The effects of gender differences in the acceptance of biometrics authentication systems within online transaction

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Abstract—Today, biometric technology, which uses physical or behavioural characteristics, could be considered as a reliable individual secure authentication method that helps to determine the identity of an authentic user especially in e-commerce technology. Along with a variety of modalities of biometrics, fingerprints are well-known to be the oldest method used in law enforcement with a verified performance. This paper continues this tradition by using an extending Technology Acceptance Model (TAM). For this work, which is part of a larger body of research, 306 Saudi participants were involved in a large scale experiment, consisting of men and women between the ages of 18 and 55. The experiment included the development of a fingerprint authentication system to examine the differences in male and females and their acceptance of biometric authentication systems within online environments.

Keywords- authentication; biometrics; e-commerce; fingerprint; gender; TAM.

I. INTRODUCTION

The implementation of new technology might still result in failure despite huge financial investment. While organizations seek to accomplish return on investments from implementation of a new technology or system, there is an urgent need to understand the users own understanding of the technology. To achieve a better appreciation of the users, this study investigates gender differences, which is a research area that is not widely covered [1, 2].

Acceptance of any new technology has been recognized as a main factor affecting its successful implementation. The TAM [3] model is a well-known model for assessing such success. This study adopts the extend TAM model presented by Hernández-Ortega et al [4] to decide which factors are significant for the two gender groups.

There are high levels of concern surrounding the use of such a new technology, in the cyber world; but few have sought to identify gender differences with relation to the acceptance of using biometric technologies. Males and females seem to have particular differences in online environmental attitudes and behaviour [5]. This study aims to take an exploratory look at whether users with different genders differ significantly in their acceptance of biometric authentication systems in online services. To explore this, more than three hundreds male and female participants were studied in a large scale laboratory experiment.

The majority of the internet's early users were men, but based on Krantz [6] the gender gap in terms of internet usage is getting smaller and smaller. Since more women are using online services, they are taking part in increasingly different online activities including purchasing [7]. Men and women are both required to make the internet successful [8].

Most the users’ behaviour literature focuses on the diffusion of innovations and user adoption of new technological-based products and services and has paid little consideration to the role of gender [7, 9]. Many studies have ignored the possible role of gender differences in attitudes toward using technology, or in the adoption of new technology [7]. A study in the UK by Brosnan and Lee[10], and another study in the USA by Balka and Smith [11] have analysed gender differences in IT and have shown that women are laggard in their IT use compared to men, skills and knowledge. However, these differences are not entirely accepted by all studies because, while users obtain knowledge and experience of IT, both genders may well tend to stabilise their behaviour [4]. With a lack of systematic studies focusing on the effect of gender differences on the acceptance of new technology - such as biometric authentication system. We need to understand the role that gender plays in the adoption and acceptance of technologically based products. The purpose of this research was to focus on gender differences with respect to using biometrics authentication system within e-commerce applications. Nevertheless, there is limited published research
exploring the factors that capture the gender differences in behaviour and acceptance of new e-commerce applications especially in the Middle East. This paper focuses upon Saudi Arabia that has a diverse immigrant population, a Sharia-inspired legal system and a developing economy [12] and therefore a compelling and unique case study.

We analyse the differences in behaviour between groups of males and females who have carried out the systematic experiment of login through a fingerprint authentication system, our findings contribute to the discussion on the differences among genders within the topic of this paper. Moreover, practitioners and researchers will be better able to understand how gender influences the attitudes of consumers and predict how they will react to the characteristics and stimuli of a biometric system.

In the following section, the literature review is explained and the hypotheses are formulated. In Section 3, the methodology is explained and in Section 4 relevant empirical analysis is carried out. Finally, discussion of the results and conclusions are presented in sections 5 and 6.

II. LITERATURE REVIEW

A. Authentication and biometrics

The need for stronger consumer authentication in e-commerce environments has developed into a necessary means of reaffirming consumer safety, confidence, and acceptance [13]. Username and passwords, used as a common authentication by many institutions are no longer sufficient to guarantee suitable access control to consumers’ accounts [13]. Institutions should be proficient in making stronger user authentication within the online environment to protect their clients and preserve confidence and acceptance.

