From exigential hypothesis to cognitive ergonomics: a discipline in support of sensory and sustainable design

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ABSTRACT

The aim of this paper is to illustrate how the designer can use and exploit results obtained by applying different methods and techniques of cognitive ergonomics. In particular, this study made use of the Eye-tracking tool and other qualitative projective techniques in order to assess the user perception based on different attributes in different contexts (from packaging to jewelry, car seats and taps fitting). Specifically, one of the most investigated attributes has been the perception of benefits coming from environmental sustainability. Moreover, the presented case studies have also been focused on other communicative aspects of the products such as the perception of elegance, cost, convenience and quality. As a result, the present study does not set out guidelines for the design process of products which can implicitly communicate their usage function, communicative and their environmental performance, but aims to highlight and understand how the designer can use the techniques, tools and methods of cognitive ergonomics and the results obtained through them. In order to consider the consumer point of view, and not only the designer one, the message of the product perceived by the consumer became a validation of the design and a suggestion for the choices to be made during the design process in relation to both usage and communicative functions.

Keywords: Design process; Design methodology; Product design; Cognitive ergonomics; Sensory perception; Sustainability; Eye-tracking.

1. INTRODUCTION

The paper proposes to evaluate and understand, through some case studies, what is the added value and strength data given by the use of methods and tools of cognitive ergonomics, in particular the Eye-tracking device, as an integral part of the design process [27]. Specifically, the Eye-tracking device allows to understand the unconscious behavior during the observation of an object (web site, product, print advertising): Eye-tracking is a technique for recording and analyzing eye movements and it uses sensors to record the reflections of a beam of infrared rays projected on the pupil. Since this signal changes depending on the position of the pupil (and thus of the direction of the gaze), by recording and analyzing ocular movements it is possible to determine in which specific point and for how long the viewer looks at a particular object. Analyzing what viewers observe or ignore, when they examine a particular object, provides decisive information about the capability of the product/interface/object to attract and hold or rebuff observers’ attention [17]. It could be interesting to understand and analyze, thanks to the support of qualitative techniques, such as questionnaires, what eyes’ position in space means: attention to specific areas of a product means a good or a bad perception? In fact, individuals’ decision-making mechanisms contain inconsistencies and errors, and individuals tend to depend on a few specific pieces of information or cues while they are processing information [14]. Moreover, we do not see with our eyes but through a complex cerebral process that fills in space-time voids with credible hypotheses based on experience, not on how the world is, but how it should be [2]; [5]. Similarly, when studying an object, we do not analyze the entire object but only those few significant elements that comply with our hypotheses of reality [15]; [2] and these significant elements do influence the design process. The present study will introduce the use of a methodology, consisting of qualitative techniques and instruments (such as the Eye-tracking tool) during the design process [2]. In particular, the analysis with the Eye-tracking tool is already widespread in areas such as cognitive science, psychology, human-computer interaction (HCI), market research, medical research and other fields. In the field of market research, tests are made on web sites, packaging, print advertising, retail; particular attention in this paper will be given to different kinds of products, [22] such as packaging (and not only labels, picture, formats), taps and jewels, in order to understand crucial elements that must be elaborated from designers as a guide-line during the design process. According to Piqueras-Fiszeman, Velasco, Montejo and Spence, these analyses are very important considering a design product from the consumers’ decision perspective, products’ sensory characteristics [18]; [25]; [24] and consumers’ experiences [21].

2. INSTRUMENTS AND METHODS

It is important to emphasize that the data resulting only from the devices are not sufficient in order to understand a phenomenon in its entirety. Must be remembered that there is a huge difference between what it’s perceived through a sense and what, on the other hand, is processed by our brain [2]. For this reason, the case studies and the methodology presented are focused on integrating analytical and qualitative techniques with the sensorial analysis instruments that are currently available. These techniques are aimed at identifying the emotive levels - and their relationship with cognitive aspects - the “weak signals” inherent in the
perception of any interface and the new creative ideas that grow from the requirements of the users themselves. Specifically, this paper presents the results obtained by using qualitative techniques (in particular questionnaires and semantic differentials) and the Eye-tracking instrument. These techniques also represent a valid vehicle for confirming or disproving data resulting from the tools used for the analysis: in fact, the involved research group also use other cognitive ergonomic techniques, such as qualitative session, the positioning on the FBC grid [29] and specific instruments for sensory evaluations of products and materials (Sensotact® by Renault and SounBe®) [2].

