

The Influence of E-commerce Website Colors on Usability

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ABSTRACT

This chapter aims to study the effects of the colors of e-commerce websites on consumers' behavior, in order to better understand website usability. Since color components (Hue, Brightness and Saturation) affect behavioral responses of the consumer (memorization and buying intention), this research reveals the importance of the interaction between hue and brightness, in enhancing the contrast necessary to ensure an easy navigation. By comparing graphic chart effects according to their level of saturation and brightness according to the hue, it aims at focusing on particularly important consideration of webdesign, linked to choices of color. The obtained results were conveyed through the changes in internal states of the organism, which are emotions and mood. The interaction of hue and brightness, using chromatic colors (as opposed to Black & White) for the dominant (background) and dynamic (foreground) ones, supports memorization and the intent to purchase, reinforcing the importance to attach to usable websites. This is even more evident when contrast rests on a weak situation of brightness. The data-gathering was carried out during a laboratory experiment so as to ensure the accuracy of measurements regarding the color aspects of e-commerce websites. The details of the methodology employed are described precisely below.

Keywords: color, usability, memory, e-commerce, consumer behavior

INTRODUCTION

The impressive rise of e-commerce, while inspiring dismay in some and awe in others, merits closer examination. One of the factors which has contributed significantly to this success, is the enhanced "ease of movement" on the site, otherwise referred to as the "usability of the site". Moreover, the ease of recognizing functional zones such as the navigation bar, the search engine, the possibility to sort the information, constitutes a major aspect of this research. A significant part of this chapter is dedicated to the usability of websites, and to the quantity of information retained following a visit to an e-commerce website. By usability, we mean "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" (ISO 9241-11). The possibility of identifying the links and the useful buttons to change pages constitute other key factors in the success of e-commerce. Characteristics such as hue, brightness and saturation, all of which are related to color are crucial in getting the consumers attention. Indeed, the design of e-commerce website interfaces is receiving increasing managerial and research attention in the online retail context.

People don't take the time to read the contents if they are not appealing enough: the consumer's decision is based on a first impression. This is especially true when people cannot read the text because of poor contrast, for example. Though the color variable is a widely researched topic (see the periodical published by Divard and Urien, 2001), to this day, very few studies focus on this phenomenon within the context of the Internet. Yet color is omnipresent on e-commerce websites. The lack of research on the effects of the colors used on e-commerce websites suggests that more study in this area is needed. In their

effort to spur Internet users to buy, brands do not seem to focus systematically on color choice when conceiving or updating websites.

While several studies on the impact of colors on Internet site readability provide advice about how to choose the most harmonious colors (Hill and Scharff, 1997 ; Hall and Hanna, 2004), experts in research on usability such as Nielsen (2000) have made managerial recommendations. However studies have not addressed the variation of hue, brightness and saturation on e-commerce. In an attempt to address this gap, this paper aims to shed light on how customers perceive the usability of e-commerce website interfaces, and how colors can be helpful for them, in order to improve the usability of the website.

The aim of this chapter is to increase awareness of the scope and nature of the needs we are investigating in this research, and to stimulate interest in research and in the implementation of systems that enable access to information technologies by users with disabilities, among other users.

OVERVIEW OF THE CHAPTER

How colors can enhance the effects of an e-commerce website with regard to consumer behavior is explained in this chapter. E-commerce website studies consistently demonstrate the importance of carrying out further research in the usability field. The methodology used to demonstrate how colors effectively affect people facing a computer is then described. First the use of an exploratory analysis, which was based on semi-directing talks, is explained. The confirmatory analysis, based on laboratory experimentation, is developed thereafter. Finally, the analysis and findings of this research are presented and evaluated in terms of what they suggest for future research.

The qualitative study complements the quantitative analysis

The fact that the state of a color changes when a user passes over a link counts among the standards recognized by consumers. It thus seems very important to change the color of this link when it is passed over because the users visiting a page, which does not respect this convention may:

- revisit the same pages unintentionally,
- get lost more easily because his comprehension of the significance of each link is reduced,
- badly interpret or be unaware of the difference between two similar links if he is not sure which ones he already visited,
- give up the navigation more quickly because he or she has a diminished sense of control over the direction of the visual interface when the website does not reflect his actions. The lack of “easy to find” links thus does not help him to continue using the interface (Nielsen, 2004).

By examining the customer’s description of this type of electronic shopping environment, and the main constructs which are taken into account in the presented qualitative analysis, particularly those in the direction of color. This paper attempts to introduce some important recommendations to consider when conceiving an e-commerce website, especially when thinking about its usability. Results from recent work (Pelet, 2008) demonstrate the importance of considering chromatic colors vs. achromatic ones, taking into consideration the effects of the three color components: hue, brightness and saturation. These results will be presented below.

Among the many variables supporting a consumer’s positive experience of an e-commerce website, color plays an important part. In an online environment, a vendor’s competence will largely be assessed through the presentation of products and product information. Overall, most e-commerce websites present a product using images. These should be clear, of high quality and color precision (Papadopoulou, 2007).

The needs of disabled people don’t seem to receive as much consideration with regard to website design and evaluation. Webdesigners are apparently not sufficiently aware of the community of people with disabilities (McMillan, 1992). Taking into account an increasingly older population, perhaps

suffering from eye trouble, poor perception of color or, moreover, from cognition problems, online retailers will need to re-examine their e-commerce website's interface. Indeed it has been estimated that 95% of the commercial sites were inaccessible to the people with visual or auditive "handicaps" (Gignac, 2000). If they want to avoid the cancellation of an order, due to an apparent lack of protection of the website or because it is impossible to carry out the transaction, online e-merchants have to consider the issue of accessibility of information in more depth. Inaccessibility should not slow down e-commerce websites, and the atmosphere of the website can help in this direction.

Definition of the atmosphere constructs

Atmosphere is a marketing tool which is used as the number of competitors on the market increases. More exactly, the action of the physical environment of the store can constitute a means of attracting new customers and of developing the loyalty of former customers. The same happens with e-commerce websites, where the interface is considered as the atmosphere of the store. From a cognitive point of view, the simple fact of getting lost on a webpage, for example, seems to be a consequence of a user's difficulty in simultaneously managing two cognitive activities, i.e. processing and locating (Tricot, 1995). A homepage simply indicates which actions are possible, which zones of the screen correspond to such and such an action (e.g. to visit the catalogue, look for the search engine, to recommend a page or a product to a contact); these actions constitute important control levers in the eyes of the consumer. He or she considers them attentively to feel comfortable and to be ready to return to the site as was revealed in the interviews conducted during the qualitative analysis.

