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The role of personality characteristics in informing our preference for visual presentation: An eye movement study

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Abstract. Individuals' preferences are an important consideration in society, and different personality traits may contribute to those preferences. Personality traits can be used to understand what people would prefer or like about certain events or activities. Despite this, it appears that there is little understanding about the role of personality characteristics in visual design display. This study investigated the role of personality traits in users' preferences. We examined the eye-movement behavior of 50 participants to identify their preferences in visual design presentations. A Bagging classifier with a genetic search method was used to assess the predictions of eye parameters based on personality dimensions. The results showed that high conscientiousness and agreeableness tended to influence eye-movement behavior toward visual design. Our findings may offer new insights for human-computer interaction, personalization, and rational choice theories. This study also addresses new trends related to the regulation of eye movements toward preferred visual design elements based on personality traits.

Keywords: Personality and design, interface design preferences, design prediction, user interaction

1. Introduction

Certain theories in cognitive use observations about preferences in human-computer interactions [10] to gain insight about the process of human learning [23]. Current studies have attempted to predict visual perceptions based on a person's individual nature or personality. Individual visual preferences can predict certain cognitive and decision making behaviors. With this in mind, some researchers have explained differences in preferences in terms of differences in individuals' behavioral patterns, cognitions, and emotions [32]. Henderson, et al. [20] explained how individuals' perceptions and cognitions associated with displays are processed based on a fraction of the available information. This led us to consider the possibility of utilizing user preferences concerning displayed information as indicators of certain behavioral aspects. Nienaber, et al. [33] and Rentfrow and Gosling [38] stated that individuals' preferences can be associated with specific personality dimensions. However, the picture emerging from these studies is incomplete; they have not precisely explained the role that personality dimensions play in influencing viewers' preferences. It can be also noted that little evidence exists to explain the possibility of predicting preferences on the basis of these dimensions.

The Big Five personality traits divide the cognition-related aspects of the personality into five different dimensions (openness, conscientiousness, extraversion, agreeableness, and neuroticism). Rauthmann, et al. [37] stated the potential of using gazing behavior in personality related studies. On the other hand, Fleeson and Noftle [14] noted that we have "very little knowledge about how personality is present in behavior and about what behaviors are relevant to personality," and that this is "partly because of the difficulty in speci-

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fying the level at which behavior should be studied" (pp. 1668, 1679). Because eyes exhibit complex movement patterns, which can be captured in terms of different parameters [39], individual differences in personality can be correlated with eye-movement behavior [1]. Hence, this study is intended to contribute to the current understanding of how individuals' preferences are associated with eye-movement behavior during visual design presentation based on their personality profiles.

Specifically, this study contributes to the current understanding of UI customization by linking one's personality traits to his/her behavioral preferences of the design elements. This was achieved by building a prediction model for inferring users' preferences of these elements based on the eye-movement behavior to the preferred regions of these elements (color, layout, font size, font style, and alignment).

This paper proposed a new way to customize interface design elements by modeling users' behavior, using their eye movement patterns and their personality traits. There is not yet a working example of this study, and that's why it's in the preliminary stages with potential effectiveness specifically for the domain of user interface customization. This includes:

1. Providing an advanced approach to enhance the responsiveness of the user interface, so that users' preferences related to certain design elements are automatically customized.
2. Modeling eye movement patterns in accordance with users' personality traits.
3. Showing the association between eye movement parameters and one's preferences.
4. Enabling smart online environments to effectively adjust their presentation in order to suit certain seeking tasks or behaviors.
5. Using predicted behavior to solve the problem of display inflexibility within the user interface. Users cannot customize their interface in the previous version; this version improves the flexibility of the user interface with customization.

In addition, this study provided a novel concept to the design of pervasive computing and utilized data on the user's profile, so that interface adaptation is entirely focused on the end user.

The nature of the task does influence the way a person seeks or processes information. Hence, we examined and linked the preference of a person to the eye-movement behavior, so in order to make a prediction, we used his or her personality trait to direct this behavior. In this study, we explored the eye-movement behavior of 50 participants by engaging them in five visual design experiments. This was done after the participants' personality dimensions were identified. Prediction models were built using the Bagging algorithm to help understand the associations between eye-movement behavior and preferences based on personality.

2. Method

We examined eye-movement behavior in five visual design trials (color, layout, font size, font style, and alignment). Specifically, we examined precisely how personality dimensions impacted the eye movements associated with the participants' selection preferences. A supervised classifier (Bagging) was used to predict the eye-movement parameters associated with individuals' selection preferences for certain elements of the visual design presentation.

