Indexing of UI using NeuroMarketing techniques

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***Abstract*— User Interfaces of websites are usually evaluated using subjective means such as self-reporting, etc. However, such methods are not always reliable. Here, we use several objective measures of User Experience to judge the User Interface of Various web pages.**

***Keywords*— User Interface; NeuroMarketing; Computational Neuroscience; Eye-tracking; EEG**

I. INTRODUCTION

In this age of technology, humans are spending increasingly more time in front of computers and mobile phones. We are always surrounded by technology and browse through multiple web pages per minute. With such a vast number of options available, and relatively little time and attention paid to one particular activity, the design of interfaces is crucial. If the design is poor, the user will not be attracted towards a given app/website because he/she will have several other alternatives and also because our attention spans are reducing every day, so people do not enjoy using technology that requires a lot of effort to use.

One way of judging a platform's user interface is by using subjective methods such as self-reporting. However, results from these methods may be unreliable. Instead, we can use measures of actual behaviour such as cognitive load, clickstream data, etc.

II. METHODS

A. Stimuli and Task

The design for our experiment was inspired by [1]. We compared the UI of websites of several academic institutions. The participant was required to perform one of two possible tasks:

1) Before the task begins, the participant is shown the name and department of a Professor in the institute. The participant lands at the homepage of the institute's website. Without using any search functions, the participant has to reach the Professor's profile on the website.

2) Before the task begins, the participant is shown the name of a publication. When the task begins, the participant lands at the personal webpage of a Professor. Without using any search functions, the participant is required to locate the given publication on the Professor's website.

Details about the exact stimuli are present in the Appendix.

Figure 1: Screenshots of an academic website at different stages during the task.

B. Data Recording

EEG: We used a 64-channel EEG recorder having 2,500 Hz sampling rate. The layout of the cap was according to the extended 10/20 system.

Eye Tracking: Eye tracking data was collected using Tobii Pro Glasses 2.

Clickstream: We used screen recorder to record the activity of the participants. We then manually computed the statistics for the participants. It was easier to perform the computations manually because the number of participants was small.

Task Load Index: We collected participants' responses to the questions in NASA-TLX.

C. Participants

All participants were students at IIT Delhi. Participation was completely voluntary and no compensation was given. There were 2 participants for EEG and Eye-tracking, 6 participants whose clickstream data was recorded, and 4 participants to whom the NASA-TLX was administered.

III. DATA PRE-PROCESSING

A. EEG

All the pre-processing was done in MATLAB. Some steps were done using EEGLAB toolbox. The following steps were performed:

1) Manual removal of artifacts by inspection
2) Band-pass filtering between 0.5-30 Hz
3) Re-referencing
4) Artifact removal using Independent Component Analysis
5) Baseline removal

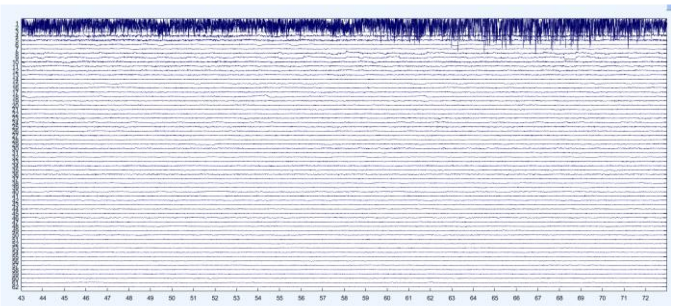

Figure 2: Activations of ICA components.

Figure 3: Spectral maps of ICA components.

From Figure 2, we can see that, the first component contains a large amount of noise and is therefore removed during the pre-processing phase. From Figure 3, we can see that components such as IC3, IC8, etc. contain artifacts from eyes, muscles, etc. Hence, we can remove these components. However, we did not remove components like IC20 because they may potentially contain useful signal.

B. *Eye-tracking*

The data was processed using Tobii pro lab software. We created snapshots and selected regions of interest. Subsequently, we selected times of interest and mapped fixation data from selected time of interest to the snapshot.

