Objective

The objective of this research project is to utilize an online assessment and its associated eye-tracking data to understand whether distractions, and more particularly those that have an impact on an individual’s concentration while completing a task. In this phase of the project, the goal is to develop and apply an assessment which features questions from a computer science technical question database, and where audio stimuli are introduced as distractions for the user. This assessment was administered through an online portal that utilizes a webcam and eye-tracking capabilities. Data from subjects’ performance on this assessment and the eye-tracking data was used to create Linear Regression, Polynomial Regression, and k-means clustering models that reflect the behavior of test subjects based on the collected data (performance, time spent per question, seconds, and eye movements). These models are meant to clarify the effect of patterned versus randomly timed audio distractions on their ability to provide more information regarding the impact on the test subjects’ performance through factors like overall scores and time spent per question (seconds).

Approach

An exploratory study was defined. The study included the completion of an online assessment through the React framework using questions from a computer science technical question database while an eye-tracking device and performance on the assessment were collected. In order to collect eye-tracking data, the user was asked to turn on the “recording” feature on the GazeRecorder application before they began their assessment. The webcam is turned on for the GazeRecorder tracking software, and a recording feature is included in the assessment. In order to remove any bias regarding the order of the tests, each participant was given a random order in which to take the assessments.

Method

The study was completed through an online assessment tool, React framework, with the GazeRecorder eye-tracking software.

1. Data Collection

13 subjects (6 females; 6 males, age = 19.33 years, age SD = 1.07 years) completed the assessment through the GazeRecorder software. Each subject completed the three test conditions: control (no audio stimuli), randomly-timed audio distractions, and patterned-timed audio distractions. The data collected included performance on the tests (scores), time spent on each test, and eye-tracking data.

2. Data Pre-Processing

It is vital to preprocess the data so that the formatting and quality are appropriate for use in the regression and prediction models. A python data cleaning script was used to either remove or reform the results from the online assessment.

3. Processing of Data

Linear regression and k-means clustering to analyze the data were performed. The insight from this model allows for a better understanding of the distraction’s effect on the user’s cognitive abilities.

Results and Findings

Effect of Distractions on Assessment Scores

To determine if the audio stimuli had any effect on the subjects’ scores, a one-way ANOVA was performed with an alpha level of 0.05. The null hypothesis was that the audio stimuli had no effect on the subjects’ scores; while the alternative hypothesis was that the audio stimuli did influence the subjects’ scores. The determined p-value was 0.05. Since p > 0.05, we fail to reject the null hypothesis. Based on this evidence, it is reasonable to suggest that the score was not affected by the presence or the tempo of the audio distractions. Also, computed a multiple comparison one-way ANOVA test to determine if there was any significant difference between any of the three tests (similar null and alternative hypotheses). However, the p-value for each comparison was above 0.05 which indicated there was not a significant difference between the scores of each test.

Time Used per Question

Participants had up to sixty seconds to complete each question on the assessment. To determine whether there was a linear relationship between the time spent per question and the test scores, an ANOVA regression was performed using the Numpy Python library for all three assessment conditions. For all three assessments, there was a weak linear correlation, with an average r-squared value of 0.40. Therefore, polynomial regression was performed with degree 2. The graphs for the control, patterned, and randomly audio distraction assessment are as follows. Figure 4 shows that there is a broader range of time spent (seconds) on the control assessment compared to time spent on the assessments with an audio distraction. The Control assessment had a smaller average time spent per question than both the Patterned Stimuli Assessment and the Randomly-timed Stimuli Assessment. However, the difference between the growth of the time spent between the Patterned Assessment and Random Assessment was marginal as evident in Figure 4.

Eye-tracking Data

Using the GazeRecorder software, a heatmap was provided for every question. The scores were split into three sections: 1. instructions score; section 2, question and answer choices; section 3, white space, and through the use of this heat map it was apparent which section had the highest focus. To determine if there was a relationship between the time subjects spent per question and the highest focus point in their heatmaps, k-means clustering was used. For the control assessment, no audio-distractions, the clustering model was able to predict the region with highest focus based on time spent per question (seconds) with 80% accuracy for section 1, and 67% for section 2. The predictions for section 3 were inaccurate due to the lack of data. For the patterned audio distraction assessment, the clustering model was able to predict the region with highest focus based on time spent per question (seconds) with 45% accuracy for section 1, and 58% for section 2. The predictions for section 3 were inaccurate due to the lack of data. For the randomly-timed audio distraction assessment, the clustering model was able to predict the region with highest focus based on time spent per question (seconds) with 73% accuracy for section 1, and 51% for section 2. The predictions for section 3 were inaccurate due to the lack of data.

Conclusion

The objective of this experiment was to investigate the effects of different tempos of auditory stimuli on the user’s cognitive ability. This phase of the project focused on completing testing and analysis on the data to draw a conclusion on the effects of this audio stimulus on a subject’s performance. The data analysis was successful in determining how much more time users spent per question under the three given conditions. Based on the results of the polynomial regression, it was observed that there was a clear increase of time between the control and other assessments that featured patterned and randomly-timed audio distractions. However, there was not a significant difference between the increase in time spent per question (seconds) between the assessments that featured patterned and randomly-timed audio distractions (refer to graph). The one-way ANOVA test determined that there was no effect on the subject’s score on the assessments despite the different audio-stimuli. Finally, using a k-means clustering to predict user focus based on the time they spent per question yielded promising results as the model hovered around 50-60% accuracy. Given the limited data used for training, this model learns at a correlation between the time users spent per question and the section of the screen that they most focus on. All k-means clustering models used for the three assessments suggested a correlation between the most time used per question and users focusing on section 2 (question and answer choices) and the least amount of time used per question and the users focusing on section 1 (instructions). There was not enough data to find a correlation between time used per question (seconds) and users focusing on section 1 (white-space). Based on this data, this study can suggest that there is no significant difference between impact of the patterned and randomly-timed auditory distraction on a subject’s performance measured through multiple categories. One limitation of this study that must be considered is the small sample size. Future work could include to perform a similar study with a bigger sample size as well as considering collecting more eye-tracking data such as the actual gaze and pupil dilation to better identify the focus of the subject.

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For more information, visit the GazeRecorder website and set up a demonstration. Online eye-tracking: Webcam eye tracking.