2.1. Ethics statement

A signed consent form was obtained from each participant.

2.2. Participants

Fifty graduate students (21 males and 29 females) from the Universiti Sains Malaysia were initially recruited for this study; their ages ranged from 23 to 28 years old. All participants had normal or corrected-to-normal visual acuity. All participants underwent personality and eye calibration tests.

2.3. Materials

A total of five selection trials were displayed in a random order. The experimental stimuli were used to examine the participants' preferences regarding visual design elements of color, layout, font size, font style, and alignment. Zhao and Jiang [44] stated that individuals' preferences concerning components of visual presentations such as color, text style, font size, images, and animation can vary based on their personality, which can affect human aesthetic choice. The selection of these trials was based on the suggestions of prior studies on interface design and its relation to individual personality traits [2,26,35,41]. The first trial presented a combination of colors. The second trial presented different sets of layouts. The third trial pre-

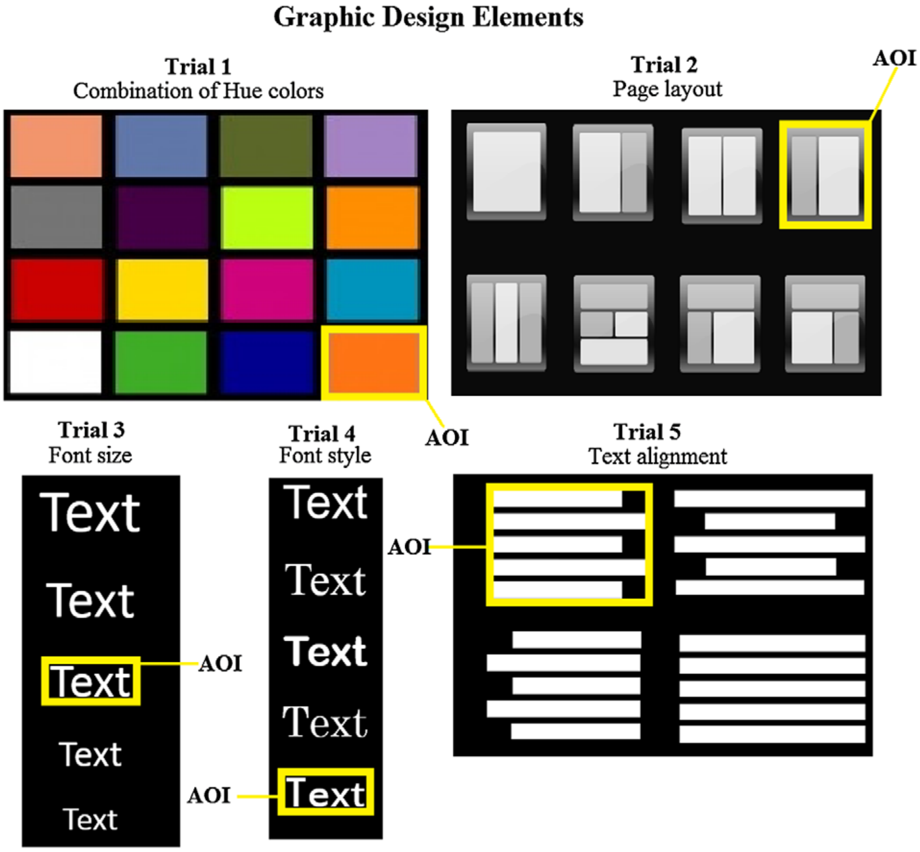

Fig. 1. The design of the study trials labeling of AOI for each participant.

sented a combination of different font sizes. The fourth trial presented a combination of different font styles. Finally, the fifth trial presented different alignments of text as shown in Fig. 1. The selection of design element in each trial was based on the participants' preferences of the element labeled under an Area of Interest (AOI). The eye movement data on each AOI was extracted and fed to the classifier for building the prediction model.

2.4. *Eye-tracking configuration*

SMI iView X was used to capture the participants' eye-movement data. All participants were seated comfortably on a chair, with their eyes about 50 cm from the monitor [5]. All the participants were asked to undertake a standard nine-point calibration to ensure that the eye tracker accurately tracked the participants' gazes.

