Journal of Information Systems and Informatics
Vol. 6, No. 1, March 2024 e-ISSN: 2656-4882 p-ISSN: 2656-5935
DOI: 10.51519/journalisi.v6i1.673 Published By DRPM-UBD

Usable Security of Online Banking Authentication: An Exploratory Factor Analysis

Mathias Mujinga[1]

[1]Department of Information Systems, University of South Africa, South Africa
Email: [1]mujinm@unisa.ac.za

Abstract

The usability and security of information system applications significantly affect the users' willingness to adopt the applications; online banking is one such service. The emergence of innovative technologies in all facets of our daily activities makes usable security critical to protect users' privacy and personal information. The paper aims to investigate the usability and security of the online banking authentication process. The study is based on users' perceptions of the login system of their respective banks' online banking services, using the attitude questionnaire statements related to usability and security aspects of the authentication process. The paper presents the results of 1190 survey responses in South Africa. The findings show that younger and inexperienced users are not satisfied with the usability of online banking authentication systems as they scored the system very low compared to the older and experienced users. Given the prevalence of online security breaches, improving the authentication process' usability will help create a secure online environment.

Keywords: Online Banking, Usability, Usable Security, Exploratory Factor Analysis

1. INTRODUCTION

Authentication mechanisms are the initial line of defence in protecting information and the integrity of information systems. As such, a review by [1] revealed a reliance on text-based authentication solutions, especially the knowledge-based (password) approaches, compared to token- and biometric-based approaches. Passwords are still a popular solution despite the emergence of alternatives to password-based authentication [2]. Password authentication is considered a simple and cost-effective mechanism.

The usability of authentication mechanisms to protect information systems has gained momentum. This has led to numerous usable security studies in different environments that have been conducted to provide insight; these include email encryption [3], e-health [4], and online banking authentication [5]. Usable security design aims to develop information systems with adequate security mechanisms that users find easy to use. Studies have been conducted to design guidelines to improve security-oriented design.

Some notable usable security principles studies include those by [6] and [7]. These studies proposed design principles that have gained significant recognition in the field. However, the study identified six usable security principles to investigate the underlying characteristics of online banking in South Africa. Security and privacy are also explored through some questions for the two constructs. Online banking has become pervasive in our daily activities, allowing users to access and manage their finances conveniently 24/7 [8]-[9]. The banking activities offered through online banking vary from simple balance inquiries to more complex inter-account transfers. Online banking has crucial links to electronic commerce (e-commerce) [10] as it offers an additional way to make e-commerce payments as an alternative to credit card payments, especially in developing economies [11]. Studies have investigated challenges to the successful adoption of online banking; these include poor internet infrastructure [12], [13], security risks [14], usability [15], and user experience[16], to mention a few. Akpan *et al.* [17] identified technology adoption challenges that include the lack of ICT infrastructure and socio-economic challenges such as poverty and unreliable provision of enabler infrastructure such as electricity and internet. This study examines the level of online banking authentication mechanisms to help reduce the chances of users circumventing security measures.

The pervasiveness of innovative technologies in our daily activities has brought about significant benefits but is also accompanied by security risks. Hence, developing usable and secure information system applications is critical to protecting users' privacy and improving technology adoption regarding these applications. Many studies have since identified the impact of poor security and usability on adopting online applications that collect and use users' personal information. This study uses online banking as the case study to investigate the usability of the online banking authentication process by asking the following research question: What is the level of usability in the online banking authentication process?

2. METHODOLOGY

A descriptive quantitative research method was used to evaluate the usability of the online banking authentication process based on users' perceptions. The descriptive research method examines the situation as it exists in its current state and involves identifying attributes of a phenomenon and exploring the correlation between two or more phenomena [18]. This study followed the research process outlined in Figure 1. The phenomenon under investigation is the usability of the online banking authentication process, of which a usability instrument [19] was identified and used to ascertain the level of usability. The respondents came from South Africa's five largest retail banks and were invited using different online platforms, including email and social media networks such as LinkedIn, Facebook, etc. Only banking customers who use online banking were eligible to answer the

questionnaire as the study sought perceptions of online banking users on the usability of the authentication mechanisms of the system. The questionnaire was administered using Google Forms as the online survey tool.