Biometrics can be seen as measurable physiological and behavioral characteristics that can be used to authenticate individual identity, and include fingerprint, hand geometry, retinal, iris, facial, and signature recognition [14]. Authentication methods based on biometric features are increasingly achieving extensive use and attractiveness. Frequently, vendors of the commercial biometric systems claim remarkable performance based on various proprietary figures. The choice of fingerprint identification methods over other solutions would overcome some cultural barriers such as the prohibition of women’s facial recognition in some Muslim countries such as Saudi Arabia. AL-Harby, Qahwaji and Kamala [15] stated that the majority of Saudis would have a preference to use fingerprint identification methods. Intended for authentication functions, a person should first be enrolled in a real-time fingerprint system and the system must authenticate the claimed identity by comparing the scanned image with a reference template.

B. Extended TAM

The most common model used to study technological acceptance is the Technology Acceptance Model (TAM) as illustrated in Figure 1. TAM has gained extensive approval for studying the attitudes and behaviours of individuals using a new technology [3]. In 2008, Hernández-Ortega et al [4] reproduce the TAM model to test the moderating effect of gender on e-purchasing behaviour; their extended model was used in this research to measure the differences between the genders in the case of running biometric authentication via online services.

Nevertheless, an experiment was carried out to measure these differences. TAM uses specifying causal linkages among sets of constructs: Perceived Usefulness (PU) and Perceived Ease of Use (PEOU), Attitude (ATU), Behavioural Intentions (BI) and actual usage. PU is defined as the user’s “subjective probability that using a specific application system will increase his or her job performance within an organizational context” [3]. PEOU refers to “the degree to which the user expects the target system to be free of effort” [3]. Together PU and PEOU predict attitude towards using the system, defined as the user’s desirability to use the system [3]. Recently, many studies have integrated other new factors; this addition allows us to clarify the individual’s behaviour more accurately. The most important factors considered are those associated with internal motivation, such as perceived self-efficacy [4, 16]. Perceived self-efficacy (PSE) is defined as “people's judgement of their capabilities to organize and execute a course of action required to attain designated types of performances” [4, 17].

Figure 1. TAM model
In Hernández-Ortega et al. model [4], perceived self-efficacy was incorporated as this strongly affects the behaviour of the online user [4, 18]. The following hypotheses have been formulated to verify the effect of self-efficacy:

H1: Perceived self-efficacy has a positive influence on the perceived ease of use of a biometric authentication system in an online environment.

H2: Perceived self-efficacy has a positive influence on the perceived usefulness of a biometric authentication system in an online environment.

One more factor common in models that focus on the acceptance of new technologies is attitude (ATU) [3]. According to Winter et al. [19], users who have a positive attitude towards computers make better use of them than others since they perceive less anxiety and phobia before, during and after their actions [4, 19]. Within e-commerce applications, attitude determines the intention to use the application (BI) [20]. PEU and PU describe the attitude towards a certain technology [21]. Formulating the following hypotheses:

H3: Perceived ease of use has a positive influence on attitude towards a biometric authentication system in an online environment.

H4: Perceived usefulness has a positive influence on attitude towards a biometric authentication system in an online environment.

H5: Attitude towards the biometric authentication system in an online environment will positively affect the intention to use the biometric authentication system in that environment.

C. Gender

Gender was described by Schlegel [22] as “the way members of the two sexes are perceived, evaluated, and expected to behave.” Gender is a significant variable in explaining differential outcome in consumer behaviour research [7, 23]. There has been a limited amount of gender-based study in information technology research [1, 2, 7, 24]. However, the differences between men and women have been studied in various contexts such as electronic mail [1], information retrieval [24], e-learning [25], communication technologies [26] and online purchasing behaviour [2].

The majority of the studies appear more favourably towards men than women. Anandarajan et al. [27] stated that men were more likely to access work pages than women. Nevertheless, gender was not linked with individual factors such as ease of use, frequency of use and time usage.

