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ORIGINAL PAPER

Towards conscientiousness-based graphical user interface design guidelines

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Abstract
Although designers aim at offering the best possible user experience, products are designed for a general audience with a common pool of characteristics. Since intrinsic psychological characteristics model the human interaction, ignoring that each individual has different experiences may lead to a failed product. From these constructs, personality has shown strong results by shaping how users process and act on the world, and how individuals perceive and accept technology. In this work, we focus on conscientiousness, a personality trait that models one's organization, persistence, and motivation for goal-oriented behavior. In particular, we study ($N = 40$) whether conscientiousness affects the design preferences for graphical elements in a user interface. Additionally, we assess ($N = 60$) if designing graphical user interfaces based on the design preferences of individuals with different conscientiousness scores affects perceived usability and ease-of-use. Results show that designing interfaces for conscientiousness-based personality profiles influences user preference but has no significant effect on perceived usability and ease-of-use. Our findings support the incorporation of conscientiousness in the design process to develop graphic user interfaces that focus on goal-oriented behavior for the correct audience.

Keywords Conscientiousness · Personality psychology · User interface design · Design guidelines · Human-computer interaction · User studies

1 Introduction

Research has leveraged personalization techniques to counter the limitations of the one-size-fits-all approach (e.g., [9, 59, 73]). Indeed, while new technologies are designed for a general audience with a common pool of characteristics, each user has their own experience when they interact with technology, resulting in a different mental model regarding that artifact. Since mental models are internal mechanisms that allow users to understand, explain, operate, and predict the states of systems [28, 62, 68], their creation is typically tailored to individual factors. Some factors may include age, gender, job function, language culture, or fundamental idiosyncratic attributes, such as personality and motivation. By including such factors, designers can take into account not only how individual characteristics impact user interaction, but also consumers' expectations from providers across a large range of fields.

Notably, Kostov and Fukuda [40] found that users performed better when they handled an interface that matched their personality type. Among all characteristics of a construct as complex as personality, the trait of conscientiousness from the Five-Factor Model (FFM) shows promise in the optimization of graphical user interface (GUI)s. According to the Dictionary of Psychology of the American Psychological Association (APA), conscientiousness is "the

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tendency to be organized, responsible, and hardworking."[1] As such, the present work considers the aforementioned definition, characterizing conscientiousness as the preference for an organized approach to life as opposed to a spontaneous one as well as the self-use of socially prescribed restraints that facilitate goal completion, following norms and rules, and prioritizing tasks [27]. While people high on conscientiousness are more likely to be well organized, reliable, and consistent, individuals with low conscientiousness are generally more easy-going, spontaneous, and creative. Given these characteristics, we believe that customizing the way graphical elements of an interface are displayed may lead individuals with different levels of conscientiousness to be more prone to use or prefer a certain technology. However, there is limited evidence of the usefulness of designing GUIs based on individual psychological variables [4].

Weighting how personality affects perception [35] and design efficiency [71], we focus on how in-depth synergies between conscientiousness and GUI preferences can be applied to graphical user interface design in a website layout to accommodate the preferences of diverse users. At a broader level, websites currently personalize their content, optimize their marketing strategies, and tailor their search results using audience profiles encompassing demographic features, such as age, gender, and income [30]. Nevertheless, including personality in the design process is often overlooked. For example, personality-based recommendation systems are more effective in decreasing cognitive effort and increasing users' loyalty towards the system compared to other systems that do not consider personality information [31]. Moreover, this inclusion in the design pipeline may be applied to attract larger audiences with a distinct personality profile, and expand the understanding companies have of their users, thus improving the quality of service and user experience [39].

Regarding our research field, the potential of GUI design based on personal characteristics has been studied by customizing the display to meet certain demands [34]. Only Sarsam and Al-Samarraie [64] specifically address the trait of conscientiousness, alongside neuroticism and extraversion. Their results showed how visual experience improves when using the interface designed based on users' personality characteristics. Nevertheless, the trait of conscientiousness was not studied independently, which may hinder the potential of addressing it separately. From the remaining work, Lawrence and Selvaraj [41] actually provide design guidelines for extravert and neurotic learners. While extravert learners can easily recollect information presented in blue color with "Times" font style, neurotic learners favored green colors with "Times" font style. Therefore, there is a lack of research regarding how personality and, notably, conscientiousness affects user preferences for certain interface design features. Additionally, the set of interface elements covered by Sarsam and Al-Samarraie [64] is tested in the mobile context, which limits the variation of styles have been studied in GUI design. While Sarsam and Al-Samarraie [64] focus on the mobile GUI context, we opt for a broader GUI domain: website layouts. The former context has several constraints that are not present in our own such as the limited screen size for home, menu, or login screens, or the interaction actions with the GUI, e.g., hover. Some of their style options for the design of interfaces are utterly dependent on that context. Therefore, by changing the domain in which we are operating, the style options that we consider for our features are different from Sarsam and Al-Samarraie [64], since we are not as restricted in terms of context, which adds knowledge to our research field.

With this in mind, our research goal is to understand how this psychological construct has an effect on user preferences in a website layout context. Our contribution is two-fold. In our first study, we start by analyzing how conscientiousness models user preference for a large set of features and its styles in a website layout. Taking into account our results, we follow-up with a user testing phase in order to verify how conscientiousness-based user preferences are affected by changes in each feature of the website layout. Our final results show that participants prefer the GUI that is designed in accordance to their conscientiousness level. In addition, we study whether a website designed specifically for the user's conscientiousness level has an effect on perceived usability and ease-of-use.

The paper is organized as follows: In Section 2, we present a selection of studies that have designed interfaces to match specific personality types, and examine the influence of different personality variables on those designs. Section 3 follows, with a description of the methodology used to collect both participants' personality and design preferences. Next, Section 4 covers the study on how conscientiousness has an effect on user preference, perceived usability, and ease-of-use. Finally, we conclude our work with a discussion on future directions, tackling the limitations of our current approach.

2 Related work

Recent research has leveraged individual characteristics to personalize user interfaces and improve user experience [49, 64]. In particular, GUIs designed in accordance to user personality have been shown to affect both information-seeking performance and behavior [1, 36], as well as user preference [40]. Regarding the former, Al-Samarraie et al. [1] found that the traits of extraversion, agreeableness, and conscientiousness modeled the use of information-seeking strategies and

[1] https://dictionary.apa.org/conscientiousness, retrieved on November 3, 2021.

how much time users took to complete search tasks. Moreover, results suggest that participants high in conscientiousness engaged in some kind of mental reflection [55].

Nevertheless, it is still unclear which interface features are relevant for user adaptation based on personality (e.g., structure [14], navigation [23, 74], layout [7], font style attributes [19], font size [42, 74], buttons [33], color [15, 60], list [61], information density [60], support [60], and alignment [26]). Recent work by Sarsam and Al-Samarraie [64] tried to determine whether user experience would improve if users interacted with an interface designed for their personality. First, the authors performed an interview with several users to collect their personality data and design preferences regarding GUI elements. Afterwards, Sarsam and Al-Samarraie [64] used a k-means to group individuals in two clusters based on similar values on the personality traits and its facets, while one group had participants with higher neuroticism values, the other by having high extraversion and conscientiousness levels. Next, Sarsam and Al-Samarraie [64] used an a priori algorithm to create association rules of design preferences for each cluster, where the authors found that the design elements that showed greater differences among participants from different clusters were color, fonts, structuring, and alignment within the screen. After conducting user tests with both interfaces, Sarsam and Al-Samarraie [64] concluded that, independently of their personality, participants' perceptual attention was positively affected when interaction with the GUI design specifically for their personality group. While users interacted with their specific GUI, they paid less attention to irrelevant objects in the interface, and exhibited higher visual efficiency and comfort, compared to using the other interface. In contrast, participants showed signs of demotivation when they interacted with a GUI targeted for the other cluster [64]. Additionally, Lawrence and Selvaraj [41] found that subjects preferred different design parameters such as font family and color on a learning interface based on their personality. In particular, the distinct parameters led to variations in efficiency and recollection tasks. While subjects with high extraversion easily recollected information presented in blue with a "Times" font style, neurotic learners easily recollected information presented in green with a "Times" font style [41].

