Investigating the Impact of Combining Speech and Earcons to Communicate Information in E-government Interfaces

Dimitrios Rigas[1] and Badr Almutairi[2]

[1] INSPIRE, University of West London, London W5 5RF, UK
Dimitrios.Rigas@uwl.ac.uk
[2] Faculty of Technology, De Montfort University, Leicester LE1 9BH, UK
Badr@dmu.ac.uk

Abstract. This research investigates the use of multimodal metaphors to communicate information in the interface of an e-government application in order to reduce complexity in the visual communication by incorporating auditory stimuli. These issues are often neglected in the interfaces of e-government applications. This paper investigates the possibility of using multimodal metaphors to enhance the usability and increase the trust between the user and the application using an empirical comparative study. The multimodal metaphors investigated include text, earcons and recorded speech. More specifically, this experiment aims to investigate the usability in terms of efficiency, effectiveness and user satisfaction in the context of a multimodal e-government interface, as opposed to a typical text with graphics based interface. This investigation was evaluated by 30 users and comprised two different interface versions in each experimental e-government tool. The obtained results demonstrated the usefulness of the tested metaphors to enhance e-government usability and to enable users to attain better communicating performance. In addition empirically derived guidelines showed that the use of multimodal metaphors in an e-government system could significantly contribute to enhance the usability and increase trust between a user and an e-government interface. These results provide a paradigm of a design framework for the use of multimodal metaphors in e-government interfaces.

Keywords: e-government, Recorded Speech, Earcons, Multimodal, Trust, HC1.

1 Introduction

For the time being, most of web interfaces applications are visually crowded and difficult to communicate the intended message correctly to users via the visual channel. Therefore, other human senses could be involved in human computer interaction to employ more interaction metaphors within the visual channel, the auditory channel or both. This research describes an empirical exploration that has been carried out to investigate the usability aspects of an e-government interface that incorporates a combination of typical text with multimodal metaphors such as recorded speech. The main question asked in this study is whether the inclusion of these metaphors can

M. Kurosu (Ed.): Human-Computer Interaction, Part IV, HCII 2013, LNCS 8007, pp. 23–31, 2013.

enhance usability and communication with the user. A secondary question relates to the contributing role that each of these multimodal metaphors can play in the expected enhancement. An e-government experimental platform, with two interface versions, was developed to serve as a basis for this investigation. The e-government software solution described uses an input interface to send messages and an output interface to receive messages. The study involved two groups of users (one group for each interface version) in which the usability performance of the two groups, in terms of efficiency, effectiveness, and user satisfaction was compared.

1.1 Literature Review:

Usability Evaluation in e-government Interfaces

Usability is one of the most important factors to evaluate Human-Computer Interaction [1] and software quality [2]. It can be defined as the *"extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction"* [3]. The effective system can be implemented and developed only by understanding better government websites, expectations of the users' under the citizen-centric approach, and the barriers that might hinder these interfaces in order to provide the desired services through the Internet. This technology can be used to improve the efficiency of governments; improve interaction between government and public, facilitating economic development, reduce costs, and move towards meeting citizens' expectations for service delivery, by facilitating the process of administrative procedures [4, 5].

Multimodal Interaction

Rigas and Memery stated that *"the auditory channel, as a whole, has been neglected in the development of user-interfaces, possibly because there is very little known about how humans understand and process auditory stimuli"* [6]. Interfaces that offer interaction using more than one channels of communication are often more usable. Rigas et al, suggest that the use of multimodal metaphors in application interfaces increases usability and the volume of information that can be communicated to the user [7, 8, 9]. Also, they found that the use of speech and other auditory stimuli in an interface helped users to make fewer mistakes and reduced the time taken when accomplishing their tasks [10]. Several other studies have been carried out to test the use of multimodal metaphors in visual user interface and to evaluate and examine the affect of these metaphors on the usability of computer applications [11, 12].

