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Using interface preferences as evidence of user identity: A feasibility study

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A B S T R A C T

Research on human-computer interaction currently focuses on enhancing system usability by establishing an appropriate user interface (UI) that depends on users' features. Online users typically have different perceptions of their favored interface design depending on their preferences. Thus, those interface preferences could be utilized to recognize online users' identities. User authentication is another critical issue that should be considered to improve online security mechanisms without compromising usability. This study investigates the feasibility of using UI preferences as evidence of user identity. The proposed method applies to the design preferences of users dealing with online systems (e.g., e-exam and e-banking). These preferences are closely associated with individual characteristics, whether physical, cognitive, psychological, psychomotor, demographic, or experience based. Many design characteristics could be used in online systems; for example, the e-exam interface design may use features such as the font (size, color, and face), the number of questions per page, background color, questions group, timer type, and sound alert. The feasibility evaluation of this study indicated that 96.8% of research participants have variations in their preferences, and each participant kept 94.5% of their design preferences throughout different sessions.

1. Introduction

The technological development in telecommunications and information technology has revolutionized online systems such as e-commerce, online banking, e-learning, etc. (Karim & Ali, 2021). In the last few decades, internet usage significantly increased because of the spread of computers around the globe. This led to growth in the use of the World Wide Web, a computer technology invention that has changed communication and information dissemination. The intranet, online systems, and the internet, as modern work mediums, are currently used by many individuals. Online systems provide numerous opportunities to develop new services and products (Cabrera-Sánchez et al., 2020; Salameh et al., 2016). These opportunities offer institutions opportunities to expand, attract new users, and reduce costs. These evolutions in IT and computer technology emphasize the importance of user interface (UI) design of online systems (Helander, 2014). as new technologies are emerging to improve usability (Sherman, 2016). Thus, UI design has become one of the critical assets and a part of human-computer interaction (HCI) research, which involves the study of human interaction with computer systems (Lazem et al., 2022; Panda

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& Roy, 2022). Technology has allowed us to create highly effective and usable interfaces. UI has been defined by (McDaniel & International Business Machines Corporation, 1994) as follows:

"*Hardware, software (including menus, screen design, keyboard commands, and command language), or both that allows users to interact with and perform operations on a system, program, or device".*

The UI design is considered a vital aspect of computer systems that largely determines how well clients approve, understand, and react to the whole computer application. Regardless of the technology used in systems design, end-users use UI to interact with any application (Karim et al., 2020; Yu & Kong, 2016). For example, those who take an e-exam relate to an interface consisting of several features, such as the exam question displayed, thereby making it more convenient for the exam-taker to partake in the e-exam professionally (Karim & Shukur, 2016a).

Users still lack confidence in such online environments because of the large number of attackers. Thus, user authentication is considered an important issue in such situations (Karim et al., 2020). User authentication methods are categorized into three types (Fig. 1): (1) something the user knows or knowledge-based authentication (KBA), (2) something the user has or possession-based authentication (PBA), and (3) something the user is or biometric-based authentication (BBA) (Kang et al., 2014; Karim & Shukur, 2016b), where KBA demands knowledge of confidential and secret information of a user to permit access to secured resources. A user identification number (ID), password, and security questions are typically used. KBA techniques are the most extensively used authentication method. KBA includes text and picture-based authentication (Bhana & Flowerday, 2020). However, good passwords can sometimes be difficult to remember (Karim et al., 2020; Papathanasaki et al., 2022). PBA is a type of authentication based on the individual's private items (i.e., token-based authentication). Whereas a token is mostly a physical device that can be held by the user. Nevertheless, demonstrating a valid token is not sufficient proof of ownership because the token may have been copied or stolen by adversaries. (Karim et al., 2020). Common instances of PBA are security keys, memory cards, smart card tokens, and dongles (Kruzikova et al., 2022; Moon et al., 2015). As for BBA, it is described as the authentication of individuals based on their behavioral or physical characteristics. Besides, physical biometrics are based on the physical characteristics of the user, with commonly used physical characteristics being face, fingerprint, hand, iris, retina, ear, skin, etc. (Juneja, 2017). Behavioral biometrics depend on the user's behavioral characteristics (Jancok & Ries, 2022). The commonly used behavioral characteristics include keystroke dynamics, voice print, mouse movement, gait, signature, and pulse (Karim et al., 2020). Biometric authentication is technically complex and usually expensive because it requires special devices (readers) to read biometric data, specifically with physical biometrics (Islam et al., 2016; Karim et al., 2021). Additionally, the BBA offers the most reliable and precise way of identification since biometrics cannot be easily stolen or transferred (Nedjah et al., 2017; Shakil et al., 2017). However, biometrics authentication is uncommon because it is perceived as a violation of personal privacy (Hublikar et al., 2023). Furthermore, putting biometric authentication into place might be difficult and not always be successful for all users. When using biometrics in online systems, elements like the necessary technology and accuracy must be considered (Karim et al., 2020).