Although the aforementioned work focuses on GUIs in a typical website or application layout, there has been a lot of research regarding the impact of individual differences in information visualization [47]. Among the most relevant work, Ziemkiewicz et al. [78] concluded that neurotic individuals attained high accuracy on hierarchical search tasks. In addition, introverted participants were more accurate in answering the questions posed by the tasks. Moreover, Braun et al. [10] studied three different approaches in the context of a driver state visualization system. The first is titled *quantified-self* and visualizes user vitality and emotion data in circular diagrams. *Gamification* is the second approach and displays current stats of car and driver in an interactive way. Finally, *notification* presents a minimalistic background animation combined with text notifications in case of negative user valence. Results show high variances in answers on attractiveness and dependability from participants with high values in neuroticism and openness to experience. Additionally, high openness to experience led to directly proportional variances in perspicuity. Regarding the user preferences, people high on extraversion rated higher the *notification* concept, while people high on neuroticism attributed better rates to the *quantified-self* one. In contrast, the *gamification* approach showed no significant results when the authors looked for interaction effects [10].

In another work, Oscar et al. [58] manipulate the visualization's information granularity to approximate the moment at which an adaptive system presents a visualization to the user. Both neuroticism and extraversion traits showed direct effects on task performance regarding both accuracy and time to complete. In particular, the authors found that high values in extraversion led participants to be less likely to indicate that not enough detail is available to answer the task. Moreover, these individuals were also less likely to accurately complete a low need for detail task, regardless of whether it was a find or compare values task. Regarding neuroticism, people with high values were less likely to be deceived by spurious correlations. Regarding conscientiousness, only Brown et al. [12] and Ziemkiewicz and Kosara [77] consider that trait in their study and they found no significant effects regarding information visualization.

In the light of this, there is limited evidence of the effect of designing GUIs based on individual psychological variables [4, 47]. In particular, the trait of conscientiousness has not been studied independently of the other traits, which may hinder the usefulness of this personality variable in GUI design. Our reasoning is based on the Five-Factor Model, since the five personality traits are independent of each other [51]. Indeed, creating user profiles based on multiple personality traits leads to interaction effects among them, which prevents researchers from isolating a personality trait in the user profile. Therefore, we decided to consider only conscientiousness as a factor in our study to verify whether it is relevant as an independent variable. This trait is particularly relevant in information-seeking tasks given its relationship to one's tendency of efficiency and organization [27]. Moreover, there is limited research in regard to interactions between GUI design and personality factors on user preferences and perceived usability. With this in mind, we believe that it is of utmost importance to study how an important psychological construct such as conscientiousness models these self-assessment factors. Not only it may have an effect on how people like the organization of the elements on their GUIs, it may also lead users to perceive the usability of it before any interaction. Therefore, the next sections present how our study tries to bridge this gap.

3 Data acquisition

The first step to understand how conscientiousness affects user preferences in GUI design is to collect user personality and preferences. The objective of this initial study is to create groups of participants based on their conscientiousness level and then verify which are the most common user preferences for these groups.

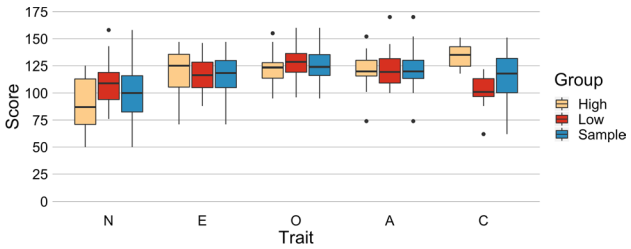


Fig. 1 Boxplots of the distribution of traits between clusters and the sample of the first study

3.1 Personality data

Personality data was collected with the Revised NEO Personality Inventory (NEO PI-R). The Portuguese version of the NEO PI-R was developed by Lima and Simões [46]. The NEO PI-R has a high internal consistency with values ranging from 0.79 to 0.86 [46]. It has 240 items and allows researchers to assess the FFM five personality traits and its 30 facets. The questionnaire identifies the intensity of each personality trait of a person using high-score and low-score features. The questionnaire has 30 different subscales (one for each facet), with eight items for each subscale. Thus, every trait has 48 different items.

After obtaining the approval of the school's Ethics Board, subjects were recruited through standard convenience sampling procedures including direct contact and through word of mouth. Subjects included any Portuguese interested in participating if they were at least 18 years old. Participants answered the questions in a Google form, using a computer and a computer mouse. Personality data was stored in a private institutional cloud repository with no association to contact data, which was stored in a local hard-drive, as a means to preserve the data anonymization. Then, we decided on how we would approach personality based on the results of the questionnaire.

One approach is to first convert each personality variable to categorical values following either the quartile distributions of the sample or the Portuguese norm [46], and then analyze each personality variable separately. The other approach is by clustering users according to their personality characteristics and find whether participants with similar personality profiles share preferences for certain GUI elements. In our work, we focus on the first approach, since we are studying a specific trait instead of the whole FFM model. Moreover, categorizing participants based on their value on the conscientiousness trait scale allows us to start our research at a broader level to study whether there are in fact differences between people with distinct conscientiousness levels. Therefore, we classified each participant with a value smaller than the 50^{th} as *Low* and greater or equal to the 50^{th} as *High*. This allows us to limit the number of design guidelines to a practical level and, at the same time, present a balanced set of users.

Our final data set comprises 40 participants (25 males, 15 females) between 18 and 36 years old ($M = 20.80; SD = 2.95$). All participants had normal or corrected-to-normal vision, and there were no color blind subjects as assessed by a validated simplified version of the Ishihara test [17]. In addition, all participants worked with a desktop-based computer daily.

Both *Low* and *High* conscientiousness groups have 20 participants. Figure 1 depicts the distributions of the personality traits of the FFM across the two clusters as well as of the complete sample. As it is possible to observe, a one-way ANONA showed that the scores of the conscientiousness trait were significantly different between the *Low* and *High* groups, $p < .001$. Additionally, the scores of neuroticism were also significantly different between groups, $p = .008$. In contrast, extraversion ($p = .614$), openness ($p = .271$), and agreeableness ($p = .798$) showed similar intercluster scores. These results highlight how the two groups differ in the conscientiousness scores and, in particular, provide a strong basis to derive the user preferences of each cluster.

3.2 User preferences data

We started by choosing which features to address regarding user preferences. Based on the most used GUI elements of the state-of-the-art (e.g., Sarsam and Al-Samarraie [64] and Alves et al. [4]), we chose the following:

- ***Body***: It is divided into three segments: (i) **margin size** (the size of the lateral margins, where the possibilities are very small, small, medium, large, and very large); (ii) **layout** (whether the focus is on text, images, or both, i.e., neutral); and (iii) **information density** (the amount of information displayed on the interface, which varied between low, medium, and high density).
- ***Buttons***: There are four segments: (i) **horizontal positioning**, in which the buttons may appear aligned to the left side of the interface, centered, or to the right

side; (ii) **vertical positioning**, where the buttons can be either in the header or in the footer; (iii) **type**, where the user can choose between "Previous/Next" buttons or the page numbering buttons, which allow the user to immediately navigate to the desired page; and (iv) **shape**, i.e., either curved or squared corners.