2 Multi-Modal E-government Experimental Platform (MMEGP)

The main aim of this experiment was to measure the impact of combining recorded natural speech and earcons on the usability of e-government interfaces. It also aimed to evaluate the extent to which the addition of these multimodal metaphors can affect

the ability to communicate with users. More specifically, this experiment is aimed at evaluating the efficiency, effectiveness and user satisfaction of a multimodal e-government interface, as opposed to a typical text based interface. An additional aim was to explore these usability factors with different tasks in terms of complexity (i.e. easy, moderate and difficult) and message types (suggestions, complaints and comments) using both input and output and question types (i.e. recall and recognition). Therefore, this experiment aimed to investigate usability aspects as well as communication performance of e-government interfaces that combine text, recorded speech and earcons in order to also improve trust between users and the e-government interface.

Fig. 1. Multi-Modal e-government Experimental Platform (MMEGP) showing the input interface

Given the aims, the objectives of this study were to measure the performance of the users in terms of efficiency (time taken by users to complete tasks), effectiveness (successfully completed tasks by users), and user satisfaction by requesting users to rate the communication metaphors used in the platform.

Figure 1 shows an example screenshot of the multimodal e-government interface. Creation of the involved multimodal metaphors was primarily based on the connection between these interaction metaphors and the information being delivered. This connection also considered the previous interface that demonstrated the usefulness of multimodal interaction. The e-government interface contained information which was delivered in a textual way with recorded speech and earcons. Information could be communicated by the visual channel and by making use other communication channels in the interaction process (e.g. recorded speech, earcons and images). Guidelines for multimodal information presentation [13] and multimodal user interface design were followed. For example, the multimodal input and output was used to widen the bandwidth of information transfer [13, 14]. Also, graphical displays, speech messages

were combined to obtain an effective presentation [15] in a way that speech can be used to transmit short messages.

2.1 Variables

The variables considered in the experimental design can be classified into three types which are: independent variables, dependent variables and controlled variables.

Table 1. Independent variables considered in the experiment

Variable Code	Variable	Levels	State 1	State 2	State 3
IV 1	Presentation method	2	TOEGP	MMEGP	
IV 2	Message complexity	3	Easy	Moderate	Difficult
IV 3	Message type	3	Suggest	Complain	Comment

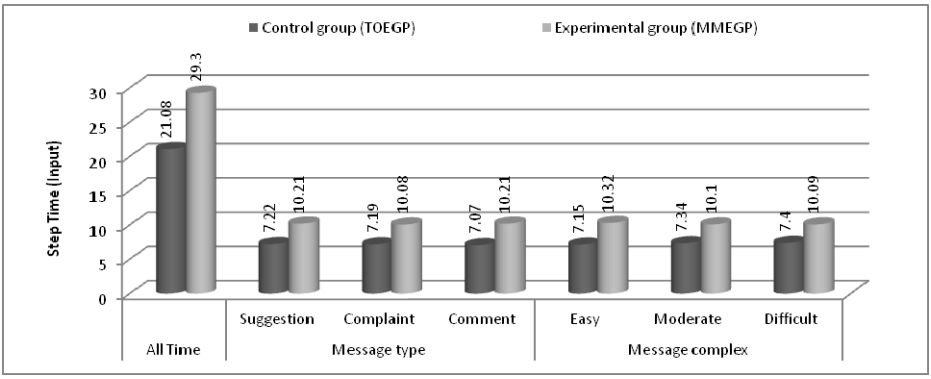

Fig. 2. Mean values of time taken by users in both groups to enter all tasks, grouped by message complexity and message type for the (input interface)

2.2 Efficiency

The time spent to enter message tasks and answer the required questions was used as a measure of efficiency. This measure was considered for all tasks for the input interface and for the output interface (according to the question type, recall and recognition), message complexity, as well as for each task and for each of the users in both groups.

