modified by the interruptions (Piolat, Roussey, Olive & Farioli, 1996).

4.2. Verbal Protocols

Both the paradigm of Kellogg (1987) and the one of Levy and Ransdell (1995) are based on the analysis of verbal protocols. Such techniques were also the object of criticism (see, for instance, Ericsson & Simon, 1993; Russo, Johnson & Stephens, 1989; Wilson, 1994). Two main types of concerns have been expressed about the validity of verbal protocols. First, do simultaneous verbalizations modify cognitive processes? Second, especially when considering retrospective or *a posteriori* verbalizations, isn't it a risk that the ideas are forgotten and reconstructed at the end of the task?

In order to answer such questions, Levy and Ransdell (1995) as well as Levy, Marek and Lea (1996) made a comparison of the content of simultaneous verbalizations and retrospective verbalizations from writers. They observed that the writers could not remember with precision the processes they developed during the writing task (in the best cases, 60% of retrospective protocols matched with the observations vs. only 10% in the worst cases). Therefore, it seems possible to argue that simultaneous verbalizations are preferable to retroactive verbalizations.

Concerning the impact of simultaneous verbalizations on the current activity. Ericsson and Simon (1993), analyzed the types of verbalizations that could be induced by the experimenter's orders:

- simple vocalization of interior articulation (level I);
- verbalizations that convey a description of the content of thoughts (level II);
- verbalizations that convey explanations (level III).

After having performed several experiments, Ericsson and Simon (ibid.) concluded that only level III verbalizations can disturb the activities linked to the main task, since such verbalizations require too much attention. In the study presented next, we used a triple task, inspired by the paradigm of Levy and Ransdell (1995). We used simultaneous verbalizations and incited participants in these studies to express level I verbalizations.

5. Empirical Study of Lay-Designers

As previously mentioned, our objectives were to study the evolution of the designers' mental representation, to analyze their planning activity, their changes in focus of attention, and to determine the cognitive effort such activities required. Towards this end, we conducted an experiment with ten students who had just attended a class on creating web sites using the "Netscape Composer" authoring tool. Though Composer offers less functionality than many professional web tools, it does support the easy and rapid creation of basic web sites through its WYSIWYG interface.

5.1 Experimental Design

The experimental participants were asked to design a small, three-page web site to create a painting gallery (see Appendix 1). They had one hour to create the site, which seemed sufficient given the limited size and complexity of the site. This task was inspired by a real task we encountered in a small web site company, and painting gallery-type functionality is also commonly found on many personal web sites, giving the choice of task some ecological validity.

In addition to this main task, the designers had to perform two additional tasks inspired by the triple task paradigm (Levy & Ransdell 1995):

- to think aloud (simultaneous verbalization),
- to react to signals by pressing a button, in order to record reaction times and, on this basis, to determine the designers' cognitive effort.

To simultaneously record the participants' verbalizations and their reaction times, we used a tape-recorder and the SCRIPTKELL software (Piolat, Olive, Roussey & Thunin, 1999) to both deliver sonory signals and record reaction times. Since previous research showed that experimental instructions can influence the allocation of attentional resources, we instructed participants that even though they were being asked to perform two additional tasks, their primary task was to design the web site. We also had to define the best time interval (or "range") to present signal, in order to measure the cognitive effort associated with various cognitive processes without disrupting the overall design process. Previous research (Piolat et al. 1996) showed that the best range for studying cognitive processes involved in text writing is the one used by Kellogg (1987b), i.e. presenting signals at varying intervals ranging from 15 to 45 seconds (the range is never constant in order to avoid expectations from the participants in the study). However, the tasks performed by web designers are longer; i.e., typically requiring several hours or even days. We analyzed interviews and observational data from our previous studies of web site designers (Bonnardel & Chevalier, 1999) in order to characterize the frequency of changes of cognitive processes. On this basis, we adopted a slower cadence than the one used in studies of text writing and presented signals within 40 to 70 second intervals, as it was the case in a previous study of design activities (Bonnardel & Gaden, 2000).

Prior to the recorded experiment, participants were trained to perform the two additional tasks. Specifically, they were trained to react to signals independently of any other task; such motor reaction times were also important for calculating each participant’s basic reaction time. This calculation was based on the mean recorded reaction time, excluding the first five reaction times, which enabled the participants to be familiarized with the task to perform. Each participant’s basic reaction time is subtracted from reaction times recorded during the experimental task. Additionally, they practiced simultaneous verbalizations by thinking aloud while designing a boat using paper and pencil.

