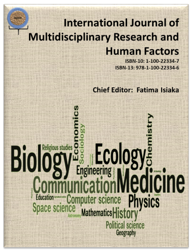

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Analytical Constraints of Basic Eye Movement By Modelling Users' Cognition To E-Commerce Webpages

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Abstract

The purpose of analytics of user experience (UX) is to determine how users find and consume web content, also how they understand the cognitive processes and everyday nuances users go through when looking for and consuming content online in addition to important architecting the ideal experience for future design decisions. This paper discusses the concept in human cognition and real-time business webpage used as stimuli with a list of properties on which design methods would be designed for a composite system. The web contents are assembled to integrate user cognition based on the users' saccade and fixation of eye movement. A simple logistic regression model was developed as the inference engine for each data model and predictions were made on a classified set of pupil dilation and constriction. Error test was conducted ; the fixation duration and mapped fixation on the X-coordinate of the Cartesian plane has the least error for both the test and training set. This indicates the reliability of using fixation index and duration for predictions of eye movement metrics.

Keywords : User experience, Cogitive psychology, Model prediction, Error computation, Fixation duration, Fixation index, Saccade

1 Introduction

When the emphasis is based on user cognitive psychology, the user experience experts might want to focus on the process the people process information. The process in this cognitive psychology looks at how the user processes information they sometimes receive and the method of how the treatment of these pieces of information contributes to their ever-present responses. The most interest is played on what is occurring within the users' minds that is connected to the stimulus as the *input* and the response as the output. To achieve an important purpose for UX experimental study it is most interesting for a designer to carefully study the internal processes that include perception, thinking, attention, memory, and language of the subjects' cognitive faculties. The research questions here are : What do the users store and process certain information ?, What and how do the users receive information from basic stimuli ?

What errors in their cognitive faculties lead to emotional distress and steady negative behaviour ? and finally, How will a breakdown in the users' perception of how they few these content results in errors in their cognitive faculty ? For user experience to be advanced, cognitive and perceptual user emotion should be considered through the basic parameters of eye movement of a visual interface. User interaction and Cognitive psychology. To explore the relationship between eye movement parameters a simple modelling technique is utilised between the variables and these are assessed synchronously through a simple covariance analysis that would translate the cognition and perception of each unique user. The theoretical perspective is also investigated in cognitive psychology as a branch of science to understand user experience and perception.

2 Literature Review

The terminology in "cognitive psychology" was first introduced in late 1967 by [*Neisser [28, 29, 30], Neisser and Kerr [31]*], and since then, a lot of inventions have emerged from this study. This has benefited the field of psychology and so many other related disciplines such as education, design, business, and Human-computer interaction. The concept in cognitive psychology is one of the major fields that has contributed to Human-computer interaction (HCI) research by application of its principles to the understanding and development of models that explain the predictions of human performance [*Davies et al. [5], Green et al. [9, 10]*]. The major components in cognitive psychology are similar to those found in design and how it also deals with problems that are focused on goal-oriented and problem-focused design. The problem is first identified by the user which is then formulated to a specific goal for a self-purposed design frame.

The human memory limitations, decision-making, attention, and perception are taken into account based on the cognitive science guidelines, that is when designing an operative graphical user interface. Numerous research principles have been proposed [*Blasi et al. [1], Fernandes et al. [6], Ho and Griffiths [11], Hovhannisyan [12], Ince et al. [14], Kelly and De Block [15], Lin [21], Mazzuca and Santarelli [24], McGann [25], Neufeld and Shanahan [32]*], with cues from five (5) different aspects of cognitive load theory, retention theory, gestalt law, and schema theory. All of these theorems proposed similar concepts and have individual advantages and defaults but there are no specific principles that can specifically give a concrete definition to standard building or design of a perfect and instinctive graphical user interface. In the integration of human cognition and user experience, questions like what comprises an intuitive interface are often asked and most designers tend to comprehend the cognitive load and its barriers before they are capable of designing advanced prototypical GUI than the previous ones.