A figure 2, 3 shows the time taken by users to complete the various types of tasks. It can be seen that the use of recorded speech was more efficient, as tasks took less time - unlike other groups which took more time to read the tasks.

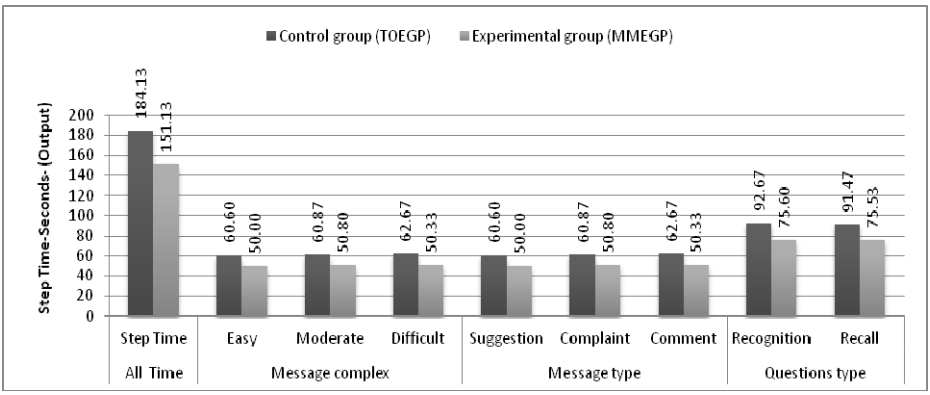

Fig. 3. Mean values of time taken by users in both groups to enter all tasks, grouped by message complexity and message type for the (output interface)

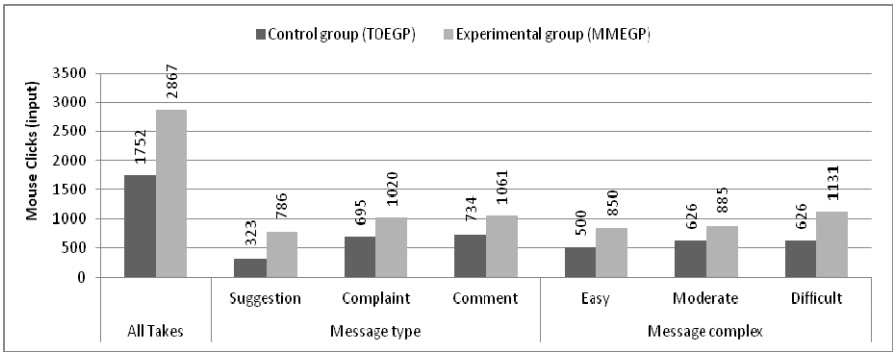

Fig. 4. Percentage of mouse clicks performed by users in both groups

2.3 Effectiveness

The numbers of correctly completed tasks were used to measure the effectiveness. This measure was considered for all messages and all the questions, according to the question type (recall and recognition) and message complexity (easy, moderate and difficult) and message type (suggestion, complain and comment), as well as for each user in both control and experimental groups.

Figure 4 shows the percentage of mouse clicks to enter messages for all tasks for the TOEGP and MMEGP. It can be noted that users of the TOEGP used less mouse clicks that users of the MMEGP. This was due to the requirement when using the input interface to enter text only, in contrast to the experimental group that required users to enter text and spoken speech. Figure 4 shows that the users of the TOEGP performed better than the users of the MMEGP with regard to the number of mouse clicks for all messages. The mean number of mouse clicks for the MMEGP was (2867) more than that attained in the TOEGP (1752) for all messages. The t-test results showed that the difference in mouse clicks between MMEGP and TOEGP was significant ($t(16)$, $MD=-2.9$, $p<0.05$). As a result, the MMEGP users outperformed the users of the TOEGP, who send their information using text only.

It can be seen that users of the TOEGP exceeded MMEGP users in terms of the number of mouse clicks used to enter messages for all tasks. The multimodal metaphors applied in the MMGEP assisted in reducing the number of mouse clicks used for the required tasks in the input interface.