Importance of the visual dimension on Internet

Research concerning the atmosphere of physical places of sale, postulates that it is essential to consider this in its entirety to obtain usable results related to the consumer's behavior (Filser, 2003b; Lemoine, 2003) since the five senses (sound, touch, sight, sense of smell, and taste sometimes) are stimulated. The situation is different when considering the atmosphere of e-commerce websites. Even if the Internet promises improvements, in this research dedicated to the field of e-commerce usability, consumer behavior depends mainly on the information retained and this thus characterizes his perception of the place of sale. Only two senses are stimulated on the Internet: sight and sound.

On the one hand, sight on an e-commerce website relates to colors, images and animations in the form of buttons, navigation bars, advertising and everything related to the iconicity of the website. Furthermore, hearing (the sound dimension) relates to the sounds of the site's interactivity; for example, the passage of the mouse over a link.

The visual dimension is particularly important for our subject as pertains to the impact of variables such as sight. In this case, color has evident importance. This study suggests that color serves largely to clarify and inform the consumer; therefore sound is not a focus of this research. Indeed, 80% of the information memorized by an individual comes from the visual sense, and other forms of perception of the environment are also heavily influenced by sight (Mattelart 1996). Consequently, we can show that on the Internet and in the context of e-commerce websites in particular, given the scarcity of the sites offering sound animation, sight is more frequently stimulated than hearing. It then makes sense that almost all information retained, determining the perception of the e-commerce website by the consumer, comes from sight.

We have chosen to measure the influence of e-commerce websites' colors on usability, with the help of system intended to measure retained information. Previous research on the effects of the colors of e-commerce websites on memorization and on the intent to purchase helps us to understand the utility of using a flexible measuring instrument for memorization and buying intention. The design of the experiment, carried out following a qualitative analysis based on 21 interviews, made it possible to develop constructs rarely encountered in the emerging literature, such as the "playability" of the interface. This refers to the pleasure of moving on the website as measured by the ease of use worked out by web designers. The conditions of the experiment, based on the use of exhaustive measurements of the

perception of the website, have enabled us to deduce that the Internet consumer's environment also deserves to be taken into account when designing e-commerce websites.

USABILITY AND E-COMMERCE

Since the birth of the Internet, e-commerce has experienced a constant expansion and its returns on investment speak for itself. All products and services together, e-commerce reached a global turnover of approximately 15 billion euros in 2008 (ACSEL, 2009) and has been able to preserve its image year after year. However, many consumers on the Internet give up the purchasing process prematurely (Cho, 2004). This is mainly due to access problems or to a complicated processes of payment (Ranganathan and Grandon, 2005). Navigation modes that make the understanding of the offer difficult, constitute a reason for giving up a purchase on an e-commerce website (Ladwein and Ben Mimoun, 2006). On the basis of the qualitative analysis we have undertaken, we think that colors and the length of the text format, account, in part, for this weakness.

COLOR AS A MAIN VARIABLE OF E-COMMERCE WEBSITE INTERFACES

Color has always been used by human beings as an aid to distinguish important information from unimportant or irrelevant information. It is essential in strategies of camouflage, for example. It also aids an individual's memory in many uses such as presenting information, assisting in education or even with the intention to buy.

Color contains three principal components (Trouvé, 1999) :

Hue (or chromatic tonality), is the attribute of the visual sensation defined according to color denominations such as blue, green, red...;

Saturation refers to the proportion of chromatically pure color contained in the total sensation;

Brightness refers to the degree to which an illuminated surface seems to emit more or less light.

Unlike most empirical studies dealing with color which compare warm and cold colors, this study focuses on hue, brightness and saturation so as to demonstrate that the influence of color varies according to the intensity of each one of those components. These various levels occasion particular contrasts according to the chosen hue, which can then enhance or disturb the readability of the whole page. This can represent an obstacle for the website's usability.

Generally speaking, colors affect consumer behavior in compliance with Mehrabian and Russell's psycho environmental model, the SOR model (Stimulus Organism Response) (Mehrabian and Russell, 1974). Even within colors themselves, Bellizzi and Hite (1992), Dunn (1992), Drugeon Lichtlé (1996), and Pantin-Sohier (2004) chose hue as the main variable. They also showed in their experiments that brightness and saturation should be taken into consideration when conducting experiments about color.

As Valdez (1993), Drugeon-Lichtlé (2002), Camgöz & alli. (2002) and Gorn & alli. (2004) demonstrated regarding the brightness component of color, it seems more pertinent to compare hue and brightness than to compare warm and cold colors when trying to ascertain what consumers recall and what spurs them to buy. Indeed, in everyday life, there is no trigger helping consumers to recall the content of an e-commerce website they visited or to compare it with another offer. The feeling of aggressiveness experienced by consumers when visiting an e-commerce website – partly due to the use of rather bright colors – does not result in a more effective retention of information, nor to a stronger buying intention.

When consulting a website, Internet users browse web pages designed to arouse their attention through the employment of various components such as color, sound, animation, texts, pictures, textures, graphic design and advertising. E-commerce website interfacing seeks to place consumers in a particular context by activating the sensory system (hearing or sight) so as to be able for web designers to perceive their emotional, cognitive, psychological, physiological and behavioral responses through their being altered.

Color perception within interfaces

To this day the effects of the three color components on the Internet have been seldom documented. On a website, the interface represents the graphic chart, a set of rules composed of two colors: the foreground color, also called the “tonic” or “dynamic” color, and the background color, labeled the “dominant color” by webmasters. These colors reveal the contrast, which comes from a strong opposition between the foreground and the background colors, as the W3C defined it (Accessiweb, 2008). The main function of the contrast serves to improve the readability of the displayed information, and, *a fortiori*, the memorization process. We contend that a better retention of information will enhance the perceived usability of the website.

Kiritani and Shirai (2003) show that the effects of background screen colors upon time perception vary according to the tasks performed by Internet users. When reading a text written on a white, blue or green background screen users have the feeling that time passes more slowly. When users are merely doing a simple search and only need to understand the meaning of the sentence, then the screen background color does not have any impact on how they perceive time duration. This temporal aspect figured significantly in the responses of interviewees to questions concerning usability.

Hill and Scharff (1997) have demonstrated the importance of contrast (dynamic color vs. dominant color) when searching for information within a page. They obtained better readability scores when resorting to chromatic colors (green dynamic color on yellow dominant color). This difference between colors (chromatic versus achromatic) merits some consideration since most current websites visited are black and white. Chromatic graphic charts and achromatic ones were differentiated during the experiment.

The results of the research undertaken by Corah and Gross (1967) suggest that recognition between the colors was achieved when the differences in contrast between the various forms and the standard forms were larger. The size and form of the displayed information contribute more than color to the perception of usability.

