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Effects of Static Cue and Post Completion Warning Message on Post Completion Error

S. Alshomrani, S. Akram, S. Qamar and S. Jan

***Abstract*— Post completion error is the kind of human error which occurs when the main task is completed and there is a known (but not vital) final step which has to be done and that is forgotten or not performed. This paper aims to add to the research being done by conducting experiments imitating the real life door to door sales scenario, where salesmen use electronic devices to sign customers up to contract. The study aimed to examine the effect of a static cue button and a warning message and to find an answer to the hypothesis, "A Post Completion Warning message is more effective than a static cue button to reduce the Post Completion Errors." The experiment has three versions, version 1 being conducted using the simple prototype without a cue and warning, version 2 being conducted using the prototype having a cue, and version 3 being conducted using the prototype having a post completion warning message. The results from the experiment showed that a static cue button is useful to reduce human post completion errors; however, a post completion warning message is much more effective than static cue button in reducing post completion errors.**

***Index Terms*— Static Cue, Post Completion Error and Prototypes**

I. INTRODUCTION

HUMAN Error can simply be described as the error made by a Human. It is very critical and sometimes the consequences can be very disastrous e.g., according to the World Health Organization (WHO), one of the Philippines' worst maritime disasters was caused by a Human Error when a ferry sunk leaving nearly 800 people dead and missing [1]. In Feb 1989 a compiled report was put forward in the Technical committee meeting organized by International Atomic Energy Agency (IAEA), which concentrated on the classification of human errors and how it can be reduced to ensure the safety in nuclear plants [2]. Since the consequences of Human Error can be fatal, this study aims to contribute to the studies being conducted on different kinds of Human Errors specifically Post Completion Errors (PCEs) to identify its root cause(s) and how its occurrence can be reduced and/or eliminated.

S. Alshomrani is with Faculty of Computing and Information Technology, King Abdulaziz University, Jeddah, Saudi Arabia; e-mail: sshomrani@kau.edu.sa

S, Akram is an independent researcher; email: shehram.akram@gmail.com

S. Qamar is with Faculty of Computing and Information Technology, King Abdulaziz University, Jeddah, Saudi Arabia; e-mail: sqamar@kau.edu.sa

S. Jan is with University of Engineering and Technology, Mardan Campus, Khyber Pakhtunkhwa Pakistan; e-mail: sadaqat@ nwfpuet.edu.pk.

A Post Completion Error (PCE) is the kind of human error [3] which occurs when the main task is completed and there is a known (but not vital) final step which has to be done, but it is either forgotten or not performed. Examples from daily life include forgetting the original documents in the photocopier after the copying is done [4] or forgetting the cash card in ATM after withdrawing the cash [5] etc. Many researchers have tried different ways to reduce the rate of human error, one of which is adding a visible cue to their design. Cue is the word used for a signal [6]. Adding a cue to the system design would mean adding a signal to the design to facilitate user and help him not to forget an important thing to do. A cue has many forms [7] like static cues which can be a button or any other stationary symbol or signal, just in time cues which appears just in time before the potentially erroneous step. Post completion warning is a warning message which will appear if the post completion step is forgotten to alert the user.

This study aims to add to the research being conducted on the different types of human errors and concentrates on one specific type known as a Post Completion Error (PCE) in order to find an answer to the hypothesis, "A post completion warning is more effective than the static cue button to reduce the post completion error". This research compared the effects of added static cue and a post completion warning message on the rate of human post completion error and thus provides evidence for the improvement of system designs.

The rest of the paper is organized as follows: Section II presents the literature review. Section III discusses the methodology carried out for this research. Section IV presents the results and discussion. Finally, Section V concludes this paper.

II. RELATED WORK

Many studies have been conducted to investigate the actual causes of the human errors because if the cause is found, the error rate can be reduced. The author in [8] identified two approaches to human error, first is "person approach" which blames the individual for the error which might be caused by forgetfulness, inattention or other weaknesses and second is "system approach" which concentrates on the working conditions. But person approach and system approach can be linked together for instance the individual might forget a bit more if there is high working memory load, or unable to pay full attention if the mind is busy processing something else, or the system is too complex. This argument is supported by the authors in [9] who investigated further through experiments

claiming that human errors may occur more if working memory load is high. In real life there may be many factors affecting the error rate for example the fatigue.

