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***Research paper***

# The Application of Eye-Tracking in Consumer Behaviour

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**Abstract**

Eye tracking is one of the important technologies that is used to identify individual's interest by recording and analysing his/her eyes' movements. The attention and interest identification can be, then, used in various applications such as marketing and education. In this research, we utilise this technology and apply it in consumer behaviour application namely in retail items display and shelves organising. The gaze points data obtained from eye trackers is analysed and the consumer interest is discussed based on the analysis. From the analyses, it is shown that the human attention could be attracted by adding some irregularity in colour, shape, and size to the scene.

***Keywords:*** *eye tracking, consumer behaviour, marketing, irregularity.*

## 1. Introduction

Eye-tracking studies have witnessed a growing attention and an increasing interest recently due to the technology advancement in the field, where smaller and more efficient devices have been made and more comprehensive software have been developed. As eye trackers can give indication about human interest by providing information about his/her attention through recording gaze locations and extracting fixations and saccades, in addition to, some other measures and information, many applications have been proposed utilising this technology in various fields. Many scholars have suggested applications in marketing and advertising [1], [2], human-computer interaction [3], business [4], aviation [5], linguistic [6], education [7], [8], and medical imaging [9] have been proposed.

In this research, we present a study of how eye trackers can be utilised to identify consumers' interests. The consumers are classified in this research into two categories: aiming-consumer and aimless consumer. In the first category, the consumer knows exactly what he/she is looking for and searches for that object with a pre-knowledge of how it looks like or even its location. The second type is the consumer who observes the retail items aimlessly and does not search for a specific item. Based on this classifying two types of attention studies have been presented: bottom-up attention and top-down attention. In the case of aiming-consumers, top-down attention is applied where the consumer searches for an object he knows its shape, size, or colour. While, in the second case where the user does not know exactly what he/she is searching for, the bottom-up attention is applied.

## 2. Human attention and Visual information processing

Before going deeper in the eye tracking techniques, we need to take a look at how the visual information is processed by the human's brain. The information flows from the human's eyes into the brain where it is processed and useful information is extracted. Since the brain is incapable to process all the amount of received information, the human adapted an approach in which the brain can filter parts of the scene it feels they are not important and focuses only on the other important parts.

Human attention is attracted by different stimuli such as sounds and abrupt change in light or colour [10]. After the human attention gets attracted by a stimulus, it goes through three aspects which are: orienting, filtering, and searching phases. In other words, the human orients his attention to the most abrupt stimulus, filter the unnecessary information, and search for the useful information [10].

Mainly there are two aspects of attention, bottom-up and top-down [11], which were proven to be independent [12]. In the bottom-up attention, the observer has no goal in his mind and does not search for a specific thing; Therefore, his attention is attracted by stimuli, while in the second type the observer knows exactly what he is searching for.

In order to understand the relationship between human interest and attention with the eye movement recording and tracking, we need to understand more the nature of eye's vision. The first feature obtained from eye tracking is the gaze points, which are the point where the observer looks. The aggregate of the gaze points is known as a fixation, from which one can inform the observer's interest. The fast movement of the eye from one fixation to another is known as saccade. Saccades usually contain information that is unimportant to the observer. Region of interest (ROI) is the region which contains the fixation points. It is possible to have more than one ROI in a scene. The eye movement from one ROI to another is known as a transition. The sequence of eyes' movement among fixations is called a scanpath, which gives information about the search behaviour of the user [13].

## 3. Eye trackers

Eye trackers are devices that can follow and record the eye movement and extract information from this movement. This includes gaze point's coordinates (x and y), span time, fixation, saccades, and scanpaths. Some eye trackers provide information about the pupil size and eye blinking [14], which can be used in human attention and interest identification. For example, the longer time the human spends looking at a point (gaze span time), the more important that point to the user is. Same thing is applicable to the size of pupil, number of gaze points in a fixation point, the more fixations in a region of interest, the more important the region is. In contrast, the large number of saccades indicates that the region is not important or not of interest to the user.