The Eye-tracking is a hi-tech instrument for recording and analyzing the user’s eye movements during exploration, for example, of a website or while observing an object. It is designed to study the behavior of the human eye as it reads an image or a product. In effect, it is possible to deduce the user’s level of attention to what is being observed, how the user processes the information contained in a page or advert, the strategies and any possible problems that may be encountered during these activities. Eye-tracking is now applied to interfaces and web design and allows to precisely track the user experience, recording areas, words, graphics, space, time and sequence of movements of what is being observed by the user; it is actually a very interesting methodology because it allows not only to record the physical point on which the eyes are directed, but also, thanks to the identification and interpretation of physical postures unwittingly hired by the eye, understand where the users’ attention is focused [7]. In other words, with the Eye-tracking it’s possible to determine where users’ attention poses and how it flows instant after instant. Eye-tracking is also widely used in different fields like packaging and advertising, in publishing and television broadcasting; it allows comparison between different creative ideas in order to understand which is the more efficient version; increases a deeper analysis of the message components (brand, labels, product, creativity, headline, etc.) that attract the attention of users; enables an evaluation of the communicative effectiveness and the emotional impact of a single message.

This tool is also applied to design retail outlets through the study of the buying habits of consumers by tracking their visual pathways within the exhibition spaces, with a consequent saving in terms of economic impact [9]; [22]; [16]; [27]. In this paper we present a new use of Eye-tracking and related cognitive ergonomic methods: in fact, the use of these methods and tools, is not only adopted in order to understand attentional processing, consumer behavior [27] and consumer evaluation of a product, but could also be adopted in order to understand the actual perceptual areas, such as, for example, the practicality, the ‘goodness’ of the product itself, the cost or the environmental sustainability [7]. The innovation consists both of the use of the mentioned techniques/tools and of the method of application to different industry sectors such as faucets, jewels and car seats; moreover, regarding the packaging, it’s used to determine not only innovative aspects of a product compared to another, such as label and the usability [16], but also to understand how to combine the appropriate design elements to predetermine consumers’ gaze patterns in order to convey the desired messaging on product [21].

The analyses with the Eye-tracking were performed with the instruments Tobii T120 and Tobii T60, which look like normal 17” monitors and provide a recording without any contact with the test participant’s eyes and does not require the use of a head-mounted device. In order to allow a better assessment of the data resulting from the analyses made with Eye-tracking, it has been necessary to have the participants compile a semantic differential evaluation. The semantic differential consisted of a set of bipolar adjectives (having opposite meanings) to be rated-by the subjects on a Lickert scale with 5 or 7 points, placed on the opposite ends of the scale. Assessment of 5 adjectives (and their opposites) was proposed for the definition of the products selected, i.e. 5 adjective pairs. To prevent an effect of de-concentration, the positive and negative polarities were placed at random, on the right or left of the scale.

Each participant made a semantic differential appraisal for each image, on a scale of 1 to 5, in which 1 was the worst case (very negative) and 5 the ideal case (very positive). Another technique used in the researches was the questionnaire [2]: the individuals involved in the test were invited to express through different levels of investigation, judgments and inclinations on different aspects of interest. This was done by completing value scales, but also by answering to closed and open questions or by adding stylized graphics of the object in question [7]. In this way, qualitative techniques have been applied and combined with the use of the Eye-tracking device permitting us to understand users attitude, emotive and cognitive behavior to different kinds of products.

3. CASE STUDIES AND PROCEDURE

The case studies presented in this paper have been developed by following the same procedure and involved both packaging and product analysis. The first phase of the research has been dedicated to the introductory questionnaire through which we began to verify the candidates’ general evaluation of the product, always taking into account the communicative elements of interest for the research. The candidates were also asked to draw an outline of the analyzed product, with the aim of identifying the aspects considered “typical”. We started to identify the “markers” of the products [7], i.e. those elements that contribute to a rapid processing of the product and its content. In particular, it turned out that the marks of environmental compatibility, materials and some communicative aspects of products were an essential contribution for the immediate and heuristic perception of the packaging that could be defined as “sustainable”.