Camgöz & alli. (2002) observed that not only brightness and saturation but hue as well had a specific impact on each colored background screen they observed during an experiment where colored labels had been stuck on to background screens. Once again, a clear differentiation of the hue in association with particular brightness and saturation levels contributed to precise detailed recommendations with regard to the web designer’s color choices while conceiving the website’s interfaces.

Biers and Richards (2002) studied the impact of dominant color upon the perception of promoted items and found that backgrounds with cold hues such as blue display items to their advantage and reduced the risk of purchase postponement, especially as regards regular Internet users.

Hall and Hanna (2004) studied the readability of web pages according to their dominant and dynamic colors. According to them, sites promoting knowledge transfer must display black texts on white backgrounds and achromatic colors with maximum contrast. On the other hand, e-commerce websites should use chromatic colors due to the higher aesthetic appreciation score which is correlated to higher intents of purchase. These results underline the importance of taking into consideration the impact of the color’s components (hue, brightness and saturation), as well as the contrasts occasioned by the foreground and background colors, to upgrade the usability of the e-commerce website interfaces. The consumer tends to remain longer on the e-commerce website according to certain criteria related to his or her perception of the interface. Pleasure, in particular, is thus increased by the deployment of colors whereas boredom can occur because of an inadequate deployment of them (Lemoine, 2008). The explanation of measures on the retention and buying intention variables reinforce the interest of these variables for this type of study.

EXPLANATION OF THE RETENTION AND BUYING INTENTION VARIABLES

From ergonomics to memorization

The concept of design on the Internet is often associated with ergonomics. The ergonomics of an e-commerce website refers to the readability of its pages, their composition, the whole structure of the website and its design. Its aim is to facilitate navigation inside the website. In the case of behavior directed towards a goal, ergonomics makes it possible to have easier access to the available, relevant information (Helme-Guizon, 2001). Although the Internet frees the consumer from space and time constraints (Sheth and Sisodia, 1997), the products and services sought must be easily found thanks to the ease of navigation facilitated by the interface. The respondent of interview 1 underlines this: "... *yes I want to go quickly, because I look for pieces of music (profile of respondent: he is a musician) thus navigation must be fast*".

The design and the readability of the Web pages influence the efficiency and the quality of the search for information. The consumer is able to act because of the interactivity of the computer which is, furthermore, under his control and so his fear of mishandling is overcome. "*Ensuring the readability of a web page, allows the visitor to obtain available information. Consequently, he has the optimal conditions under which to deliberate if purchasing on the commercial website is a possible goal. If the goal of the visit is to gather information with a view to purchasing later on the commercial website or at a sales outlet, then it is easier for him to memorize relevant information*" (Ladwein, 2001).

To measure the effects of color on interfaces, measures of the retained information allows us to identify which quality and which quantity of information an Internet user has memorized while visiting an e-commerce website. In agreement with the work of Hall and Hanna (2004), we suggest that retention varies according to the colors of the website, and especially according to the contrast arising from the dominant and dynamic colors. By taking the memorization variable into account, we wish to find a way of measuring how usable is an e-commerce website.

The memorized commercial information

Memorization is a very important factor considering the large amount of information that exists on e-commerce websites. It is an important variable in this domain, since the users' tasks are often facilitated when they can retain information from one page to another. Thus, measures of high level processing, such as memorization, seem to be important in examining the impact of foreground and background color combinations on usability.

In general, information is stored according to an encoding process enabling one to sort out information thanks to criteria which will then allow one to retrieve this information. The role of these criteria is to connect one piece of information to other similar pieces of information already stored (Ladwein, 1999). In order to measure the information memorized by each participant, recognition and recall have been examined: two processes belonging to information retrieval based on overall stimulus in long-term memory. After visiting Musicashop.net – an e-commerce website selling music CD's especially designed for the experiment – participants were asked to answer questions related to the items they had just viewed. Users were instructed to look at, at least two items so as to make the survey accessible. Their memory had to be sufficiently complete in order to consider the questions related to memorization, that is why they had to consult two articles at least. Be it free or cued, recall enables individuals to mimic mentally a stimulus to which they are not exposed at the time of the evocation, for instance their past reaction to a promotional action (Filser, 1994).

Buying intention

Intention is activated by a desire or a need (Darpy, 1997) and desire is viewed as an active process (O'Shaughnessy, 1992). Though buying intention is more than a mere desire, it is not a promise to buy (O'Shaughnessy, 1992), it is the outcome of a cognitively handled desire. Here is the definition given by Darpy (1997) echoing the studies of O'Shaughnessy (1992), Howard (1994) and Belk (1985): "*Intention results from a desire or a need handled on the cognitive level and leading the intention to purchase*". Among the environmental factors recognized to produce important emotional and behavioral reactions on the consumer, color seems to play a big role. It serves to retain consumers longer on the e-commerce website according to certain criteria related to their perception of the interface. This duration thanks to a

proper use of colors can help maintain user interest in a site (Bucklin and Sismeiro, 2003, Hanson, 2000) and give users more time to consider and complete purchase transactions (Bucklin and Sismeiro, 2003).

AFFECT: A MEDIATING VARIABLE

Another aspect we wish to bring to the fore concerns the effects of colors upon the affective response, which includes the emotions and moods experienced when visiting e-commerce websites. One can indeed think that the usability afforded can enhance the experienced affective response. Emotions are short-lived but extremely intense. Their cause is often apparent and their cognitive content is obvious (joy, sadness, anger, fear, disgust). Their most obvious features are brevity and intensity. While emotions imply some kind of awareness of the information about the background and consequences of actions, moods refer to affective states of mind less likely to reach our consciousness. Moreover, they last longer than emotions but are less intense (Forgeas, 1999).

THE EXPLORATORY QUALITATIVE ANALYSIS

In order to adapt the conceptual model applied in our research to the literature, and in order to check and validate the nature of the constructs we wished to measure, we needed to conduct exploratory, qualitative analysis prior to the experiment. This was also a way to acquire primary data in order to explore and become familiar with the usability topic. Its form was based on a clinical approach in which semi-directing talks were conducted. It also incorporated a method of projection likely to bring the researcher(s) more details of what the respondents were really thinking about when describing a website. These interviews were appropriate since people felt freer to describe their experience than during focus groups or than if an open questionnaire had been solicited. The limits of our topic were then defined according to the exploration of the motivations, attitudes and values of our respondents. This analysis was a way to understand their behavior and decision-making processes, in order to prepare the confirmatory analysis. Both analyses (exploratory and confirmatory) are essential to this research project.

The interviews were carried out with consumers and webmasters. Our aim consisted of investigating whether changes on the Internet interface would lead to consumer satisfaction with respect to e-commerce websites.

The objectives of the qualitative study were pursued on the basis of the following questions:

Is color one of the atmospheric elements which most influences the consumer's answers?