More authentication methods fall outside the above-mentioned classification, each with advantages and disadvantages. Unique identifiers such as MAC addresses and IMEI numbers assigned to devices can improve security measures (Hassan & Shukur, 2022). However, they could be more foolproof since determined attackers can fake or alter them. (Hammood et al., 2021). Geolocation and IP addresses can increase security by confirming the user's location. (Akhtar & Haq, 2011). However, they can be masked or manipulated using proxy servers or virtual private networks (VPNs), reducing their effectiveness as standalone authentication methods (Moepi & Mathonsi, 2021). CAPTCHA tests contain visual or audio puzzles that require human interpretation to solve in order to distinguish between humans and automated bots. (Kheshaifaty & Gutub, 2021). While CAPTCHAs serve as an effective deterrent against bots, advanced algorithms or Optical Character Recognition (OCR) technology can potentially bypass them, compromising their reliability. FIDO (Fast Identity Online) is another authentication method that uses public-key cryptography and biometrics to provide passwordless authentication (Vinbæk et al., 2019). FIDO offers enhanced security by eliminating the need for passwords and relying on strong authentication through biometrics and cryptographic keys. However, FIDO's implementation, infrastructure, and compatibility may pose challenges that need to be considered in online banking systems (Zhang et al., 2018).

In this study, we investigate a novel concept that could be utilized to distinguish the identities of users who deal with UI preferences of online systems, "something users prefer/something reflects you." Utilizing HCI research is one way to accomplish this—particularly the studies on adaptive user interfaces, which are concerned with the usability of UI design. To do this, we must ascertain whether users' preferences for interface design are constant across time and whether there are variations among them.

In this paper, we contribute the following:

- We examine the feasibility of using UI preferences as user authentication methods for online systems.
- We try to solve the problem of the classical trade-off between security and usability by evaluating the feasibility of using preferences (usability factor) to authenticate users (security).

- We try to contribute to the user authentication field by suggesting a new way to authenticate users (something you prefer)
- Suggest a secondary authentication method that could be used with other user authentication methods as a combination of two-factor authentication (2FA) or Multi-factor authentication (MFA).

The rest of this article is structured as follows. Section 2 explains user interface preferences and user identity. Section 3 covers the research method. Results are described in Section 4. The findings are discussed in Section 5. Finally, Section 6 summarizes the research and provides the limitations and future research directions.

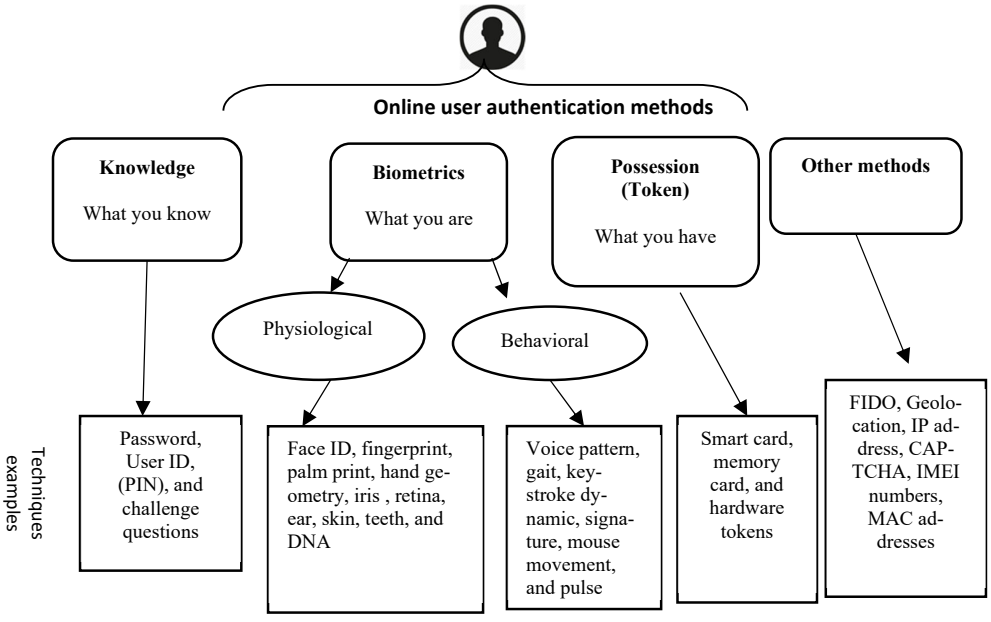

Fig. 1. Online user authentication methods and examples (Abdel Karim, Nader, Shukur, 2015).