The semantic issue of whether or not a user experience can be designed is a separate issue and user interface designers are more aware of what each user's experience requirements are based on individual uniqueness. The potentiality of every user experience to be unique depends on the unique cognition of each individual. There are also psychological principles that are related to this cognitive response of users which can raise the level of designs for each user experience. Additionally, a simple cognitive barrier presents a difficult experience to a person when performing some basic actions that are necessary to achieve a certain goal. These barriers are temporary and can be overcome by information processing. They are also complex cognitive barriers such as if a user has difficulty filling out an extensive form format which contains several complex fields with steps for omission and would require a lot of cognitive load for the user. This can be replaced by shorter steps that impose shorter and lower cognitive barriers than the longer and more difficult steps. It would be also recommended to decrease inconvenient difficult steps and the users will be more inclined to complete difficult steps if the comprehension of redundant procedures for form completion is minimised.

The eye movements are studied extensively in this particular area and the cognitive load or memory of the user is achieved in the shortest time frame i.e. the less the user has to think about what is needed to achieve a certain goal, the more likely the user will achieve it a hundred [*Cook [4], Ghemawat et al. [7], Glasersfeld [8], Hu et al. [13], Kirsh [16], Lazar et al. [20], McGann [26], Rader and Gray [34]*]. In cognitive declination, the user faces a large number of items they have to choose from, and the more items they have on the visual field, the harder and longer they make choices. The natural decision for pivot points for learning is to assume that users manipulate the saliency of decision-making for elements and this is a key to ensuring users are rapidly familiar with the contents and can make swift choices that are observed from their eye movement. The proceeding sections discuss methods and results obtained from eye movement data components for performance and error detection.

An eye authentication software or tool is a form of the embedded module that includes an image data extraction front-end unit for determining the main concentric circle of the image of the eye as an integrating circle ; a pupil radius detection unit which is used for detecting the integrated value of the integrating circle in stepwise order. This paper dealt with this

3 Method

To investigate the interrelationship between eye movement parameters a simple modelling technique is utilised between the variables and these are assessed synchronously through a simple covariance analysis [*Bres-*

low [2], Koch et al. [17], Laird and Olivier [19], Littell et al. [22], MacCallum et al. [23], Porter and Raudenbush [33], Wickizer [35]] (Equation 1) where X is the input matrix or vector containing eye movement parameters (x_n^T). This technique examines the structure of the inter-relationship which is expressed as a series of regressional equations hypothesized by mediating the effect to produce direct and indirect effects (Equation 2). There is an assumption of zero-mean samples both giving a formulation of covariance estimates. The individual samples are used for the eye movement data matrix with the rows having the vector matrix containing the entries of parameters.

$$X = \begin{bmatrix} x_1^T \\ x_2^T \\ \vdots \\ x_n^T \end{bmatrix} \tag{1}$$

with a covariance estimate given as $\epsilon = \frac{1}{m-1} X^T X$ is equivalent to :

$$\frac{1}{m-1}[x_1 x_2 ... x_n] = \epsilon = \frac{1}{m-1} \sum_{i-1}^{n} (x_i x^T). \tag{2}$$

The resultant covariance eye movement matrix is given as (Equation 3). This requires a population variance (Equation 4 and a population covariance (Equation 5). And predictions can be made from the group representation of this matrix for each eye movement parameter.

$$X = \begin{bmatrix} Var(x_i) & \dots\dots & Cov(x_{ii} x_i) \\ \vdots & & \vdots \\ Cov(x_{ii} x_i) & \dots\dots & Var(x_i) \end{bmatrix} \tag{3}$$

where,

$$Var(x) = \frac{\sum_1^n (x_i - \delta)^2}{m} \tag{4}$$

$$Cov(x_{ii} x_i) = \frac{\sum_1^n (x_i - \delta_x)(y_i - \delta_y)}{n} \tag{5}$$