Do consumers feel particular emotions while shopping on e-commerce websites? If yes, does color affect the emotions of the consumers?

Does an e-commerce website's color make it possible to define the behavioral responses of the consumer?

Which aspects of quality and quantity of information are retained following a period of shopping on an e-commerce website?

We thus used an interview guide to collect the needed information to accomplish our objectives. Once we conducted our literature review and analyzed what the respondents said during the exploratory analysis, we were able to suggest some assumptions as follows:

FORMULATED ASSUMPTIONS

Our research is based on the "Stimulus-Organization-Answer" model of the atmosphere of an Internet website found in the Mehrabian and Russel (1974) model (Figure 1). The formulated assumptions of these models are the following:

H1: The usability of the e-commerce website with regard to colors and text positively influences the memorizing of commercial information and the intention to purchase.

H2: The usability of the e-commerce website with regard to colors positively influences the affective response of the consumer.

H3: A positive affective response felt by the consumer while shopping on an e-commerce website positively influences the memorizing of commercial information and the intention to purchase.

After this exploratory qualitative analysis, we conducted a quantitative analysis to confirm the results obtained so far. To do so, we carried out a lab experiment based on the conceptual model of the experiment. This is presented below, before describing the experimental design of the experiment conducted.

Conceptual model of the experiment

The model explains how the atmosphere of an e-commerce website and particularly the color variable and its components (hue, brightness, saturation) can have an impact upon the buyer's emotional and cognitive state, upon his or her perception, which affects his or her buyer behavior on several levels as well as his memorization. Both can then lead to an appreciation of the perceived usability of the e-commerce website. This model draws inspiration from Mehrabian and Russell's SOR model (Stimuli Organism Response) used in environmental psychology (Mehrabian and Russell, 1974) (Figure 1).

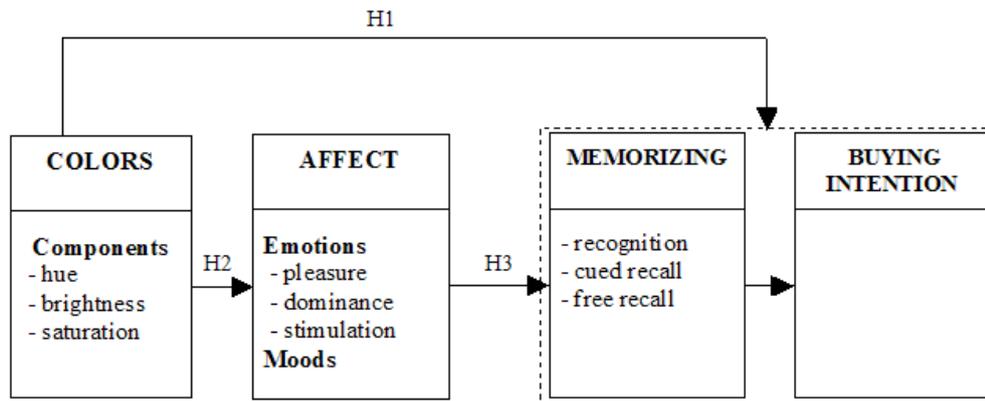


Figure 1: Conceptual model of the research

ANALYSES AND RESULTS

Measures

Memorization

Memorization was gauged by measuring recognition, cued recall and free recall. To measure recognition, we observed how participants recognized the CD cover when seeing it simultaneously with two other covers of different albums by the same artist. Recall scores varied from 0 to 2 at the minimum. It is worth noting that some participants had viewed more than two items.

Cued recall was measured by observing how users reacted to the seven commercial pieces of information appearing on each page of the catalogue, presented the same way for each item. Scores could thus be graded from 0 to 7 for each item visited. Since participants were required to consult at least two items, scores for the cued recall could then range from 0 to 14 at the minimum. Participants had sometimes examined more than two items.

In order to measure free recall, participants typed their answer to an open-ended question related to the CD cover they had just examined. A certain number of items used in the product's description were expected to be identified. No matter what the item was, the description could not exceed 142 characters and there was an average number of 20 items per product. Since participants could visit more than two articles, the score to measure free recall could range from 0 to 40 at the minimum.

The score of commercial information memorization refers to the sum of the recognition score, cued recall score and free recall score.

Buying Intention

Considering that e-commerce's website's colors are likely to have an impact on the intent of purchase, we set out to measure these. We used a three item scale developed by Yoo and Donthu (2001) which had already been used in a similar context and in which its internal consistency proved reliable. The items were measured on a 5-point Likert scale ranging from strongly disagree (1) to strongly agree (5). Already used in a similar context, its internal consistency had proved to be reliable.

Affective response

Emotions

In order to interpret colors one must go through a cognitive process which, in turn, arouses emotions in the Internet user. These emotions can fill users with a desire to buy, leading them to make a purchase or to leave the website. Perceived differently by each Internet user, depending on his or her own way of perceiving colors, emotions involve a shift in his or her behavior as a consumer.

Mehrabian and Russell (1974) point out two sets of methodological issues related to colors and emotions. The first one has to do with the lack of control or specification over the color stimulus; take, by way of illustration, the lack of control over saturation and brightness when focusing on hues. We endeavored to control this aspect by resorting to Munsell's system (Munsell, 1969) of defining the colors selected for our experiment's chart. The second methodological issue has to do with the question of reliability and validity of the tools used to measure emotional responses to color stimuli.

To measure the emotions of participants visiting an e-commerce website, we used Mehrabian and Russell's PAD scale (Pleasure Arousal Dominance) (Mehrabian and Russell, 1974).

Pleasure: pleasure / displeasure, assessing the well-being experienced by the individual;

Arousal (stimulation): arousal / non-arousal, assessing the consumer's level of awareness (to the item) and activation;

Dominance (domination): dominance / submission, assessing the feeling of freedom pervading the consumer when buying something on a website.

Since the reliability of the PAD scale remained continuously high and satisfactory throughout the experiments conducted by Valdez and Mehrabian (1994), this method was chosen. Originating in the studies of Osgood & alli. (1957) already centered on the "evaluation, activation and potency" triptych, this scale is still the most widely used to measure the consumer's affective state (Derbaix and Poncin, 2005).

Moods

An emotion related to a color is perceived either as positive or negative according to the individual's personal associations with this color (Boyatzis and Varghese, 1993). As a rule, different colors tend to call forth different moods (Odom and Sholtz, 2004). Therefore, we have chosen to measure the latter. To do so we utilized Mayer and Gaschke's BMIS 16-constructs scale (Mayer and Gaschke, 1988), the "Brief Mood Introspection Scale". We selected it because it provides a quite exhaustive range of moods and is easy to implement.