2.5. *Personality measurement*

Before beginning the eye-tracking session, the personality traits of each participant were examined using a popular online personality test by Goldberg [18]. The use of this test (also known as the "Big Five") is supported by empirical evidence from prior studies [42,43]. The test measures the subject's openness, conscientiousness, extraversion, agreeableness, and neuroticism to determine the subject's personality dimensions. Participants who had certain personality traits were grouped separately. We identified 32 participants who were high in agreeableness and 18 who were high in conscientiousness. We labeled the trials for each participant based on these dimensions.

2.6. *Procedure*

We gave a short demonstration explaining the purpose of the study and the participants' roles in the visual design trials. Participants were asked to scan their preferred visual design elements in each trial. The display time for each trial was set to five seconds. In order to increase participants' familiarity with the visual design presentations, two different visual design presentations were given as a demo before moving on to the main experiment. Because there is no standard selection of eye-movement parameters mentioned in prior studies of visual preferences, we collected the following commonly used eye-tracking data: the number of the participants' fixations, the duration of the fixations, the durations of the saccades, the amplitudes of the saccades, and the participants' average pupil sizes.

2.7. Data analysis

In this stage, we selected the eye parameters (subset) from the overall dataset; the prediction model was built based on this subset. We then used a "genetic" algorithm [17] to search for the nominated subsets. For the genetic algorithm, we set the maximum number of both generations and population size to 20, with a 0.033 probability of mutation occurring. After finding the required subset using the genetic algorithm (number of fixations, fixation durations, saccade amplitudes, and average pupil size), a Bagging scheme was utilized with its standard configuration in order to evaluate the merit of the selected subset. We used this algorithm because of its fundamental accuracy results [8], which are superior to those of other learning schemes, such as NaiveBayes, Lazy-IB1, and Decision Tree-J48. Figure 2 illustrates the receiver operating characteristic (ROC) curve, where the Bagging algorithm has the highest area under the ROC value. After validating the selected subset, a classification process was applied to build a classifier model. This model was used to identify participants who scored high in the traits of conscientiousness and agreeableness in each visual design presentation based on the participants' eye parameters. To ensure that the classification results were the same as those that would be obtained for independent test sets, we used ten-fold cross validation as an evaluation technique [16,25].

3. Results

Table 1 presents a summary of eye-movement data for conscientious and agreeableness in the five trials. In the first trial (color preferences), the classification yielded three predictors – fixation duration, saccade amplitude, and average pupil size – for both agreeableness and conscientiousness. Based on the results, for highly conscientious participants, color was associated with shorter fixation durations (*Mean* (*M*) = 4470.00, *Standard Deviation* (*SD*) = 270.20), lower saccade amplitudes (*M* = 63.63, *SD* = 69.07) and smaller average pupil sizes (*M* = 190.16, *SD* = 24.40) than

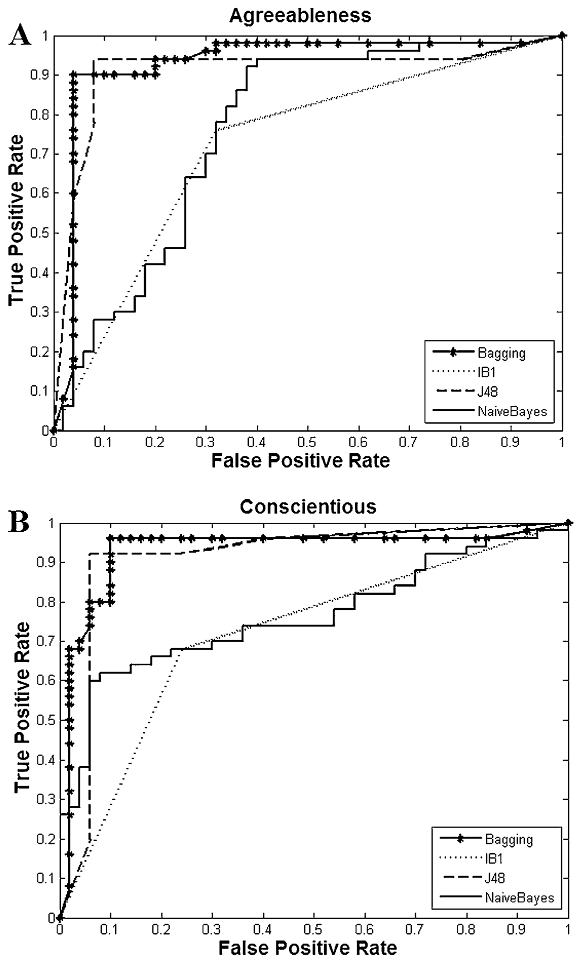

Fig. 2. Classifier-recommendation-based compression. Panel A: Agreeableness; panel B: Conscientiousness.

for highly agreeable participants, who had longer fixation durations (*M* = 6452.00, *SD* = 2798.72), higher saccade amplitudes (*M* = 77.95, *SD* = 16.75), and larger average pupil sizes (*M* = 333.33, *SD* = 89.59). These differences in eye-movement parameters could help predict certain personality traits.