IV. MEASURES

A. *Cognitive Load using EEG*

Cognitive load refers to the load on the mind due to the cognitive demands of a task. In the context of UI, it is concerned with the design of interfaces that efficiently use users' processing mechanisms.

For this project, we followed [2] and used Alpha band activity in frontal and temporal lobes as a measure of cognitive load. Higher the cognitive load, higher is the power in Alpha band.

We identified 7 electrodes having significant activity in the alpha band using spectral plots (such as the one shown in Fig. 4). After this, we used `spectopo()` function from EEGLAB to compute spectral power in the alpha band.

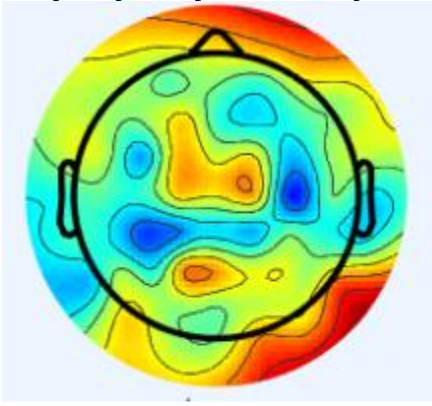

Figure 4: Spectral map for frequency = 9 Hz

B. *Eye Tracking:*

We have considered following parameters as our comparison metrics:

a. Fixation : average fixation duration and Total fixation count at a page as our comparison metrics. Intuitively, Website with better User-Interface should have lesser fixation duration, and fixation count should depend on position/location of relevant information on the UI.

b. GazePlot: Intuitively, this should be much spread for improper positioning of different elements in the website and it will be less dense for good User Interface.

We will try to verify these intuitive analysis using Eye-tracking data.

C. *Clickstream:*

a. Number of excess clicks: Number of clicks used by the participant to complete the task - optimal number of clicks to complete the task.

b. Redundant page visits: visiting the same page more than once.

D. NASA-TLX: the test has 6 measures of task load, of which we used 3 -- mental load, effort, frustration. Participants responded by adjusting a slider having minimum value 1 and maximum value 21 (see Fig 5).

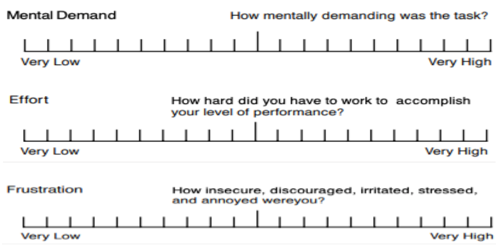

Figure 5: Questions in NASA-TLX.

V. RESULTS

A. *EEG*

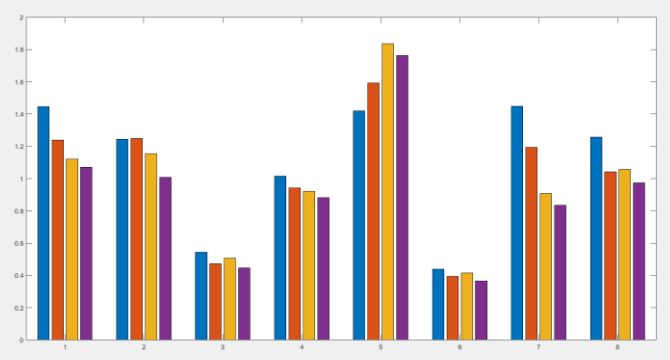

Figure 6: Alpha band power for 4 websites (each represented by a different color) across 7 electrodes. (blue: Tokyo; red: Italy; yellow: Stanford)

From Fig. 6, it can be seen that for all electrodes except one, there is a clear trend in the Alpha band power: Tokyo > Italy > Stanford. Hence, cognitive load for these websites also follows the same order.