Morris et al. [28] found that as age increased, men were increasingly influenced by attitude toward using the technology than women. In contrast, as age increased, women were more influenced by perceived behavioural control than men. Gefen and Straub [1] found that the perceptions of men and women vary. The perceived social usefulness of email was found to be lower with male than women. Conversely, men perceived ease of use higher than women. Nonetheless, the actual use of email did not vary across gender. Venkatesh et al. [24] proposed that gender would sensible the association between perceived usefulness, perceived ease of use, and subjective norm on intention to use the technology. These factors were more important for men than women [2].

1) Gender differences within online behaviour:
The behaviour of online users with new IT might be conditioned by their gender [29]. Internet addiction was argued to be more likely a male addiction [30]. Typically females show higher levels of computer anxiety [22, 24] as well as lower levels of self-efficacy towards using computers in general, the Internet and e-commerce in particular [31]. It is taken into account that females feel less confident than males in using IT which implies that self-efficacy has less influence on usefulness and ease of use [4, 32]. Based on the above discussion, it is hypothesized that:

H6: The effect exerted by perceived self-efficacy on perceived ease of use is greater for males than for females.

H7: The effect exerted by perceived self-efficacy on perceived usefulness is greater for males than for females.

In the past, studies have found that females show less ease of use in IT, which is considered to be one of the most significant obstacles to technological improvement [33]. Based on research by Im et al. [34], the effect of PEU on intention is stronger for females. Previous research has stated that male students consider computers to be more useful than female students do [4, 35]. Furthermore, males realize more benefits from the use of some IT; thus, the effect of PU on attitude was stronger for males [34, 36].

Many studies have illustrated that males exhibit more positive attitudes towards IT and, by extension have more intention of using them [4, 31]. Males are more likely to adopt and use new IT, even in the first stages of learning [4, 31]. Therefore, the following hypotheses were formulated:

H8: The effect exerted by perceived ease of use on attitude is greater for females than for males.

H9: The effect exerted by perceived usefulness on attitude is greater for males than for females.

H10: The effect of attitude on intention to purchase online is greater for males than for females.

The relationships between the variables and the moderating effect of gender showed in Figure 2. [4]
III. METHODOLOGY

To investigate the use of fingerprint systems within online applications, fingerprint login systems were designed. The study has a survey instrument to evaluate the differences between male and female. This study is part of a larger study measuring the adoption and acceptance of a biometric system to facilitate secure online transactions. Most of the survey items used the 5-point Likert scale format, ranging from ‘strongly agree’ to ‘strongly disagree’.

The items included in the study were those that have commonly been used in previous TAM–based research [3, 4, 18, 36]. As stated previously, 306 participants responded in the laboratory experiment; 171 (55.9%) were male and 135 (44.1%) of the participants were female. Ages ranged from 18 to 55 years. More than half of participants (178) were studying at the undergraduate level, with only 7.8% at the postgraduate level.

The contributors were invited to create a virtual personal account and register their index fingerprint by using the fingerprint device. When they completed this task, they were asked to answer questions about their perception in terms of its perceived self-efficacy, usefulness and ease of use, their attitudes towards its usage, and their behavioural intention of using the system. Figure 3 shows the distribution of gender.

IV. RESULTS

A. Reliability and validity analyses

For reliability, all scales used were above the minimum recommended values based on the study by Nurosis [37] which recommended eliminating all indicators with an item-total correlation of under 0.3. It is commonly agreed that the minimum satisfactory value of Cronbach’s alpha is 0.70 [38, 39], however, this could be reduced to 0.6 for exploratory studies [40].

The outcomes for all factors were evidently satisfactory. The final data inputs were loaded into Amos ver. 16 as a structural equation modelling (SEM) software solution from SPSS Inc.

This software is used for various statistical analyses. Table 1 shows the reliability and validity analysis.