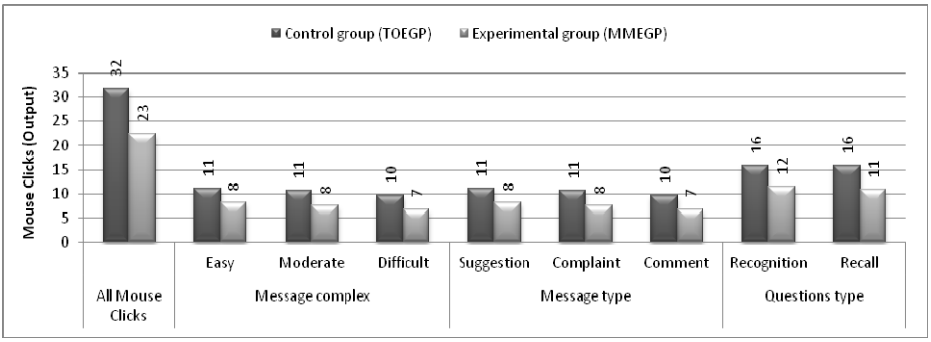

Fig. 5. The mean number of mouse clicks by users in both groups to enter message for all the tasks

Figure 5 shows that users of MMEGP performed better than the users for TOEGP in terms of the number of mouse clicks used for all messages. The mean number of mouse clicks used in the MMEGP (23) was less than that used in the TOEGP (32) for all messages in the output interface. The t-test results showed that the difference in mouse clicks between MMEGP and TOEGP was significant ($t(6)$, $MD=9$, $p<.05$). As a result, TOEGP outperformed the users of the MMEGP when received the messaging information via text with metaphors. The correct combination of more than one communication metaphor of different channels in the MMEGP helped users in the experimental group to discriminate between the different types of information delivered by each of the recorded speech extracts, thus enabling them to understand this information in a short time period and reduced the number of mouse clicks. In summary, the multimodal interaction metaphors used in the MMEGP were more effective in communicating and considerably assisted the users in the experimental group to achieve a higher effectiveness rate, as opposed to the control group users using the output interface.

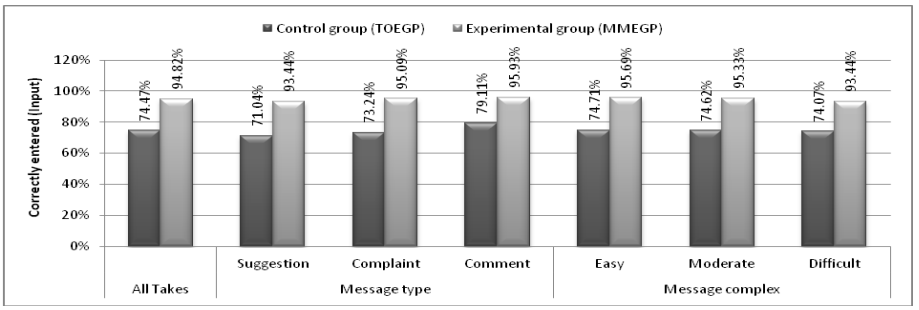

Fig. 6. Percentages of correctly completed tasks by type

By analysing the "correctly entered" measure we can find the percentage of users that entered the correct message at the input for all tasks. Figure 6 shows the percentage of test results of information correctly entered for all tasks in the TOEGP and MMEGP.