2. UI Preferences and User Identity

Many HCI studies focus on establishing adaptive UIs to enhance system usability. This helps to improve user suitability by creating a proper UI based on user features and preferences (Loitsch et al., 2017; Miraz et al., 2021; Pu et al., 2012) (Fig. 2).

The interface design is affected by user characteristics (Newell et al., 2011; Tao et al., 2022). Bernard et al. (2001) identified an association between an individual's characteristics and font type selection. Besides, authors (Karsvall, 2002), specified that individual personal features impact an individual's interface design preference. Authors (Evers & Day, 1997), determined that the preferences of UI design influence interface acceptability. Authors (Chen & Liu, 2017) thought interface designs with straightforward layouts were more user-friendly and usable for elderly users with dementia; As a result, complex arrangements and displays of information that require creative engagement should be avoided when designing user interfaces. The outcomes offer guidelines for creating perceptive and considerate user interfaces for elderly users with dementia. According to authors (Rangraz Jeddi et al., 2020) it is crucial to consider the needs and characteristics of diverse user groups while analyzing and designing the national health information online system. Therefore, user characteristics should be considered when creating the interface design of any online system. As stated by literature (Aranyi & van Schaik, 2015; Nunes et al., 2016), the categories of cognitive, psychological, physical, psychomotor, experience, and demographics are used to classify individual characteristics that might impact UI design.

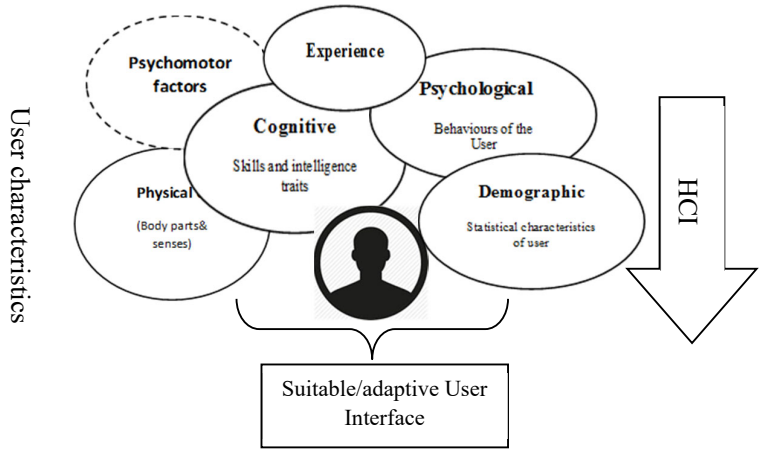

Fig. 2. User characteristics and the UI design.

Cognitive characteristics are the mental strategies consumers employ when interacting with a user interface (UI). These comprise processes like concentration, memory, and judgment. For instance, a user interface (UI) should be made to be simple to focus on and not overwhelm users with information. Additionally, users should be able to recall their previous actions and choose what to do next (Sarsam & Al-Samarraie, 2018). The emotional and personality characteristics of users are their psychological characteristics. Personality, motivation, and mood are a few examples of these. For instance, an engaging and compelling UI should be created. Additionally, the personality of the user should be considered when designing it. As an illustration, an impulsive user would pick a fast-paced, thrilling UI, whereas a cautious user might favor a more organized, predictable UI (Tong et al., 2018).

