EXPERIENCE WITH AN EYE TRACKER IN VISUAL COMMUNICATION EVALUATION

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INTRODUCTION

A consumer who purchases a product no longer deals with a local shop keeper, but makes a direct selection from the shelves of a supermarket or from the pages of a catalogue. When he buys gas, he uses a self service gas pump and pays his purchase with a credit card to an automated cashier. As a large part of today's service industry relies less and less upon direct human interaction, there is an increasing need for objective tools to assess the effectiveness of these new communication modalities.

Among the numerous methods available, the analysis of eye movements should furnish the most objective evidence of the centers of interest within a picture (BUSWELL, 1935). The rationale behind this statement is that observers fixate mainly "informative" areas in pictures : a local variation in the spatial frequency content, a pattern irregularity or a "cognitive" irregularity (LOFTUS, 1983). The applications of eye movements analysis have been limited to research laboratories mainly for technical reasons. As the general pattern of eye movements when looking at a picture shows wide individual variations (BUSWELL, 1935), the identification of specific features cannot be based upon the recording from one individual but requires a large group of subjects.

For exemple, if data is to be collected from a group of 60 subjects within one day, no more than 8 minutes are left for each subject's installation, explanations, adaptation, calibration and recording. This cannot be accomplished with most currently available eye movements recording instruments as they require the attachment of some device to the eye or to the head and necessitate time consuming procedures for their adjustment and calibration. Most existing systems are also limited to a qualitative analysis of eye movements scan paths. Specific tools are needed to allow users with a limited knowledge about computers and statistical analysis to develop their own procedures for a quantitative analysis of the results collected from groups of subjects . We present in this paper several solutions which have been implemented and tested in order to overcome these limitations.

BACKGROUND

A steady eye can only catch detailed information within a small visual angle of about 4 degrees, coincident with the fovea where the density of photoreceptors is highest.

The capacity of resolving fine details decreases sharply with eccentricity. It is reduced to about one tenth of its central value at only 12 degrees from the visual axis. Thus, the detailed inspection of large stationary objects involves the succession of rapid eye movements (saccades) which shift the fovea from different areas of interest. Detailed information is only perceived during fixations, i.e. when the eye remains steady for a minimum period of 200 ms (SALTHOUSE et al, 1981). This property results from two physiological mechanisms : visual suppression which inhibits visual perception during the saccades and a latent period of 120 to 180 ms (SOLOMONS, 1978) which precedes each new saccade.

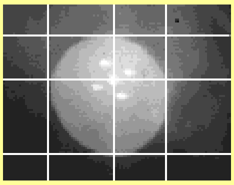
RECORDING EYE MOVEMENTS

Among the numerous methods available for measuring eye movements, the optical methods, including those based on television, are the only ones which do not require the attachment of some device to or near the eye. The differential optical techniques are the only ones to eliminate head movement artifacts without immobilization of the head or fixation of the image sensor to the head. These techniques record the relative movement of two images which move differently during lateral and rotary motions of the eye.

This study uses the position of the corneal reflex relative to the pupil (MERCHANT et al, 1974). An automated identification of a specific pattern of corneal reflex and of the pupil shape (figure 1) is implemented in order to reduce adjustments and calibrations to a minimum (CHARLIER et al, 1985). It also provides a solution to problems such as changes in pupil contrast, partial masking of the pupil by the eye lids or eye lashes, parasitic reflections over the sclera, on the skin and other similar problems.

Figure 1

Image of the eye recorded from the near infrared camera, showing the pupil and the pattern of corneal reflex (5 points) used to determine the gaze direction.



This technique has been experimented in the museum of La Villette in PARIS for 28 months over more than 20,000 subjects. It has been shown to provide reliable results over a wide range of population (BUQUET et al, 1988). In the set up used in this study, the subject is seated, his head resting on a chin rest. The screen where slides are projected covers a visual angle of 40 degrees horizontally and vertically. The optical system used for measuring eye movements is located in the upper region of the visual field, 45 degrees over the central line of vision.