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Table 1. Reliability and validity analysis

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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>PSE</td>
<td>4</td>
<td>63.3%</td>
<td>0.844</td>
<td>0.690</td>
<td>0.589</td>
<td>0.581</td>
<td>0.833</td>
<td>0.566</td>
<td>0.547</td>
<td>0.575</td>
<td>0.547</td>
<td>0.575</td>
</tr>
<tr>
<td>PEOU</td>
<td>7</td>
<td>32.2%</td>
<td>0.758</td>
<td>0.566</td>
<td>0.581</td>
<td>0.581</td>
<td>0.566</td>
<td>0.581</td>
<td>0.566</td>
<td>0.581</td>
<td>0.581</td>
<td>0.625</td>
</tr>
<tr>
<td>PU</td>
<td>5</td>
<td>50.5%</td>
<td>0.887</td>
<td>0.655</td>
<td>0.625</td>
<td>0.625</td>
<td>0.797</td>
<td>0.625</td>
<td>0.625</td>
<td>0.625</td>
<td>0.625</td>
<td>0.797</td>
</tr>
<tr>
<td>ATU</td>
<td>15</td>
<td>62.4%</td>
<td>0.831</td>
<td>0.777</td>
<td>0.547</td>
<td>0.547</td>
<td>0.753</td>
<td>0.547</td>
<td>0.547</td>
<td>0.547</td>
<td>0.547</td>
<td>0.753</td>
</tr>
<tr>
<td>BI</td>
<td>6</td>
<td>73.2%</td>
<td>0.885</td>
<td>0.818</td>
<td>0.661</td>
<td>0.661</td>
<td>0.728</td>
<td>0.661</td>
<td>0.661</td>
<td>0.661</td>
<td>0.661</td>
<td>0.728</td>
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Table 2. Structural model analysis

<table>
<thead>
<tr>
<th></th>
<th>Entire Sample (n=306)</th>
<th>Males (n=171)</th>
<th>Females (n=135)</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R²</td>
<td>Sig. (t)</td>
<td>R²</td>
<td>Sig. (t)</td>
</tr>
<tr>
<td>BI</td>
<td>0.42</td>
<td>0.57</td>
<td>0.23</td>
<td>0.93</td>
</tr>
<tr>
<td>ATU</td>
<td>0.86</td>
<td></td>
<td>0.66</td>
<td></td>
</tr>
<tr>
<td>H1 PSE-PEOU</td>
<td>0.71</td>
<td>14.1</td>
<td>0.71</td>
<td>14.1</td>
</tr>
<tr>
<td>H2 PSE-PU</td>
<td>0.73</td>
<td>8.4</td>
<td>0.73</td>
<td>8.4</td>
</tr>
<tr>
<td>H3 PEOU-ATU</td>
<td>0.63</td>
<td>7.6</td>
<td>0.46</td>
<td>3.88</td>
</tr>
<tr>
<td>H4 PU-ATU</td>
<td>0.83</td>
<td>8.2</td>
<td>0.81</td>
<td>6.34</td>
</tr>
<tr>
<td>H5 ATU-BI</td>
<td>0.61</td>
<td>7.5</td>
<td>0.68</td>
<td>8.26</td>
</tr>
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</table>

Table 3. Indirect and total effects

<table>
<thead>
<tr>
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<th>Males (n=171)</th>
<th>Females (n=135)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ATU</td>
<td>BI</td>
<td>ATU</td>
</tr>
<tr>
<td>Indirect Effect</td>
<td>PSE</td>
<td>0.71</td>
<td>0.41</td>
</tr>
<tr>
<td></td>
<td>PEOU</td>
<td>-</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td>PU</td>
<td>-</td>
<td>0.64</td>
</tr>
<tr>
<td>Total Effect</td>
<td>PSE</td>
<td>0.71</td>
<td>0.41</td>
</tr>
<tr>
<td></td>
<td>PEOU</td>
<td>0.13</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td>PU</td>
<td>0.83</td>
<td>0.64</td>
</tr>
</tbody>
</table>

B. Structural model analysis

To analyse the formulated causal relationships, the structural model was tested with data from the entire sample of males and females together, whilst each of the sub-samples was taken separately. Given that the majority of values achieve the optimal theoretical values [41] it was found that the model fits well, significance and standardised path coefficients. The R² for attitude and behavioural intentions toward use of the biometric system are illustrated in Table 2. For the entire sample set, it is found that all five hypotheses are supported.

C. Analysis of the differences between females and males

The research model was tested through Structural Equation Modeling (SEM) with Amos ver. 16. The goodness of fit indices illustrated in Table 4 suggests that the model fit was reasonable in measuring the results of the structural equation model.