The authors in [10] predicted the association of high working memory loads with post completion errors. The investigator in [9] used Collaborative Activation-based Production System (CAPS) [10] to prove that post completion errors can occur in the laboratory setting too, by filling up participant's memory. Similarly researchers tried to explore other options too which can be used in the lab settings to cause PCE. One of the ways is interruption position as the researchers in [11] studied the effect of interruption position and its duration on the rate of PCE. Their results showed that interruption had effects on the rate of PCE, and the interruptions just before the post completion step had more effect than the interruptions at other positions, however, the duration of interruption did not have any significant effect.

The authors in [12] shed light on the importance of the timing of the cue, their movement and characteristics especially in dynamic tasks with external loads. In their study, they compared the different timings and places of the cue, studying the effect of enhanced visual cue and mode cue on the rate of post completion errors. Their findings suggested that visual cue was much more effective than the normal controlled state where there was no cue, and the error rate was even lower than the mode cue. In [13] the authors made use of working memory load to ensure participants make post completion error and test them with cue to observe the effect of cues on the error rate. The results suggested that adding a cue can reduce errors. But for cues to perform well in reducing the error they should be prominent as the author in [14] suggested. Further, the procedural (internal to the cognitive system) and sensory (external to the system) cues should be salient and strong enough to interrupt individual's attention away from the normal actions. This is necessary to make them attend to the cue (which will suggest avoiding the error). The studies have proved that adding a visible and salient cue can considerably reduce PCE.

In [15] the authors have studied another aspect of the potential of PCE happening. They conducted experiments by making games and the result of the participant were reset to zero whenever they made a post completion error, this built their motivation to avoid PCE, however, their results concluded that an individual is prone to post completion error even if he/she is motivated to avoid them; they also concluded that the vulnerability to this type of error will be more in demanding situations.

In all of the previous studies the main focus was on the use cues in order to avoid or reduce PCE. In this study we are not only focusing on the static cues but also on the post completion warning messages to avoid or reduce PCE.

III. METHODOLOGY

This section explains the methodology adopted to reach the research goal.

A. Scenario

To test our hypothesis a door to door gas and electric sales scenario was adopted. During sales, specially designed light weight computer devices are used to sign the customers up to contract. They are normally touch screen while some are like the small laptops. The screen of this device is like an electronic *application form* which is connected to the company through the Internet. It helps the contract to go through to the company electronically and on the spot. Due to a small design flaw, the sales advisors sometimes make an error after completing the procedure to sign them. This error sometimes puts the sales advisor in a situation where he loses the client and the contract which is a loss for him and the company. The contract is completed successfully but he forgets to "SAVE" the contract and directly hit the "SEND" button. The chances of sending the contract without saving (or in other words, a PCE happening) are even more when the customer asks questions and the agent is engaged in the conversation while also filling out the details. The contract normally goes through to the company but due to the network problems sometimes the contract is not received by the company or partially received with some data missing. Using this scenario this study is to test the hypothesis: "A post completion warning message is more effective than a static cue button to reduce the post completion errors".

B. Prototypes

The study required three prototypes to conduct the experiment, each slightly different from the other. The aim of the prototype is to emulate the screen of the electronic device used in door to door sales to sign the customers. The prototypes should have an electronic application form where the customer data can be entered. They should also have functional buttons and drop down menus. And finally there should be a way to keep track of the participant's error rate by storing the essential data with the respective participant ID on a database as shown in the Fig. 1.