To study the influence of the level of problem specification on the designers' cognitive processes, the participants were divided into two groups. Half of the participants were provided with an "ill-defined" schedule of conditions and the other half with a "well-defined" schedule of conditions (see Appendix 1 for details). The distinction between a well-defined and an ill-defined schedule of conditions reflects the amount of specification data provided to the participant. Designers with the well-defined schedule of conditions were given supplementary relevant information beyond the basic requirements. However, for these participants, the overall design process is still ill-defined because they still have to complete and refine their mental representation during design.

In order to have two homogeneous groups, participants were chosen that followed the same study program at the university (Masters in cognitive psychology), and had just attended the same web design class with the same teacher. In addition, participants had to fill out a questionnaire asking about their general level of computer science skills as well as their specific prior experience with web sites. The results allowed us to create equivalent groups with regard to these aspects.

5.2 Analysis Methods

The verbal protocols were transcribed and separately analyzed by two judges, in order to compare our findings. This analysis allowed us to characterize the designers' planning activities, based on the reviewing and postponing of actions or decisions. Reviewing refers both to giving up previous actions and going back over previous actions. More precisely, "going back over an action" was identified each time an action was taken that contradicted a previous action. The protocol analysis also allowed us to identify the specific viewpoints (e.g., user, customer, designer) and the classes of criteria and constraints that designers focused on, as identified during previous analyses (i.e., the functional, costs, technical, and aesthetic classes considered by professional web site designers).

Due to the relatively small number of study participants, the statistical technics used were *non parametrical tests*. Since data were gathered on two independent groups, we used the U of Mann-Whitney test to deal with the main hypotheses. In addition, in order to analyze the evolution of cognitive processes, we devided the whole design process in thirds, with regard to the total time to create the web site (which was limited to 1 hour) and we calculated frequencies according to these three time periods in the design process, hereafter called "design phases". The measures are thus repeated at these three times, so we also used the Friedman test.

The designers' intermediate and final productions, i.e. story-boards and web sites, were also analyzed with regard to the presence or absence of features in these productions. In particular, we noticed the number of features that satisfied constraints specified in the well-defined schedule of conditions as well as new features created by the designers. We also compared the composition of features and pictures in the sites.

5.3 Results and Interpretations

We present and interpret our results in each of the following four areas:

- Construction of mental representations and planning
- Changes in focus of attention
- Designers' cognitive effort
- Designers' productions

5.3.1 Construction of mental representations and planning

The results show an important influence of the level of problem specification (or schedule of conditions) on the designers' planning activities, which are indicative of the construction of mental representations. As shown in Figure 1, designers provided with the ill-defined schedule of conditions (ISC) reviewed and postponed more design decisions (17.37 versus 8.8, in mean) than designers with the well-defined schedule of conditions (WSC). This difference is significant at $p < .05$.

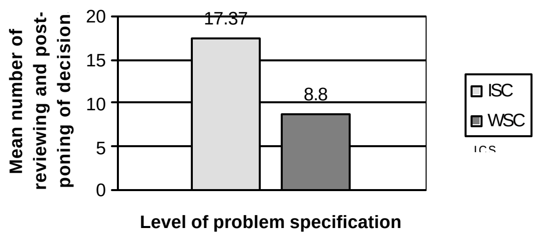

Figure 1: Mean number of reviewing and postponing of decisions, according to the level of problem specification.

The design process appears to be directly dependent on the level of specification in the schedule of conditions. Designers provided with the well-defined schedule seem to have been able to use some of the requirements presented in the schedule to construct a relatively precise and complete mental representation or mental model of the web site being considered. This mental representation allowed them to more easily plan their design activity and, thus to perform less reviewing and post-poning of decisions. On the contrary, designers provided with the ill-defined schedule adopted a process characterized by frequent reviewing and post-poning of decisions, as if they were having more difficulties making decisions.

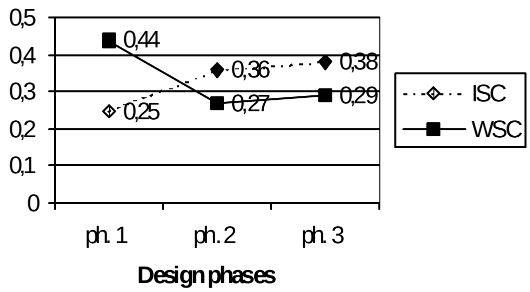

Figure 2: Mean frequency of reviewing and post-poning of decisions according to thirds of the design activity (or design phases) and to the level of problem specification.