The results of the second trial, which concerned layout, yielded three eye-movement predictors: fixation duration, fixation number, and average pupil size. We found that highly conscientious participants had shorter fixation durations (*M* = 4348.00, *SD* = 399.78), a smaller number of fixations (*M* = 126.00, *SD* = 24.55), and a smaller average pupil size (*M* = 164.86, *SD* = 39.62) than highly agreeable participants, who had longer fixation durations (*M* = 6269.50, *SD* = 2325.67), a greater number of fixations (*M* = 186.00, *SD* = 134.35), and a larger average pupil size (*M* = 255.30, *SD* = 90.79).

Table 1
A summary of eye-movement data for conscientious and agreeableness in the five trials

Personality trait	Trials	Fixation number		Fixation duration [ms]		Average pupil size [px]		Saccade amplitude [°]	
		Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
Conscientious	Color	–	–	4470.00	270.20	190.16	24.40	63.63	69.07
Agreeableness	Color	–	–	6452.00	2798.72	333.33	89.59	77.95	16.75
Conscientious	Layout	126.00	24.55	4348.00	399.78	164.86	39.62	–	–
Agreeableness	Layout	186.00	134.35	6269.50	2325.67	255.30	90.79	–	–
Conscientious	Font size	110.33	58.18	4364.33	569.64	185.66	73.33	–	–
Agreeableness	Font size	192.00	55.15	6369.50	2868.73	142.53	46.66	–	–
Conscientious	Font style	150.66	52.53	–	–	165.26	8.95	–	–
Agreeableness	Font style	225.50	170.41	–	–	274.55	137.24	–	–
Conscientious	Alignment	–	–	4377.00	493.90	146.53	16.55	–	–
Agreeableness	Alignment	–	–	6666.50	3000.25	216.10	86.97	–	–

The results of the third trial, concerning font size, yielded the same predictors as the second trial. Highly conscientious participants had shorter fixation durations ($M = 4364.33$, $SD = 569.64$), a smaller number of fixations ($M = 110.33$, $SD = 58.18$), and a smaller average pupil size ($M = 185.66$, $SD = 73.33$) than highly agreeable participants, who had longer fixation durations ($M = 6369.50$, $SD = 2868.73$), a greater number of fixations ($M = 192.00$, $SD = 55.15$), and a larger average pupil size ($M = 142.53$, $SD = 46.66$).

The fourth trial, concerning font style, yielded only two eye-movement predictors: the number of fixations and the average pupil size. Highly conscientious participants had a smaller number of fixations ($M = 150.66$, $SD = 52.53$) and a smaller average pupil size ($M = 165.26$, $SD = 8.95$) than highly agreeable participants, who had more fixations ($M = 225.50$, $SD = 170.41$) and a larger average pupil size ($M = 274.55$, $SD = 137.24$).

Finally, the fifth experiment, concerning alignment, also yielded two eye-movement predictors of fixation duration and average pupil size. Highly conscientious participants had shorter fixation durations ($M = 4377.00$, $SD = 493.90$) and a smaller average pupil size ($M = 146.53$, $SD = 16.55$) than highly agreeable participants, who had longer fixation durations ($M = 6666.50$, $SD = 3000.25$) and a larger average pupil size ($M = 216.10$, $SD = 86.97$).

Based on the results of all the visual design trials, it can be noted that higher conscientiousness was associated with eye movements that processed visual data more quickly than eye movements associated with high agreeableness. With respect to changes in average pupil size in the two personality dimensions, we found that highly conscientious participants paid more attention (with a smaller pupil size; see Bradley, et al. [7]) than highly agreeable participants (with a larger pupil size; see Bradley, et al. [7]). This indicates that eye-movement behavior can be used to measure the effect of personality traits on visual preferences.