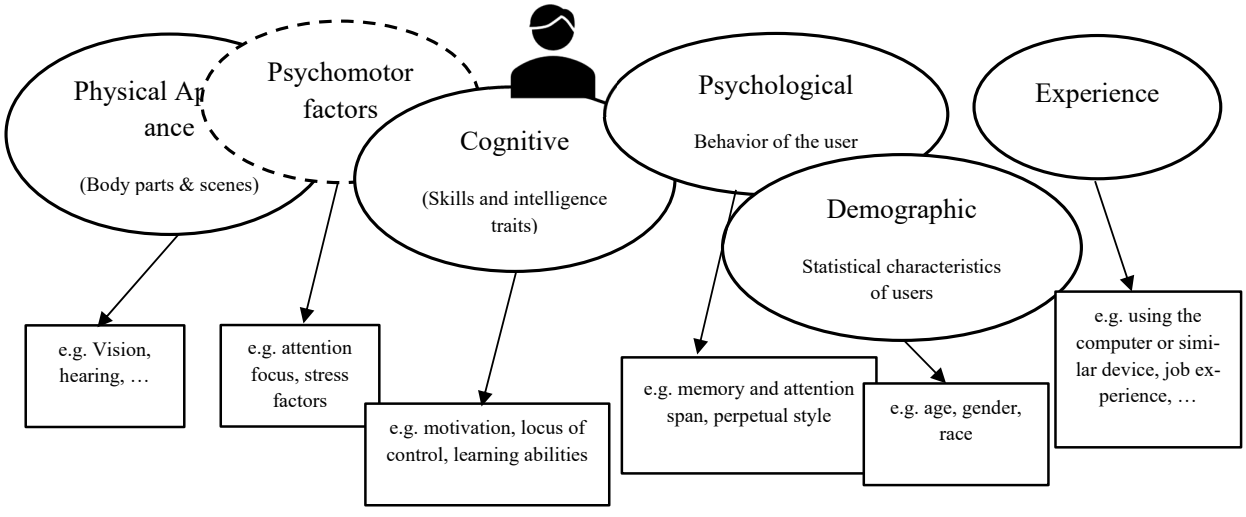

Fig. 3. User characteristics might affect how the interface is designed (Abdel Karim & Shukur, 2016).

Users' physical characteristics include things like their age, gender, and dexterity. For instance, a user interface should be accessible to users of all ages and skill levels. Additionally, it needs to be built to be pleasant for extended periods (Du et al., 2022). The abilities and skills users need to interact with a user interface are known as psychomotor characteristics. These include abilities like quick typing, visual acuity, and hand-eye coordination. For instance, a user interface (UI) should be made simple to use by users with various psychomotor skills. It should also be made so that the user's visual acuity is not overly taxed (Abdel Karim & Shukur, 2016). Experience is the amount of exposure users have to a specific UI or UI type. For instance, a user who has never used a particular form of UI may require more assistance and instruction than one accustomed to it(Chung, 2023). Age, gender, and income are a few examples of a population's demographics. A UI, for instance, might be created differently for a younger audience than an older audience(Al-Sa'Di & Al-Samarraie, 2022) (Fig. 3).

2.1 Interface Preferences

The interface preferences are alternative uses of the interface elements, which together make up the entire user interface. So, is there a relationship between a user's characteristics and preferences for an interface? many authors in previous studies (Lu & Rastrick, 2014; Walia et al., 2016; Young & Rudin-Brown, 2018) mentioned that design preferences impact interface acceptance. Authors (Bernard et al., 2001) said that there is a relationship between an individual's characteristics and chosen font types. (Karsvall, 2002) and (Ling & van Schaik, 2007) stated that personality factors affect a UI design preference (Karsvall, 2002; Ling & van Schaik, 2007). Therefore, Each user has specific preferences for various interface designs, which are influenced by their characteristics. Thus, in addition to using these characteristics as proof of the user's identity, we should determine the kinds of options that users may provide to improve the effectiveness and convenience of candidates taking an e-exam.

Authors (Jakobsson & Siadati, 2012) emphasized that using facts is the primary flaw in many KBA (such as password and security questions) approaches. People need to remember these facts, and they need to be hard for adversaries to find. Since preferences are more stable than a user's long-term memory, he advised switching from a fact-based to a preference-based approach (Crawford et al., 1986; Kuder, 1939).

2.2 Design Features

The user interface design of any system in the online environment often comprises many "design features" used to display content. Due to this design, the user should be able to engage with the system quickly and professionally. Depending on the type and nature of the system, these "design features" vary. For instance, background color, font size, type, color, and style are design features that can be utilized to build the user interface of any online system (Table 1). The following table lists potential design elements for several significant public online systems, including social networks, online banking, and e-exam.

Table 1
Popular online system design features

System	Possible design features	References
e-exam	• Font (i.e., size, type, style, and color) • Background color • Questions group • No of questions/page • Sound alert • Time counters	(Abdel Karim & Shukur, 2016; Bonnardel et al., 2011; Karim et al., 2021)
e-banking (e.g., CIMBclick)	• Font (i.e., size, type, style, and color) • Background color • Change theme (list of themes) • Language • System clock display (digital or analog) • Virtual keyboard (Numeric keypad and full ASCII keyboard) • Social network design -The modern design style is to integrate social networking into online banking websites- (e.g., Facebook, Twitter, YouTube, and Google Plus) • Alert text (messages on your mobile, mobile banking app alerts, or email) • Display accounts on the main page (view all, current/savings, credit card, etc.) • Account summary (choose accounts and display on the panel on the main page)	(America, 2016; Banerjee et al., 2011; Bonnardel et al., 2011; CIMBBank, 2017; Eze, 2014; Luo et al., 2020; Rello et al., 2012, 2013; Ubam et al., 2021)
Social networks (e.g., Facebook)	• Font (i.e., size, type, style, and color) • Background color • Language • Language translation (e.g., translate into English) • Notification (sound on/off) • Add-ons for Facebook (e.g., PayPal, Uber Ride Reminder, etc.). • Video setting (default quality, auto-play, and show captions) • Change theme (list of themes) • Timeline and tagging setting (who can add things to a Timeline? Who can see things on the Timeline? Manage tags people add and tagging suggestions) • Manage to block (restricted list, block users, etc.)	(Banerjee et al., 2011; Bonnardel et al., 2011; Eze, 2014; Facebook, 2017; Ferrucci et al., 2021; Massa & Spano, 2016; Rello et al., 2012, 2013)