We also analyzed the evolution of planning throughout the design process with regard to the three stages. As suggested by Figure 2, the reviewing and post-poning of decisions appear to diverge according to the schedule of conditions. For the designers with the well-defined schedule, reviewing and post-poning of decisions are important in the first phase of their activity, but it decreases considerably in the second phase and remains relatively stable in the third phase. These designers seem to have completed an exploratory process in the first stage of their activity; then, to have constructed a mental model of a web site adapted to the situation, which allows them to subsequently follow an approach characterized by less reviewing and post-poning of decisions.

To the contrary, for designers with the ill-defined schedule, reviewing and post-poning of decisions appear relatively less frequent, in the first phase, but these activities increase considerably in the second phase and remain relatively important in the third phase. For even this relatively simple design task, the lack of design specifications appears to make it more difficult for these designers to construct a mental representation of the site and to plan their design activity.

5.3.2 Changes in focus of attention

In order to better understand the evolution of designers' mental representations, we analyzed changes in their focus of attention, particularly with regard to the broad categories of concerns exhibited by professional designers; i.e., functional, technical, cost, aesthetic.

In Figure 3, we notice that designers provided with the ill-defined schedule appear to change of viewpoints more often than designers provided with the well-defined schedule (mean of 18.5 vs. 11.4 changes of viewpoints respectively, p = .08). This result is consistent with the design process described in the previous sub-section. Being less constrained by the requirements specified in the schedule of conditions, these designers had more liberty in their choice of action, but they also encountered difficulties in making decisions. Such difficulties appear in the numerous reviewings and post-ponings of decisions, and in the numerous changes in focus of attention. These observed behaviors are characteristic of opportunistic planning. While opportunistic planning is frequently interpreted as a positive process when observed in experienced designers, the observations here highlight the difficulties encountered by lay-designers adopting such a process.

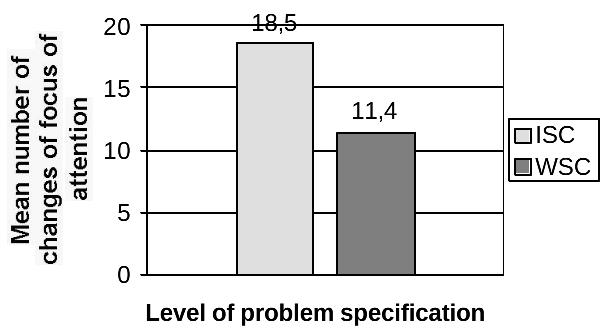

Figure 3: Mean number of changes in focus of attention according to the level of problem specification.

Two categories of criteria — functional and aesthetic — appear to be preponderant, whereas the other two (cost and technical) are rarely taken into account by the lay-designers (see Figure 4). The two preponderant categories are both linked to perspectives on the perception and use of the site. For instance, about aesthetic aspects, a designer mentioned that he placed a smaller image than the others in the middle of the page, in order to create a "style effect"; other designers also tried several colors to determine which ones were more aesthetically pleasing. About functional aspects, some designers chose to place in the welcome page pictures of artists who were exhibiting paintings in the art gallery and to use these pictures as links to each artist's page of paintings; some designers also decided that the art gallery's logo will be used systematically to return to the welcome page. Such aspects are thus related to the superordered "user" viewpoint. This finding differs fundamentally from observations made in other interface design situations, where designers have difficulties adopting the view of the user (Norman, 1986; Polson, Lewis et al, 1992; Bell, Citrin et al, 1992) This result suggests that even inexperienced web site designers try to take into account the needs of future users, even though, as pointed out by Bastien, Scapin and Leulier (1999), web site lay-designers lack knowledge about ergonomic recommendations or guidelines. Thus, these lay-designers were able to adopt the superordered viewpoint "user", which can perhaps be explained by their prior personal experiences with web sites. As noted by others, the web acts as a large, shared design space that promotes propogation of design elements and this "design space" aspect perhaps also contributes to the internalization of the "user" perspective (Furuta and Marshall, 1995).