The basic eye movement parameters that can be projected include the gaze point (Fixation point), time of fixation (TFF), fixation duration (FD), fixation index (mapped fixation in both the X and Y Cartesian plane, assuming we portray the visual interphase as a 2-D plane), number of fixations (NF) and the gaze accuracy. These attributes are modelled in this paper using Equation 2. Here$p$ is the predicted user parameter from eye movement where a performance error can be derived, the resultant error rate is given as Equation 7.

$$p = \frac{e^{a+bX}}{1 + e^{a+bX}} \tag{6}$$

$$error = 1 - \frac{1}{1 + e^{-(a+bX)}} \tag{7}$$

3.1 Task

From a local setting for the experimental setup, a group of participants (50) were recruited to take part in the study. The participant signed a consent form which confirms that agreement and commitment to the experiment. They were simply asked to interact with a dynamic business webpage (www.konga.com) placed on a visual screen in front of them. The rationale for applying a business webpage is that it contains dynamic web widgets and displays many options while theoretically evading the 7 ± 2 rule [Cao et al. [3], Koehler [18], Mohanty et al. [27]], different product contents are organised attractively in sections in a consumer-centred display manner (Figure 1), with suggestions based on some user history and auto-suggest list (ASL). The users or participants have to choose an item of their choice after observing the list of products on display while the eye movement was recorded from the local eye tracker where the webpage stimulus is placed (Figure 2), some of these containers are placed in a carousel fashion.From a local setting for the experimental setup, a group of participants (50) were recruited to take part in the study. The participant signed a consent form which confirms that agreement and commitment to the experiment. They were simply asked to interact with a dynamic business webpage (www.konga.com) placed on a visual screen in front of them. The rationale for applying a business webpage is that it contains dynamic web widgets and displays many options while theoretically evading the 7 ± 2 rule [Cao et al. [3], Porter and Raudenbush [33]], different product contents are organised attractively in sections in a consumer-centered display manner (Figure 1), with suggestions based on some user history and auto-suggest list (ASL). The users or participants had to choose an item of their choice after observing the list of products on display while the eye movement was recorded from the local eye tracker where the webpage stimulus is placed (Figure 2), some of these containers are placed in a carousel fashion.

Before designing the task, the assumption is noted that the user experience is how users find and consume web content in business webpages, and understanding their cognitive processes and nuances when looking for these contents is most paramount in architecting and designing an ideal business webpage which can be applied in general terms in designing a set of the convention that could support user ideal web experience and behaviour.

4 Result

The user-generated data is simulated to 1,500 samples and divided into test and training sets ; each sample and aggregate is used to represent the participant's response and cognitive load which is classified into average, relaxed, stress, and neutral mood. Figure 2 shows an aggregate from the training data, with the eye movement