The above design elements have potential values that can be examined to create an ideal user interface that caters to their efficiency and convenience. For instance, to optimize the designs of e-exam interfaces (Karim et al., 2016) proposed characteristics (Fig. 4).

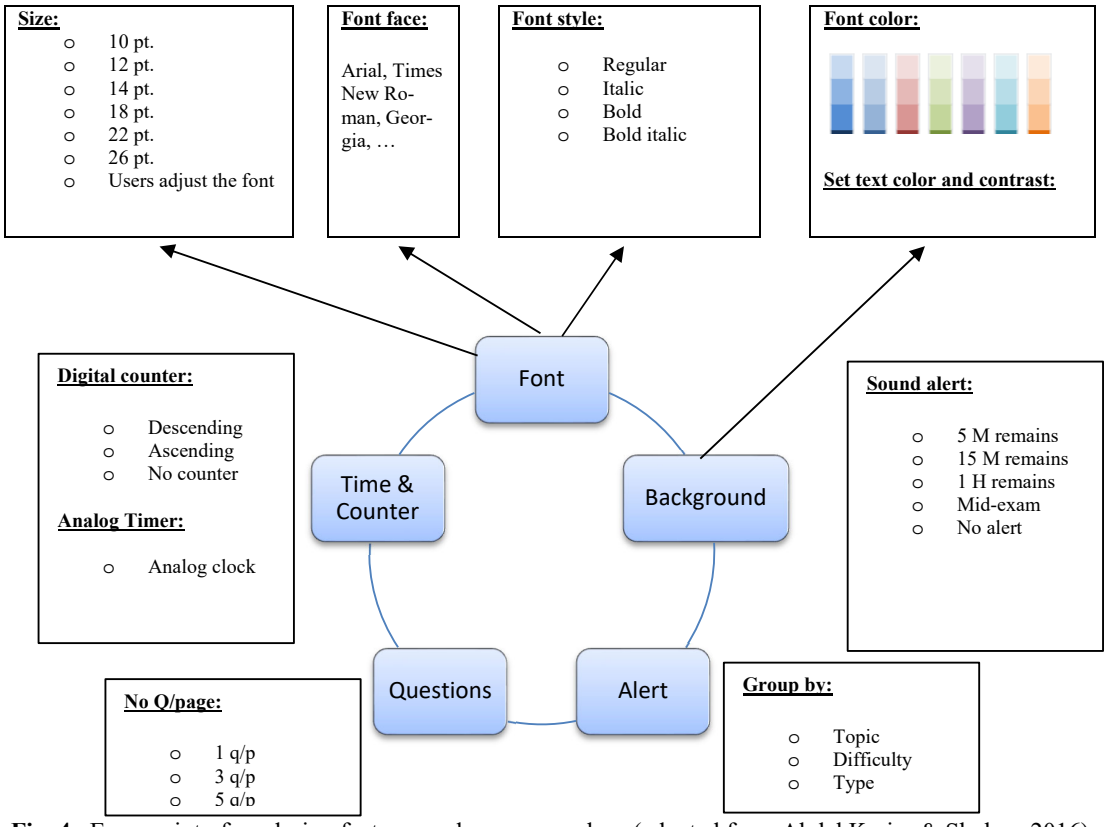

Fig. 4. E-exam interface design features and common values (adapted from Abdel Karim & Shukur, 2016)

3. Method

An experiment has been conducted to examine whether UI preferences may be used to determine a user's identity. Fig. 5 shows how our experiment used the experimental website, www.preferencesexp.com. The e-exam was chosen as a case study for the present study because the design features of the user interface and their potential values were studied, and their values were previously defined (Fig. 4). Additionally, the e-exam systems were regarded as less crucial in comparison to other E-Systems (such as e-banking and e-commerce), as the user can share their data without worrying. The main objective of this experiment was to "*determine the variations in the interface design preferences between users and the stability of these preferences for each user*".