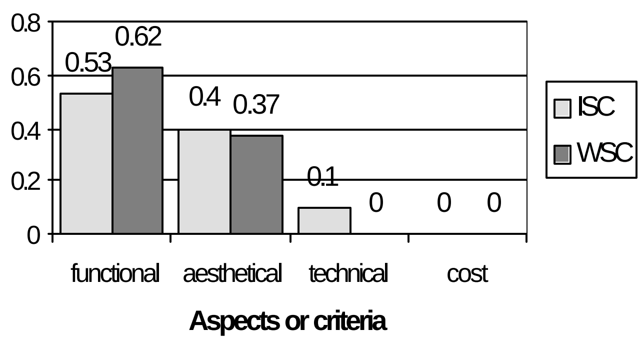

Figure 4: Mean frequency of taking into account of aspects or criteria according to the level of problem specification.

No participant took into account financial criteria and only a few of the participants (exclusively in the WSC condition) took into account technical criteria. There are several possible explanations for this observed behavior stemming from a lack of background knowledge. For instance, such commercial and technical concerns are important for professional design (e.g., the choice of environment for the creation of web sites has an influence on the functionality which can be developed, on the speed of development and, thus, on the cost). However, these concerns do not arise in beginning training courses which tend to focus on learning how to use a single authoring environment. Thus, the priority of lay-designers may be to create the desired web site, using the means they know (without looking for others) at whatever cost.

5.3.3 Designers' cognitive effort

As shown in Figure 5, designers provided with the well-defined schedule need longer time to react to the probes: their reaction time is, in mean, twice that of designers provided with the ill-defined schedule (0.186 sec. vs. 0.372 seconds respectively, significant at $p < .01$). This indicates that activities of designers with the WSC required more cognitive effort than the activities of designers with the ISC. This result may reflect the amount of requirements designers with the WSC had to deal with.

We also analyzed the evolution of the designers' cognitive effort across the three stages (or thirds) of the design activities. We observed that the cognitive effort of designers provided with the WSC decreases, whereas the cognitive effort of designers provided with ISC increases — though cognitive effort of the designers with the WSC remains, during all activities, higher than for designers with the ISC (Figure 6).

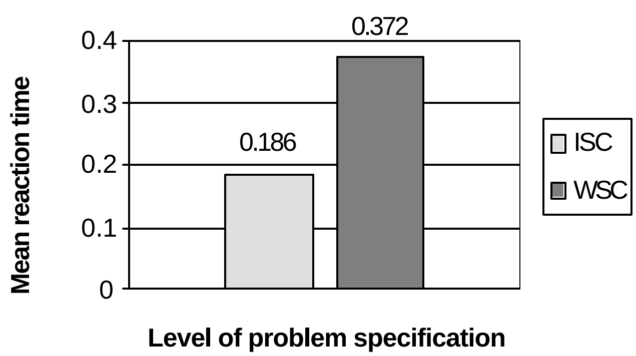

Figure 5: Mean weighted reaction times of designers, according to the level of problem specification.

As soon as they are provided with the WSC, designers in this group directly consider the requirements presented in the schedule of conditions, especially the prescribed constraints, which explains their relatively high cognitive effort in the first phase. They progressively have fewer requirements to deal with, which can explain the decrease in their cognitive effort in the second and third phases. Designers who are provided with the ISC have only a few explicit requirements to deal with at the beginning of their activity, which explains their low cognitive effort in the first phase; then, becoming conscious of the need to define supplementary requirements, they elaborate more and more "constructed constraints", which would explain the increase in their cognitive effort in the second and third phases.

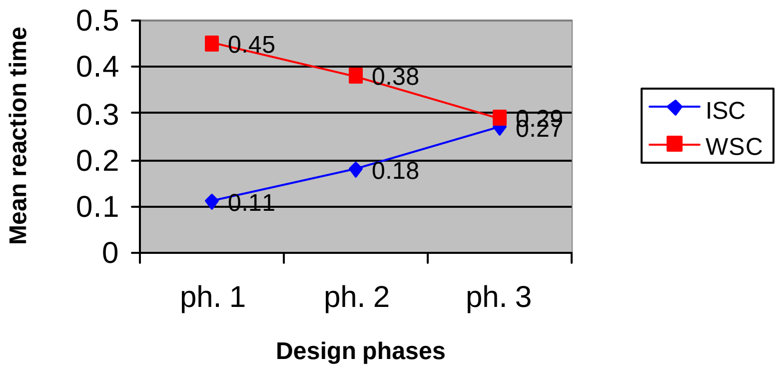

Figure 6: Mean weighted reaction times of designers,
according to the evolution of the design problem (design phases or thirds)
and to the level of problem specification.