Subsequently, we proceeded to make the Eye-tracking analysis, through which, alongside the assessment of the main points of interest identified by the initial scanpaths, the interviewees were invited to concentrate on a series of “stimuli” provided by the researcher during the session. This was aimed at identifying the actual areas of packaging perception, such as elegance, practicality, cost and sustainability [7].

Thereafter, the semantic differentials led to the identification of similar or opposing trends in the semantic areas presented to the candidates. This allowed us to infer which stimuli are immediately combined and which ones, on the other hand, appear to be in dichotomy (fig.2) [2].

- The first two case studies were part of an existing parallel multi-disciplinary research of the Pollenzo University, Index environmental and economics design (2009-2012) [1] whose objective is to outline an evaluation index of social, environmental and economic sustainability of the food products. As part of this research, a specific task has been focused upon analyzing food packaging, with the dual aim of outlining an evaluation system, based upon the functional, communicative and environmental performance [19] [26] that a type of packaging must satisfy throughout its entire life cycle [3] [4] and, at the same time, investigating how the various end users perceive the eco-sustainability performance [2] of the analyzed packaging.
In particular, the first case study dealt with the analysis of the perception, by users, customers and tasters, of different chocolate bars (chocolate bars produced by different manufacturers and bars of different tastes by the same manufacturer).

We started to analyze the packaging of three chocolates bars, selected, after a first evaluation about their environmental impact and for their attention to environmental sustainability of package and content. These bars come in three different flavors (white, dark and milk chocolate) and were produced by three different companies (fig. 1). Then we explored other three bars (by a single company) featuring different typologies/three taste of chocolate (classic, “maja” - with cacao from south central America, and extra dark - creamy filling) (fig. 3) [6].

This double analysis was performed in order to know if users’ perception and attention will vary in front of different colors and different pictures and information present on the packaging (in particular one chocolate bar was analyzed twice, as shown).

The aim of the research was to understand the aspects of communication of the chocolate bar packaging and the specific elements related to it, such as perception of elegance, cost, practicality and eco-sustainability of the product [2].

- The second experiment presented in this paper has been conducted on wine bottles and bricks (by different producers and in different tastes- white and red ones).
- The last one example concerns the perception of jewels and was part of the research “EDEN EcoDesign Network. Cross border network aimed at the engineering of eco-compatible product” whose objective is to support Piedmont based SMEs into conceiving innovative environmental sustainable products and processes, which should be assumed as the keys driven for their future development [8]. Different typologies of jewels (earrings, rings, bracelets and necklaces) have been tested, all produced by an Italian company, very sensitive to ethical problem of gold and projected towards new materials (not only precious materials).

Moreover, other interesting analyses were focused on tap fittings, one of the subjects of the research “EDEN EcoDesign Network” [8] (a comparison between different kinds of taps from different producers and a comparison between taps produced by a single manufacturer, characterized by different materials, colors and coating treatments) and on car seats concepts (the objective was then to analyze, compare and assess the concepts, examined in their sensorial aspects, with a view to furnish an aid to the designers in the choice of the upholstery to use).

Participants and analyzed stimuli

Different small groups of volunteers, consisting of at least 20 people, men and women aged between 22 and 45, completed the analysis: every small group carried out the test related to one of the presented case studies. All the participant were volunteers and reported normal vision; in total, almost 80 people performed the analysis. The tests proceeded following these steps: the participants were presented, on the Tobii device, with pictures/photos of the products previously prepared; each image was shown for 6 seconds in random sequence; after each image, on the monitor appeared a neutral screen for 3 seconds so that the subjects attention could be brought again at the centre of the monitor. During the neutral screen vision, the volunteers were exposed to the some vocal/written stimuli related to product elements such as strength, appearance, aesthetics, durability of the content and portability (in the case of packaging), practicality, originality, pleasantness, innovation and attention to environmental sustainability; the participants had to answer to these stimuli without speaking, just by looking to the images. At the end of the Eye-tracking test the volunteers had time to compile the semantic differential. Before the test, the subjects were given instructions about it, and were invited to answer to the already mentioned questionnaire, developed in order to understand their behavior towards the product in object (packaging, taps and jewels).

