

The Fifth Information Systems International Conference 2019

Preliminary Insights in Security Warning Studies: An Exploration in University Context

Devinna Win Anak Boniface Emang^a, Zarul Fitri Zaaba^{a,*}, Azham Hussain^b, Nur Azimah Mohd^a

^a*School of Computer Sciences, Universiti Sains Malaysia, 11800 Pulau Pinang, Malaysia*

^b*School of Computing, Universiti Utara Malaysia, 06010 Kedah, Malaysia*

Abstract

Security warning is a form of message that is designed to imitate authorized security alerting function to notify, warn and advice user about the consequence of an action by allowing random applications to run on the computer system. On the other hand, regular computer users tend to ignore the security warning that conveys excessive technical messages which are difficult for them to understand and lead to lack of motivation for decision making. Consequently, an online survey has been utilized by a group of 250 participants to gain general insights based on the user's understanding of security warning. This paper describes one main finding utilizing the Chi-Square test. From the finding, it can be suggested that 2 hypotheses were statistically significant in terms of user's understanding and their assessments towards computer security warning. On the other hand, variable of gender indicates with the highest significant values with three statistically significant 0.004, 0.017 and 0.000 respectively. The overall results from the test given indicate that for each variable were connected between computer user's skills and their understanding in order to improve security warning in the future.

© 2019 The Authors. Published by Elsevier B.V.

This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>)

Peer-review under responsibility of the scientific committee of The Fifth Information Systems International Conference 2019.

Keywords: Security Warning; Chi Square; Human Computer Interaction, usable security, usability

* Corresponding author. Tel.: +60-4-653-4758; fax: +60-4-653-3335.

E-mail address: zarulfitri@usm.my

1. Introduction

Security warning plays an essential role to alert the user and heed the user to a better and secure decision. Regardless of the importance of the security system, the user continuously faces significant difficulties or problems with the security dialogues. The main problem occurs when the computer security system is complicated and difficult to handle, thus, this leads to miscommunication between the end user and the system itself [1]. The warning explains that risk might occur, and possible precautions should be considered before users proceed with the potential risk action [2]. Commonly, the warning can be described as a statement or event that warns of something or that serve a cautionary sample. In computing context, security warning can be depicted as a representation of warning that distracted user's attention to allow the user to be aware of the vulnerable situation in advanced [3]. On the contrary, security warning message has a feature that enables to protect the computer system from potential threats to help users reduce the security threats [2]. To simplify, the warning can be defined as one of the pop-up warnings that protect computer users from any harm such as viruses, information theft and malware. In general [4], showed that the pop-up warning can be classified into error messages, warning messages, notification and confirmation. Among all this classification, warning messages have been of the possible threats to users. Therefore, security warning can be categorized into five types which are a dialogue box, in-place system, notification system, balloon system and banner system. In this paper, the dialogue box has been chosen as the type of security warning because it is the most common warning that pop-up in the computer system [5, 6, 7, 8].

Despite the general use of computer security warning, the user continuously facing significant difficulties or problems with the security dialogues. The reasons are, lack of attention security warning [9, 10, 11, 12], use of technical warnings in computer context [13, 14, 5, 15, 7], user did not understand the security warnings [16, 17, 18, 19] and poor mental model of computer security [20, 21, 22]. From all the reasons above, it can be understood that there is still a need for the developers to create or develop better security warnings in the future.

This paper organized as follows: Section 2 the studies of related work and literature studies: Section 3 describes the methodology implemented in this paper, Section 4 explains the significant value of Chi-Square test based on the related hypotheses. Section 5 presents a brief discussion and finally, Section 6 ends with conclusions highlighting the limitation and the future work of this study.