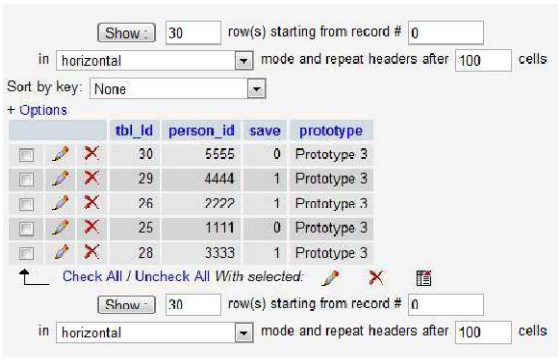

Fig. 1: Database storing results

Prototype 1 or P1 is the simplest of the three. It contains data fields which needed to be filled out by the participants, drop down menus containing the option to save the contract before sending, and the Send button at the bottom right of the screen. Fig. 2 shows prototype 1. Prototype 2 (P2) is slightly different from the P1. In addition to the data fields, drop down menus and send button, it has an additional save button (static cue button) adjacent to the Send button, which can also be

used to save the contract/form. Fig. 3 shows prototype 2. And finally Prototype 3 or P3 is slightly different from both P1 and P2. In addition to the data fields, drop down menus and send button, it has an additional feature which asks for the participant's confirmation through a (post completion) warning message if the participant hit the send button without saving. Fig. 4 shows prototype 3.

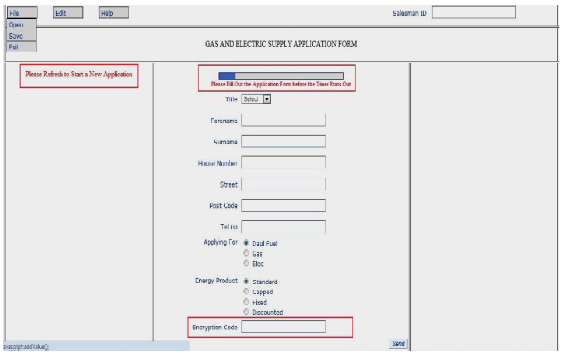

Fig. 2: Prototype 1- P1-Simple

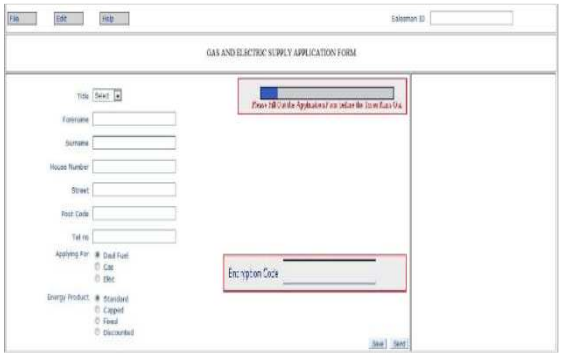

Fig. 3: prototype 2 (P2) with static cue button (save button)

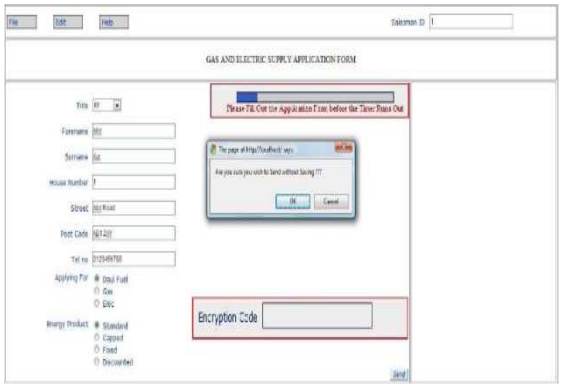

Fig. 4: Prototype 3 (P3)-with Post Completion Warning Message

C. *Participants*

Twenty four participants (undergraduate and post-graduate students) aged between 18 and 45 were recruited to volunteer in this study. They were equally divided in three groups, named as G1, G2, and G3, each containing eight participants.

D. *Design*

The experiment was designed in such a way that it had three versions. Version 1 had G1 using P1 for the experiment; similarly version 2 and 3 had G2 and G3 using P2 and P3 respectively for the experiment. The task in the experiment was the electronic application form which needed to be completed by the participants during the experiment. Each participant had to fill out electronic application forms for 10 customers using his/her respective prototype. In normal life there are many factors affecting the rate of PCE, but since that is not possible so there were a set of questions asked from each participant to ensured distraction.