- ***Icons***: Users could choose to have icons in their interface and, if they did, they could choose the position in relation to the text (left or right).
- ***Images***: Images have two components: (i) **caption alignment**, related to the caption alignment between being displayed on the left, center or right; and (ii) **image side**, which addresses where to position images (left or right).
- ***Image Slideshow***: The interface features a slideshow with several images. The user will be able to choose whether he/she wants these images to change automatically or to be done manually, thus giving him/her control.
- **Menu**: Refers to the position of the menu on the interface. The available positions are header, footer, left, and right. The choice of the menu in the header also allows the user to choose a fixed menu or a non-fixed menu. The fixed menu consists of a menu that is permanently at the top of the interface and never disappears even if it descends in the content of the interface. The non-fixed menu disappears when the content of the page goes down.
- ***Text***: There are four segments: (i) **font family**, whose options are serif, sans serif, cursive, monospace with serif, and monospace without serif; (ii) **font size**, where the possibilities are very small, small, medium, large, and very large); (iii) **text alignment**, divided into left, center, right, and justified; (iv) **text wrapping**, i.e., whether text wraps around images; and (v) **style** where users users can choose to present information in simple text, in bullet points, or in a table.
- ***Theme***: The theme changed the color of text elements, background, and interface elements, such as buttons and menu bar. Although Stimpson and Stimpson [66] found no relation between color preferences and personality, recent work by Condeço et al. [15] found that extraversion suggests certain color preferences. Thus, we decided to study color regarding conscientiousness by producing a total of eight different themes in shades of gray, dark blue, red, orange, light blue, green, pink, or purple (Fig. 2).

We believe that the number of features we are addressing allows us to filter which ones are relevant for the different personality groups and provide more freedom to the user instead of restraining their actions in a small space set, which may hinder their ability to create a website layout based on their preferences.

Fig. 2 Different themes used in the adaptable GUI. The text is a direct translation of the native language, Portuguese, which was how the apparatus was presented to the participants

Fig. 3 Two examples of random states of the adaptable interface

3.3 Method

Next, we conducted a testing phase with the participants aforementioned to obtain GUI elements preferences. To do so, we started by creating a customizable interface with a website layout. The GUI was designed for information-seeking tasks, where participants have to learn about a particular subject. It was composed of elements relevant for this type of interface such as a text with a title and a subtitle, an image, and a slideshow of three images. The text on the interface

Table 1 Styles chosen by the majority of the participants for each level of conscientiousness

Feature	Low Conscientiousness	High Conscientiousness
Button Position Horizontal	center (55%)	center (60%)
Button Position Vertical	footer (90%)	footer (90%)
Button Shape	squared (60%)	rounded (60%)
Button Type	page numbers (60%)	previous/next (60%)
Focus Layout	neutral (75%)	neutral (65%)
Font Family	sans-serif (45%)	sans-serif (50%)
Font Size	small (50%)	medium (57.9%)
Icons	yes (90%)	yes (90%)
Icon Position	left (90%)	left (85%)
Image Caption Alignment	left (50%)	center (75%)
Image Side	left (52.9%)	right (82.4%)
Image Slideshow	automatic (80%)	automatic (55%)
Information Density	low (65%)	low (55%)
Information Style	table (55%)	table (40%)
Margin Size	large (45%)	medium (45%)
Menu Position	header (%)	header (%)
Menu Fixed	yes (81.8%)	yes (81.8%)
Text Alignment	justified (80%)	justified (80%)
Text Wrap	wrap (90%)	wrap (85%)
Theme	orange scale (45%)	orange scale (35%)

Highlighted rows present differences in design styles from distinct personality groups

was *lorem ipsum* and the images were default gray images in order to avoid influencing the user by their content. Additionally, each user was presented a random initialization of the GUI in order to avoid bias. Figure 3 presents two examples of the GUI.

After an assistant explained how the customization process works, participants were free to change the website layout for as long as they wanted. Regarding the task itself, participants were instructed to change the features in order to create a GUI as close to their preferred website design as possible. Based on user-centered design philosophy [54], subjects could manipulate the presentation of various features through a dropdown menu present in the interface, which is the customization tool. Besides hiding the menu, the user could change its position through drag and drop in order to see elements that were behind it. When the participant clicked on one of the styles for a certain feature, the GUI would immediately reflect the change so that the user could perceive the overall look of it. Each individual was prompted to manipulate each feature before focusing on achieving their preferred design so that they were aware of the extent in which they could manipulate the GUI. Each session was around 10 min. Finally, when the participant was satisfied with the final look of the GUI, we saved the preferences and thanked them for their time.

Table 1 shows the most chosen styles for each feature according to the level of conscientiousness. Although the majority of the features have the same preferred style, both groups diverge on body margin, image side, image caption alignment, font size, and button type and shape. Therefore, we conclude that:

– *Low conscientiousness individuals prefer large body margins, images on the left side, image captions left aligned, small font size, and squared numbered buttons.*
– *High conscientiousness individuals prefer medium body margins, images on the right side, image captions center aligned, medium font size, and rounded "Previous/Next" buttons.*

Following these preferences, the next step in our study is to understand whether interfaces created based on these preferences have an effect on user preference and perceived usability.

4 Evaluation

Since conscientiousness has not been studied independently of other personality variables, our first step is to understand whether preference-based changes in a GUI affect the processing of visual context. In our approach, we extract user preferences based on a user preference. As such, we believe that participants will prefer a version that is designed according to the guidelines for their group. Therefore, we create our first hypothesis as:

H1: Conscientiousness affects user preference. We address this hypothesis by asking users to rate their preference for each of the interfaces among a set of GUIs based on the design preferences which they preferred the most. Moreover, we want to address whether conscientiousness has an effect on how participants report their perceived usability. In particular, we believe that conscientiousness, having an effect on how users tend to be efficient and organized, may also affect how users assess whether an interface enables them to achieve their goals effectively, efficiently and with satisfaction [32]. As such, we expect that users will rate with higher perceived usability the interface that was designed for their conscientiousness group. With this in mind, we created the following hypothesis:

H2: Conscientiousness has an effect on perceived usability. Perceived usability is assessed through the System Usability Scale (SUS) [11] which will then be used to compare differences across groups in in-between and mixed designs. Finally, we want to verify whether conscientiousness models how users perceive ease-of-use. Perceived ease-of-use is defined as "the degree to which a person believes that using a particular system would be free of effort" [16]. Since effort has been shown to be positively correlated with conscientiousness [76], we believe that each individual's personality profile will lead them to report different levels of perceived ease-of-use, as they would evaluate their effort while interacting with the interface differently. Additionally, our assumption is that users rate with higher ease-of-use the interface that is designed to their conscientiousness level. Therefore, we defined the last hypothesis as:

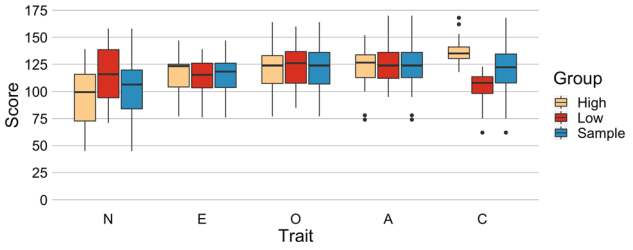


Fig. 4 Boxplots of the distribution of traits between clusters and the sample of the second study

H3: Conscientiousness has an effect on perceived ease-of-use. This metric will be assessed with the items associated with it in the Technology Acceptance Model 3 (TAM3) [69]. Similarly to perceived usability, perceived ease-of-use scores are compared with in-between and mixed designs.