2. Related research

There is always a warning occurred when people are confronting themselves in danger or unsafe event. For instance, it may warn the user about safety awareness regarding natural disaster, workplace accidents or even in any products available in the marketplace. The warnings explain that risk might occur, and possible precautions should be considered before users proceed with the potential risk action [2]. On the other hands, Bravo-Lillo [6] defined warning as a form of communication that implement to protect people from any dangerous type such as health problem, personal injury and workplace accidents. Commonly, the warning can be described as a statement or event that warns of something or that serves as a cautionary example [23]. Hence, the warning can be acted as cautionary advice to the user about any possible harm and consequences. In computing context, warning can is a representation of context that distracted user's attention to allow the user to be aware of the vulnerable situation in advance [3]. The following are the examples of computer security warning (i.e. dialogues box) that pops up which require users to make prompt decision. It can be noted that most of computer security warnings are depicted in dialogue box types rather than the rest [6, 17, 21, 22].

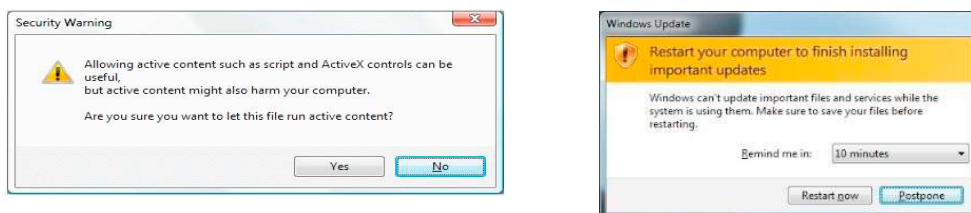


Fig. 1. Example of Computer Security warning dialogs [4, 7].

According to Microsoft [4], the vulnerable situation is involved in losing an important asset, system access and privacy over confidential information. Software or application installation, opening a file from email attachment items or window update and restart are the examples of scenarios that enable to trigger the content of the security warnings. These warnings usually pop-up immediately upon encounter the scenarios.

In addition, Microsoft [4] also explained that there were a series of design guidelines and explanation based on the usage of security warning interface. These guidelines are explained clearly based on its terminology, capitalization and punctuation, standard message phrasing and the appropriate design icon use. The different type of security warnings might trigger various direction of user's perception and understanding. However, not many researchers performed the assessments of how the context of security warning had presented to computer users. Amongst notable approaches were the security warning design in polymorphic [24, 25, 26], audited dialogue approach [24] and use of mental model [21, 27, 28]. Therefore, all the previous approaches give an impact of the results user's perception and understanding towards security warning. Therefore, this paper determines to investigate further given results from the survey where Chi-Square is used as a mean of evaluation. By performing this test, the relationship between two variables can be helpful when interpreting the data using statistically significant values [29].

3. Methodology

An online survey is conducted to have an insight about user's understanding and behavior toward the security warning. The online survey is chosen because it will provide a high rate of the respondent to participate in this survey. The online survey was published mainly through social media and word mouth communication which consists of open and closes ended questions. The responses were treated as confidential and anonymous. Table 1 shows the results of the age of participants.

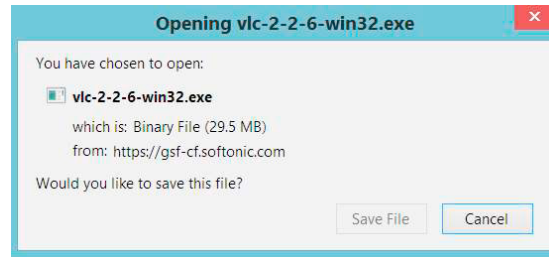
Table 1. An example of a table.

Age (n=250)	18	19	20	21	22	23	24	25	28	30	31	35	36	50
Frequency	1	34	31	33	59	60	11	9	4	1	1	3	2	1
Distribution														
Mean=22.176, σ =3.249														