We can conclude from the results shown in table 5 that there are significant differences in the behaviour of biometric authentication systems between males and females. Results gathered illustrate that PEOU has a stronger influence within the female sample than in the male sample, therefore H8 is accepted. Further to which, males have a more positive attitude towards using biometric authentication systems in online transactions, which exerts a stronger effect on the intention to using the system. Hence, H10 can be confirmed. While the males and females differences present the tendency theoretically expected (males>females), none of them attains significant values. Therefore, H6, H7 and H9 are not supported. Similarly, the effects of PSE on PEOU and PU showed no significant differences between the two samples. The outcome of PU on attitude has similar significance.

Table 4. Fit Indices

<table>
<thead>
<tr>
<th>Measure of fit</th>
<th>Recommended values</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi-squared divided by degrees of freedom (chi²/df)</td>
<td>Less than 3.0</td>
<td>2.8</td>
</tr>
<tr>
<td>Goodness of Fit Index (GFI)</td>
<td>Greater than 0.9</td>
<td>0.91</td>
</tr>
<tr>
<td>Normed Fit Index (NFI)</td>
<td>Greater than 0.9</td>
<td>0.91</td>
</tr>
<tr>
<td>Non-Normed Fit Index (NNFI)</td>
<td>Greater than 0.9</td>
<td>0.91</td>
</tr>
<tr>
<td>Comparative Fit Index (CFI)</td>
<td>Greater than 0.9</td>
<td>0.92</td>
</tr>
<tr>
<td>Root Mean Square Residual (RMSR)</td>
<td>Less than 1.0</td>
<td>0.08</td>
</tr>
</tbody>
</table>
This study aimed at examining the differences between females and males in their use of biometric authentication systems within an online environment. The findings demonstrate that self-efficacy is a key observation in the improvement of e-commerce applications as they exert a considerable effect on PEOU and PU. Clearly, our results are in line with those of the Decomposed Theory of Planned Behaviour [42], and the Social Cognitive Theory [17], which state that self-efficacy, directs the user to act more efficiently. In spite of gender, the effect of these factors is similar. Thus, decline the statements that show a higher anxiety in females when interacting with IT [22]. Most likely the similarity in self-efficacy is caused by the knowledge and the experiences of the sample investigated. Several researches have shown that IT experience helps in narrowing the gap in gender differences [43]. PEOU influences female behaviour but is not accepted in the male sample. Conversely, PU has the strongest effect towards using biometric authentication system behaviour and showed no difference between males and females. As for the R², the model tested fits male behaviour better, with attainment at 57%, which contrasts the 23% for females.

VI. CONCLUSIONS

The conclusions derived here could have significant implications for organizations, business and future research. From the researchers’ point of view, most studies carried out in recent years have treated online application users in the same way regardless of their gender. Nevertheless, e-commerce services have improved significantly, therefore the use of biometric systems behavior can be analyzed based on the gender of the e-commerce users.

Males demonstrate a more positive attitude to the use of biometric authentication systems; in contrast, males place less importance on the effect exerted by PEOU on ATU. The effect of PEOU was rejected by the male sample altogether, whilst it played a significant role in the females behavior during their use of the biometric system.

PSE and PU are the same for both genders. The variations found in user perceptions in relation to the use of biometric systems illustrate the need for considering gender in the improvement of new systems. It is concluded that the differences discovered in this research are not similar to those previously established by studies investigating e-commerce application behavior.

Organizations, managers and developers can raise intention to use a biometric system through PU and self-efficacy. Institutions may arrange training programs to develop knowledge about the benefits of biometrics authentication system compared to traditional authentication systems within e-commerce applications.

It is necessary to point out the limitations of the study, namely that the investigation has not defined the importance of online transactions to the users. The importance of online transactions for the users may modify their behavior and their perceptions with regards to using the system.

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REFERENCES


2. Thomas, P. and K. Taskov, Extending gender differences and technology acceptance to a database environment in In proceedings of the 6th annual ISOnEworld conference. 2007: Las Vegas, Nevada, USA.