Qualitative analysis

On the basis of semi-directing talks conducted with web designers and average consumers, topics referring to the emotional states experienced by the consumer were elicited while shopping on the Internet. These topics related to emotions and moods, demonstrate the importance attached to the facility of use of a website by the consumers. They also reinforce the effects of variables such as color as well as the quality of the images perceived by the consumers.

Participants

The consumers who we questioned were chosen according to their expertise in the use of websites (webmaster/simple user), their age, their sex and their social background. The identification of experts as opposed to your average user was significant in meeting the qualitative criteria as regards the selection of people. The control question which we posed was: *“have you already conceived or built a website?”*.

Method

For the criterion of saturation of the data being retained (Mucchielli, 1991, p. 114), we interviewed 21 people. The interviews were semi structured. This allowed us to obtain interviews based on subjects connected to the experience of consumption regarding the references on e-commerce websites. These interviews were often handled with a certain emotion. We adopted a neutral attitude with regard to the participants so as not to influence them in the way they answered. The participants had to respond to questions without being able to see a computer screen, so that they only answered by recalling the information gleaned during their navigation on the e-commerce website of their choice. Once every interview was transcribed, this amounted to one hundred pages. The interviews lasted from 13 to 47 minutes.

Results

The exploratory qualitative analysis enabled us to note that color was actually an integral part of the atmosphere on e-commerce websites. Color even seems to hold a more important role than we originally anticipated: it was referred to more than 79 times during the interviews. Some elements which appear essential to the interface are:

- elements related to usage and to the organization of the website, thanks to its clarity and the readability of its tree structure;

- elements allowing a rapid navigation within the site, by the provision of search engines in particular.

Color was actually mentioned by all the interviewees as a means of principal location within the interface of the site. It is perceived as an aid to move on the website and sometimes caused aggravation if it appeared too violent.

“ at times you feel aggravated, irritated, because it does not function well, because there are bugs or because it attacks you, yes it can attack you, when it is too “violent” at the level of the colors ” (respondent 14).

Not only is color part of the design of the website, but when soft, it also seems to comfort consumers thus filling them with enough self-confidence to buy an item in an environment to be “tamed”: *“ What I like in the Boursorama website is that it is comfortable. Comfortable visually speaking I would say.” (respondent 16)*

Color serve the organization of the information by highlighting useful zones systematically sought by the surveyed Internet users: “ it remains practical, therefore with really accessible doors, or in any case visible, where I am able to make my reference marks easily; by zones possibly defined by executives, and then zones of text in fact. A regrouping of texts on certain places.” (respondent 5).

When used in compliance with the contrasts advocated by Itten (1970), color can prove very timesaving, a major asset in the relationship between consumers and websites.

“I will spend more time on a site which has a large catalog, or products similar to what I seek, therefore always containing contents.”

As we mentioned earlier, making the information search easier by implementing strategies specific to ergonomics and human computer interaction, the colors encountered when browsing an e-commerce website enable Internet users to appropriate it more easily, according to its layout.

“Thus there is the speed already, it is important but it can be faster due to the material with ADSL or not,... I do not know if one can control this, and if not, colors help to locate what one wants a little bit, how to explain that... if it is clear and neat if the screen were looked at by far, one knows what the various parts of the site contain more or less. But it is true that the most important things for me are the links.”

The usability thus seems to play an important role in the consumer’s perception of the e-commerce website’s services and information provided. The content analysis allowed us to verify that the color played an important role in the emotional states experienced while of shopping on the Internet. This also allowed us to determine certain characteristics appropriate for the Internet purchase which differentiates this act from those used to traditional buying conditions. The respondent of interview 19 confirms this by saying that “...*the more readable the site, the more one wants to spend time on it*”. He further reinforces his assertion about the factors which discourage him from revisiting a particular website: “... *if the site is complicated to access, has a complicated address in the address bar which is completely unmemorizable in order to revisit the same page, difficult to read, too busy...* ”. This testimony corresponds to that of the respondent of interview 3 who is more direct about the appearance of the e-commerce website: “... *its brightness encourages me to go and consult a commercial website, if it is clear and convivial. And what discourages me is if it is all the contrary*”.

Discussion

Links need to be easily located. Their recognition can be facilitated by color, which constitutes one of the characteristics of information systems: to make any zone of the page more easily interactive by the creation of an effect which changes the state of a textual link or a button when the mouse scans over it. Independently of the graphic style of the link, it is important that the visitor can discriminate very quickly what the important links are and understand where they lead (Spool & alii, 1999).

The non-recognition of these links can quickly become tiring and frustrating. Their recognition, which corresponds to fast identification of the possible actions on the website, is crucial for the consumer to get the impression that he is in control of the website. The recourse to color is thus pivotal in making links easily recognizable.

A quantitative analysis follows, showing that the effects obtained by the colors of an e-commerce website on the Internet user, and in particular on his affective states, are not neutral.

Quantitative analysis

The essential purpose of the experimentation is to measure the cause and effect relationship and thus to verify hypotheses of causality. This is accomplished by the comparison of various factorial plans, which were various graphic charts in our case.

Method

Participants

Undergraduate students (440) from design school marketing classes participated in the experiment. After a few adjustments with the fictive e-commerce website and after deleting those participants who did not finish the questionnaire and those who were color blind, we finally obtained 296 useful responses. The sample of these final respondents is presented hereafter:

Characteristics		Percentage of the sample
Sex	Female	160
	Male	136
Age	Under 25 years old	242
	25 à 34 years old	29
	35 à 44 years old	13
	45 à 54 years old	11
	55 à 64 years old	1
Education	Certificate	2
	High school	166
	2nd-year university diploma	49
	License / Master I /Master II	36
	Postgraduate / doctorate / post-graduate / Master degree no diploma	42 1
Job	Executives and academics	32
	Intermediate occupations	3
	Manuel Workers	2
	Students	244
	Storekeepers and business managers	4
	Pensioners	1
	Other (to clarify)	10
Income per month	From 0 to 500 euros	247
	Under 1000 euros	15
	From 1000 to 1399 euros	11
	From 1400 to 1799 euros	5
	From 1800 to 2199 euros	9
	From 2200 to 2599 euros	9

Table 1: characteristics of the sample of respondents to the experimentation

Design

The experiment design included 8 treatments (4 x 2) related to the 8 graphic charts devised for the website dedicated to the experiment. We observed the results related to brightness and saturation, the variations of which depended on the hues carefully selected beforehand.