4. RESULTS

Thanks to the combined use of different techniques, instruments presented and Eye-tracking device, it has been possible to find out which elements of the analyzed products are considered topic by the interviewed consumers/users; moreover, it has been possible to understand which area is perceived in coherence or in opposition, in relation to the considered stimuli (for example we note a good coherence between the perception of elegance that, when positive, is also linked to the goodness of the product).

- Regarding the first two case studies (chocolate bars), we underline the results of the Venchi chocolate bar case. In comparison with the other two types of analyzed packaging (by different producers), the Venchi packaging was found to be the one which best satisfies environmental performance requirements [4]. However, although it presents the best environmental performance (low material content, low value of embodied energy or CO2 emissions), this aspect of the product does not emerge from the data obtained during the analysis relating to the perception of sustainability. The Venchi product was found to be the most efficient also as regards the aspects of elegance and goodness, while the brands’ packaging, expressed sustainability more strongly, evoking the adverse effect; therefore, the question spontaneously arose whether the concept of sustainability communicated in the packaging actually affects the perception of goodness and elegance of the product itself. These aspects of the research led to an initial reflection on the communication of sustainability features on packaging and in future, it will be necessary to reduce the dichotomous opposition between sustainability and elegance. The results of this analysis may be useful for creating an appropriate perceptive path in the design of chocolate bar packaging [2].

In the first test, the Venchi chocolate bar was made of white chocolate; in the second case, three Venchi chocolate bar have been examined and one of these was different from the previous one only in taste (dark chocolate) and for the color on the packaging (fig. 3), in fact, the pictures in front of the packaging were different just colors [6].

Fig.1: example of the heat-map related to the sustainability stimulus obtained by the Eye-tracking on the three selected chocolates bars (white, dark and milk chocolate) produced by three different companies.

In particular, we noticed that don’t exist big differences in the chocolate bars packaging’s perception: specifically, the dichotomous opposition between sustainability and elegance is confirmed (fig. 2).
The research about wine packaging demonstrated how wine bottles are perceived as a packaging that need a further pack, in particular a secondary packaging [9], in order to avoid problems of portability and convenience. Moreover, the used methods and tools allowed to observe how elements such as the elegance and the perceived quality of the product are mutually consistent. However, it was found that the concept of sustainability is in decisive opposition to the semantic areas related to luxury, higher cost and thus the perceived quality of the wine itself [7]. Moreover, it was possible to individuate which areas of the product/packaging could be considered “markers” [7] synthetic index that our mind uses to activate automatic processes for the creation of attitudes or the implementation of real behavioural schemes.

Principal results deriving from this research are about understanding how to communicate sustainability in food products: sustainability should not be stressed, because in opposition with good food quality perception. For this reason, sustainability of food products, and on their packaging, could be “hidden”, in order to give greater weight to the good perception of food quality by consumers.

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The analytical method of research about jewels combined cognitive techniques with the support of the Eye-tracking device in order to identify which areas of jewels are perceived under prevailing stimuli such as elegance, sustainability, preciousness, portability and versatility. The performed analyses permitted us to define four types of jewels identified by consumers/users and on which the design could go in deep (fig. 4). Summary results useful for designers are related to perception of sustainability and elegance: respectively the first one seems to be linked to the presence of stones in the jewels; the second one seems to focus on light and colours in the essence of jewels.

· With the Eye-Tracking, in the case of the taps (fig. 5), it has been shown that innovation is searched in the mechanism of the lever; on the contrary, colours originality is not perceived by consumers as an innovative element (moreover both innovation and sustainability are not related to the ‘taps’ colours, such as chrome, steel or iridescent colours).

6. DISCUSSION

Why using Eye-tracking machine and other qualitative methods specific for the cognitive ergonomic discipline in the design process?

In order to consider the consumer point of view, and not only the designer one, the message of the product perceived by the consumer became a validation of the design and a suggestion for the choices to be made during the design process in relation to both usage and communicative functions.

The design process, in fact, according to the performance-based and deductive methodology [11], is like a sequence of steps where a product can be considered the materialization of a project cycle whose assessment parameters are the needs and requirements, and the demanded performance levels are offered and provided.