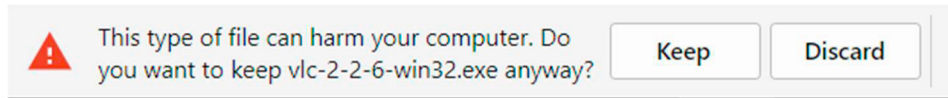
The survey has gathered 250 participants (i.e. convenient sampling) which a majority of them were derived from the age range of 18 to 25 years old. Most of the participants are commonly from the Universiti Sains Malaysia, Penang, Malaysia. The survey began with the demographic's details such as participant's age, educational skills, computing skills and years of using the computer. The questionnaire was presented in numerical rating on a five-point Likert scale of the given scenarios and the analysis was grouped into three classifications. In terms of ranges, we classified the range of 1 to 2 is equal to No, 3 is equal to Neutral and 4 to 5 is equal to Yes [2]. Fig. 2 shows three scenarios chosen in the survey based on different web browsers where previous works demonstrated a similar context before [7, 21, 8, 12]. We attempt to continue from the previous studies to utilize the same types of computer security warnings in three different web browsers. By using these scenarios, we would focus on the significance of Chi-Square towards end-users' assessments.



(a)



(b)



(c)

Fig. 2. Security warning dialogs presented in the online survey study (a) internet explorer; (b) mozilla firefox; (c) google chrome.

4. The relationship of Chi-Square

As mentioned in the methodology section, a chi-square test was used to evaluate the significance of differences between participant's skills in beginner, intermediate and skillful towards the understanding and perceiving the warning presented based on one scenario which is utilized four warning from a different web browser that shown in Fig. 1. Therefore, we proposed four hypotheses to test the significance of these participants skills. These hypotheses were created because we want to investigate whether the level of participants skills plays an important role in perceptions towards computer security warning. The hypotheses were created for further explanation based on issues on the online survey questions as follows:

- There is no difference between beginner, intermediate and skillful in terms of "I understand what the computer security warning is all about." (H1)
- There is no difference between beginner, intermediate and skillful in terms of "The signal word used make me more understand of the warning." (H2)
- There is no difference between beginner, intermediate and skillful in terms of "The technical terminology used makes me more understand of the warning." (H3)
- There is no difference between beginner, intermediate and skillful in terms of "The computer security warning dialogues can help me to make a secure decision." (H4)

The survey has made used four available statements which were asked in the survey using 5-Likert-scales to the participants and compare it using a Chi-Square test. [29] explained that a Chi-square test can utilize the comparison between one or more variable where there shows the difference between actual data and hypothetical data. Thus, a Chi-Square is considered as significant when the value of $p < 0.05$. From the beginning of the online survey, the classification of the computing skills was grouped into four namely beginner, intermediate, advanced and expert. Despite that, we determined to re-group the participants into three groups namely beginner, intermediate and skillful. The skillful compromises of the group of participants which is expert and advanced users while the beginner and intermediate remain the same. The rationale of doing that is because the number of experts and advanced users are quite small comparing to the other groups. These same approaches have been implemented by another researcher [2].

4.1. Results and findings 1

The overall response has gathered 72.8% female and 27.8% male respectively. It is noted that the percentage of female participants is higher than the percentage of male participants. In terms of age, there were 24% which is from 23 years old participants are participating most in the online survey. 22 years old is the average of the participants that participate in this survey. Other than that, it can be noted that more than 90% of the participants have higher educational skills. Besides that, each of the participants was also asked to rate their own computing skills according to their computer usage and understanding about computers. As depicted in Fig. 3, the majority of the respondent rated their computing skills as intermediate with a total of 169 of the participants whereas 21 of the participants rated their skills as a beginner. In addition, 59 of the participants rated their skills as advanced and one participant rated his/her skills as an expert.