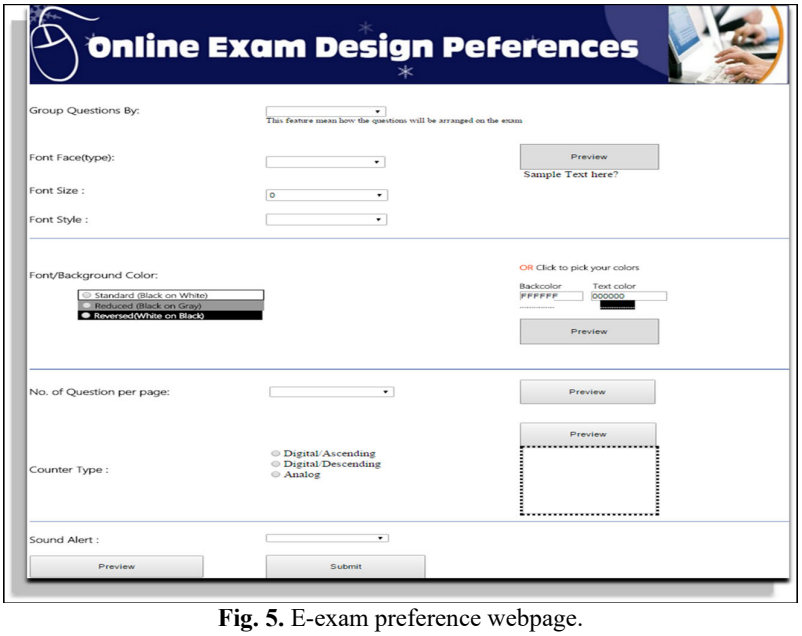

Fig. 5. E-exam preference webpage.

The research experiment was divided into two stages:

Stage I investigated whether variations exist in the students' e-exam interface design (i.e., preferences). The experiment's population at this stage was students (54 females and 102 males, between the ages of 18 and 47, with an average age of 28.4 years). Those participants were students from computer science departments of four universities located in three countries, Universiti Kebangsaan Malaysia (Malaysia), Patra Private University (Jordan), and Salaman Bin Abdel Aziz University (KSA), where the use of IT background samples is appropriate for computer-based and online environment experiments. Users with an IT background are frequent Internet users and active participants in online activities, and most of them deal with various online systems (e.g., e-banking and e-learning, e-exam)(Stavova et al., 2016).

Stage II: The second stage investigated whether each student's preferences while logging into the e-exam were consistent. This stage had about 90 students from Stage I (with a mean age of 31.4 years and a gender split of 29 girls and 61 males, ages 18 to 47). Users were instructed to repeat the experiment three times at this stage to check for consistency in each student's preferences at each e-exam login when compared with their own saved template. Nine design features, including font (face, size, color, and style), background color, number of questions/pages, questions group, time counter, and sound alert, were chosen. Fig. 4 illustrates the e-exam design features and their suggested values. All participants were led to the test preferences homepage after registering to select their own "exam interface preferences" for training and practice (Fig. 5). After the participants had completed the practicing phase, they were notified to log in to and access the e-exam design preference website to pick their main template “exam interface preferences.” The chosen preferences were repeated three more times by the users who continued the experiment (Stage II). To keep the experiment independent, the experiment was conducted within different periods (Table 2).

Table 2
Experiment time plan (Stage 2)

No. of the trial (Experiment)	Days								
	1	2	3	4	5	6	7	…	21
1: Practice and first selection (main template) (Stage I/Stage II)									
2: Second selection (Stage II)									
3: Third selection (Stage II)									
4: Fourth selection (Stage II)									

4. Results

Stage I results indicated that five students had exact preferences, with a rate of (3.2%). Thus, 96.8% of users had different UI preferences (Table 3).

Table 3
Matched and non-matched students’ preferences

Details	Matched preferences	Different preferences	Total
No. of students	5	151	156
%	3.2%	96.8%	100%

In the experiment’s stage II, 19 negligent participants were detected among 90 participants and were not asked to complete the experiment. Therefore, 71 students completed all three logins in the experiment’s stage II. After the analysis of the saved preference templates of the users, the experimental results indicated that 23 students (32.3%) selected precisely the same preferences during the three logins with a 100% accuracy rate, and 17 students (23.9%) made one change in comparison to the first trial with 96.2% accuracy rate, 12 students (16.9 %) selected two different choices in contrast to the first trial with 92.5% accuracy rate, ١٣ students (18.3%) chose three different preferences based on the first trial with an accuracy rate of 88.8%, and ٦ students (8.4%) chose four different preferences based on the first trial with an accuracy rate of 85.1%. The average accuracy for all participating students was approximately 94.5% (Table 4 and Fig. 6).