According to the “methodological approach” adopted by the training project for the Industrial Design course at Politecnico di Torino [11], the designer could be considered as an “explorer”, a professional who can be seen in three distinct ways (explorer 1 - a “conscious” designer; explorer 2 – a “scenario” designer; explorer 3 - a “navigation” designer), that are not only stages along an evolutionary path but possible and alternative states, which may be chosen...
according circumstances (particular moments, interlocutors, or research opportunities). These three different aspects are just parts of the same flexible figure of the designer, thus preparing the way one for the other [11]. The methods presented and analyzed in this paper, according to the stages of the design process, for a “conscious” designer, for a “scenario” designer and for a “navigation” designer, can then be considered in different ways: tools for validation the design choices made to provide feedback design or useful to find new paths to explore.

The Eye-tracking, the methods and techniques presented in the paper may be considered as a validation tool for the choices made by the designer: design solutions, defined on the basis of functional, technical, environmental and sensory properties, can be measured and verified in terms of perceived quality [17]. In addition, these techniques and tools can become a means to obtain feedback design, and could be considered a checking tool not only for products, but also for concept, materials and finishes. The analysis can be applied with equal effectiveness on real and virtual prototypes: virtual reality has an interesting rule in order to optimize costs.

Another purpose is intended to identify the users’ desired: based on the analysis performed with Eye-tracking and through techniques such as semantic differential or questionnaires, can be defined the areas of a product that are perceived by the users as strictly connected aspects (sustainability, pleasantness, innovation, etc.). For example, in the case of wines’ packaging, and in particular glass bottles, some markers located in specific areas make sure that the potential purchaser, even without reading any-information written on the labels, is able to build pre-attitudes related to quality, value and appropriateness of the use of the product [7]. Therefore, the identification of elements that can be defined markers, allows designers to understand which areas of a product are related to concepts of perceived quality, and to specific elements, such as functionality, economic value, etc.

The identification of strategic points is a very important input for the designer in order to strengthen the functions of use and the communicative functions of the product. These points can be used to improve or design the products’ affordance in the correct way, [20], allowing the user to understand the functionality in an immediate way; moreover, understanding which areas of a product are observed for certain aspects (strength, hygiene, sustainability) let the designer to make a choice, in order to transmit the right content and values [28], related to colour, shape, materials, surface treatments, etc.

7. CONCLUSIONS
What then is the role of the designer, following the assessments carried out with (some of) the tools and techniques common in the cognitive ergonomics? The designer is not just a simple “acquisition system" of data resulted from research and analysis conducted with Eye-tracking and qualitative techniques; the designer participates in evaluations in order to strengthen the design point of view, the processes data, "translates" and transfers them in the properties.

At the end of the cognitive research, the designer uses the processed data in order to develop design choices, to return on the choices made before or to re-define project requirements.

The designer then has the task of collaborating to analyze the data and to evolve them in design inputs: the information obtained in the sessions are numerous, belonging to different levels (behavioral, emotional and cognitive evaluations) and must be processed in order to create a value hierarchy. It is necessary, in fact, to determine if the resulting data (referring to previous researches), can be used to ratify certain designer insights, if these data disconcert some project elements, and which data therefore need to be investigated further to determine new product requirements.

The cognitive ergonomics, therefore, could be a discipline in support of designer: the designer, after the analysis of data and the evaluation of the information obtained, has to find which are the possible links between the design research and the data obtained from the analysis. Designer can decide to walk through new roads, even if these aren’t the most obvious, by identifying new design paths. The task of the designer therefore is not limited to the design of a product as a result of cognitive ergonomics researches, but also to tend to find solutions to a higher level: define areas and elements in order to communicate specific messages, intuit new approaches to product, whether in terms of shape, colors and materials.

In summary, cognitive ergonomics falls within the methodological, multidisciplinary design approach, and can support designers in the research of solution related to sensory, functionality, sustainability and communicative perception. In fact, through scientific methods, this discipline allows, once the audience has been questioned, to understand and anticipate likings and behaviours: the data resulted from these analysis can then be inserted within the table of needs and exigential hypothesis (basis of the design process).

8. REFERENCES

[1]. A.A.V.V. (2013), Index Environmental and economics Design - Indice Poliedro, Bra, Italy: Università degli Studi di Scienze Gastronomiche