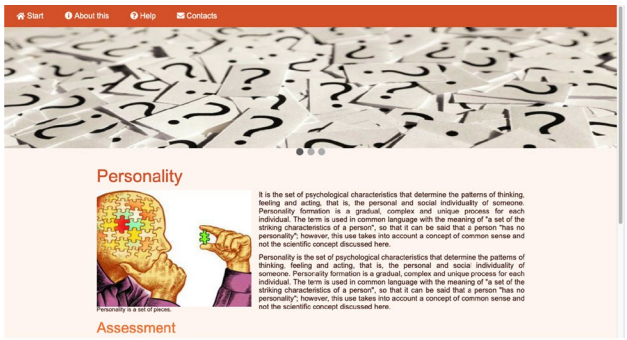
4.1 Participants

This user testing phase counted with a total of 60 participants (33 male, 27 female), 29 with *Low* conscientiousness and 31 with *High* levels, ranging in age from 18 to 60 ($M = 23.73$;$SD = 8.15$). Twenty-nine were new to our study as a means to introduce some new variance to better understand whether conscientiousness did in fact lead to different ratings from the users. Again, participants had normal or corrected-to-normal vision, and there were no color blind subjects as assessed by a validated simplified version of the Ishihara test [17].

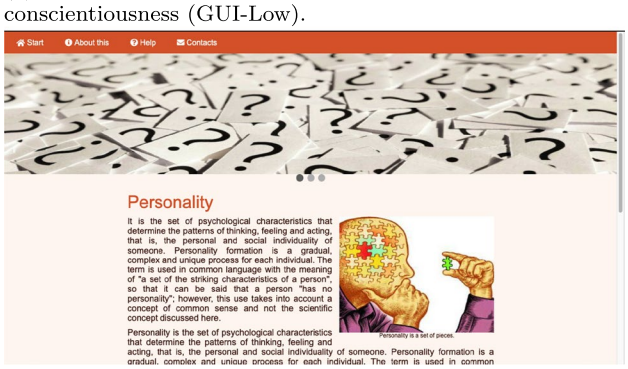
As it is possible to observe in Fig. 4, each group of subjects significantly differs in conscientiousness scores ($p < .001$). Similar to the first study, subjects have significantly different scores in neuroticism ($p = .001$), and the remaining extraversion ($p = .332$), openness ($p = .849$), and agreeableness ($p = .849$) traits do not present these differences.

4.2 Apparatus

We employed the Portuguese version of the SUS [50] to collect perceived usability. The SUS [11] is a subjective measure of usability that should be used right after the respondent interacts with a system. It is composed of ten items scored on a 5-point Likert scale from *strongly disagree* to *strongly agree*. The SUS is the most widely used measure of perceived usability [45], showing strong flexibility as well as reliability properties [6, 44]. In particular, the SUS provides a unidimensional scale that encodes a global measure of system satisfaction as perceived by the user. Regarding ease-of-use, it was assessed with the TAM3 [69]. We found no validated Portuguese translation, since most studies (e.g., [21, 65, 70]) just translate the original scale [69] and adapt to their context by replacing "the system" with their specific product. We used the four items to collect the perceived ease-of-use dimension. The perceived ease-of-use scale acts as a unidimensional scale that reports how effortless the user believes that interacting with a system is. The TAM3 has been shown to be a valid and robust model that has been widely used [38], showing a strong reliability [43].



(a) Screenshot of the GUI designed for individuals with low conscientiousness (GUI-Low).



(b) Screenshot of the GUI designed for individuals with high conscientiousness (GUI-High).

Fig. 5 Both GUIs used for the global change design guidelines. The text is a direct translation of the native language, Portuguese, which was how the apparatus was presented to the participants

Considering the most chosen styles, we designed one interface with a website layout for each conscientiousness group according to Table 1. The GUIs (Fig. 5a and b) are designed as information-seeking interfaces. For clarity, the GUI designed for the group with low conscientiousness values will be henceforth called GUI-Low, while the one for high conscientious individuals will be GUI-High. There is a slideshow of images on top and three pages, each with images and their caption. The subject is related to personality models, as it is a topic not commonly known, so that it prompts the participant to read the content without having prior knowledge of it. While the first page contained general information about personality and how to measure it, the second page shows personality disorders. Finally, the third page shows the traits of the FFM

and their descriptions. Additional material for these sessions includes a list of questions that address information-seeking behavior in order to elicit interaction between the subject and the GUIs, and a consent form.

4.3 Procedure

Every session took place in a quiet room with the participant and an assistant present. As preparation for the session, the assistant randomly ordered the interfaces according to the Latin squares technique and chose five questions for each interface. Each participant was asked to answer the following set of questions that are on the topic of personality psychology:

- What kind of concept is used in the phrase "That person has no personality"?
- How are values measured for different personality models?
- Who developed the Portuguese version of the NEO PI-R?
- How many subscales and items does the NEO PI-R have?
- Extraversion is related to what?
- What reflects agreeableness?
- How are the symptoms of disorders experienced by the individual?
- What is the danger of personality disorders?
- What is the method used by the current classification systems?
- How long do symptoms have to be present to diagnose personality disorder in an individual under 18?

Each question could only be associated with an interface per participant, who was prompted to learn from the website layout the needed information to answer. This design decision allows us to guarantee that each participant has to perceive and work based on the styles of the graphical features, thus prompting an evaluation of the general look of the website layout. In addition, the randomly order allows us to avoid the learning bias. When the participant arrived, the session started and the assistant introduced the study and the equipment to the participant and told them what to expect to do in the session. The participant then sat in front of the computer and they were asked to fill in a consent form. Next, the assistant opened the first interface in the participant's computer and asked the questions associated to it, each time waiting for the correct response by the participant. Afterwards, the participant filled in the SUS regarding that GUI and repeated these steps for the remaining interface. Each session was around 20 min. Finally, the participant was asked to point which was their favorite interface. The assistant then thanked them for their time and gave them their compensation.

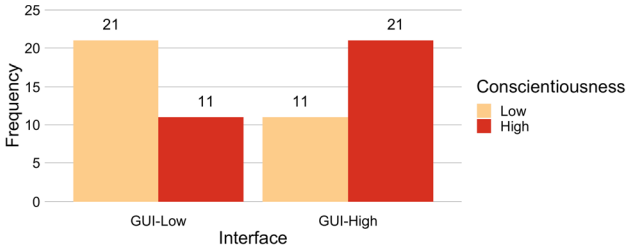


Fig. 6 User preferences for both interfaces according to conscientiousness groups

4.4 Research design

User preference was assessed by checking which interface the users rated higher. In case there was a tie, we counted a preference vote for each interface. We used a chi-squared test of association (2×2 tables) [52] to study whether the preference counts were significantly different for both independent variables (conscientiousness group and GUI instance). For the remaining hypotheses, we used a two-way mixed-design ANOVA to analyze effects of conscientiousness (between-subjects) and the developed GUIs (within-subjects) on the dependent variables' perceived usability and ease-of-use scores. Both the conscientiousness variable and the GUIs' variable have two levels: high and low for the former, GUI-High and GUI-Low for the latter. Regarding the two dependent variables, while perceived usability was calculated following the formula of the questionnaire [11], perceived ease-of-use scores are the sum of the four items regarding that dimension in the TAM3 questionnaire [69]. ANOVAs were followed by post hoc Tukey's range tests, which include Bonferroni corrections. Finally, data is presented as mean $\pm$ standard deviation.