To devise our first experimental design we employed the graphic chart used by Hill et Scharff (1997) which registered the best readability rate in relation to contrast and we chose as chromatic colors a yellow dominant and a green dynamic. Starting from this chart, we inflected the brightness level of the two colors so as to obtain the second experimental design (Tables 3 and 4). For experimental designs 3 and 4 we kept the same colors but switched dynamic and dominant colors. Experimental designs 5, 6, 7 and 8 are based on black and white (achromatic colors), the ones most frequently used on e-commerce websites with different brightness and saturation levels, such as the experimental designs we chose relying on green and yellow hues.

Graphic charts	Plan	Background			Foreground			Plans explanations		
		Name	H	B	S	Name	H		B	S
Chart 1 - chromatic colors- Green and Yellow	1	 Magnolia yellow	60	100	20	 Newsvine Green	120	40	100	(Hill and Scharff, 1997) showed that the sharp contrasts of his chart offered users the fastest reading speed possible.
	2	 Magnolia yellow	60	100	20	 Granny Apple Green	90	80	100	Same chart as in the Plan 1 with increased dynamic color brightness (from 40 to 80).
	3	 Newsvine Green	120	40	100	 Magnolia yellow	60	100	20	Same colors as in Plan 1 . Dynamic and dominant colors were switched.
	4	 Newsvine Green	120	40	100	 Sunflower yellow	60	100	60 ¹	Same color chart as in Plan 3 with a decrease in dynamic color brightness (from 80 to 40).
Chart 2 - Achromatic colors - Black et White	5	 White	0	100	0	 Black	0	0	0	This chart is the most widely used one on e-commerce websites.
	6	 White	0	100	0	 Grey	0	60	0	Same color chart as Plan 5 with increased dynamic color brightness (from 0 to 60).
	7	 Black	0	0	0	 White	0	100	0	Same colors chart as in Plan 5 . Dynamic and dominant colors have been switched.
	8	 Black	0	0	0	 Grey	0	60	0	Same color chart as in Plan 7 with a decrease in dynamic color brightness (from 100 to 60).

Table 5. Factorial design of the experiment

A lab experiment was conducted on 296 participants. Carrying out this experiment under laboratory conditions allowed us to draw valid conclusions about the groups surveyed (Jolibert and Jourdan, 2006). A study focusing on the color variable requires that at least three aspects of e-purchase be taken into consideration (Table 2). (Read Appendices 1 for details)

¹ The color which should have been used for the text of the experimental plan 4, in order to preserve rates of luminosity and saturation in relation to the background color, could not be preserved. Indeed, this chart could not be used given the lack of contrast between the two colors (foreground/background) which made the reading impossible on a more or less old or difficult screen, for an individual with difficulty distinguishing colors we refer to the directives of the w3c. We thus varied its degree of saturation.

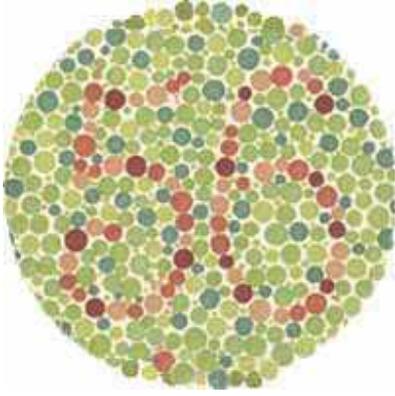
 <p>Figure 2: The screen adjustment (calibration) of screens is possible with a probe</p>	<p>We can make sure that the colors featuring in the different charts framing our experiment appear just as we have defined them on the screens of our participants.</p>
 <p>Figure 3: The luxmeter enables to set the brightness of the room at 1000 lux</p>	<p>By carefully defining the color of the walls and the brightness of the environment in which participants stay we can make sure that the colored appearance of the websites used for the experiment will not be altered by dim lighting or, on the contrary, by a too brightly lit room.</p>
 <p>Figure 4: Sample of the Ishihara test</p>	<p>One must make sure that participants do not have any color blindness, which is extremely hard to check. Only two solutions can be resorted to: one can either rely on the good faith of the participant's statement, or ask an eye specialist to provide a certificate stating the participant's vision is not impaired².</p>

Table 2: conditions of the experiment

Procedure

In order to measure the differences in color perception, we created 8 different graphic charts with varied hues, brightness and saturation levels. The color stimuli were modified in accordance with Munsell's system (Munsell, 1969), considered to be the most accurate **such** system (Aumont, 1994) which enabled us to precisely define several levels of brightness and saturation for each hue. Respondents were asked to enter a room where all conditions had been controlled before they started the procedure.

Data Analysis

² Asking a participant for such a certificate would assuredly have allowed him/her to guess that our experiment was focused on color, which would have biased the experiment. Following recommendations from eye specialist Professor Lanthony, we decided to have each participant take the Ishihara test in a room separate from the one where the experiment was conducted.

We followed both the General Linear Model (GLM) to test the impact of the colors of the graphic chart and the analyses of variance (ANOVA) to analyze experimental data to define the meaning and accuracy of the variables. By incorporating interaction effects with a series of regressions for each of the dependant variables, we tested the interaction variables.

Relationship between colors, memorization and buying intention

Direct effects of the colors of the graphic chart upon memorization

The colors did not show a significant impact upon cued recall, according to the GLM analysis. However, an interaction effect on free recall was noted ($F = 2.484$; $p \leq 0.061^*$) (Table 4).

Effects of graphic chart colors upon cued recall			
	DF	F	p-value
Hue	3	0.404	0.750
Brightness	1	0.771	0.381
Hue x Brightness	3	0.616	0.616
Effects of graphic chart colors upon free recall			
	DF	F	p-value
Hue	3	0.288	0.834
Brightness	1	0.049	0.835
Hue x Brightness	3	2.484	0.061*

Table 3: Effects of graphic chart colors upon cued and free recalls

Participants managed to provide equivalent answers to closed questions about the content of the website, no matter which colors were featured in the graphic chart (cued recall). Those questions actually helped Internet users to retain information in that they accurately summarized the information that could be easily memorized by consumers. When no help was provided and visitors had to remember what they saw on the website (free recall), colors proved very helpful to them. This is significant in that it shows that color needs to be taken into consideration when conceiving usable graphic charts. Indeed, color helps to retain the information and memorization seems helpful to evaluate the e-commerce's website usability.

After studying the ANOVAs carried out, we noted that brightness affected free recall most significantly when hue 2 (green dominant color, yellow dynamic color) was implemented. Individuals exposed to a low level of brightness (brightness 1) remembered the content of the website better than individuals exposed to a high level of brightness (brightness 2) (Figure 2).