It does not interfere with the visual exploration of the projection screen. A large beam splitter separates visible light from the near infra-red light used by the oculometer. Adjustments are limited to the positioning of the subject's head within the field of view of the oculometer camera. The image of the subject's eye is brought to focus automatically. Calibration of the relationship between the gaze direction and the position of the corneal reflex relative to the pupil is made with 5 references points generated by the slide projector at the center of the screen and in each quadrant, at 10 degrees eccentricity. The results of this calibration are compared to normal values, providing a control of the subject's cooperation.

If the calibration is performed successfully, the computer generates a selected sequence of slides. The eye movements are then sampled 30 times per second and automatically stored on a hard disk. A real time display of eye movements superimposed with the image of the slide collected by a camera allows a direct control of the subject's cooperation.

The installation, calibration and recording of eye movements during the presentation of a sequence of 5 images can be performed within about 5 minutes per subject.

ANALYSIS OF FIXATIONS

The eye movements data recorded from each subject are filtered in order to detect fixations defined as gaze steadiness with a minimum duration A 2 degrees clustering size and 200 ms minimum duration have been used in the present study. These parameters can be changed thanks to an editing menu. The following analysis is performed over groups of subjects. The total scanning area is divided into a 32 by 32 matrix.

The percentage of subjects who have accessed to each element of the matrix after a given amount of time is calculated, assuming that an area of a given extent is accessed around each fixation locus. Several parameters influence these results : the specifications of the filter which detects fixations and the extent of the area which is "grabbed" at each fixation, which depends upon the spatial content of the image and the variations of the visual system sensitivity with eccentricity (DE VALK and EIJKMAN, 1984). In the previous example, this area was assumed to be 4 degrees in diameter.

These parameters can also be changed with an editing menu. As an example, figure 2 shows the areas which have been accessed by more than 50 % of 60 subjects after different periods of time, providing a direct understanding of what information is received by this group. A similar analysis determines the percentage of time spent by the group of subjects in each element of the matrix.

Figure 2

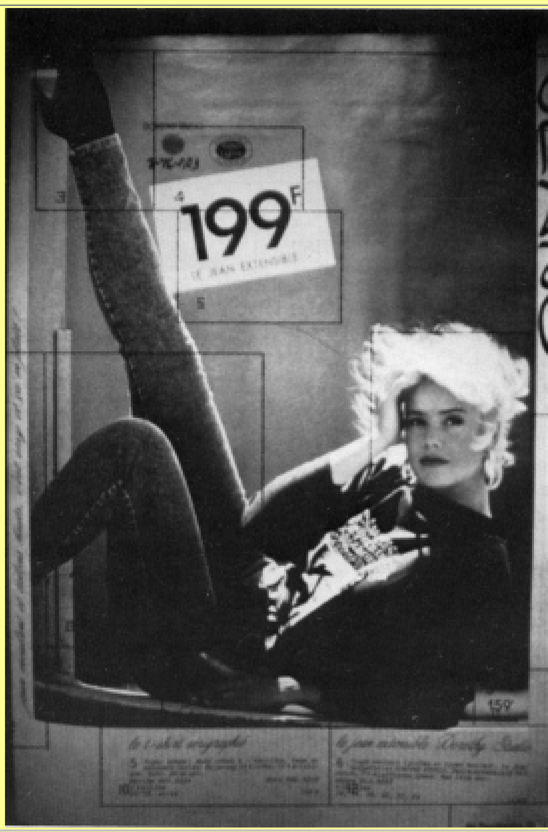
Results from the analysis of fixations. Areas fixated by more than 50 % of the subjects are shown as a white uniform pattern superimposed upon the image. Non fixated areas appear with a vertical grating pattern. Results from a group of 60 subjects obtained after 1, 2, 3, 4, 5 and 6 seconds of presentation.