4.5 Results

We started by studying **H1** with a chi-squared test of association (2×2 tables) [52], which showed significant differences ($p = .012$) in the preferences for both conscientiousness groups with a large effect size, $\phi = .313$. In particular, 65.63% of the participants from the *Low* group and 65.63% from the *High* level preferred the version designed for their degree of conscientiousness (Fig. 6). Therefore, we accept **H1**, since **conscientiousness has an effect on user preferences**. Interestingly, our results show that the *High* and *Low* categorization of conscientiousness scores produces symmetric results between groups. This means that creating a graphical user interface based on the design preferences of a conscientiousness group leads members of that group to prefer that interface. In particular, it highlights the potential of targeting the design of graphical user interfaces to personality traits. Nevertheless, besides this preference

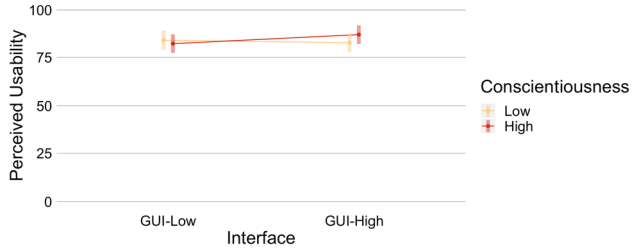


Fig. 7 Estimated marginal means of perceived usability across groups for the different interfaces

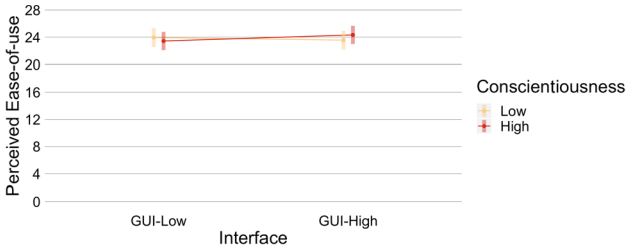


Fig. 8 Estimated marginal means of perceived ease-of-use across groups for the different interfaces

self-assessment, it is also important to consider other metrics of quality, such as the perceived usability and ease-of-use.

We used a two-way mixed ANOVA to find differences between the perceived usability that participants attributed to each interface based on their conscientiousness level. There was no statistically significant interaction between the conscientiousness group and interface preference, $F(1,58) = 2.355, p = .130$, partial $\eta 2 = .039$. Additionally, we found no significant differences in perceived usability score between high ($Mdn = 88.75$) and low ($Mdn = 87.5$) conscientiousness individuals, $F(1,58) = 1.74, p = .679$, partial $\eta 2 = .003$, and between the interface designed for the high conscientiousness group ($Mdn = 90$) and for the low conscientiousness one ($Mdn = 86.25$), $F(1,58) = .772, p = .383$, partial $\eta 2 = .013$. Indeed, a closer look at the distributions in Fig. 7 shows that, for the GUI-Low, the participants with lower values ($M = 84.05; SD = 12.29; SE = 2.57$) present a smaller interquartile range (IQR) compared to their counterparts ($M = 82.76; SD = 13.33; SE = 2.54$) of conscientiousness. In addition, the mean for individuals with lower conscientiousness is higher compared to their counterparts. This suggests that individuals with lower conscientiousness levels tended to prefer the interface designed for them compared to people with high conscientiousness. A contrasting effect can be observed in the interface designed for individuals with higher scores on this trait, since they also lean to higher perceived usability ratings ($M = 87.02; SD = 14.03; SE = 2.46$) for the interface designed according to their preferences compared to participants with lower conscientiousness ($M = 82.26; SD = 13.34; SE = 2.48$). Nevertheless, a pairwise comparison showed no statistically significant score variations across GUIs; there was a nonsignificant decrease of 1.293 (95% CI, −4.380 to 6.957; $p = .650$) for the low group and a nonsignificant increase of 4.758 (95% CI, −.729 to 10.246; $p = .088$) for the high group from the GUI-Low to the GUI-High. Therefore, we reject **H2**, since **conscientiousness does not have an effect on perceived usability**.

Finally, we addressed whether conscientiousness has an effect on perceived ease-of-use. A two-way mixed ANOVA showed no statistically significant interaction between the level of conscientiousness and GUI on perceived ease-of-use, $F(1,58) = 1.687, p = .199$, partial $\eta 2 = .028$. Indeed, we found no significant differences in perceived ease-of-use score between high ($Mdn = 24.5$) and low ($Mdn = 24$) conscientiousness individuals, $F(1,58) = .24, p = .877$, partial $\eta 2 < .001$, and between the GUI-High ($Mdn = 25$) and the GUI-Low ($Mdn = 24$), $F(1,58) = .281, p = .598$, partial $\eta 2 = .005$. Taking a closer look into the estimated marginal means (Fig. 8) in perceived ease-of-use, we can see that all distributions are similar. While the GUI-Low led these individuals to rate ease-of-use slightly higher ($M = 23.93; SD = 3.26; SE = .67$) compared to highly conscientiousness participants ($M = 23.55; SD = 3.92; SE = .72$), a dissimilar effect was present while interacting with the GUI-High: people with high levels rate ease-of-use slightly higher ($M = 24.32; SD = 3.76; SE = .70$) compared to their counterparts ($M = 23.42; SD = 4.03; SE = .65$). Nevertheless, no conscientiousness group significantly varied their score across GUIs, showing a nonsignificant decrease of .379 (95% CI, −1.042 to 1.800; $p = .595$) for the low group and a nonsignificant increase of .903 (95% CI, −.471 to 2.278; $p = .193$) for the high group from the GUI-Low to the GUI-High. In the light of this, we reject **H3**, since **conscientiousness does not have an effect on perceived ease-of-use**.

5 Discussion

In this section, we discuss our findings and their implications for design, as well as the limitations of our work.

5.1 Explanation of findings

Our results show that conscientiousness has an effect on user preferences. In addition, they suggest that conscientiousness does not act as a factor in the way users perceived usability and ease-of-use according to those preferences. We identified that users with low levels of conscientiousness prefer squared buttons, while high levels would rather have rounded ones. When focusing on navigational buttons, the former prefer page numbers and the latter "previous" and

"next." Although Sarsam and Al-Samarraie [64] considered more personality traits, the authors also found differences in user preferences regarding buttons. Similar to their work and the work of Xavier and Gama [74], we found dissimilar preferences in font size. In particular, people from the *High* group preferred medium-sized fonts, while the other participants chose small sizes. Additionally, we found novel results in the alignment of image captions, the side of the layout where images should be displayed, and the size of the margins. People with high levels of conscientiousness prefer left-aligned image captions, left-aligned images, and large margins, while people from the lower values would like centered image captions, images on the right side of the layout, and medium body margins. Regarding perceived usability and ease-of-use, changing the whole interface suggested interaction effects with the conscientiousness trait. In particular, applying these styles as a whole points towards an effect on perceived usability and ease-of-use. Nevertheless, it corroborates how people perceive a website layout modeled according to their preferences.