Figure 3 represents the classification accuracies for all the participants in each trial in a boxplot. We referred to the correctly classified instances for measuring the accuracies of all the trials for both personality dimensions. In all the visual design presentations, the classification for participants with relatively high levels in certain personality traits had greater accuracy, with a skew of distribution above the chance baseline 0.25.

On the other hand, it is well known that calculating the similarity of predictive models (the model for each visual design presentation) can help to determine the models' diversity. Such a process usually relies on the model's performance, which we calculated in this study using the confusion matrix shown in Fig. 4. The eye-movement predictors were tested using a standard 2×2 confusion matrix design. Evaluations of the performance of the predictions were based on the correctly classified instances (CCI) and "receiver operating characteristics" (ROC) in each trial.

The overall accuracy of the classification models yielded from the first trial (CCI 0.70, ROC 0.75), second trial (CCI 0.66, ROC 0.70), third trial (CCI 0.83, ROC 0.87), fourth trial (CCI 0.93, ROC 0.92), and fifth trial (CCI 0.69, ROC 0.72) showed that preferences for visual design elements were accurately predicted by agreeableness and conscientiousness. According to the confusion matrix (Fig. 4), we can conclude that eye-movement predictors can accurately indicate individuals' visual design element preferences based on their personality dimensions. We also note that the prediction accuracy for both agreeableness and conscientiousness varied from one trial to another. This can reasonably be taken to indicate that these personality di-

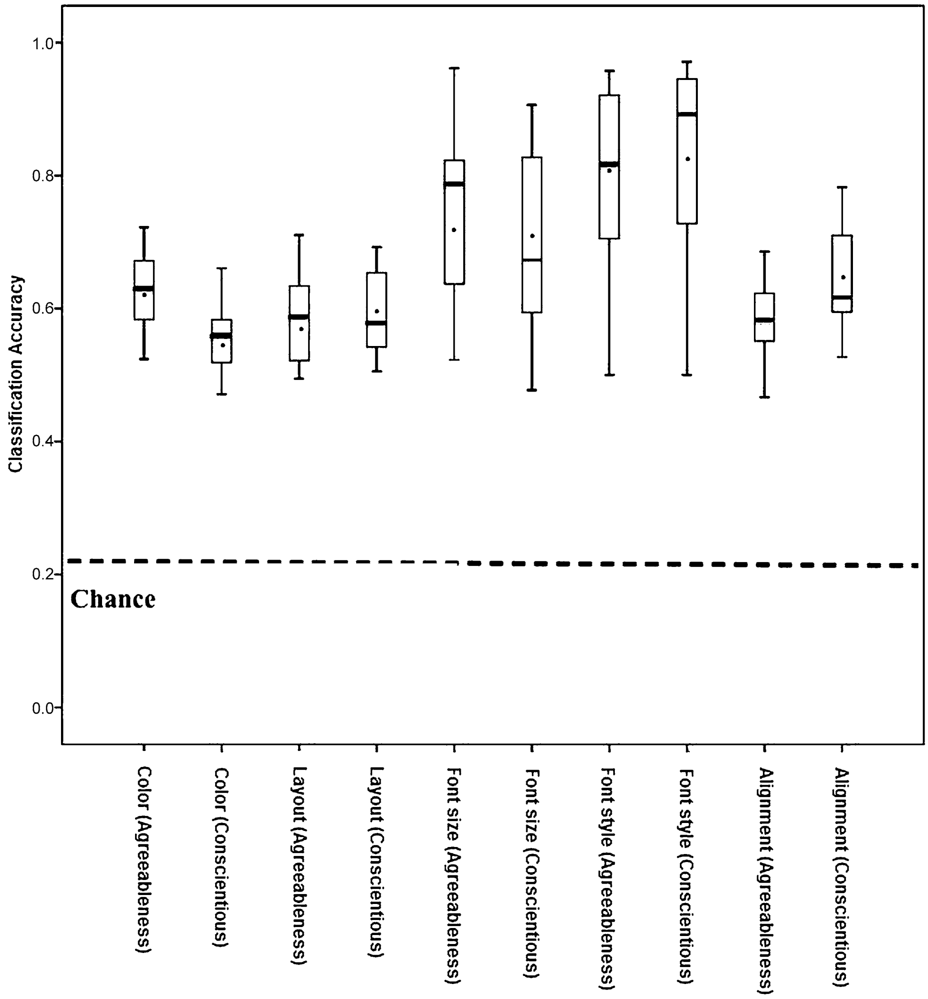

Fig. 3. Accuracy boxplot for all of the trials. The median for each box is considered to be the central value of the measure. Each box has two edges at the 25th and 75th percentiles, where whiskers are not considered outliers.

mensions might regulate the degree to which participants' preferences are affected by the characteristics of the visual design elements.