Figure 1. Research process

A 31-item quantitative questionnaire using a 5-point Likert scale with options from 'strongly disagree' to 'strongly agree' was adopted from [19] as the data collection instrument (Table 1). The instrument measures users' perceptions on a range of aspects, including ease of use, complexity, reliability, and security, to mention a few. Biographical data was collected to provide insight based on group comparisons during data analysis. Structure matrix is used to extract factors from the data using exploratory factor analysis in IBM SPSS 28.

Table 1. Questionnaire structure

Section	Description
Biographical details	Gender, age, experience, use frequency, device
31-items	Aspects of the login process: complexity, reliability, trustworthy, appearance, security, etc.

3. RESULTS AND DISCUSSION

The IBM SPSS Statistics 28 software package was used to analyse the data. This section presents empirical findings ranging from descriptive to more advanced inferential statistics. The inferential statistics include factor analysis and mean comparisons using independent t-tests, analysis of variance, and correlation. The data consists of 31 items on the usability of online banking authentication systems, and 1190 valid responses were obtained. Additionally, the study collected biographical data to be used as moderating factors for group comparisons during mean difference analysis of authentication item scores.

3.1 Descriptive statistics

The distribution of respondents across different variables and groups is shown in Table 2. There were more male respondents than females, with 52.3% and 47.7%. The 30-39 age group was the largest (38.2%), followed by the 20-29 age group (24.5%) and the 40-49 years group (22.6).

Table 2. Frequency of respondents' groups (n = 1190)

Factor	Category	Freq.	Percent	Cum. percent
Gender	Male	622	52.3	52.3
	Female	568	47.7	100.0
Age	< 20	71	6.0	6.0
	20–29	291	24.5	30.4
	30–39	455	38.2	68.7
	40–49	269	22.6	91.3
	> 50	104	8.7	100.0
Experience	< 12 months	166	13.9	13.9
	1–4 years	337	28.3	42.3
	> 5 years	687	57.7	100.0
Use frequency	Every day	504	42.4	42.4
	Once a week	452	38.0	80.3
	Once a month	234	19.7	100
Device	Mobile	796	66.9	66.9
	Desktop/laptop	87	7.3	74.2
	Both	307	25.8	100.0

Most online banking users (86.1%) had at least one year of experience using the service, with a significant portion (57.7%) with over five years of experience. The experience is coupled with a substantial portion that accesses online banking at least once a week (80.3%), including daily users (42.4%). Lastly, most users access online banking using a mobile device (66.9%), with a significant portion using mobile devices and desktop computers (25.8%).

3.2 Exploratory factor analysis

The data collection instrument had 31 unstructured authentication usability items. Using exploratory factor analysis (EFA), the factor extraction from the items used the component analysis method. EFA is a scientific approach to exploratory factor analysis that streamlines data by generating concise summary variables. This methodology is particularly beneficial in uncovering the correlation between variables and respondents [20]. The factor loading results in Table 3 were done using the principal component analysis method based on the structure matrix. The extraction resulted in three components (factors) with shaded highest correlation values for each item.

p-ISSN: **2656-5935** http://journal-isi.org/index.php/isi e-ISSN: **2656-4882**

Table 3. Structure Matrix

Item	Factor		
	1	2	3
1	-.057	.144	**-.657**
2	-.123	.072	**-.772**
3	-.087	.055	**-.817**
4	-.091	.052	**-.812**
5	-.073	.069	**-.774**
6	**.666**	.028	.040
7	**.706**	.145	.181
8	.006	.248	**-.518**
9	-.077	.337	**-.432**
10	**.765**	.052	.063
11	**.803**	.098	.110
12	**.797**	.043	.050
13	-.009	**.513**	-.227
14	.005	**.546**	-.176
15	**.777**	.026	.026
16	**.775**	.093	.119
17	**.774**	.129	.198
18	**.812**	-.018	-.020
19	-.026	**.726**	.028
20	**.814**	-.046	.004
21	**.821**	-.101	-.043
22	**.770**	-.018	.020
23	-.137	**.541**	-.205
24	-.137	**.540**	-.251
25	-.001	**.666**	.056
26	**.759**	-.111	-.044
27	**.790**	-.241	-.309
28	-.075	**.438**	-.358
29	-.005	**.695**	-.068
30	**.705**	-.109	-.096
31	**.773**	-.077	-.036
Total	**16**	**8**	**7**

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.