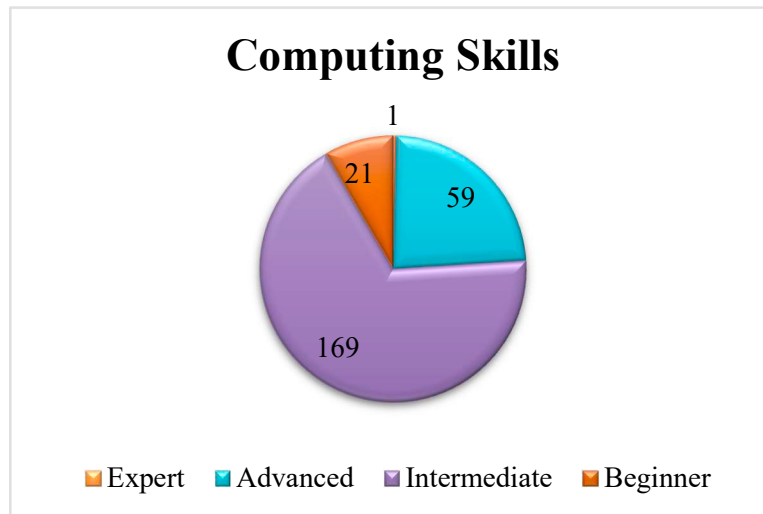


Fig. 3. Computing skills of participants.

As mentioned in the earlier section, a chi-square test was used to evaluate the significance of differences between participant's skills in beginner, intermediate and skillful towards the understanding and perceiving the warning presented based on one scenario which is utilized three warnings from a different web browser as shown in Fig. 2. The participants were asked how they agree with the statements regarding the usability of the warning.

Table 2 shows the overall results on the hypothesis testing. It can be noted that two hypotheses (i.e. H1 and H4) were statistically significant while the remaining H2 and H3 were not statistically different. Although these two results were not supported, the significant values can be considered as nearly significant.

Table 2. The results of the hypotheses and chi-square values.

Hypotheses	Results
There is no difference between beginner, intermediate and skillful in terms of I understand what the computer security warning is all about" (H1)	$\chi^2 = 11.349, p = 0.023, df = 4$
There is no difference between beginner, intermediate and skillful in terms of "The signal word used make me more understand of the warning." (H2)	$\chi^2 = 8.540, p = 0.074, df = 4$
There is no difference between beginner, intermediate and skillful in terms of "The technical terminology used make me understand more of the warning." (H3)	$\chi^2 = 8.357, p = 0.079, df = 4$
There is no difference between beginner, intermediate and skilful in terms of "The computer security warnings dialogue can help me to make a secure decision." (H4)	$\chi^2 = 12.779, p = 0.012, df = 4$

4.2. Results and findings 2

Table 3. The cross relationship between variables (test of independence).

Hypotheses	Gender	Educational Level	Computing Skills
First Action Taken	0.004	0.518	0.109
Understanding of warning	0.579	0.348	0.023
Signal word used	0.055	0.445	0.074
Technical terminology used	0.172	0.309	0.079
Read through warning	0.017	0.289	0.162
Run rather than save	0.695	0.174	0.068
Don't care about warning	0.427	0.366	0.819
Secure decision	0.000	0.049	0.012

As depicted in Table 3, it indicates the cross relationship between three main variables of gender, educational level and computing skills. A Chi-Square test of independence was conducted to test whether is there any significant difference in each variable based on the given hypothesis. In regard to the hypotheses, it covers the elements of usability of warnings, decision making and attitude while encountering warning. Variable of gender indicates with the highest significant values with three statistically significant 0.004, 0.017 and 0.000 respectively. On the other hand, only one hypothesis was significant in educational level and another two in computing skills.

5. Discussion

From the results and findings, the test has been implemented in order to evaluate the correlations between participant computing skills towards their assessment by using Chi-Square test based on all four hypotheses that had been proposed. There was a statistical difference between computing skills in participants such as beginner, intermediate and skillful in terms of computing understanding and the level of assessments. It can be noted that the majority of the participants were having the difficulties to understand the technical terminology and signal words when they receive the computer security warnings. In addition, the previous study [5, 13, 14, 30] also derived use of the technical words are one of the problems and challenges in computer security warnings.

Other than that, based on the hypotheses, it can be noted that the p-value shows that there are statistical differences between skills in participant such as beginner, intermediate and skillful in terms of understanding of the warning and the warning can provide a secure decision. This may be caused by the common download warning is utilized in the study and influenced by a large sample size of the participants obtained in the survey.

Besides that, this study utilized the test of independence between independent variables (gender, education levels and computing skills) and dependent variables of the participants. One striking finding occurred in gender variable with a significant level at 0.000 (very significant) in terms of “making a secure decision”. It indicated that there were significant differences amongst gender in this hypothesis.