E. *Experiments*

Three versions of the experiments were used in this study.

a. *Experiment Version 1*

Experiment version 1 was carried out by group 1 (G1) using prototype 1 (P1). G1 contained 8 participants, and P1 is the simple prototype without the static cue button or post completion warning message. Each participant had to fill out the electronic application forms for 10 customers while they were being asked questions. A timer that would expire in 90 seconds was also in operation to force time constraint for each form. At the end of each form the participant had to save the form using the "File drop down menu and then send it by hitting the send button on the bottom right of the screen. The PCE occurred if a participant sent a form without saving.

b. *Experiment Version 2*

Experiment version 2 was carried out by group 2 (G2) using prototype 2 (P2). G2 contained 8 participants, and P2 is the prototype having a static cue "Save" button adjacent to the "Send button. Each participant had to fill out electronic application forms for 10 customers while they were being asked questions. A timer that would expire in 90 seconds was also in operation to force time constraint for each form. At the end of each form the participant had to save the form either by clicking the "Save button or clicking "Save in the "File" drop down menu and then send it by hitting the "Send" button on the bottom right of the screen and the results were stored in database. They were also being observed while performing the experiments to draw different conclusions and identify any trends. The PCE occurred if a participant sent a form without saving.

c. *Experiment Version 3*

Experiment version 3 was carried out by group 3 (G3) using prototype 3 (P3). G3 also contained 8 participants, and P3 is the prototype having a post completion warning message which popped up if the post completion step was forgotten. This means that a warning message appeared if "Send" is clicked without saving. Each participant had to fill out electronic application forms for 10 customers while they were being asked questions. A timer that would expire in 90 seconds was also in operation to force time constraint for each form. At the end of each form the participant had to save the form by clicking "Save" in the "File" drop down menu and

then send it by hitting the "Send" button on the bottom right of the screen and the results were stored in a database. The participants were also being observed while performing the experiments to draw different conclusions and identify any trends. The PCE occurred if a participant sent a form without saving.

F. Constraints

The participants were asked to take no more than five minutes on one application form. When the form is sent without saving, it meant a PCE has occurred and the result of this was recorded. If a participant took more than the allowed time, an added message was appeared to ask the participant to send the form which put an extra pressure on him/her.

IV. Results and Discussions

A. Experiment Version 1 Results

The results from version 1 of the experiment are shown below in the Table 1.

Total Participants	Trails	PCE Occurred	Error Rate (%)
8	80	32	40

Table 1: Results Experiment Version 1 (G1 using P1)

As we can see from the Table 1, that 8 participants filling out form for 10 customers make it 80 trials on prototype 1 (P1). Out of 80 trials, the PCE occurred on 32 occasions which means the post completion step of saving the form before sending was forgotten 32 times. This makes an error rate of 40% which is quite high. Figure 5 below shows the outcome graphically.

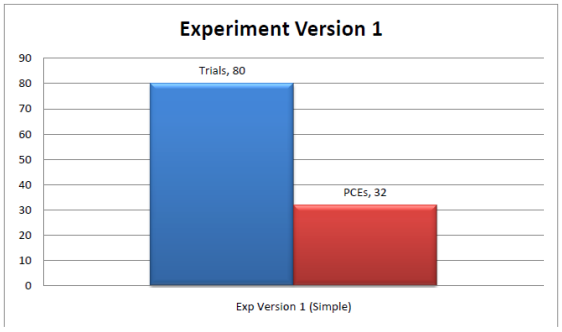

Fig. 5: Graphical representation of the outcome from Experiment Version 1

B. Experiment Version 2 Results

The results from version 2 of the experiment are shown in Table 2.

Total Participants	Trails	PCE Occurred	Error Rate (%)
8	80	8	10

Table 2: Results Experiment Version 2 (G2 using P2)

As we can see from the Table 2, that 8 participants filling out form for 10 customers make it 80 trials on prototype 2 (P2). Out of 80 trials, the PCE occurred on 10 occasions which means the post completion step of saving the form before sending was forgotten 10 times. This makes an error rate of 10% which is considerably lower than the version 1 of the experiment which was carried out by G1 using P1. Figure 6 shows the outcome graphically.