The first factor consists of 16 items with a positive correlation, and respondents were asked about favourable aspects of online banking authentication, such as user-friendliness, reliability, and security. The second factor had eight items with a positive correlation while asking about unfavourable aspects of online banking, such as poor presentation, lack of privacy, and difficulty understanding. Lastly, the third factor consists of seven negatively correlated items that address page organisation, navigation, and user expectations.

3.3 Instrument Reliability

The study tested the instrument reliability after conducting EFA based on three factors. Table 4 lists Cronbach's alpha for the three extracted factors and overall instrument reliability. The reliability for the whole instrument was 0.915 based on 31 standardised items, making the instrument reliable as it is above the minimum acceptable threshold of 0.70 [21]-[22].

Table 4. Reliability statistics

Item	Cronbach's Alpha	N of Items
Factor 1	.741	31
Factor 2	.957	16
Factor 3	.856	8
Whole	.915	7

3.4 Independent samples t-test

The independent samples t-tests on the mean values of the three factors were performed on gender, which is the natural dichotomous moderating factor. Gender means analysis used independent samples t-tests with variables with two categories. The t-tests test the null hypothesis that the mean values of factors are equal for both gender groups.

Table 5. Independent samples test: Gender

		Levene's Test for Equality of Variances		t-test for Equality of Means							
						Significance				95% Confidence Interval of the Difference	
		F	Sig.	t	df	One-Sided p	One-Sided p	Mean Diff.	Std. Error Diff.	Lower	Upper
Factor 1	Equal variances assumed	5.586	.018	2.912	1188	.002	.004	.14715	.05054	.04800	.24630
	Equal variances not assumed			2.900	1151.478	.002	.004	.14715	.05074	.04760	.24669
Factor 2	Equal variances assumed	4.548	.033	-2.650	1188	.004	.008	-.12681	.04784	-.22068	-.03294
	Equal variances not assumed			-2.639	1149.369	.004	.008	-.12681	.04805	-.22108	-.03254
Factor 3	Equal variances assumed	18.167	<,001	-2.786	1188	.003	.005	-.14855	.05332	-.25317	-.04394
	Equal variances not assumed			-2.767	1124.618	.003	.006	-.14855	.05368	-.25388	-.04323

Two independent t-test findings are presented in Table 5: *Levene's test for equality of variances* and the *t-test for equality of means*. Levene's test *p*-values for all three factors are less than 0.05 for both *Equal variances assumed,* and *Equal variances not assumed.* Hence, the study accepts the alternative hypothesis that there is a statistically significant difference between the means in gender groups. Concludes that the variance in mean values for males and females is unequal. Considering the test for equality of means that provides the actual independent samples t-test, the same conclusion is reached as *p*-values are also less than 0.05. Hence, the study accepts that gender plays a significant role in how users evaluate the usability of online banking authentication systems.

3.5 One-way ANOVA

The ANOVA was performed for the categorical users' biographical data with two or more independent groups to determine whether there was statistical significance in the difference in means for each factor. While t-testing measures the difference in means for dichotomous variables, one-way ANOVA allows the same testing with the added advantage of comparing at least two groups [23]. Table 6 provides one-way ANOVA results that include the test statistic *F*- and significance level values for moderating factors on mean values for each factor, including *post hoc tests* for group comparisons.