5.3.4 Designers' productions

Only two designers out of five from each condition produced a storyboard before beginning to develop the web site. We analyzed the features present in each of the storyboards; those produced by designers in the WSC were more precise (more design elements at greater detail). While the numbers are too small to be conclusive, this finding is congruent with the notion that well-defined design specifications support planning activities.

Interestingly, the final productions, i.e. the web sites, were very similar: they all contained a title, a picture of the painting gallery, and a link for each artist as well as one for the gallery. In addition, regardless the schedule of conditions, the features presented in the welcome page were the same and the pages relating the artists were similar. The main difference is that designers provided with the ill-defined schedule of conditions used more pictures than designers from the other group (where the number of pictures to include in the site was specified). Thus, there was little sign of innovation in these site designs, even amongst those with greater design freedom in the ill-defined schedule of conditions. Though designers' mental representations and planning activities were influenced by the level of specification in the schedule of conditions, the outcomes were not: lay-designers produced similar, simple web site designs.

Why this similarity? It is possible that the experimental task and material may have induced a specific site composition, or the limited functionality of the authoring tool used in the experiment may have contributed to the observed similarity. Another possibility relates to the emergence of "genres" for web sites, re-occuring design patterns (such as picture galleries) that are internalized and propagated by sites producers and consumers (Furuta and Marshall, 1995).

6. Discussion

We first summarize difficulties encountered by lay-designers of web sites and then describe possible ways to support lay-designers through authoring tool design or training course design.

6.1. Difficulties Observed

Three types of difficulties were observed in our study.

First, these designers appeared to depend heavily on the requirements specified in the schedule of conditions. Deriving design constraints and requirements, in addition to those explicitly given, appeared relatively difficult as shown by the high frequency of reviewing and post-poning of decisions as well as by the cognitive efforts correlated to them. Furthermore, these derivations tended to be performed rather late in the design process, introducing a greater potential for designers to head deeper down an unproductive path before discovering potential problems. This result is in accordance with our earlier studies comparing experienced and inexperienced designers in other design domains, confirming a tendency for lay-designers to follow rules and specifications even when these lead to problematic or poor designs (Bonnardel and Sumner, 1996; Sumner, Bonnardel and Kallag-Harstad, 1997). Studies of experienced designers suggest that "knowing when to break the rules" is a hallmark of experience (Schon, 1983).

Second, these lay-designers were able to adopt the viewpoint of the "user" but not that of the customer who commisioned the site to be created. For personal web sites, this is probably not an important issue. For professional web sites, this could be a problem as the design challenge is to recognize and reconcile these two perspectives. As mentioned in the Introduction, many lay-designers end up in web designer or web master positions, particularly in small enterprises.

Third, though different design processes were observed depending on the schedule of conditions provided, all the designers were able to create a prototype picture gallery web site. However, none of the designs were particularly innovative, despite aesthetic concerns ranking as the second most considered criteria.

6.2. Improvements to Training and Tool Design

Contrary to what has been observed for years in the design of user interfaces, the designers in this study were (at least somewhat) able to adopt the "users" viewpoint. Thus, we did not observe the usual difference between the "logic of design" and the "logic of use" (Norman, 1986). However, this "intuitive" adoption of the users’ viewpoint appears to be insufficient when designers are landed with an ill-defined schedule of conditions. Indeed, they encounter difficulties in completing prescribed constraints (derived from the schedule of conditions) with their own constructed constraints. Therefore, improvements to tools and training could aim at facilitating the construction of a mental representation or a mental model of the site to create. Additionally, it would be useful to support lay-designers in evaluating the sites they produce with respect to usefulness and usability. This double objective, supporting "problem-framing" as well as site evaluation, suggests lay-designers specifically need help to further articulate their intuitive mental representation of user needs (and eventually the needs of the customer as well).

Towards this end, training courses and tools should consider incorporating usability inspection techniques into their design. Usability inspections are similar to a peer-review process, involving expert evaluations of designs or systems, either from the perspective of usability guidelines or criteria, the user, or key tasks the system should support. Two types of techniques are possible candidates for consideration: heurisitc evaluations (Nielsen and Molich, 1990 ; Nielsen, 1992) and walkthroughs (Lewis, Polson, et al 1990, Polson, Lewis, et al, 1992 ; Wharton, Bradford et al, 1992)

Heurisitic evaluations were designed to function as a low-cost inspection technique that doesn’t require a lot of training and doesn’t require people to remember large numbers of ergonomic guidelines. Heuristic evaluations provide designers with a small number of generic criteria to evaluate designs against (Nielsen & Molich, 1990). Examples of these criteria include "be consistent", "provide feedback", "prevent errors", "use simple and natural dialogue", etc. Unfortunately, despite the design intentions, while the technique is easy to learn, it is still difficult to do well; studies show that people lacking a background in usability typically find only about 20-50% of potential problems in a given design (Nielsen, 1992). We would argue that this technique is still useful for web site evaluation since helping lay-designers find 20-50% of potential problems is still better than being unaware that problems may exist at all. In our experience, it is possible to give learners a flavor of the technique in about an hour, so incorporating this method wouldn't unduly lengthen short training courses.