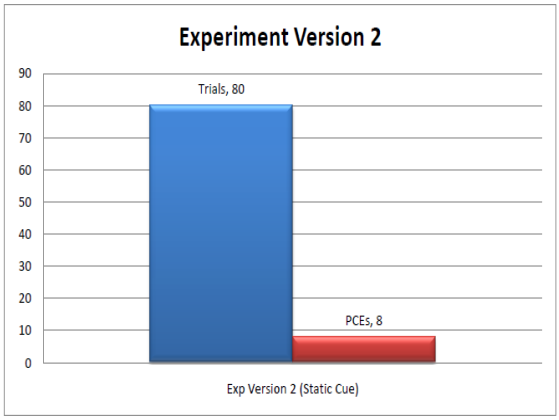

Fig. 6: Graphical representation from Experiment Version 2

C. Experiment Version 3 Results

The results from version 3 of the experiment are shown in the Table 3.

Total Participants	Trails	PCE Occurred	Error Rate (%)
8	80	1	1.25

Table 3: Results Experiment Version 3 (G3 using P3)

As we can see from the Table 3, that 8 participants filling out form for 10 customers make it 80 trials on prototype 3 (P3). Out of 80 trials, the PCE occurred on just one occasion which means the post completion step of saving the form before sending was forgotten just one time. This makes an error rate drop to just 1.25% which is insignificant as compared to the results obtained from version 1 and 2 of the experiment which involved G1 using P1 and G2 using P2 respectively. Figure 7 shows the graphical presentation of the outcome from experiment version 3.

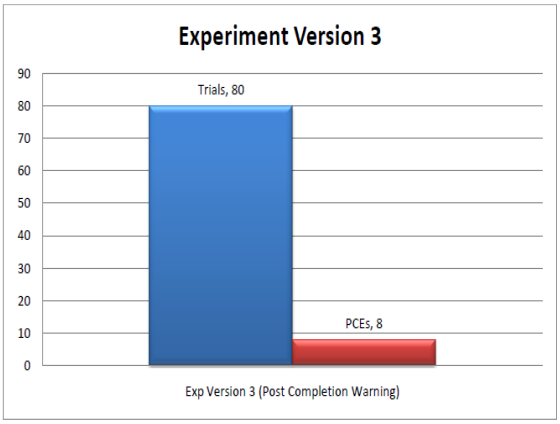

Fig. 7: Graphical representation from Experiment Version 2

Fig. 8 shows the comparison of the error rate observed in all the three versions of the experiment. It clearly shows the effect of a static cue button and post completion warning message on the rate of PCE as it drops from 40% to 10% with a static cue, and drops from 40% to 1.25% with a post completion warning message.

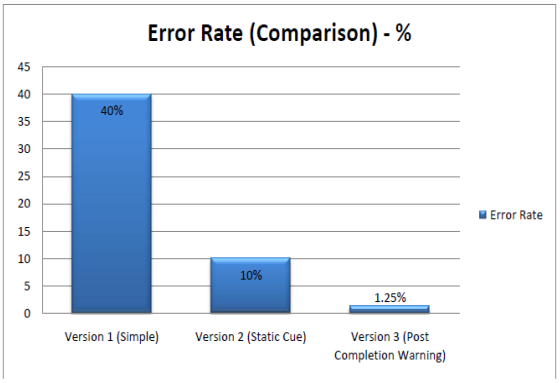

Fig. 8: Graphical representation of the comparison of Error Rate from three versions of experiments

D. Discussion

During the experiment it was observed that the working memory load alone was not sufficient to cause many PCEs; it were also the questions asked in the middle and the timer put an extra pressure on the participants. The participants, after the experiments, revealed that the questions in the middle made them forget the five digit encryption code which they had to memorize in the start and enter at the end of each form. This means the working memory load, as defined by Byrne and Bovair [1997], played its part but it was also supported by the distractions of the questions and timer during the process. One of the participants from G1 using P1 failed to save the form in all of his 10 tries even though the observer hinted twice during the experiment that the process included saving the form before sending. The participant described this failure as a result of pressure of remembering the Encryption ID which forced him in to PCE every time. The one PCE that occurred in version 3 of the experiment was termed as the result of a timer by the participant. He explained that seeing himself running short on time forced him pressing "Enter" button in quick succession in order to send the form in time which also, accidently according to him, selected "YES" button on the post completion warning message that read, "Are you sure you want to send without saving ???".