Age. There were five age groups; when the study compared the mean-variance between groups, only the youngest group (less than 20 years), which had 6% of respondents, showed a statistically significant difference in means compared to all the other four groups. The rest of the inter-group comparisons were insignificant at a 0.05 significance level. This trend was present for all three factors. Hence, the results suggest the youngest users have a different assessment than the older users on how usable online banking authentication systems are. The difference is based on younger users scoring the service's authentication system usability poorly compared to older users.

Experience. The comparison between three groups of different experience levels showed statistically significant differences in mean values for all three factors. The groups included less than a year, 1 – 4 years, and over five years of experience, resulting in three groups. The mean value results indicate a significant difference among all group comparisons at a 0.05 significance level. This suggests that users' evaluation of the usability of online banking authentication systems depends on how long the user has been using the service, with more experienced users having a favourable assessment of the service compared to their inexperienced counterparts. Therefore, the study findings were consistent with other studies in the literature. These studies found that as users familiarise themselves with the interface, it becomes more usable since functions are located and used more efficiently [24]. Hence, the study concluded that user interface usability improves

as interface familiarity increases since users become less frustrated as they can navigate and locate functions quickly.

Table 6. Factors one-way ANOVA vs moderating factors

Factor	Component	df	F	Sig.	Post hoc tests (multiple comparisons)	
Age	Factor 1	4	7.879	.001	Less than 20 years & All	$p < 0.05$
	Factor 2	4	6.405	.001	Less than 20 years & All	$p < 0.05$
	Factor 3	4	12.441	.001	Less than 20 years & All	$p < 0.05$
Experience	Factor 1	2	38.805	.001	All	$p < 0.05$
	Factor 2	2	35.904	.001	All	$p < 0.05$
	Factor 3	2	62.943	.001	All	$p < 0.05$
Use frequency	Factor 1	2	35.355	.001	All	$p > 0.05$
	Factor 2	2	15.582	.001	All except week & month	$p > 0.05$
	Factor 3	2	38.395	.001	All	$p > 0.05$
Device	Factor 1	2	8.878	.001	All	$p > 0.05$
	Factor 2	2	6.389	.001	PC & both;	$p > 0.05$
	Factor 3	2	13.270	.001	All	$p > 0.05$

Use Frequency. Another dimension explored was the regularity at which users access the online banking service, with three options: daily, weekly, and monthly. All but one intergroup comparison was statistically significant for all three factors based on a 0.05 significance level. The exception was the group comparison between weekly and monthly users for mean values of factor 2. These results are mainly in line with the trend in experience, as frequent users are familiar with the system and tend to score usability aspects higher than infrequent users.

Device. Device analysis was based on three options: mobile, desktop (PC or laptop), and a combination. All group comparisons for all three factors were statistically significant at 0.05% except for one (desktop and both), which was insignificant for factor 2. The results show that online banking is optimised for both mobile and web platforms, as the assessment of the authentication systems does not depend on the device used to access the service.

3.6 Correlation

Correlation (denoted by *r*) measures the degree of association between dependent and independent variables. A correlation coefficient is between -1.0 and +1.0, which shows the degree of association between two or more variables [25]. A +1.0 value shows a positive direct relation that means one variable increases as the other variable increases. A -1.0 coefficient indicates a negative inverse relation, where one variable decreases as the further increases. The absence of a relation between two variables is shown by a correlation value of 0. Table 7 shows the degrees of relationship based on the range of *r* values.

Table 7. Degrees of relationship

Range of r values	Degree of relationship
±0.80 to 1.00	Very strong
±0.60 to 0.79	Strong
±0.40 to 0.59	Moderate
±0.20 to 0.39	Weak
±0.00 to 0.19	Very weak

The study performed a correlation analysis to specify the relationship among dependent variables (three factors) based on strength and direction and independent categorical moderating factors. Table 8 provides the correlation analysis performed on the dependent and four moderating variables.