Alternatively, rather than serving strictly as a design evaluation technique, heuristic evaluations could be adapted and applied continously throughout site design as an explicit means of helping designers to refine their mental representations and construct new design requirements and constraints. The criteria used could be tailored and contextualized to broad classes of web sites; e.g., informational, transactional, search (see Kantner & Rosenbaum, 1997, for further discussion), and criteria could be created to represent the perspective of the customer (e.g., time or financial costs). New web authoring tools could provide support for these criteria by reminding tool users that these criteria exist and should be considered, by providing samples and exercises about applying these criteria, and perhaps even providing active support for detecting and correcting potential problems.

Walkthroughs are another popular class of usability inspection technique amongst usability professionals (Lewis, Polson et al, 1990; Polson, Lewis, et al, 1992; Wharton, Bradford et al, 1992). Walkthroughs are a two-step process. First, the evaluator must generate a list of the steps needed to complete a specific task using the proposed design. Next, the evaluator "walks through" these steps considering the design from the users' perspective by continually asking whether: (1) it is resonable to expect users to recognize that a step is necessary, (2) the interface supports carrying out the step, (3) users will understand the feedback they are given after completing the step. Cognitive walkthroughs originally required a detailed task analysis, which limited the usefulness of the method for people not trained in cognitive psychology (Polson et al., 1992). Later efforts focused on creating variants of the technique that didn't require this special expertise, including eliminating the detailed task analysis (the programming walkthrough method (Bell, Citrin et al, 1992; Sumner, Marra & Lewis, 1994) and supporting the process with forms (the automated walkthough method). Previous studies suggest that this technique is very useful for trained usability professionals, but somewhat difficult for non-usability specialists to learn and apply as people tend to get wrapped up in completing the task rather than in performing the analysis (Sumner, et al., 1994). One possibility would be to build in support for the automatic walkthrough method directly into web authoring tools. At specific steps in the design process, designers could be provided with a questionnaire to complete inquiring about the user's goal and what this implies about steps to complete, the support currently provided in the design, and the feedback given. This approach seems overly prescriptive however, and the automatic presentation of questionnaires could be annoying.

On the other hand, this technique appears to have positive broader impacts in the sense that it heightens designers' awareness of the users' perspective and users' needs, which would be very useful to web site lay-designers. Our own experiences suggest that it is possible to give learners a flavor of this technique in two to three hours, suggesting it could be suitable for longer training courses. Perhaps one of the biggest benefits of this approach is that it requires designers to clearly and specifically articulate what key tasks the web site needs to support, typically in the form of very short narrative statements. This activity by itself is extremely useful for helping designers to articulate new design requirements and constraints early in the design process and not particularly time-consuming or onerous.

These two inspection techniques could support lay-designers to adopt the users viewpoint and, on this basis, could help designers identify and construct new requirements and constraints related to user needs. Such constraints would then allow the construction of a more precise and complete mental representation or mental model of the site and could also be used to evaluate the site as the design progresses.

As briefly mentioned earlier, another approach would be to create authoring tools that proactively detect potential problems and thus directly support design evaluation, either during the progress of the design or at the end of the design activity. Designers could benefit from the use of a "critiquing system" (see, for instance, Fischer, Lemke, Mastaglio & Morch, 1991), which would be designed to support the evaluation of web sites in progress. Such a system could analyze the designers' actions and provide the designers with "critiques" (i.e., messages) which let them know about potential deficiences in the design solution or, at least, features that appear to contradict criteria and constraints defined in the system's knowledge-base (see, for instance, the VDDE system (Bonnardel & Sumner, 1996; Sumner, Bonnardel & Kallag-Harstad, 1997) or the KID system (Nakakoji, 1993)).