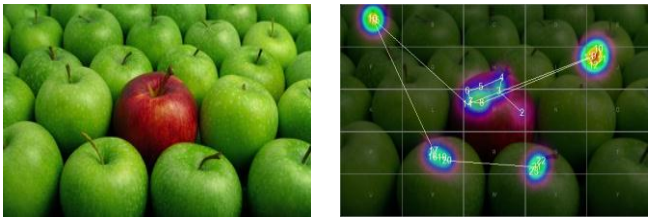
Table **1** shows sample of the row data that can be obtained from the eye trackers using OGAMA software with eye tracker to analyse the data [15]. The fixations and the regions of interest are visualised using what is known as heatmap as shown in Fig. 1.

## 4. Capturing Human Visual Attention

Human visual attention is stimulated by several ways depending on the aspect whether bottom-up aspect or top-down aspect. As it was mentioned earlier, in the bottom up aspect, attention can be attracted if the human is observing objects or goods aimlessly. In such cases, the human attention can be stimulated by the low level features of the scene such as colour, texture and lighting. It was proven that the human focusses aimlessly at the centre of the scene as the first location he looks at. Then he moves his eyes randomly in various locations in the image. When the observer's attention is stimulated by a location in the scene, he orients his vision toward that location, after that his brain filters the unnecessary information and searches for the information it feels that are of interest.

**Table 1:** Data obtained from Eye-Tracker using OGAMA software

| ID | Subject Name | Age | Sex | Hande-dness | Start Time | Length | PosX | PosY |
|---|---|---|---|---|---|---|---|---|
| 232982 | ab | 42 | female | right | 0 | 316444 | 685.2637 | 435.6329 |
| 232983 | ab | 42 | female | right | 399680 | 49994 | 722.6857 | 499.8539 |
| 232984 | ab | 42 | female | right | 483044 | 133227 | 723.3042 | 611.8802 |
| 232985 | ab | 42 | female | right | 816108 | 99851 | 758.687 | 628.2949 |
| 232986 | ab | 42 | female | right | 965956 | 216462 | 715.2978 | 627.4435 |
| 232987 | ab | 42 | female | right | 1232412 | 116606 | 488.3558 | 527.9681 |
| 232988 | ab | 42 | female | right | 1598726 | 49990 | 448.8627 | 480.2964 |
| 232989 | ab | 42 | female | right | 1665337 | 849359 | 477.5772 | 485.7603 |
| 232990 | ab | 42 | female | right | 2564688 | 183093 | 747.9918 | 569.4695 |



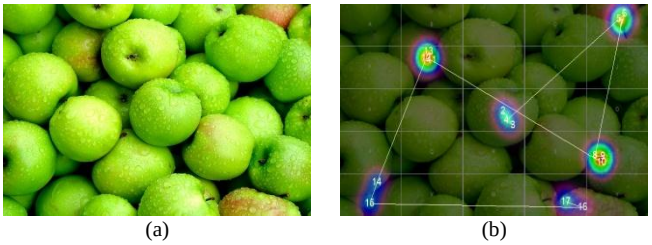
(a) (b)

**Fig. 1:** Image with salient object in the centre; (a) original image, (b) scanpath and heatmap representation for the fixations.

Irregularity in colours, lighting, shape, size, or texture can be used to stimulate the observer's attention [16], [17]. For example, in the image shown in Fig. 1, it is clear that the observer has focussed on the centre of the image for two reasons; firstly, the observer mostly starts observation from the centre of the scene and the second reason is the irregularity of the colour of the object in the centre as compare to the surrounding regions.

In order to test the effect of irregularity, the same experiment has been repeated with an image that does not contain any salient object or irregular region in the centre as shown in Fig. 2.

From comparing the heat maps shown in Fig. 1. (b) and Fig. 2. (b), one can notice that in the first image the centre contains more gaze points and the fixation is wider and heater than the second image. At the same time, it is clear that there is some kind of colour irregularity at the top-right corner where the observer has fixated his eyes.



(a) (b)

**Fig. 2**: Image with no salient object in the centre; (a) original image, (b) Scanpath and heatmap representation for the fixations.