Table 8. Correlation

		Factor 1	Factor 2	Factor 3
Age	Pearson Correlation	.103**	-.109**	-.124**
	Sig. (2-tailed)	<,001	<,001	<,001
Experience	Pearson Correlation	.245**	-.233**	-.304**
	Sig. (2-tailed)	<,001	<,001	<,001
Use frequency	Pearson Correlation	-.237**	.155**	.242**
	Sig. (2-tailed)	<,001	<,001	<,001
Device	Pearson Correlation	.067*	-.045	-.052
	Sig. (2-tailed)	.021	.118	.073

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

Most correlations are significant at 0.01 for all three factors, and the moderating factors are age, experience, and use frequency. At the same time, the correlation with the device is statistically insignificant as the *p*-value is higher than the 0.05 threshold. However, the degree of relationship is in the *weak* range. This points to an insignificant correlation across the factors.

4. CONCLUSION

The paper investigates the usability of online banking authentication systems in South Africa based on users' perceptions. Using some inferential statistical analysis, the study analysed survey responses from 1190 online banking users. The study extracted three factors using the structure matrix of exploratory factor analysis (Table 3) from the 31-item instrument as follows: Factor 1 consisted of 16 positive aspects reflecting favourable authentication process characteristics. Factor 2 consisted of 8 items that reflect negative aspects of the authentication process. Factor 3 consisted of 7 items that also measured negative aspects of the authentication process.

The mean scores of responses were tested for statistical significance in the mean differences. Firstly, gender plays a role in how users perceive the usability of online banking authentication systems, with females having a higher mean score overall than males. The findings based on group comparisons show that younger users demand more usability from service providers of information systems applications. This might be due to the prevalence of social media platforms that younger users frequently use compared to online banking usability. The other moderating factors included gender, experience, use frequency, and device. Independent samples t-test, ANOVA, and correlation show that usability assessment is based on different groups. The lack of experience from novice users results in older and more experienced users rating the system's usability as they tend to use it more frequently. Overall, users of all groups evaluated the usability of online banking authentication higher as they scored the positive aspects of the system evaluation aspects. At the same time, the negative characteristics had low mean scores based on a 5-point Likert scale.

The evaluation of individual usability principles is needed for a more comprehensive usability assessment of online banking services. Another limitation for improvement is to solicit perceptions of non-users rather than those of current users to determine the effect of usability on hesitation to adopt the service. As further research, the trend of younger users generally scoring poorly needs to be explored further to identify the underlying challenges besides the postulated lack of experience. Financial institutions can then address these specific factors to improve overall service usability, which might enhance service adoption.

REFERENCES

[1] C. Katsini, M. Belk, C. Fidas, N. Avouris, and G. Samaras, "Security and usability in knowledge-based user authentication: A review," in *Proceedings of the 20th Pan-Hellenic Conference on Informatics*, 2016, pp. 1-6.

[2] J. Bonneau, C. Herley, P. C. Van Oorschot, and F. Stajano, "The quest to replace passwords: A framework for comparative evaluation of web authentication schemes," in *2012 IEEE Symposium on Security and Privacy*, 2012, pp. 553-567.

[3] H. Hof, "Towards enhanced usability of IT security mechanisms – how to design usable IT security mechanisms using the example of email encryption," *International Journal on Advances in Security*, vol. 6, no. 1, pp. 78-87, 2013.

[4] A. Yeratziotis, D. Pottas, and D. Van Greunen, "A usable security heuristic evaluation for the online health social networking paradigm," *International Journal of Human-Computer Interaction*, vol. 28, no. 10, pp. 678-694, 2012, doi: 10.1080/10447318.2011.654202.

[5] M. M. Althobaiti and P. Mayhew, "Security and usability of authenticating process of online banking: User experience study," in *Proceedings of the 2014 International Carnahan Conference on Security Technology (ICCST)*, Rome, Oct. 13-16, 2014, pp. 1-6.

[6] K. P. Yee, "Aligning security and usability," *IEEE Security & Privacy*, vol. 1, no. 5, pp. 48-55, 2004, doi: 10.1109/MSP.2004.64.

[7] K. P. Yee, "User interaction design for secure systems," in *Proceedings of the 4th International Conference on Information and Communications Security*, Singapore, Dec. 9-12, 2002, pp. 278-290.