Table 4
Choices, accuracy, and overall changes among students across four sessions

No. of users	**Number of preferences changed (three trials)**	**Accuracy of student choices**
23 (32.3%)	0	100%
17 (23.9%)	1	96.2%
12 (16.9%)	2	92.5%
13 (18.3 %)	3	88.8%
6 (8.4%)	4	85.1%
71 students	104 changes/1,917 possible changes	Seventy-one students' average choice ac-

*Note: Every user tried the experiment three times, so the total number of options available would be (9 * 3 = 27).*

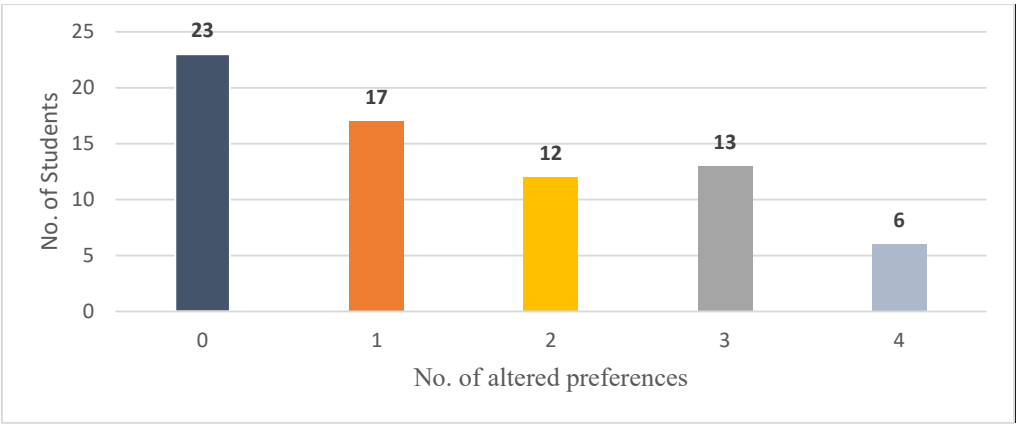

Fig. 6. Users' preferences change for three trials.

In the first and second stages of the experiment, users have differences in their preferences (96.8% difference). Each user has consistent preferences for different session logins with an average accuracy rate of 94.5%.

5. Discussion

The findings show that user interface preferences can be utilized to help differentiate system users across the Internet. Therefore, this research proposes a new method that can be used to verify the identity of users based on user interface preferences which will be named Preference-Based Authentication (PrBA) (Fig. 7). PrBA considers that individuals have distinct characteristics that directly affect the interface design (Karim et al., 2020). The proposed authentication technique lets online users select their own UI design preferences depending on their features and characteristics. User identity can be specified based on the previously picked UI design that may reflect their characteristics. Moreover, the proposed method can solve one of the traditional information security problems which are related to the trade-off between security and usability when authenticating users (Feng et al., 2012; Karim et al., 2020, 2021; Shay et al., 2014). Hence, Creating a system that is too secure will reduce usability. For example, a long password with uppercase and lowercase letters and symbols, such as "Mohm2067_$$Az", is better than a small textual password like "Mohammed." By contrast, a computer that requires authentication every few minutes with a strong password and a drop of blood could be highly secure, but no one would want to use it (Cranor & Garfinkel, 2005). Our proposed method overcomes this problem by employing usability to enhance security. However, The study was conducted on undergraduate/graduate students enrolled in the field of information technology and computer science as a study sample. Thus, the result of the current study is limited to users in the same area. Although age and gender may influence the results of the proposed technique, these factors are not considered (at this stage) and may well be considered in future research.

As demonstrated in Fig. 7, The user picks preferences for the design of his interface. The choices are constructed from various features, and every design feature has at least two values (for verification purposes). Once the user picks his UI preferences, the saved UI preferences appear, so the user characteristics and identity can be specified depending on the UI design received from the features dataset.