Our results are in accordance with previous work regarding the design of websites. Regarding self-assessment of websites, Fogg et al. [24] also found that 45% of consumers self-assessed the credibility of a website based on its design. While we found that participants had distinct preferences regarding button features, and image and overall layout, Fogg et al. [24] showed that user pay attention to several design elements such as layout, typography, font size, and color scheme. Moreover, Alsudani and Casey [3] showed that these judgments about visual stimuli are conducted in a very short amount of time. Indeed, Robins and Holmes [63] found that individuals judged the credibility of the content of a website based on its appearance in 3.42 s. Although our participants had no limit of time to answer any question, each user test took at least 10 min and finding the answers in the text covered the whole website layout, thus allowing participants to grasp the implications of designing a GUI based on the stipulated user preferences. Regarding our information-seeking tasks, we recognize that they were not complex interactions with an interface. Nonetheless, our results showed that just a simple interaction as searching for an answer in a website layout led people to prefer a more appealing GUI.

5.2 Design implications

These results are particularly interesting to the development of user interfaces for the broad public, as people are more satisfied with a beautiful product that performs sub-optimally than with a more usable but less appealing product [48]. As such, we believe that designers should aim at performing changes that have multiple GUI elements varying in style rather than performing small changes in order to provide more consistency to the users according to their conscientiousness level. In addition, we believe that there is a possible extensibility of our approach in other GUIs besides website layouts.

Regarding external validity, our scope is specifically on WIMP desktop-based interfaces. As such, we believe that graphical interfaces that strongly leverage characteristics of a WIMP interface may show similar results to ours. For instance, Sarsam and Al-Samarraie [64] also considered personality profiles with significant scores in conscientiousness and found that users preferred a mobile interface designed for their personality group. Nevertheless, the personality profiles considered in Sarsam and Al-Samarraie [64] include more than one trait, while we address conscientiousness specifically. We plan on extending our approach to other types of paradigms such as mobile and XR. Although the paradigms present different design constraints and features, our finding regarding the effect of conscientiousness in user preference should be transferred, since subjects would still need to provide their self-assessment of a graphical user interface. For the ecological validity of our findings, conscientiousness has already been found to be a predictor of preferences such as morning or evening activities [18, 29] or media preference and political orientation [75]. As such, we believe that our findings regarding the effect of conscientiousness on user preference can be generalized to real-life settings.

We suggest that our findings should be applied by designers on applications [37] as a means to potentially appeal to new users. Furthermore, psychologists have been studying how consistency in others helps people to predict what will happen when they engage with others [22], how it makes it easier to remember a person accurately [13], and, in most cases, how it lightens the cognitive load [22]. Therefore, designers should work with the set of expectations that people bring to their interaction with the artifact, thus creating intuitive "affordances" [57].

Nevertheless, in order to apply our findings, designers are required to assess the scores of the user's personality traits. Usually researchers use the traditional method of validated psychological questionnaires to assess personality. Nevertheless, there are several downfalls with this approach. Since it takes a lot of time to answer the questionnaires, their static and long nature restricts practical applications. Moreover, users may not answer truthfully, since they may provide responses in a way they think is best for a given situation or due to privacy issues [25]. In this light, personality assessment has been expanded in recent years [4] through several methods such as eye-tracking [8], social media [5, 20], and electroencephalography [67, 72]. Although there are still several ethical considerations to tackle [2, 53], we believe that current state-of-the-art sensors enable us to easily capture a rich stream of data on people's behaviors and interactions, for instance. Then, these data can be processed through several artificial intelligence methodologies to assess personality traits [8]. Coupled with the ubiquitous

nature of technology nowadays, we believe that in the future people will have their personality scores associated with an online identification profile. This personality profile can then be read by a piece of adaptive technology before any interaction to customize the graphical user interface to the user's personality.

None of these prospects diminishes the importance of allowing the user to adapt the graphical user interface afterwards. We argue that although personality profiles encompass a variety of people with similar scores in the traits, there can still exist differences between them. For instance, if we consider two facets from the conscientiousness trait — *competence* and *dutifulness* — two persons can have symmetric scores in these facets yet have the same conscientiousness score. As such, although they would be categorized with the same personality profile in our study, these intrinsic differences may lead to small changes in design preferences, for instance. It makes sense that the user may still be able to have control of the final appearance of the graphical user interface, as the adaptation beforehand converges on the common design preferences within a group but may not account for individual preferences independent of personality.

5.3 Limitations

There are some important factors that may explain the lack of significance observed in some of our results. First, the number of participants in this experience could have been larger. A larger number of participants would allow conclusions with a stronger impact. In particular, we could have extracted a larger number of preferences which would allow us to explore more in-depth differences in preferences. Additionally, the user groups in both studies were significantly different in both conscientiousness and neuroticism scores. Although McCrae and John [51] focused on creating five unique, independent traits, research has shown that neuroticism and conscientiousness are negatively correlated at the between-person level of analysis [56]. As such, the fact that individuals from the *High* and *Low* conscientiousness groups have statistically significant different scores in the neuroticism trait is a byproduct of a contradiction of the conceptual orthogonality assumption of the FFM. Nevertheless, it does not invalidate our results, since subjects had similar scores in the other traits, making conscientiousness a differential factor.

Secondly, the GUIs we designed were simple information-seeking interfaces, composed mainly of short texts and images. Additionally, the tasks users had to perform in the sessions were also simple and straightforward. There may not be more significant results because changing interface features does not lead to a significant change in the user perception, since users were able to complete the tasks without much impediment. Moreover, although we chose the most common styles for the features, there are more styles that could be shown to participants that may have revealed other preferences. Thirdly, the interfaces used to illustrate the different design guidelines may have had an effect on how people perceived them. Given its information-seeking nature, people could recollect past experiences regarding certain element styles and, therefore, assess their preference based on one particular experience instead of assuming the specific scenario. Finally, these effects may also be explained based on how people had to choose their preferences for each feature as a unitary style, i.e., participants chose the style they liked the most for a feature instead of ranking their preference across styles for a feature. By allowing participants to rate their preference with Likert scales, for example, it is possible to extract more results and avoid making users committing to a single style.

6 Conclusions and future work

The objective of our study was to assess how the personality trait of conscientiousness affects user preferences. In order to acquire design preferences, we addressed the most used GUI elements of the state-of-the-art (e.g., Alves et al. [4]) and based their style variations on past research. Our approached differentiated users based on their conscientiousness level to then extract design preferences regarding a unique possible style of a certain feature. We found that changing a set of features affected individuals, specifically regarding the user preference of the interfaces. These results empower designers with new tools to develop their goal-oriented user interfaces for the correct target audience. In addition, designers can apply the reverse technique of extracting personality traits from how users choose to customize their GUIs.

Future work includes recruiting a larger sample set. A more heterogeneous sample may allow researchers to find not only stronger results, but to further explore the way we divided the three groups between Low (0 to 25th percentile), Medium (26th to 75th percentile), and High (76th to 100th percentile). For example, future studies can consider a narrower division just between people that are either above or below the 50th percentile, or dividing them in four different groups, each with 25% of the population. Moreover, we can explore the remaining traits of the FFM, besides studying in-depth personality by extending our scope to personality facets. In addition, task types and contexts should be further explored as they may lead to different interactions of users given their individual differences. In particular, future work includes collecting design preferences in a more complex environment to verify how they affect user perception regarding the graphical elements.

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Declarations

Ethics approval This study obtained two ethics approvals by the Ethics Committee of Instituto Superior Técnico, University of Lisbon (CE-IST) with references 7/2019 and 18/2020. This paper or a similar version is not currently under review by a journal or conference. This paper is void of plagiarism or self-plagiarism as defined by the Committee on Publication Ethics and Springer Guidelines.