B. Eye tracking

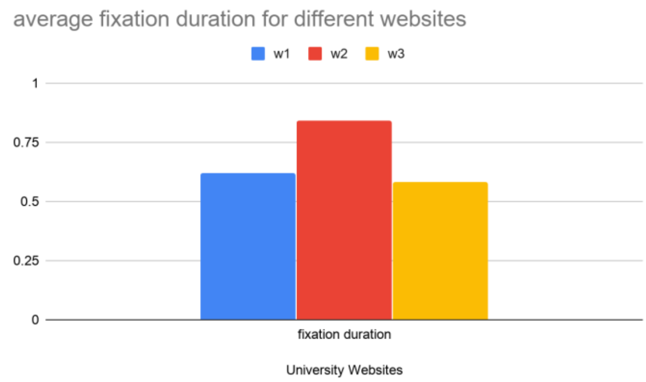

Figure 7: Average fixation duration on the homepage of different websites. (w1: Tokyo; w2: Italy; w3: Stanford)

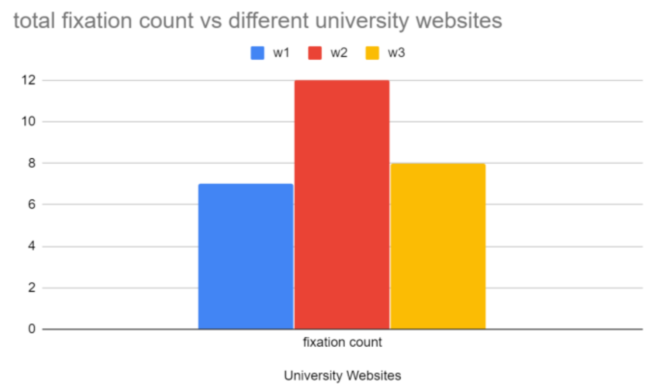

Figure 8: Total fixation Count on the homepage of different websites. (w1: Tokyo; w2: Italy; w3: Stanford)

From Fig. 7, it can be seen that website2 (Torino university) has the highest fixation duration. This tells about the bad design of UI elements. Possible reasons may be font size and spacing between texts. While stanford University has the lowest fixation duration, reflecting its best UI amongst all.

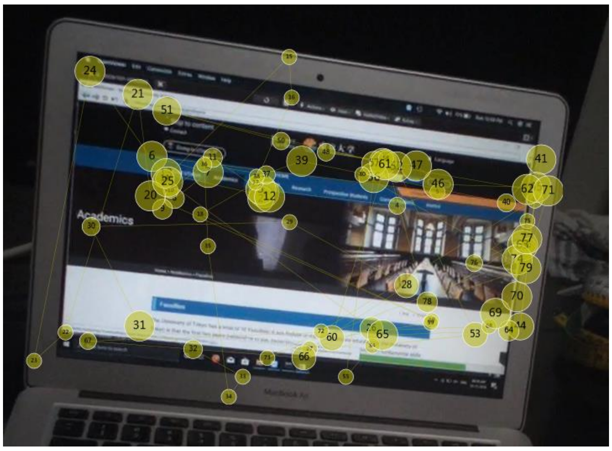

Figure 9: Gaze plot for University of Tokyo homepage

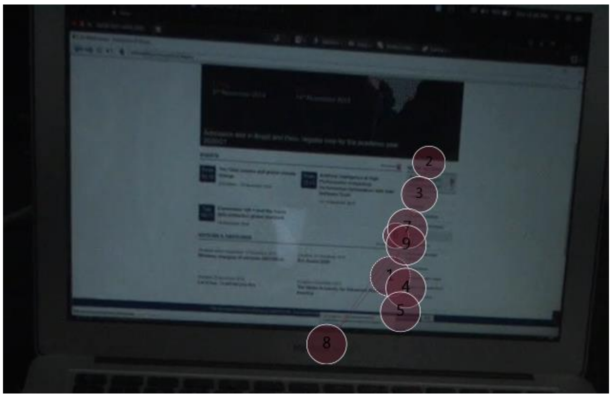

Figure 10: Gaze plot for Politecnico di Torino homepage

Figure 11: Gaze plot for Stanford University homepage

Comparing above Gaze Plots, We can observe that Gaze Plot of Website1 (Tokyo University) is Sparse. While website2 (Torino University) has compact and dense Gaze Plot and Stanford university has balanced plot. This shows that

Stanford has better UI Design and proper positioning of UI elements, website1 lacks in proper placing and website2 lacks in UI elements Design e.g. Text Font or spacing.