6. Conclusion

The hypotheses results revealed that some results were statistically significant in regard to computing skills for beginner, intermediate and skillful in terms of user's understanding and assessment of warning implementations. Although the term of a signal word and technical word shown as not statistically significant, it can be noted that this value was near. In addition, we speculated that having a larger set of sample size and different background of participants instead of from university might portray a different set of results.

The background of the participants needs to be highlighted in this study because the vast majority of participants were derived from the background with Information Technology (IT) and sciences. Having said that, this study able

to highlight useful insights on how end users perceived with computer security warnings in various context. It is expected that the results can be evidence that supports the basis of research in usable computer security warnings domain. In future, we would want to understand further each variable involved in the warnings design by utilizing interview and prototype design.

References

- [1] Dourish, P., R. Grinter, J. Delgado de la Flor, and M. Joseph. (2004) "Security in the Wild: User Strategies for Managing Security as an Everyday, Practical Problem." *Personal and Ubiquitous Computing* **8** (6): 391-401.
- [2] Zaaba, Z. F. (2014) "Enhancing Usability using Automated Security Interface Adaption (ASIA)." [PhD Thesis], University of Plymouth.
- [3] Krol, K., M. Moroz, and M. A. Sasse. (2012) "Don't Work. Can't Work? Why It's Time to Rethink Security Warnings" in *the 7th International Conference on Risks and Security of Internet and System (CRiSIS)*.
- [4] Microsoft. (2017) "Warning Messages." Available at: [https://msdn.microsoft.com/en-us/library/windows/desktop/dn742473\(v=vs.85\).aspx](https://msdn.microsoft.com/en-us/library/windows/desktop/dn742473(v=vs.85).aspx). [Accessed: 26 September 2017].
- [5] Zaaba, Z. F., and K. B. Teo. (2015) "Examination on Usability Issues of Security Warning Dialogs." *Journal of Multidisciplinary Engineering Science and Technology* **2** (6): 1337-1345.
- [6] Bravo-Lillo, C. A. (2014) "Improving Computer Security Dialogs: An Exploration of Attention and Habituation." [PhD Thesis], Carnegie Mellon University.
- [7] Amran, A., Z. F. Zaaba, M. M. Singh, and A. W. Marashdih. (2017) "Usable Security: Revealing End-Users Comprehension on Security Warnings", in *4th Information Systems International Conference 2017, ISICO 2017, Bali, Indonesia*. pp. 624-631.
- [8] Amran, A., Z. F. Zaaba, M. K. M. Singh. (2018) "Habituation Effects In Computer Security Warning." *Information Security Journal: A Global Perspectives* **27** (2): 119-131.
- [9] Whitten, A. and J. D. Tygar. (1999) "Why Johnny Can't Encrypt: A Usability Evaluation of PGP 5.0", in *USENIX Security Symposium*.
- [10] Wu, M., C. R. Miller, and S. L. Garfinkel. (2006) "Do Security Toolbars Actually Prevent Phishing Attacks" in *Proceedings of the SIGCHI Conference of Human Factors in Computing System*, ISBN 1-59593-372-7. pp. 601-610.
- [11] Seifert, C., I. Welch, and P. Komisarczuk. (2006) "Effectiveness of Security by Admonition: A Case Study of Security Warnings in a Web Browser Setting." School of Mathematics, Statistics and Computer Science – Victoria University of Wellington.
- [12] Samsudin, N. F., and Z. F. Zaaba. (2017) "Security Warning Life Cycle: Challenges and Panacea." *Journal of Telecommunication, Electronic and Computer Engineering (JTEC)* **9** (2-5): 53-57.