## 5. Experimental Result

The experiment was applied to a set of images consisting of 60 images of stores' shelves and 30 participants. In the experiment, each image is displayed for 5 seconds during which the participant is requested to look at the image and the eye tracker records information about the eye gaze points, which is analysed to find the fixation and saccades, and consequently, the heat map is drawn.
The dataset was designed such that three types of irregularity are included intentionally. The three types of irregularity are: colour, shape, and size irregularity. Fig. 3 shows sample of the heatmaps obtained from the experiment.
Since different users may look at different locations in the scene, the average of the gaze points' information for all users has been calculated and used to identify the average fixations. Thresholding single gaze point has been applied to delete the falsely recorded gaze points. The saccades have been calculated by considering the regions where no gaze points have been identified.

**Fig. 3:** Sample of the heatmaps extracted from the experiment's result.

Fig. 4. shows visual representation of the obtained results. In the experiment we considered three main measures which are: (1) number of participants (participants), (2) average number of fixations (fixations), which is calculated for all participants, and (3) total number of fixations for all participants (total), which is calculated by multiplying number of participants by the average number of fixations. The measures have been scaled by calculating the percentage of each measure by dividing the values by the sum of the values.

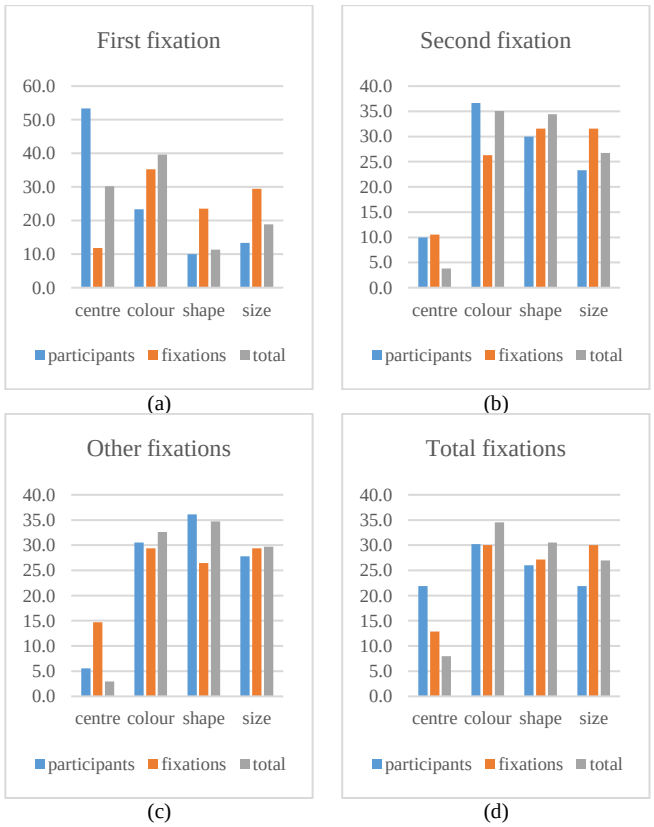



**Fig. 4.** Number of participants, average number of fixations, and total number of fixations, (a) first fixation, (b) second fixation, (c) other fixations, and (d) total number of fixations.

In the experiment we had to consider the first fixation as humans usually look aimlessly at the centre of the scene at the beginning. Therefore, from (a) it is clear that most of the participants started looking at the centre. Less number of the participants attracted by colour irregularity and the least attraction was by the size irregularity. The second fixation is where the human moves his eyes from the first aimless fixation. It is more important than the first fixation point as it mostly represents the first point that is obtained from stimulating the human attention.

Fig. 4. (d) shows the total number of fixations classified based on four criteria, which are, centre, irregularity of colour, irregularity of shape, and irregularity of size. It is clear from the figure that the irregularity in colours attracted more users and more fixations recorded than others. The second features that was identified which attracts the human attention is the size and finally the shape.

## 6. Conclusions

This research presented a brief description of eye-tracking technique and the information obtained from applying this technique on consumer behaviour in terms of retail items displaying. It was found that adding some irregularity to the arrangement of goods on the shelves may attract human attention. This can be used to direct the consumer attention to a specific location in the scene.
The experiment showed that irregularity in colour which can be achieved by adding salient colour in a regular region is the most attracting approach to stimulate human attention. Shape irregularity comes second and size comes third in attracting human attention.

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