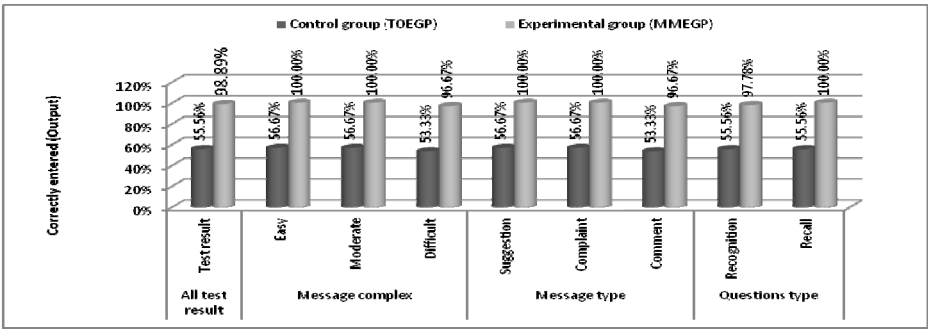

Fig. 7. Percentage of correctly completed tasks by correctly entered for users in both groups for the output interface

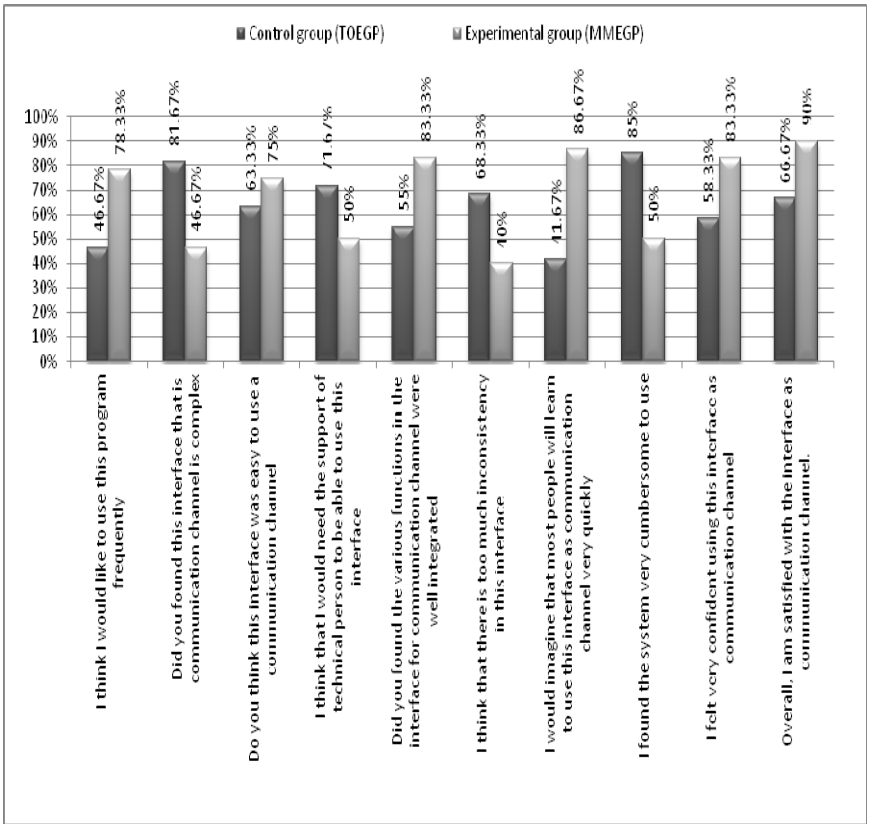

Fig. 8. Percentages of users agreeing to each statement of satisfaction for both TOEGP and MMEGP groups

Figure 7 shows that users of the MMEGP completed more tasks successfully than the TOEGP users, in terms of the number of correctly entered messages for tasks using the output interface. The MMEGP was more effective in communicating and considerably assisted the users in the experimental group to achieve a higher effectiveness rate, as opposed to users in the control group.

2.4 User Satisfaction

The user satisfaction with regard to the different aspects of the applied e-government platform was measured for both groups in terms of users' answers to the post-experimental questionnaire which consisted of 10 statements related to the ease of use.

The overall satisfaction score for each user was calculated using the SUS (System Usability Scale) method. The mean satisfaction score for the users in the experimental group was 68.33%, compared to 63.83% for the users in the control group. In other words, the MMEGP was more satisfactory for users than the TOEGP.