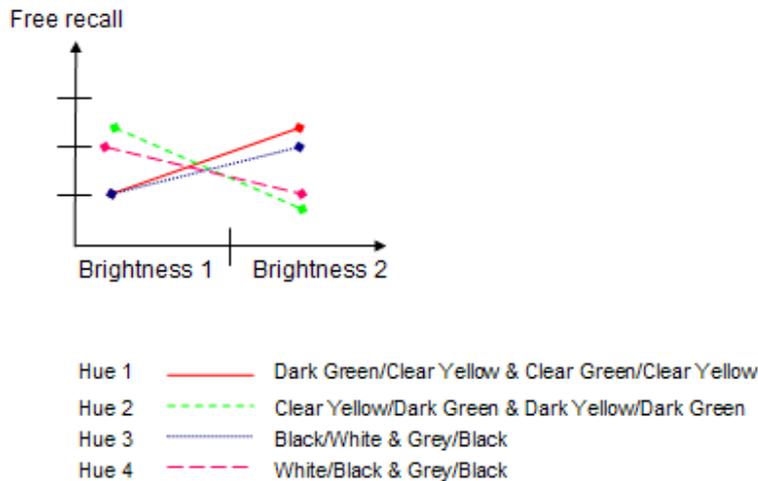


Figure 5: Effects of brightness upon free recall

Through this result, we now understand that a lower contrast between dominant color and dynamic color enhances the retention of the commercial information provided on the website.

Direct effects of the colors of the graphic chart upon buying intention

The results of the GLM analysis demonstrate that a graphic chart of an Internet website strongly influences buying intention. Brightness plays an important role in buying intention ($F = 15.201$, $p \leq 0.000^{***}$). Just as memorization does, we note that when the dominant and dynamic color brightness is not too strong, then buying intentions are the highest (Table 5).

	DF	F	p-value
Hue	3	0.349	0.790
Brightness	1	15.201	0.000***
Hue x Brightness	3	3.732	0.012*

Table 4: Effects of graphic chart colors upon buying intention

The GLM analysis shows that hue and brightness have an effect upon buying intention ($F = 3.732$; $p \leq 0.012^*$). The results of the ANOVA show that the effect of brightness on buying intention is only significant as regards hues 1 (yellow = dominant color, and green = dynamic color) and 2 (green = dominant color and yellow = dynamic color), with a chromatic color hue, but has no particular effect with a black and white hue chart. When contrast is higher and brightness increased, memorization decreases (Figure 3).



Figure 6: Effects of brightness upon buying intention

The relationship between memorization and buying intention

A simple regression enables us to observe that free recall has a positive effect on buying intentions ($F = 3.824$; $p \leq 0.051^*$). The more information an individual memorizes about a product, the stronger his or her buying intention will be (Table 6).

	DF	F	p-value
Hue	3	0.349	0.790
Brightness	1	15.201	0.000***
Hue x Brightness	3	3.732	0.012*

Table 5: Effects of graphic chart colors upon buying intention

Observation of the mediating effect of emotions

The GLM analysis demonstrates that the colors of the graphic chart affect emotions in a negative way because low brightness enhances stimulation ($F = 3.167$; $p \leq 0.076$). However, the colors of the graphic chart do not affect pleasure nor domination in any way (Table 8).

Effects of graphic chart colors upon pleasure			
	DF	F	p-value
Hue	3	1.606	0.188
Brightness	1	0.330	0.566
Hue x Brightness	3	0.567	0.637
Effects of graphic chart colors upon stimulation			

Hue	3	1.243	0.294
Brightness	1	3.167	0.076*
Hue x Brightness	3	0.154	0.927
Effects of graphic chart colors upon domination			
Hue	3	0.105	0.957
Brightness	1	0.705	0.402
Hue x Brightness	3	0.338	0.798

Table 6: Effects of graphic chart colors upon emotions

Stimulation does not affect memorization in a significant way (free recall) but does have a significant effect upon buying intention.

Observation of the mediating effect of mood

GLM analyses show that hue and brightness have a significant interactive effect on negative mood ($F = 3.042$; $p \leq 0.029^*$) (Table 9).

Effects of graphic chart colors on positive mood factor			
	DF	F	p-value
Hue	3	0.374	0.772
Brightness	1	0.041	0.840
Hue x Brightness	3	0.916	0.434
Effects of graphic chart colors on negative mood factor			
	DF	F	p-value
Hue	3	1.159	0.326
Brightness	1	0.334	0.564
Hue x Brightness	3	3.042	0.029*

Table 7: Effects of Graphic chart colors upon mood

ANOVAs show that a graphic chart based on hues 1 (dynamic = Newsvine Green / dominant = Magnolia Yellow and dynamic = Granny Apple Green / dominant = Magnolia Yellow) and 4 (dominant = black and dynamic = white) offers an interactive effect between hue and brightness. When resorting to hue 1 (Newsvine Green/Magnolia Yellow and Granny Apple Green/Magnolia Yellow), an increase in brightness entails a significant increase in negative mood, while with hue 4 (White/Black - Grey/Black), an increase in the brightness level contributes to toning down negative mood ($F = 3.815$; $p \leq 0.055^*$). Two simple regressions give evidence that negative mood has a significant and negative impact upon buying intention ($t = -0.129$; $p \leq 0.001^*$), but does not have any effect upon memorization (free recall) (Table 10).

	Buying intention
Negative mood	-0.129**
Constant	- 8.215E-17
$F = 3.824$; $R^2 = 1.3\%$	

* $p < 0.1$ ** $p < 0.01$

Table 8: Regression between negative mood and buying intention

DISCUSSION AND IMPLICATIONS

The results of the research suggest that the effects of the colors used on e-commerce websites have an effect on consumer retention of information and buying intention. Two mediating variables – stimulation and negative mood – helped us to explain how colors reinforce these effects.

A broad selection and realistic colors of the product

The possibility offered on certain e-commerce websites of seeing quality representations of the products contributes to the consumer experiencing a state of mind favorable to shopping. A representation of quality depends on the consumer being able to magnify the image so that the product appears larger. This is the case with the items on music websites or data processing websites, like the Apple website, for example. An image makes it possible for the consumer to see the product in another color, another pattern or another texture as with clothes and cars websites such as Smart, for example. This reinforces the feeling of well-being when shopping.

For the respondent of interview 17, "... the fact that the images are clear is rather important, with products like music, books, photographs; there is need for at least a minimum of illustrations that hold my attention, especially if the image of the product is clear. I do not like to see a fuzzy image of a product, badly compressed". All the images that we see on the Internet are compressed so as to be exported in a readable format by the navigators such as Internet Explorer or Firefox.

The graphic composition of the website can affect the representation that the consumer retains when shopping. This composition thus should exploit the perception of the interface and the retention of the whole website and commercial information that is available on its pages.