We were also interested in understanding how instances were distributed among the predictors in all the visual design presentation trials. A statistical linear projection visualization was used to represent the density of the instances' distributions over the predictors, as shown in Fig. 5.

From Figs 5(A), 5(B), 5(C), 5(D), and 5(E), we can identify the probability of agreeableness and conscientiousness being closely associated with the average pupil size and with the number of fixations, fixation durations, and saccade amplitudes. The instance distribution for both personality dimensions was homogeneous among the predictors.

In addition, preferences associated with other personality dimensions (such as extraversion, neuroticism, and openness) are correlated with different eye-movement predictors in visual design presentations. We also found that certain personality traits are associated with preferences for certain display characteristics, which may regulate the distribution of eye-movement behavior. Such a distribution can therefore be used to predict preferences in a specific visual display presentation.

4. Discussion

Personality traits have been found to be reliable predictors of several behavioral outcomes that are linked

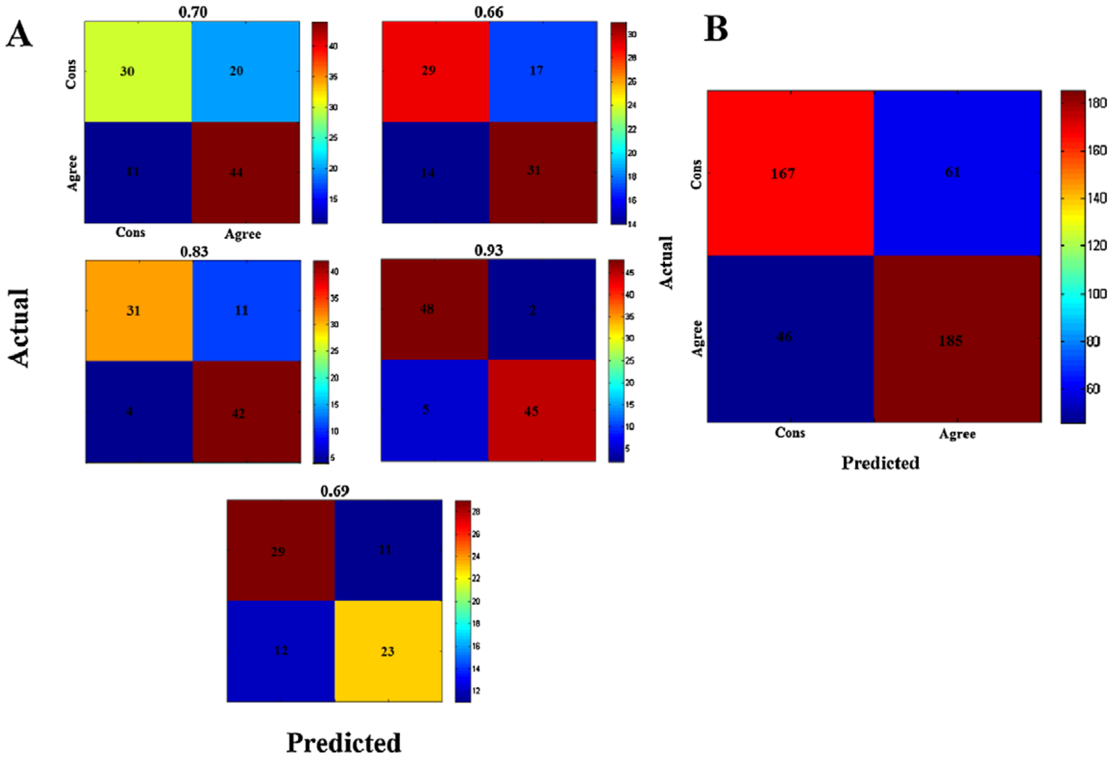

Fig. 4. Confusion matrix for the eye-movement predictors of visual preferences.

to preference [6]. The tendency of an individual to behave in a certain manner, or to successfully interact with others, is a function of his or her personality [22]. Accordingly, if we can discover the personality traits that contribute to or inhibit visual preferences concerning design elements, we can maximize our chances of design selection success by simply understanding the preferences associated with certain personality traits. Extensive work has been conducted toward developing an overall classification system for personality traits in order to systematically improve the selection and customization of visual design displays. This has led to research in personnel selection that acknowledges the effects of personality traits on career aptitude and performance. Therefore, a fundamental question is how personality traits can affect visual preferences for presentations. Hence, by understanding how personality traits influence visual preferences, one can tailor presentations for maximum effectiveness.