In critiquing systems, both the superordered viewpoints of the user and of the customer could be explicitly represented in the structure of the system's knowledge-base. The superordered viewpoint "user" could be associated to specific classes of criteria, such as "functional" and "aesthetic", which could be linked to ergonomic recommendations (e.g. "guide the user while navigating the site"). Criteria and constraints specified in ergonomic guidelines could be included in the critiquing system's knowledge base and used to analyze the designers' actions.

The superordered viewpoint "customer" could be represented similarly (by representing costs in the knowledge base) or by using a "specification" module, such as the one proposed in the KID system (Nakakoji, 1993). Similarly to KID, specific questions could be presented to the customer and, on this basis, both the designer and the customer could reach a shared representation of the site to create. Based on the customers' answers, certain criteria and constraints would be activated and used to analyze the designers' solutions in progress and tailor the critiques provided to the specific exigencies of the design. Such a tool would help designers to take into account constraints other than the ones specified in the initial design specification (schedule of conditions) and help them to adopt other viewpoints than their own (Nakakoji, Sumner & Kallag-Harstad 1994) .

Several tools already exist that help people to analyze web sites. Such tools can, for instance, analyze HTML code to detect syntax errors, test the existence of invalid links or the compliance with accessibility recommendations for the disabled (see, for instance, the "Bobby[3]" tool).. However, these tools are focusing on low level coding constructs like the use of HTML frames or "alt tags" (providing alternative textual labels for graphic elements). To date, there are no tools that help designers to detect usability errors, or even support designers to systematically consider the needs of future users of thesite or the requirements of the customer.

7. Conclusion

In summary, it appears possible and desirable to provide lay-designers of web sites with a variety of methods and tools that could support and improve their design process. While usability and user needs are vitally important for web site design, training classes and tools tend to focus on low-level authoring tasks (e.g., syntax of HTLM or the specific tool features) and not on cognitive ergonomics or human factors. Moreover, since web site design may be an occasional or infrequent activity for many lay-designers, such people may not be motivated, or have the time, for training in these areas. If we wish to facilitate their design activities, we need to provide tools and procedures that are easy-to-learn, easy-to-apply, and not time consuming. Towards this end, we considered how existing, proven usability techniques could be adapted for short training courses and even supported directly in web authoring tools. We envision further research along these lines. Particularly, we intend to examine how heurisitc evaluation-type techniques can be adapted to positively support the activities of web site lay-designers. In addition, we intend to complement our earlier field studies by systematically analyzing the activities and cognitive processes of professional web site designers in more controlled settings.

[3] http: / / www.cast.org / bobby

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Appendix 1 : Schedules of Conditions

Ill defined schedule of conditions

Mr. Piltzer has an art gallery, the "Gallery Piltzer", that he wishes to promote on the Internet.

Two artists permanently exhibit their paintings in the Gallery Piltzer: Mr. Linder and Mr. Calder.

Mr. Piltzer will let you design the web site for his art gallery however you wish, but he does want the site to consist of three pages and to present paintings by Mr. Linder and Mr. Calder.

E-mail addresses:
linder@yahoo.com
calder@yahoo.com
gal_piltzer@yahoo.com

Well defined schedule of conditions

Mr. Piltzer has an art gallery, the "Gallery Piltzer", that he wishes to promote on the Internet.

Two artists permanently exhibit their paintings in the Gallery Piltzer: Mr. Linder and Mr. Calder.

Mr. Piltzer will let you design the web site for his art gallery however you wish, but he does want the site to respect the following requirements:

• The site should consist of three pages: a welcome page and one page for each of the two artists.

• The welcome page has to contain a photo of the gallery, the gallery’s logo, a link to each of the artists' pages, and a link to an e-mail address allowing visitors to contact Mr. Piltzer.

• Mr. Linder's page should contain three of his paintings, a link to his e-mail address, a link to the welcome page and a link to Mr. Calder’s page. Mr. Calder’s page should have an analogous format. These two pages should also contain the art gallery’s logo.

• All the pages should have a background that fits with the paintings you will integrate in them.

• Each page should have a title, with a font size of 24, that is not underlined.

• The paintings should be placed so that visitors can see the whole painting, without having to scroll. Mr. Piltzer will allow you to modify the size of the paintings as necessary to meet this requirement.