Ergonomics and design rely on color

Simplicity of movement on the website makes it possible to entertain consumers. This constitutes a new area of research **which is starting to gain momentum**. This does not seem surprising taking into account the usual population of Internet consumers and consumers in general, i.e. young people or those having a young "spirit". Ergonomics and a sought-after usability, thanks to a subtle use of colors, seem to encourage the likelihood of revisiting the website. The exploratory qualitative analysis conducted within the framework of this research has enabled us to emphasize topics such as "playability". At the same time,

it has shown us to what extent the expertise of the consumer in the act of purchasing on the Internet was important. This could then facilitate the conceptual and practical grasp of the interface, making the act of buying simpler, and thus more pleasant.

Chromatic colors seem to be more likely to enhance the memorization of the displayed information than black and white (achromatic colors). These results are in keeping with the studies conducted by Silverstein (1987), who noticed that monochrome screens entailed more eye-strain and overall tiredness.

It appears indispensable to maintain the conditions under which we conducted our experiment – conditions complying with the criteria used to evaluate the color quality of digital interfaces – those which enable one to benefit from an accurate and easy to implement tool (Fernandez-Maloigne, 2004 ; Munsell, 1969). For future experiments related to the measurement of cybershopper perception, memorization or buying intention, one should undoubtedly take into consideration brightness and saturation rates. When focusing on textures, matte and glossy aspects, “an essential parameter of Japanese sensitivity that is all too often overlooked by Western standards” (Pastoureau, 1999), researchers can obtain more accurate outcomes in their studies dealing with screen colors in a business-driven context. Coupled with the use of auditory functions on e-commerce websites, these analyses would enable us to reach a better understanding of the effects of the atmosphere pervading such and such e-commerce websites upon consumers, especially according to a holistic rather than atomized approach to the phenomenon. The three-dimensional textures used on Flash billboards, videos or virtual worlds such as Second Life suggest greater complexity.

The psychobiological measurements based on the movement study of the muscles of the face and in particular on detection of electric activity in the muscles would surely also afford interesting results since the corrugator, the so called “muscle of the pathetic color”, corresponds to the frown muscle, which is likely to function when the consumer is challenged by the difficulty of reading, including/understanding or retaining information posted on the screen.

The studies rising from electromyography (a technique of recording the electrical activity of the muscles and the nerves) from Haley, Staffaroni and Fox (1994), Crimmins (1997), as well as Hazlett and Hazlett (1999), relating to the treatment of advertisements, show that the zygomatics (put in action by negative emotional reactions) highlight a better recall of the televised advertisements by evoking more emotional reactions.

LIMITS

In addition, the experiment carried out within the framework of the thesis made it possible to identify some limits such as the difficulty of retaining a large number of participants in an experiment without any control group due to the lack of motivation; an incentive, would make it possible to interest the public with regard to participation.

The design and the realization of the site of the experiment require professional skills in terms of programming to guarantee the reliability of the system and its longevity. Lastly, the conditions of experimentation require the installation of particular light sources, screens calibrated by means of a probe and vision tests such as the Ishihara test, all which represent further expenditure.

FOR FUTURE EXPERIMENTS

For the reasons mentioned above, this project would benefit from the provision of skills guaranteeing reliability and longevity, in the same way that the traditional stores are encouraged to facilitate visits by disabled people to their outlets. Products and services are therefore visible and accessible by the greatest number, and thereby respect principles of accessibility. These requirements are now sufficiently known so that web designers take them into account before designing a website. Among these principles, let us not

forget the regulations applying to public service sites of public service which force them to respect a minimum level of accessibility. Within a framework of sustainable development, the e-commerce websites sensitive to the problem of disabled people show a willingness to address their needs and as such serve as exemplars for other sites. To arrive at this level of accessibility by making it possible for the greatest number to discover the contents of a Web page, a certain number of principles of construction must be taken into account.

On the Internet, 80% of the information memorized by an individual comes from the visual sense and the other forms of perception of the environment are similarly influenced by the sight albeit to a lesser degree (Mattelart 1996). However, accessibility is not solely intended to help partially-sighted persons. Deaf people as well as physically handicapped persons must also be able to access the Internet. Among the various criteria of accessibility set up by consortium W3C and WAI (department of the W3C specializing in accessibility), worth mentioning are:

- a simple HTML code,
- the use of cascade style sheets (CSS) functioning on HTML pages,
- a separation between content and form,
- the alternatives to purely graphic, audio, video elements...

We see here that accessibility is not only related to ergonomics, but also to usability or “playability” and these do not prevent the creators from being creative. It is a question above all of indicating to the consumer the solutions which give access to information and services on the site. In addition to serving a greater number, accessibility, which is based on the use of a well structured HTML code separating the contents (commercial information) from the form (the style sheet), is easier to maintain and develop when the site loads more rapidly and is better referenced by search engines than a “normal” website. These characteristics related to the time of loading of the pages and the referencing of the Internet website constitute imperative reasons to take accessibility into account in a systematic manner in the design phase.

APPENDICES

A1. Devices and installation required to conduct the experiment effectively

Experimental Room (Fernandez-Maloigne, 2004)

Measurements were taken at different intervals by a luxmeter:

- Keep a distance of about one meter between the back of the room and the screen,
- A relationship between idle screen luminance and peak luminance (luminance is the Y coordinate of the XYZ model),
- Peak luminance of the screen,
- Room lighting (ambient illumination),
- Background chromaticity related to the D65 illuminant,
- Maximum observation angle (CRT screen) of 30°,
- High-quality assessment monitor, size 50-60 cm (22" - 26").

Participants (Lanthony, 2005)

An Ishihara test for determining color blindness was conducted in another room than that of the experiment room so as to check that participants were not color-blind and were thus in a position to provide valid answers.

Screens

All the screens used during the experiment were calibrated:

- Ensure the screens warm up for an hour before calibration;
- Ensure one can modulate Hue, Brightness, Saturation as well as the R, G, B channels for each screen used;
- Use a CRT display rather than a plasma screen;
- The target to be taken into account by the probe must be a 2.2 - 6500 Kelvin (Gamma, color temperature);
- Ambient light compensation must be disabled;
- The BLACK point must have a light level of 0.8° while that of the WHITE must reach 90°. If the weakest screen is no higher than 80°, you must calibrate all the screens to this level°. This might very likely be the case with old screens;
- The luminance of the WHITE for contrast must be set so that four more or less WHITE squares are visible to the naked eye;
- The luminance of the BLACK, for brightness, must be set so that four more or less BLACK squares are visible to the naked eye,
- Identification of color controls: press the radio button on “RGB slider”,
- Place the probe which will then provide the test patterns on the screen using the suction pads enabling it to stay stuck;
- The measurements mentioned above can be taken again two weeks afterwards, but they should not have been altered if no one has changed the screen settings;
- The probe allows for the generation of the ICC profile: Save the ICC profile which will be set automatically afterwards.

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