Measuring the way eyes behave towards a target is important for determining levels of visual interaction; therefore, eye-movement behavior has been found to help explain this interaction and its association with one's perceptions of the display [30,31]. Our examination of participants' eye-movement behavior in five selection tasks led us to conclude that individuals with certain personality traits can be identified based on the behavior of their eyes toward visual displays. This hypothesis is based on the fact that certain personality trait involves the tendency to behave in assertive and self-assured ways [4]. The argument given by Fleeson and Noftle [14], that "people can exhibit substantial variation in behavior across different occasions, but still remain 'consistent' when compared to others," supports the validity of the potential for eye-movement to predict individuals' preferences based on their personality profile. Scoring high in agreeableness or conscientiousness is associated with certain user choices of design display. This claim supports Judge, et al. [24] observation that individuals that score higher in certain personality traits influence an individual's personal decisions. In addition, we concluded that the characteristics of a display can influence individuals' preferences for certain objects in the display. We observed that people high in conscientiousness selected design preferences in the display more quickly than people high in agreeableness. These findings also extend those of Brinkman and Fine [9] on the possible correlations between personality traits and individual preferences.

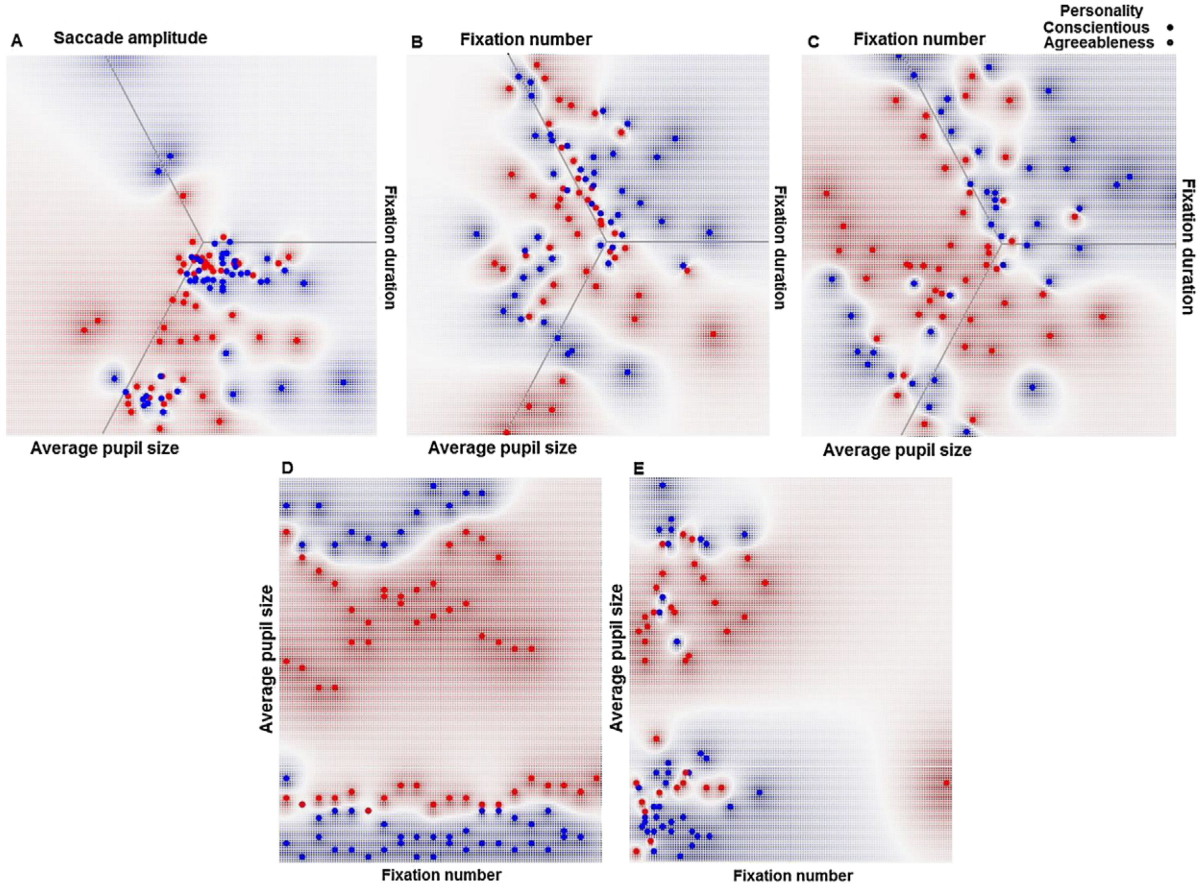

Fig. 5. Distribution of eye-movement predictors in visual design presentation based on the personality traits of agreeableness and conscientiousness.