E. Statistical Analysis

Since this experiment was unrelated and there were more than two independent conditions (three versions of the experiment) therefore one way Analysis of Variance (ANOVA) statistical test was used to analyze the data obtained from the three versions (conditions) of the experiment. Here the null hypothesis, "static cue and post completion warning message has no effect on post completion error" would be accepted if the sum of squares calculated returns zero, however, if the returned value was greater than zero than it would reject the null hypothesis. The sum of square was calculated by adding the square of differences of the grand mean (m) and the condition's mean (mi) k times whereas k is the number of conditions (in this case k=3). The grand mean (m) was calculated by adding the individual means in each condition and dividing by 240 (the total number of trials) as there were 3 conditions each having 80 trials. The three means m1, m2 and m3 were calculated to be 0.4, 0.1 and 0.0125 respectively. Therefore the grand mean (m) was calculated to be 0.0021354. The sum of squares then returned a value of 0.16798 which is not equal (or close) to zero so the null hypothesis is rejected and since its greater than zero the results from experiment versions were taken into account which strongly satisfied the hypothesis assumed that "A post completion warning message is more effective than a static cue button to reduce post completion error".

V. CONCLUSION

This study provided support to many studies and built upon the previous work. It was proven once again that working memory load can generate PCEs in laboratory conditions supporting Byrne and Bovair's [9] argument. It was also observed that the time constraint was a very good support to working memory load in generating PCEs. It was exposed that a static cue button can reduce the rate of PCE but it was also revealed that there is a more effective way of reducing error which is a "post completion warning" message. The results from the experiment strongly favored the hypothesis assumed at the start of the study that "A post completion warning is more effective than the static cue button to reduce post completion error".

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Saleh Alshomrani is a faculty member in the Information Systems Department at Faculty of Computing and Information technology, King Abdulaziz University, Saudi Arabia. He is also serving as the Vice-Dean of Faculty of Computing and Information Technology, and the Head of Computer Science Department – North Jeddah branch at King Abdulaziz University. He earned his Bachelor degree in Computer Science (BSc) from King Abdulaziz University, Saudi Arabia in 1997. He received his Master degree in Computer Science from Ohio University, USA in 2001. He did his Ph.D. in Computer Science from Kent State University, Ohio, USA in 2008 in the field of Internet and Web-based Distributed Systems. Currently he is actively working in the area of Internet and Web-based Distribution Systems.

Shehram Akram has done his Masters in Advanced Computer Sciences from Queen Mary, University of London. Shehram's main research focus are areas of Human Computer Interaction like Human Error, Design for Human Interaction and Interactive System Design. He is also a Computer Engineer with BSc Computer Systems Engineering degree from University of Engineering & Technology (UET) Peshawar.

Shahzad Qamar is working as a Lecturer in Faculty of Computing and IT at King Abdulaziz University Saudi Arabia. Shahzad Qamar has done his MS in Wireless and Mobile Networks from Bournemouth University UK. Shahzad Qamar's research focus is on the new emerging technologies like Green and Cloud Computing, QoS in WiMAX and WiFi Networks and Human Computer Interaction.

Sadaqat Jan is working as Assistant Professor in Computer Software Engineering Department at University of Engineering and Technology, Mardan Campus, Pakistan. He received his PhD degree from Brunel University, UK and Master degree from NWFP University of Engineering and Technology Peshawar, Pakistan. His research interests include Grid Computing, Mobile Computing, and Information retrieval, Distributed Systems, Semantic Web, Knowledge Engineering and Computer Networks. He is a member of IEEE.