E-mail addresses:
linder@yahoo.com
calder@yahoo.com
gal_piltzer@yahoo.com

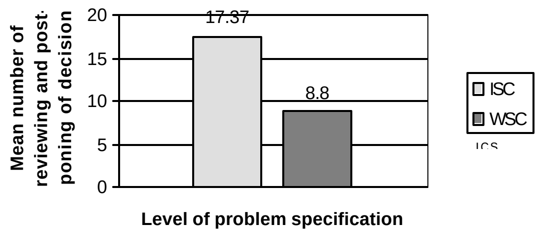

Figure 1: Mean number of reviewing and postponing of decisions, according to the level of problem specification.

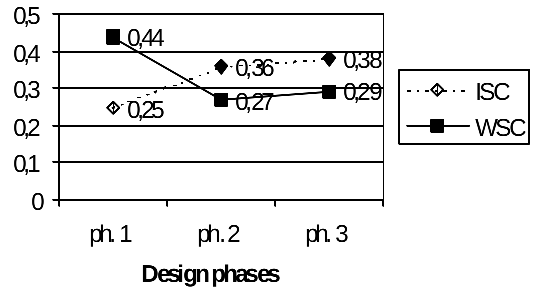

Figure 2: Mean frequency of reviewing and post-poning of decisions according to thirds of the design activity (or design phases) and to the level of problem specification.

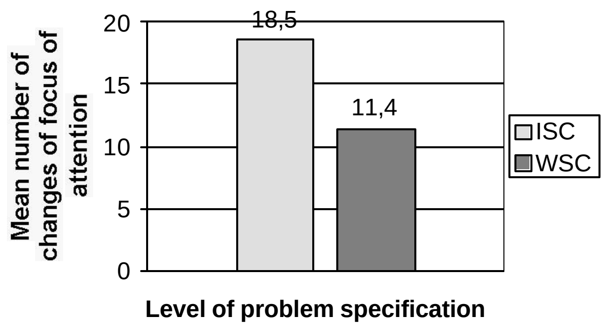

Figure 3: Mean number of changes in focus of attention according to the level of problem specification.

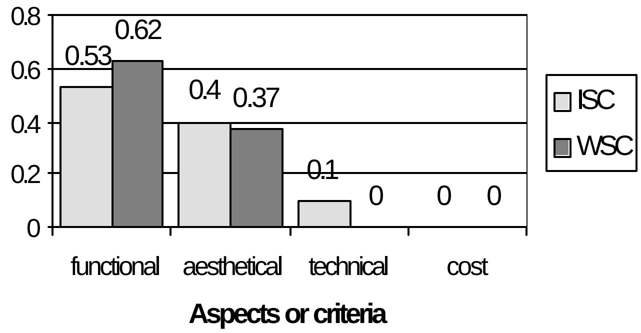

Figure 4: Mean frequency of taking into account of aspects or criteria according to the level of problem specification.

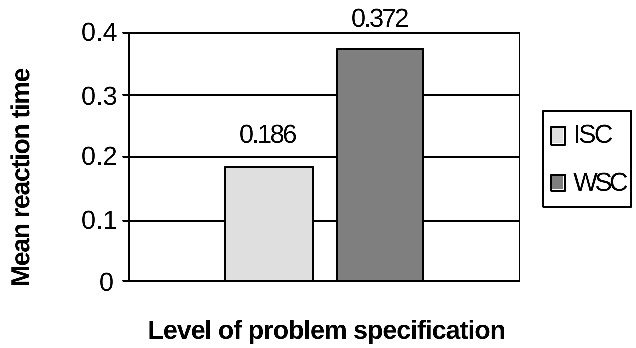

Figure 5: Mean weighted reaction times of designers, according to the level of problem specification.

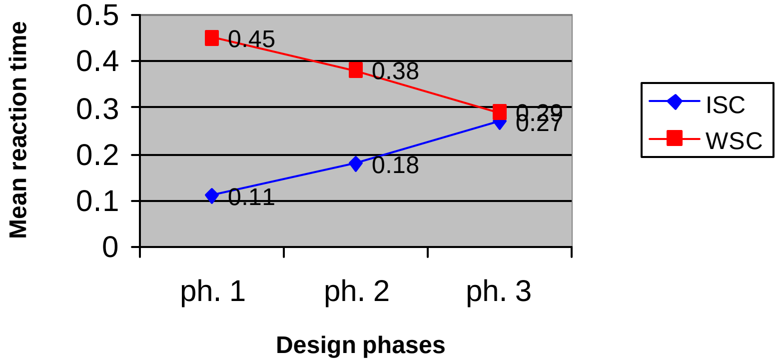

Figure 6:Mean weighted reaction times of designers,
according to the evolution of the design problem (design phases or thirds)
and to the level of problem specification.