Our findings also show that the personality dimensions of agreeableness and conscientiousness can affect eye-movement behavior. Anderson and Kilduff [4] concluded that individuals high in the personality trait of dominance consistently attain high levels of influence in situations in which dominance predicts the enactment of competence-signaling behaviors, which in turn predicts peer ratings of competence. Manning, et al. [29] added that personality traits fundamentally influence how rewards are chosen over time. They stated that certain personality traits are associated with high levels of certain personal needs. Furthermore, Hirsh, et al. [21] acknowledged that scoring high in certain personality traits is associated with particular behaviors. Diekhof, et al. [12] observed that greater trait impulsivity correlated with preference for rewards. Thus, personality variables have been related to different situations in society, but there has been no straightforward exploration of Big Five personality factors and preferences in visual design display. This can be seen in Lee, et al. [28] work; they linked conscientiousness with the practices of carrying out certain tasks in preference to others, which can be applied to understand certain behavior.

However, proving connections between personality and other factors requires robust data. This is probably why some studies have explored potential links between personality traits and one's actions or preferences [13]. This is no surprise considering that personality is one of the most complex concepts in the social sciences, and its conceptualization and analysis is one of the most challenging tasks in psychology [19]. Even so, the prediction of performance on specific tasks [11,40]. Nov, et al. [34] argued that an understanding of personality differences is necessary to ensure effective design in an online context. The authors asserted that different personalities respond differently to design cues. Aly and Tapus [3] established that individuals prefer to interact with objects that reflect or are linked to their personality profiles. Kosti, et al. [27] demonstrated the associations between personalities and work preferences. Based on these observations, we therefore hypothesized that personality traits would be associated with certain design preferences. However, this view comes with some limitations, first, our sample consists of university students who undertake certain subject. This as a result may or may not affect students' decision to prefer certain element on another. Second, this study is limited to only two dominant personality traits (agreeableness and conscientiousness), meaning that other traits may yield on similar or different conclusion. Hence, our study appears to be in its initial stage for extending the aforementioned observations of personality trait dominance in UI customization.

In conclusion, high levels of agreeableness and conscientiousness can influence behavior, indicating personal preferences for certain presentation elements. Observations about the influence of personality on eye-movement behavior could help make human-computer interactions more intuitive and efficient – for example, to avoid distraction that can result from having irrelevant features in the display [15], or to offer computer users intuitive perspectives on data by providing compatible proxy channels to customize an interface [36]. Although human vision has some limitations, our findings offer new insights about how an individual's preferences can be predicted based on variations in eye-movement behavior in different situations. This also offers new insights into simplifying personalization and guiding the rational choice of which objects to include in visual displays. In addition, our findings address a new aspect of the regulation of eye movement towards preferred visual design elements based on personality traits. It can be applied into the current customization practices of UI design. This would help increase the environment capabilities in order to meet certain users' demands of visual display.

5. Conclusion

We investigated the influence of personality, as measured by the Big Five-Factor Model, on users' preferences for certain interface design elements. During eye-movement examination of 50 participants in five display trials, we estimated a constant-sensitivity discount function that dissociates impatience from time sensitivity. Overall, higher agreeableness and conscientiousness were associated with a relatively greater preference for immediate rewards, and higher conscientiousness was associated with a relatively greater preference for certain design elements. This association was found to be high to a certain design elements. Meaning that there is a possibility that these two traits can be used to guide the preferences of user to the UI design. The utilization of supervised machine learning led us to validate our claim that eye movement predicts one's preferences in a visual design presentation based on personality traits. Given that few studies emphasize the role of eye parameters in predicting display preferences, we believe that our findings provide exceptional insight into the potential use of artificial intelligence mechanisms to model visual perceptions and changes in average pupil size, which are processing mechanisms of the human vision system.

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