3 Concluding Summary

This paper examined the impact of multimodal interaction metaphors for ease of use in terms of efficiency, effectiveness and user satisfaction and the communication performance of an e-government experimental interface. This study has been implemented by developing two different versions of the experimental e-government platform. The results obtained from this experiment confirm that multimodal metaphors do in fact help to improve the usability of e-government interfaces, and reduce the time needed for users to respond to messages, and allow users to undertake activities more accurately, and make use of the interface more pleasing and satisfactory.

We can therefore conclude that the multimodal metaphors tested can contribute greatly to improving the performance of users' communication and ease of use of e-government interfaces in terms of effectiveness, efficiency and user satisfaction. It is therefore proposed to include multimodal metaphors in e-government interfaces and this need to be taken in mind when designing such interfaces. This e-government interface approach is gaining popularity among the providers of e-government services. Its importance from the users' point of view has become the main concern for e-government services.

References

1. Nielsen, J.: Usability Engineering. Academic Press Inc., US (1993)
2. Costabile, M.F.: Usability in the Software Life Cycle. Handbook of software engineering and knowledge engineering 1, 179–192 (2001)
3. ISO, ISO 9241: Ergonomic Requirements for Office Work with Visual Display Terminals (VDTs) - Part 11: Guidelines on usability, p. 2, (1998)
4. Alzahrani, A.: Web-based e-Government services acceptance for G2C, A structural equation modeling approach. De Montfort University (2011)

5. Alsaghier, H., Ford, M., Nguyen, A., Hexel, R.: ” Conceptualising Citizen’s Trust in e-government: Application of Q Methodology". Electronic Journal of E-Government 7(4), 295–310 (2009)
6. Rigas, D., Memery, D., et al.: Experiments in using structured musical sound, synthesised speech and environmental stimuli to communicate information: is there a case for integration and synergy? Intelligent Multimedia, Multimedia, Video and Speech processing (2001)
7. Rigas, D.: Guidelines for Auditory Interface Design: An Empirical Investigation. PhD thesis, Loughborough University of Technology (1996)
8. Rigas, D., Alty, J.L.: Using sound to communicate program execution. In: Proceedings of the 24th EUROMICRO Conference, vol. 2, pp. 625–632 (1998)
9. Rigas, D., Hopwood, D.: The Role of Multimedia in Interfaces for On-Line Learning. In: 9th Panhellenic Conference on Informatics (PCI 2003), Thessaloniki, Greece (2003)
10. Rigas, D.: Guidelines for Auditory Interface Design: An Empirical Investigation. PhD thesis, Loughborough University of Technology (1996)
11. Michaelis, P.R., Wiggins, R.H.: A human factors engineer’s introduction to speech synthesizers. Directions in Human Computer Interaction (1982)
12. Alotaibi, M., Rigas, D.: A Usability Evaluation of Multimodal Metaphors for Customer Knowledge Management. International Journal of Computers and Communications 2 (2008)
13. Oviatt, S.: Multimodal Interfaces, The Human-Computer Interaction Handbook: Fundamentals, Evolving Technologies, and Emerging Applications (2003)
14. Sarter, N.B.: Multimodal information presentation: Design guidance and research challenges. International Journal of Industrial Ergonomics 36, 439–445 (2006)
15. Bonebright, T.L., Nees, M.A., Connerley, T.T., McCain, G.R.: Testing the effectiveness of sonified graphs for education: A programmatic research project. In: International Conference on Auditory Display, Espoo, Finland (2001)
16. Ciuffreda, A.: An Empirical Investigation in Using Multi-modal Metaphors to Browse Internet Search Results. In: Department of Computing, School of Informatics. University of Bradford, Bradford (2008)
17. Alotaibi, M.: Electronic Customer Knowledge Management Systems: a Multimodal Interaction Approach. In: Informatics Research Institute. University of Bradford, Bradford (2009)