6. Conclusion

Many HCI-based systems have aimed at creating compatible user interfaces to enhance usability by establishing an appropriate UI based on users' characteristics. However, can we use this interface design to authenticate user identity? Traditional user authentication methods include KBA, PBA, or BBA-based authentication. As opposed to these techniques, this paper proposes a new authentication technique, PrBA, that depends on a unique principle. It confirms that the users' characteristics affect the UI preferences and that every user has their identity and characteristics. Thus, the user's chosen online system interface design can provide evidence regarding their identity. A two-stage experiment was carried out with 159 and 71 undergraduate/postgraduate students, wherein the experiment's main objective was to evaluate the consistency and diversity in their preferences while using the UI of an e-exam homepage. The feasibility experiments indicated that UI preferences could feasibly identify users. 96.8% of research participants had variations in their preferences, and each participant maintained 94.5% of their design preferences throughout different sessions. Therefore, the proposed technique could be an alternative method for identifying user identity in E-Systems. One of the advantages of this technique is that it does not require the user to recall information and instead asks the user to choose what they prefer based on their characteristics. The limitation of this research was in persuading all participants to complete the second stage of the experiment and controlling the variations of machines that participants used for taking e-exam (e.g. Screen size). Furthermore, our future research will explore the proposed method's performance and usability, considering the potential effect of age and gender on its effectiveness.

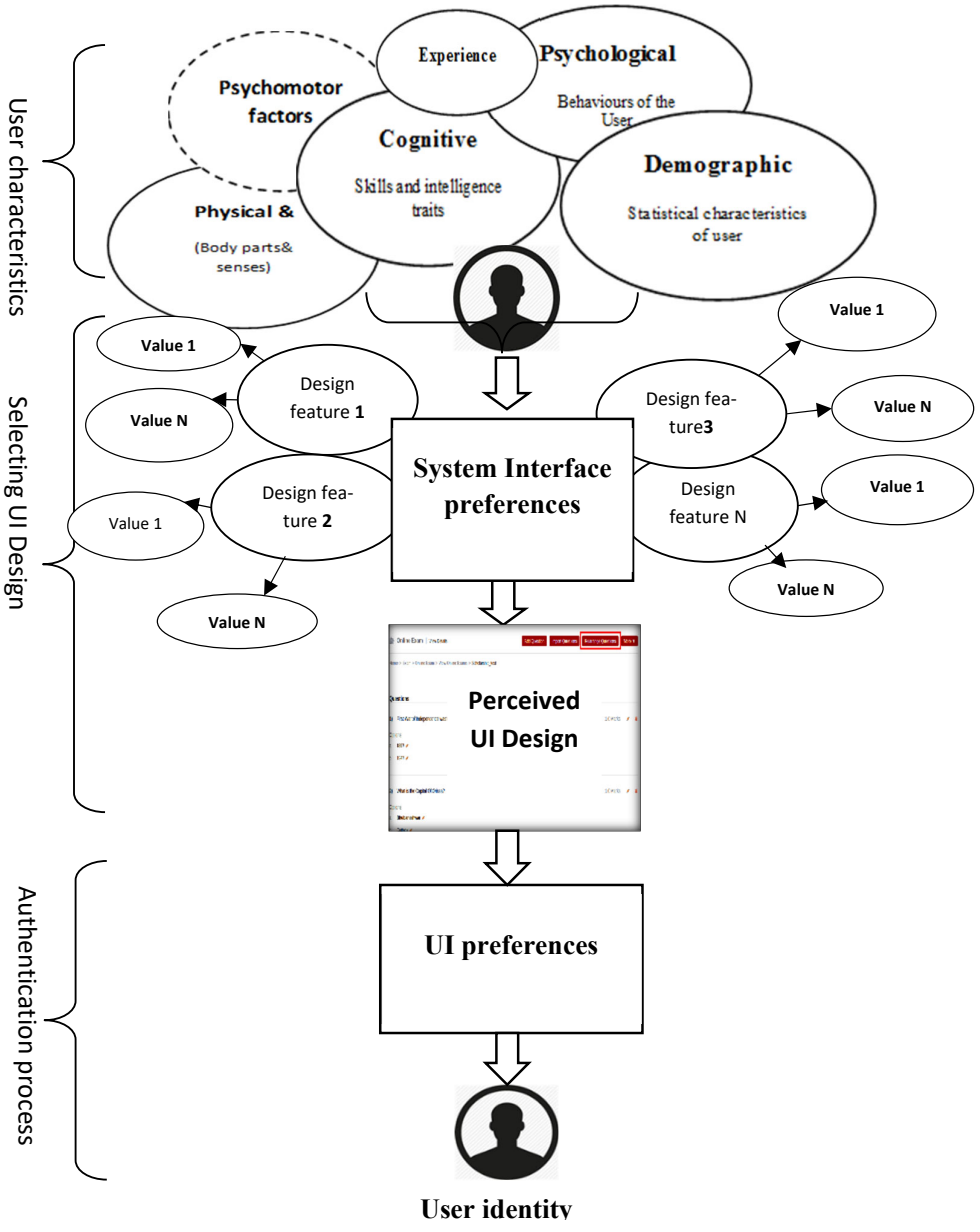

Figure 7. PrBA conceptual model.

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