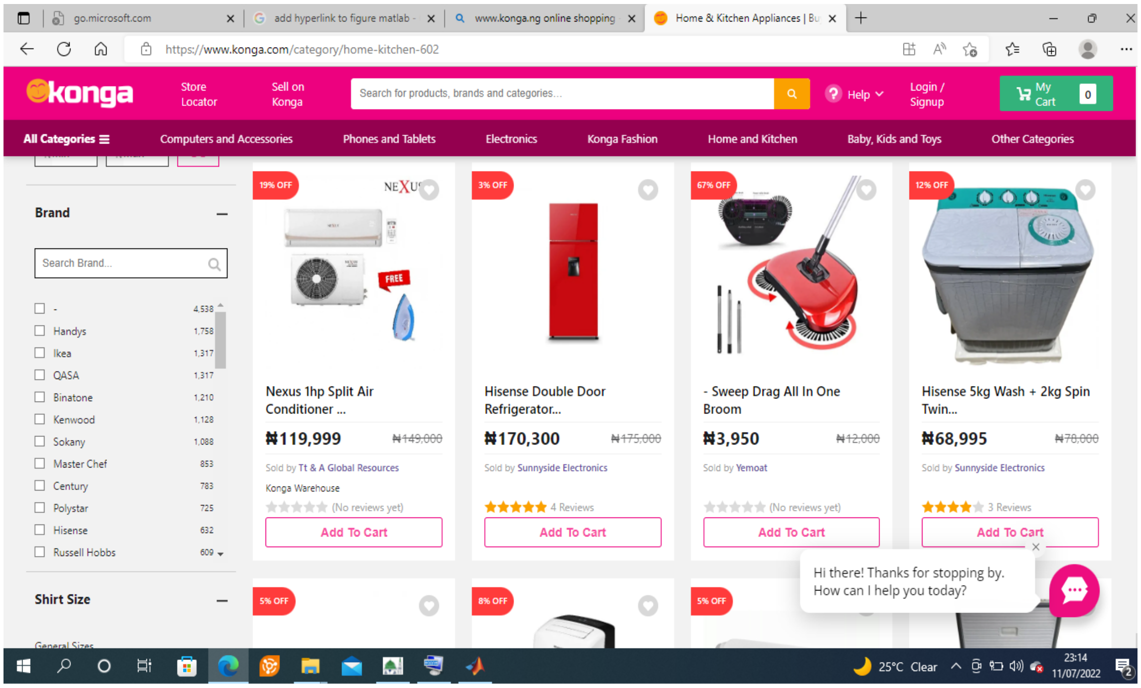

FIGURE 1 – Business webpage used as stimuli

of the participants. This is mostly based on short-term time intervals for training and test sets, the eye movements were mostly on the task-allocated area with the contents spread in attractive segments. The "average" mood of the participants is expressed on the upper area of interest (AOI) and this is the mood expressed than the other cognitive mood (Figure 2a), while the "relaxed" mood is expressed at the upper segment of the webpage from the participants than the other cognitive response (Figure 2b).

The error in performance for all data models (test and training set) of the eye movement parameters was computed using Equation 7. The least error appeared for fixation duration and Mapped fixation index X-axis of the webpage. Each error is also based on the least mean square for generalisation to obtain the performance of accuracy ; the minimum error is deducted from a single quantity of one value. And this proves the authenticity of the saccade and fixation index

5 Conclusion

The human working memory is very limited and users are more likely to have a better experience and more engagement on a simple site than that of one having a broad and deep web widgets structure that might ender rapid cognitive regression. This paper attempts to investigate the perspective modelling of user cognition based on the basic constraints of eye movement, the aim is to determine how the users feel by simply observing their eye movements in short-term time intervals. The stimulus is a simple business web page with a list of properties designed for the sole purpose of data model prediction with attributes as the parameters of eye movement on the segmented webpage. A simple logistic regression model was developed as the inference engine for each data model and predictions were made on a classified set of pupil dilation and constriction. Error test was conducted ; the fixation duration and mapped fixation on X-coordinated of the Cartesian plane has the least error for both the test and training set. This indicates the reliability of using fixation index and duration for predictions of eye movement metrics. The future perspective of the work is to design an experimental setup that can be integrated in real-time into an analytics tool and be able to visualise the eye movement of the participants compared to predetermined output to real-time results. This would help to compare the predictive accuracy of the data model and the authenticity of using eye movement behaviour data to predict users' moods.