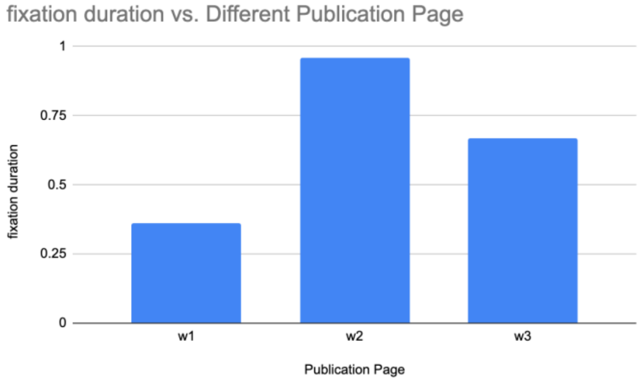

Figure 12: Average fixation duration on the publications page of faculty members

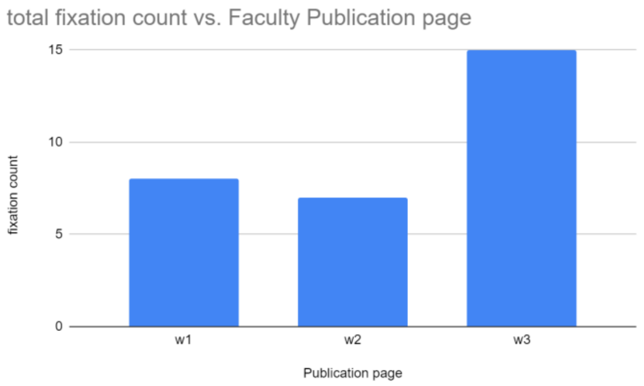

Figure 13: Total fixation Count on the publications page of faculty members

These Plots also shows similar trends.

Figure 14: Screenshot of publication page of different faculties.

Website1: Minimum Fixation Duration and moderate fixation count. This is because of highlighting of important text. on the webPage.

Website2: Highest Fixation duration because all text was in small font size and same font type and color.

Website3: Highest Fixation count and slightly higher fixation duration because of lot of highlighting.

C. Clickstream

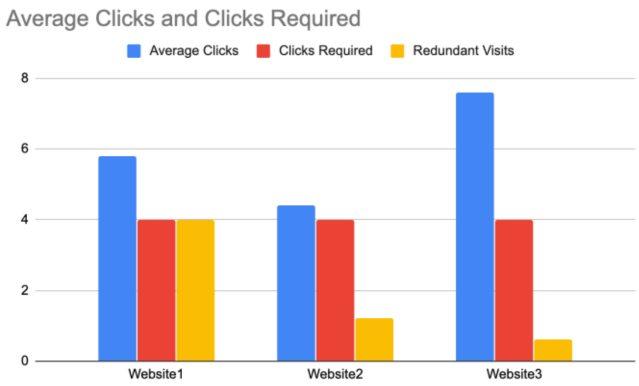

Figure 15: Clickstream data (w1: Tokyo; w2: Italy; w3: Stanford)

Clickstream data is also able to give insights about the *organization* and *hierarchy* of the website as a whole. From Fig. 14, we can see that Stanford has the highest number of clicks. This is because their homepage has a link named "faculty" which does not lead to the webpage desired in the task. For the given task, this link misled the participants so while the UI of the homepage was good, participants wrongly clicked this link and had to navigate further only to find they were on the wrong path. Similarly, UTokyo's website does not directly take users to the department homepage when the tab "Department of Pharmaceutical Sciences" is clicked. Instead, it takes participants to an information page where a link to the department website is provided. However, due to the poor placement of this link, most participants do not notice it and keep going back and fro between the homepage and this information page -- increasing the number of redundant visits to the same page. This is also evident in Figure 14, where UTokyo has a significantly high number of redundant visits.