ANALYSIS OF AREAS OF INTEREST

A second approach is based upon the definition of zones of interest. Each image is described by a number of zones defined as rectangular surfaces with the editing menu. It supposes a knowledge of the fixation clusters which can be obtained during a preliminary analysis of fixations. The scan path from each subject is split into a sequence of fixations occurring in each zone of interest (figure 3).

FIGURE 3

Individual scan path analysis showing a selection of zones of interest



The results obtained from a group of subjects are displayed as histograms assessing the percentage of subjects who have accessed to each zone of interest after a given amount of time (figure 4) or the average percentage of time spent by the group in each zone (figure 5). These analysis can be performed automatically over specific selections of subjects with criteria such as age, profession, sex, housing, etc.

FIGURE 4

Percentage of subjects accessing to different zones of interest as a function of picture presentation time. Results from a group of 60 subjects.

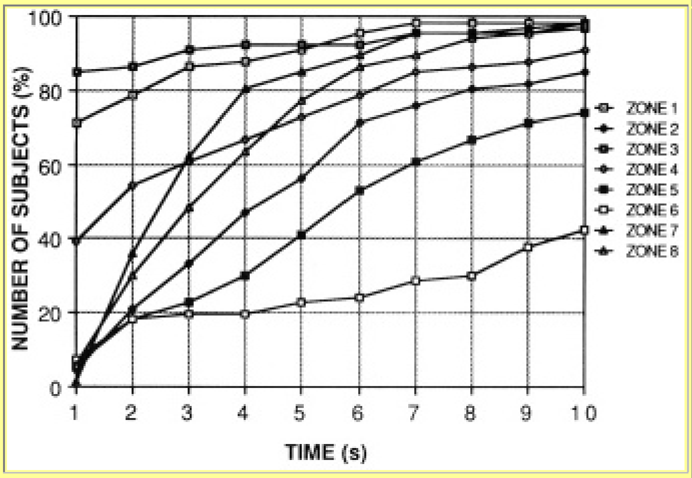
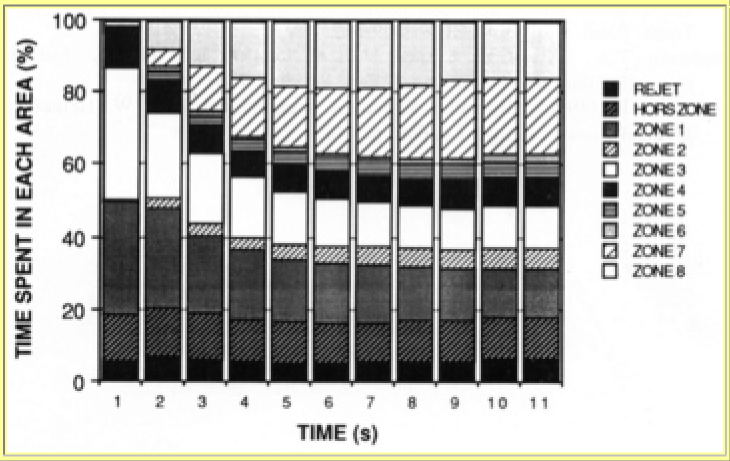


FIGURE 5

Time spent in different zones of interest as a function of picture presentation time. Results from a group of 60 subjects. The zone labelled "REJET" represents periods of time when the eye movement information is not available (eye blinks for instance). The zone labelled "HORS ZONE" includes all fixations out of defined zones.



SYSTEM EVALUATION

The eye movement recording and analysis system which has been described has been used in several advertisement and packaging evaluation studies involving a total of 2800 subjects. Users without initial technical expertise have easily mastered the recording and analysis procedures. They have been able, on a routine basis using interactive editing menus, to develop their own experimental protocols. The analysis of fixations over a 32 x 32 matrix have proved to be useful in the absence of prior knowledge of specific zones of interest. The analysis based upon specific zones of interests is more adapted to the assessment of specific questions such as the direct comparison of different packaging solutions, or the estimation of the amount of time needed before a given percentage of the subjects accesses to a given information

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