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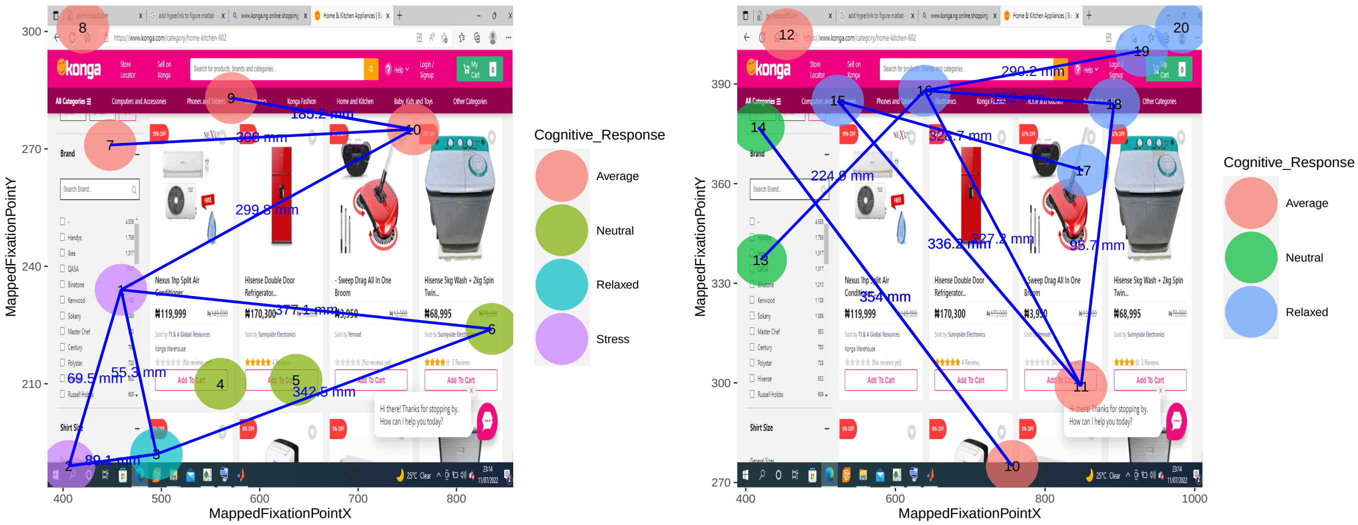
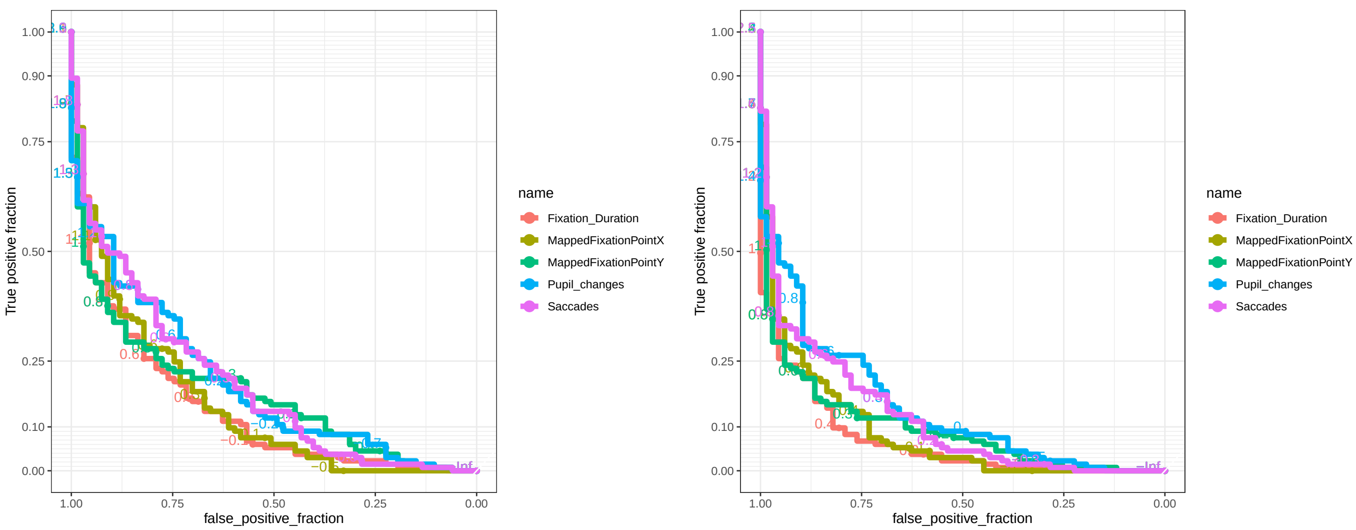


(a) Aggregate of Test set

(b) Aggregate of Training set

FIGURE 2 – An Aggregate of users' eye movement on a business webpage with predicted cognitive response



(a) Error in Test set

(b) Errorin Training set

FIGURE 3 – Error computer from parameters of users' eye movement based on their cognitive response

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