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References

1. Al-Samarraie H, Eldenfria A, Dawoud H (2016) The impact of personality traits on users' information-seeking behavior. Inform Process Manag 18:17–18. https://doi.org/10.1016/j.ipm.2016.08.004
2. Alkhatib A (2021) To live in their utopia: Why algorithmic systems create absurd outcomes. In: Proceedings of the 2021 CHI conference on human factors in computing systems, pp 1–9
3. Alsudani F, Casey M (2009) The effect of aesthetics on web credibility. In: Proceedings of the 23rd British HCI group annual conference on people and computers: Celebrating people and technology. British Computer Society, pp 512–519
4. Alves T, Natálio J, Henriques-Calado J, Gama S (2020) Incorporating personality in user interface design: a review. Person Indiv Diff 155:109709. https://doi.org/10.1016/j.paid.2019.109709.
5. Azucar D, Marengo D, Settanni M (2018) Predicting the Big 5 personality traits from digital footprints on social media: a meta-analysis. Person Indiv Diff 124:150–159
6. Bangor A, Kortum PT, Miller JT (2008) An empirical evaluation of the system usability scale. Intl Journal of Human-Computer Interaction 24(6):574–594
7. Basu S (2013) Modern UI design, Apress, pp 11–24. https://doi.org/10.1007/978-1-4302-5026-5_2
8. Berkovsky S, Taib R, Koprinska I, Wang E, Zeng Y, Li J, Kleitman S (2019) Detecting personality traits using eye-tracking data. In: Proceedings of the 2019 CHI conference on human factors in computing systems. ACM, p 221
9. Bontchev BP, Terzieva V, Paunova-Hubenova E (2021) Personalization of serious games for learning. Interactive Technology and Smart Education
10. Braun M, Chadowitz R, Alt F (2019) User experience of driver state visualizations: a look at demographics and personalities. In: IFIP conference on human-computer interaction. Springer, pp 158–176
11. Brooke J et al (1996) SUS-A quick and dirty usability scale. Usability evaluation in Industry 189(194):4–7
12. Brown ET, Ottley A, Zhao H, Lin Q, Souvenir R, Endert A, Chang R (2014) Finding Waldo: learning about users from their interactions. IEEE Trans Visual Comput Graph 20(12):1663–1672
13. Cantor N, Mischel W (1979) Prototypes in person perception. Adv Exper Soc Psychol 12:3–52
14. Chae M, Kim J (2004) Do size and structure matter to mobile users? An empirical study of the effects of screen size, information structure, and task complexity on user activities with standard web phones. Behaviour & Information Technology 23(3):165–181. https://doi.org/10.1080/01449290410001669923
15. Condeço J, Gama S, Gonçalves D (2018) Colorcode: exploring social and psychological dimensions of color. MSc dissertation, Universidade de Lisboa - Instituto Superior Técnico
16. Davis FD (1989) Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS quarterly pp 319–340
17. de Alwis DV, Kon CH (1992) A new way to use the ishihara test. J Neurol 239(8):451–454
18. Eberspach L, Fenske G, Groten SC, Neufeldt LE, Scherrer V, Preckel F (2016) Why do larks perform better at school than owls? The mediating effect of conscientiousness. International Online J Educ Sci 8(5)
19. Evett L, Brown D (2005) Text formats and web design for visually impaired and dyslexic readers—clear text for all. Interacting with Computers 17(4):453–472. https://doi.org/10.1016/j.intcom.2005.04.001.
20. Farnadi G, Sitaraman G, Sushmita S, Celli F, Kosinski M, Stillwell D, Davalos S, Moens MF, De Cock M (2016) Computational personality recognition in social media. User modeling and user-adapted interaction 26(2–3):109–142
21. Ferreira DBdS (2014) A influência do modelo de aceitação da tecnologia na utilização da rede social facebook na perspetiva do perfil pessoal. PhD thesis, Instituto Politécnico do Porto. Instituto Superior de Contabilidade e Administração do Porto
22. Fiske ST, Taylor SE (2013) Social cognition: from brains to culture. Sage
23. Fleming J, Koman R (1998) Web navigation: designing the user experience. O'reilly Sebastopol, CA
24. Fogg BJ, Soohoo C, Danielson DR, Marable L, Stanford J, Tauber ER (2003) How do users evaluate the credibility of web sites?: A study with over 2,500 participants. In: Proceedings of the 2003 conference on Designing for user experiences, ACM, pp 1–15
25. Friedman A, Knijnenburg BP, Vanhecke K, Martens L, Berkovsky S (2015) Privacy aspects of recommender systems. In: Recommender systems handbook. Springer, pp 649–688
26. GeiBler J, Gauler M, Streitz NA (1999) Evaluating gedrics: usability of a pen-centric interface. In: Human-computer Interaction, INTERACT'99: IFIP TC. 13 International conference on human-computer interaction, 30th August-3rd September 1999, Edinburgh, UK, IOS Press, vol 1, p 222
27. Halko S, Kientz JA (2010) Personality and persuasive technology: an exploratory study on health-promoting mobile applications. In: International conference on persuasive technology, Springer, pp 150–161. https://doi.org/10.1007/978-3-642-13226-1_16
28. Hanisch KA, Kramer A, Hulin CL (1991) Cognitive representations, control, and understanding of complex systems: a field study focusing on components of users' mental models and expert/novice differences. Ergonomics 34:1129–45. https://doi.org/10.1080/00140139108964851
29. Hogben AL, Ellis J, Archer SN, von Schantz M (2007) Conscientiousness is a predictor of diurnal preference. Chronobiology International 24(6):1249–1254