D. Task Load Index.

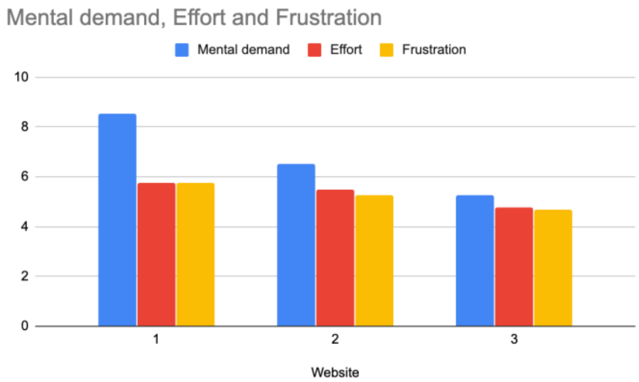

Fig. 16: Task Load Index results (w1: Tokyo; w2: Italy; w3: Stanford)

It is clear from Fig. 15 that for all the three measures of cognitive load considered here, the load follows the trend 1 > 2 > 3. This is similar to the trend followed by EEG cognitive load computation.

VI. Discussion

All the analysis done above using different methods shows the similar trend that strengthens our UI comparison. From Fig. 6, we can see that the trend followed by cognitive load (Tokyo > Italy > Stanford) is also followed by NASA-TLX (Fig. 15). Hence, it can be said that assessing cognitive load using EEG is a good way of judging the user interface of a website and is in correspondence with subjective measures of load assessment.

While EEG data gives us abstract analysis, we can compare fine details using eye tracking. Clickstream data was also successfully able to give insights about the hierarchy and organisation of the website as a whole.

Among the universities websites, website 3 has the best ui design but still mental load was similar to website 2 because of positioning of important links. Same thing had great impact on website 1.

Among the faculty webpages, website 1 was best due to better highlighting, and website 3 has a lot of highlighting that created confusion.

Our suggestions for better UI, that we could infer with this data and analysis are better positioning of UI elements (e.g clubbing of relevant points), maintaining text to image ratio and font size and highlighting of different parts.

Appendix

Tasks for locating faculty member starting from homepage:

1) S. Murata, Department of Pharmaceutical Sciences, University of Tokyo.
2) Larry Ragent, Department of Music, Stanford University.
3) Carmagnola Irene, Department of Mechanical and Aerospace Engineering, Politecnico di Torino

Tasks for locating publication starting from a faculty member's profile:

1) Publication: Coordinated Multicasting with Opportunistic User Selection in Multicell Wireless Systems -- Prof. Yao-Win Peter Hong (NTHU Taiwan)
2) Publication: On the role of wind and tide in generating variability of Pearl River plume during summer in a coupled wide estuary and shelf system -- Prof. Jianping Gan (HKUST Hong Kong)
3) Publication: Understanding In-Video Dropouts and Interaction Peaks in Online Lecture Videos -- Prof. Juho Kim (KAIST South Korea)

References

[1] Peter Schmutz, Silvia Heinz, Yolanda Métrailler, and Klaus Opwis, "Cognitive Load in eCommerce Applications—Measurement and Effects on User Satisfaction," Advances in Human-Computer Interaction, vol. 2009, Article ID 121494, 9 pages, 2009. https://doi.org/10.1155/2009/121494.

[2] Kumar, Naveen, and Jyoti Kumar. "Measurement of cognitive load in HCI systems using EEG power spectrum: an experimental study." Procedia Computer Science 84 (2016): 70-78.