- [13] Furnell, S. M., A. Jusoh, and A. Katsabas. (2006) "The Challenge of Understanding and Using Security: A Survey of End-Users." *Computer and Security, The International Source of Innovation for the Innovation Security and IT Audit Professional*.
- [14] Bravo-Lillo, C., L. F. Cranor, J. S. Downs, Komanduri, and M. Sleeper. (2011a) "Improving Computer Security Dialogs." *Lecture Notes in Computer Science, Chapter 2* **6949**: 18-35, Springer, Berlin, Heidelberg.
- [15] Samsudin, N. F., Z. F. Zaaba, M. M. Singh, A. Samsudin. (2016) "Symbolism in Computer Security Warnings: Signal Icons and Signal Words." *International Journal of Advanced Computer Science and Applications (IJACSA)* **7**(10): 148-153.
- [16] Dourish, P., and P. DiGioia. (2005) "Social Navigation as a Model for Usable Security", in *Proceedings of the 2005 Symposium on Usable Privacy and Security-SOUPS'05*, Pittsburgh, Pennsylvania. pp. 101-108.
- [17] Sharek, D., Swofford, C. and M. Wogalter. (2008) "Failure to Recognize Fake Internet Popup Warning Messages", in *Proceedings of the Human Factors and Ergonomics Society 52nd Annual Meeting*. pp. 557-580.
- [18] Zaaba, Z. F., S. M. Furnell, P. S. Dowland. (2016) "Literature Studies on Security Warning Developments." *International Journal on Perceptive and Cognitive Computing (IJUM)* **2** (1).
- [19] Zaaba, Z. F., S. Furnell, and P. Dowland. (2011) "End-User Perception and Usability of Information Security", in *International Symposium on Human Aspects of Information Security & Assurance (HAISA 2011)*. pp. 97-107.
- [20] Egelmen, S., L. F. Cranor, and J. Jason. (2008) "You've Been Warned: An Empirical Study of the Effectiveness of Web Browser Phishing Warnings," *Human Computer Interaction Institute, Research Showcase @ CMU*.
- [21] Camp, L. J. (2009) "Mental Models of Privacy and Security." *IEEE Technology and Society Magazine*.
- [22] Wash, R. (2010) "Folks Models of Home Computer Security", in *Symposium on Usable Privacy and Security (SOUPS) 2010*.
- [23] Oxford Dictionaries. (2017) "Warning". Available from: <https://en.oxforddictionaries.com/definition/warning>. [Accessed: 2 November 2017].
- [24] Brustoloni, J. C., and Villamarin-Salomón, R. (2007) "Improving Security Decision with Polymorphic and Audited Dialogs", in *Proceeding of The 3rd Symposium on Usable Privacy and Security*, Pittsburg, USA. pp. 76-85.
- [25] Anderson, B. B., A. Vance, B. Kirwan, and D. Eargle. (2014) "User Aren't (Necesserily) Lazy: Using NeuroIS to Explain Habituation to Security Warnings", in *Thirty Fifth International Conference on Information System*, Auckland.
- [26] Anderson, B. B., C. B. Kirwan, J. L. Jenkins, D. Eargle, S. Howard, and A. Vance. (2015) "How Polymorphic Warnings Reduce Habituation I The Brain: Insights From fMRI Study", in *Proceeding of the 33rd Annual ACM Conference on Human Factors in Computing Systems*. pp. 2883-2892.
- [27] Merritt, J. (2010) "What are Mental Model." Available at: <https://blog.iseesystems.com/systems-thinking/what-are-mental-models/>. [Accessed: 2 November 2017].

- [28] Bravo-Lillo, C., L. F. Cranor, J. S. Downs, and S. Komanduri. (2011b) “Bridging the Gap in Computer Security Warnings: A Mental Model Approach.” *Security & Privacy, IEEE* **9** (2): 18-26.
- [29] McCrum-Gardner, E. (2008) “Which is The Correct Statistical Test to Used?” *British Journal of Oral and Maxillofacial Surgery* **46** (1): 38– 41.
- [30] Raja, F., Hawkey, S. K. Hsu, K. L C. Wang, and K. Beznosov. (2011) “A Brick Wall, A Lock Door and A Bandit: A Physical Metaphor for Firewall Warnings”, in *Proceedings of the Seventh Symposium on Usable Privacy and Security*, Pittsburgh, USA. pp. 1-20.