30. Hu J, Zeng HJ, Li H, Niu C, Chen Z (2007) Demographic prediction based on user's browsing behavior. In: Proceedings of the 16th international conference on World Wide Web, ACM, pp 151–160
31. Hu R, Pu P (2009) Acceptance issues of personality-based recommender systems. In: Proceedings of the third ACM conference on Recommender systems, ACM, pp 221–224
32. ISO 9241–11:2018, (2018) Ergonomics of human-system interaction - part 11: usability: definitions and concepts. Standard, International Organization for Standardization
33. Kane SK, Wobbrock JO, Smith IE (2008) Getting off the treadmill: evaluating walking user interfaces for mobile devices in public spaces. In: Proceedings of the 10th international conference on human computer interaction with mobile devices and services, ACM, New York, NY, USA, MobileHCI '08, pp 109–118. https://doi.org/10.1145/1409240.1409253.
34. Karanam Y, Filko L, Kaser L, Alotaibi H, Makhsoom E, Voida S (2014) Motivational affordances and personality types in personal informatics. In: Proceedings of the 2014 ACM international joint conference on pervasive and ubiquitous computing: Adjunct Publication, ACM, New York, NY, USA, UbiComp '14 Adjunct, pp 79–82. https://doi.org/10.1145/2638728.2638800.
35. Kernberg OF (2016) What is personality? Journal of Personality Disorders 30(2):145–156
36. Kim J (2008) Modeling task-based information seeking on the web: application of information seeking strategy schema. Proc Amer Soc Inform Sci Technol 44:1–13. https://doi.org/10.1002/meet.1450440239
37. Kim Y, Briley DA, Ocepek MG (2015) Differential innovation of smartphone and application use by sociodemographics and personality. Comput Human Behav 44:141–147
38. King WR, He J (2006) A meta-analysis of the technology acceptance model. Information & Management 43(6):740–755
39. Kosinski M, Bachrach Y, Kohli P, Stillwell D, Graepel T (2014) Manifestations of user personality in website choice and behaviour on online social networks. Machine Learn 95(3):357–380. https://doi.org/10.1007/s10994-013-5415-y
40. Kostov V, Fukuda S (2001) Development of man-machine interfaces based on user preferences. In: Proceedings of the 2001 IEEE international conference on control applications (CCA'01) (Cat. No.01CH37204), pp 1124–1128. https://doi.org/10.1109/CCA.2001.974022
41. Lawrence LA, Selvaraj JC (2013) User interface design for effective e-learning based on personality traits. Int J Comput Appl 61:28–32. https://doi.org/10.5120/9998-4861
42. Lee DS, Shieh KK, Jeng SC, Shen IH (2008) Effect of character size and lighting on legibility of electronic papers. Displays 29(1):10–17. https://doi.org/10.1016/j.displa.2007.06.007
43. Lee Y, Kozar KA, Larsen KR (2003) The technology acceptance model: past, present, and future. Commun Assoc Inform Syst 12(1):50
44. Lewis JJR, Sauro J (2017) Revisiting the factor structure of the system usability scale. Journal of Usability Studies 12(4)
45. Lewis JR (2018) The system usability scale: past, present, and future. International Journal of Human-Computer Interaction 34(7):577–590
46. Lima M, Simões A (2000) Neo-pi-r manual profissional. CEGOC, Lisboa
47. Liu Z, Crouser RJ, Ottley A (2020) Survey on individual differences in visualization. arXiv preprint arXiv:2002.07950
48. Mahlke S (2006) Studying user experience with digital audio players. Entertainment Computing-ICEC 2006:358–361
49. Makris N, van Eekelen M (2016) Creating adaptable and adaptive user interface implementations in model driven developed software. MSc dissertation, Radboud University, Nijmegen, Netherlands
50. Martins AI, Rosa AF, Queirós A, Silva A, Rocha NP (2015) European Portuguese validation of the system usability scale (SUS). Procedia Computer Science 67:293–300
51. McCrae RR, John OP (1992) An introduction to the five-factor model and its applications. Journal of personality 60(2):175–215
52. McHugh ML (2013) The chi-square test of independence. Biochemia medica: Biochemia medica 23(2):143–149
53. Mittelstadt BD, Allo P, Taddeo M, Wachter S, Floridi L (2016) The ethics of algorithms: mapping the debate. Big Data & Society 3(2):2053951716679679
54. Monk A (2000) User-centred design. In: International Conference on Home-Oriented Informatics and Telematics, Springer, pp 181–190
55. Mortimer EF (1995) Conceptual change or conceptual profile change? Science & Education 4(3):267–285. https://doi.org/10.1007/BF00486624
56. Mount MK, Barrick MR, Scullen SM, Rounds J (2005) Higher-order dimensions of the big five personality traits and the big six vocational interest types. Personnel Psychology 58(2):447–478
57. Norman D (2013) The design of everyday things: revised and expanded edition. Basic Books (AZ)
58. Oscar N, Mejía S, Metoyer R, Hooker K (2017) Towards personalized visualization: information granularity, situation, and personality. In: Proceedings of the 2017 Conference on Designing Interactive Systems, pp 811–819
59. Qusef A, Albadarneh A, Elish S, Muhanna M (2021) Mitigating personalization challenges in mobile commerce: an empirical study. Computers & Electrical Engineering 89:106904
60. Reinecke K, Bernstein A (2013) Knowing what a user likes: a design science approach to interfaces that automatically adapt to culture. MIS Quarterly 37:427–453. https://doi.org/10.25300/MISQ/2013/37.2.06
61. Ribeiro J, Carvalhais M (2012) Web design patterns for mobile devices. In: Proceedings of the 19th Conference on Pattern Languages of Programs, The Hillside Group, USA, PLoP '12, pp 13:1–13:48. http://dl.acm.org/citation.cfm?id=2821679.2831283. Accessed 5 Nov 2022.
62. Ricketts D, Lockton D (2019) Mental landscapes: externalizing mental models through metaphors. interactions 26(2):86–90
63. Robins D, Holmes J (2008) Aesthetics and credibility in web site design. Information Processing & Management 44(1):386–399
64. Sarsam SM, Al-Samarraie H (2018) Towards incorporating personality into the design of an interface: a method for facilitating users' interaction with the display. User Modeling and User-Adapted Interaction 28(1):75–96. https://doi.org/10.1007/s11257-018-9201-1
65. Silva PMd, Dias GA, Almeida JRd (2013) Modelo de aceitação de tecnologia (tam) aplicado ao sistema de informação da biblioteca virtual em saúde (bvs) nas escolas de medicina da região metropolitana do recife. PhD thesis, Universidade Federal da Paraíba, Brasil
66. Stimpson DV, Stimpson MF (1979) Relation of personality characteristics and color preferences. Perceptual and Motor Skills 49(1):60–62. https://doi.org/10.2466/pms.1979.49.1.60
67. Subramanian R, Wache J, Abadi MK, Vieriu RL, Winkler S, Sebe N (2016) Ascertain: emotion and personality recognition using commercial sensors. IEEE Transactions on Affective Computing 9(2):147–160
68. Turumugon P, Baharum A, Hanapi R, Kamarudin N, Rahim EA, Omar M (2018) Users' mental model pattern for user interface design of mobile shopping apps. Advanced Science Letters 24(2):1158–1162
69. Venkatesh V, Bala H (2008) Technology acceptance model 3 and a research agenda on interventions. Decision Sciences 39(2):273–315. https://doi.org/10.1111/j.1540-5915.2008.00192.x

70. Vilar MAdS (2013) Modelo de aceitação da tecnologia adaptado às compras online. PhD thesis, [sn]
71. Viveros AM, Hernández Rubio E, Vázquez Ceballos DE (2014) Equivalence of navigation widgets for mobile platforms. In: Marcus A (ed) Design, user experience, and usability. Springer International Publishing, Cham, User Experience Design for Diverse Interaction Platforms and Environments, pp 269–278
72. Wache J, Subramanian R, Abadi MK, Vieriu RL, Sebe N, Winkler S (2015) Implicit user-centric personality recognition based on physiological responses to emotional videos. In: Proceedings of the 2015 ACM on International Conference on Multimodal Interaction, ACM, pp 239–246
73. Wischenbart M, Firmenich S, Rossi G, Bosetti G, Kapsammer E (2021) Engaging end-user driven recommender systems: personalization through web augmentation. Multimedia Tools and Applications 80(5):6785–6809
74. Xavier I, Gama S (2019) Neural: towards neuroticicism-based user interface customization. MSc dissertation, Universidade de Lisboa - Instituto Superior Técnico
75. Xu X, Peterson JB (2017) Differences in media preference mediate the link between personality and political orientation. Political Psychology 38(1):55–72
76. Yeo GB, Neal A (2004) A multilevel analysis of effort, practice, and performance: effects; of ability, conscientiousness, and goal orientation. Journal of applied psychology 89(2):231
77. Ziemkiewicz C, Kosara R (2009) Preconceptions and individual differences in understanding visual metaphors. Computer Graphics Forum, Wiley Online Library 28:911–918
78. Ziemkiewicz C, Crouser RJ, Yauilla AR, Su SL, Ribarsky W, Chang R (2011) How locus of control influences compatibility with visualization style. In: 2011 IEEE Conference on Visual Analytics Science and Technology (VAST), IEEE, pp 81–90