[8] T. S. Szopiński, "Factors affecting the adoption of online banking in Poland," *Journal of Business Research*, vol. 69, no. 11, pp. 4763-4768, 2016, doi: 10.1016/j.jbusres.2016.04.027.

[9] C. Martins, T. Oliveira, and A. Popovič, "Understanding the Internet banking adoption: A unified theory of acceptance and use of technology and perceived risk application," *Int. J. Inf. Manage.*, vol. 34, no. 1, pp. 1-13, 2014.

[10] H. Alzoubi, M. Alshurideh, B. Kurdi, K. Alhyasat, and T. Ghazal, "The effect of e-payment and online shopping on sales growth: Evidence from banking industry," *International Journal of Data and Network Science*, vol. 6, no. 4, pp. 1369-1380, 2022.

[11] M. A. Omar and K. Inaba, "Does financial inclusion reduce poverty and income inequality in developing countries? A panel data analysis," *Journal of Economic Structures*, vol. 9, no. 1, art. no. 37, 2020.

[12] I. Hernando and M. J. Nieto, "Is the internet delivery channel changing banks' performance? The case of Spanish banks," *Journal of Banking & Finance*, vol. 31, no. 4, pp. 1083-1099, 2007.

[13] R. Tiwari, "Contribution of Cyber Banking towards Digital India: A Way Forward," *Khoj: An International Peer Reviewed Journal of Geography*, vol. 6, no. 1, pp. 46-52, 2019.

[14] A. H. Alsharif, "Attitudes of patients with chronic diseases toward Management eHealth Applications Systems in post-COVID-19 times," *International Journal of Environmental Research and Public Health*, vol. 19, no. 7, art. no. 4289, 2022.

[15] M. Mujinga, "Towards a Framework to Promote the Development of Secure and Usable Online Information Security Applications," University of South Africa, 2018.

[16] A. A. de Santos and M. C. Ponchio, "Functional, psychological and emotional barriers and the resistance to the use of digital banking services," *Innovation & Management Review*, vol. 18, no. 3, pp. 331-348, 2021.

[17] I. J. Akpan, E. A. P. Udoh, and B. Adebisi, "Small business awareness and adoption of state-of-the-art technologies in emerging and developing markets, and lessons from the COVID-19 pandemic," *Journal of Small Business & Entrepreneurship*, vol. 34, no. 2, pp. 123-140, 2022.

[18] C. Williams, "Research methods," *Journal of Business & Economics Research (JBER)*, vol. 5, no. 3, 2007.
[19] C. S. Weir, G. Douglas, T. Richardson, and M. Jack, "Usable security: user preferences for authentication methods in ebanking and the effects of experience," *Interacting with Computers*, vol. 22, no. 3, pp. 153-164, 2010.
[20] A. S. Beavers, J. W. Lounsbury, J. K. Richards, S. W. Huck, G. J. Skolits, and S. L. Esquivel, "Practical considerations for using exploratory factor analysis in educational research," *Practical Assessment, Research, and Evaluation*, vol. 18, art. no. 6, 2019.
[21] L. Fiddler, L. Hecht, E. E. Nelson, E. N. Nelson, and J. Ross, *SPSS for Windows 16.0: A Basic Tutorial*, Social Science Research and Instruction Center, vol. 25, no. 8, 2011.
[22] J. Pallant, *SPSS Survival Manual: A Step-by-Step Guide to Data Analysis using IBM SPSS*, 5th ed., Berkshire: McGraw-Hill Education, 2013.
[23] J. F. Hair Jr., G. T. M. Hult, C. Ringle, and M. Sarstedt, *A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM)*, 2nd ed., London: Sage Publications, 2016.
[24] J. Arfaa and Y. K. Wang, "A usability study on elder adults utilizing social networking sites," in *International Conference of Design, User Experience, and Usability*, Crete, Greece, June 22-27, 2014, pp. 50-61.
[25] R. Antonius, *Interpreting Quantitative Data with IBM SPSS Statistics*, 2nd ed., London: Sage Publications, 2013.