Multimedia Communication in e-Government Interface: A Usability and User Trust Investigation

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Thesis submitted for the degree of Doctor of Philosophy in Computer Science

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MULTIMODAL INTERACTIVE E-GOVERNMENT:

AN EMPIRICAL STUDY

The effect of multimodal metaphors on the usability and communication performance of e-government interfaces to increase user trust and the production of empirically derived guidelines for the use of these metaphors in the software engineering process

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2014

بسم الله الرحمن الرحيم

In the Name of Allah, the Most Compassionate, the Most Merciful

Dedication

This is dedicated to

The Custodian of the Two Holy Mosques,

His Royal Highness King Abdullah bin Abdulaziz of Saudi Arabia,

My father Mohammed, My mother Nori, My wife (the twin of my soul),

My dear son Mohammed and daughters Wsan, Lana and Seema.

For their constant love, encouragement and patience.

Dr. Badr Almutairi

List of Publications

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3. Rigas, Dimitrios, and Badr Almutairi. "Multimodal learning through e-Government Interfaces." Human-Computer Interaction. World Scientific and Engineering Academy and Society. 2013. 14-16. 70003-172.

ABSTRACT

In the past few years, e-government has been a topic of much interest among those excited about the advent of Web technologies. Due to the growing demand for effective communication to facilitate real-time interaction between users and e-government applications, many governments are considering installing new tools by e-government portals to mitigate the problems associated with user – interface communication. Therefore, this study is to indicate the use of multimodal metaphors such as audio-visual avatars in e-government interfaces; to increase the user performance of communications and to reduce information overload and lack of trust that is common with many e-government interfaces. However, only a minority of empirical studies has been focused on assessing the role of audio-visual metaphors in e-government. Therefore, the subject of this thesis' investigation was the use of novel combinations of multimodal metaphors in the presentation of messaging content to produce an evaluation of these combinations' effects on the users' communication performance as well as the usability of e-government interfaces and perception of trust. The thesis outlines research comprising three experimental phases. An initial experiment was to explore and compare the usability of text in the presentation of the messaging content versus recorded speech and text with graphic metaphors. The second experimental was to investigate two different styles of incorporating initial avatars versus the auditory channel. The third experiment examined a novel approach around the use of speaking avatars with human-like facial expressions, obverse speaking avatars full body gestures during the presentation of the messaging content to compare the usability and communication performance as well as the perception of trust. The achieved results demonstrated the usefulness of the tested metaphors to enhance e-government usability, improve the performance of communication and increase users' trust. A set of empirically derived ground-breaking guidelines for the design and use of these metaphors to generate more usable e-government interfaces was the overall provision of the results.

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LIST OF ACRONYMS

AVEGP	Avatar e-government Condition
CV	Critical Value
CV	Controlled Variable
df	degree of freedom
DT	Difficult Task
DV	Dependent Variable
E-government	Electronic- government
G2C	Government to Citizens
G2B	Government to Business
G2G	Government to Government
G2E	Government to Employee
H#	Hypothesis
HCI	Human Computer Interaction
ICT	Information and Communication Technology
IV#	Independent Variable
MMEGP	Multimodal E-government Condition
MD	Mean Definition
NMEGP	New Multimodal E-government Condition
SUS	System Usability Scale
TOEGP	Text Only E-government condition
VB	Visual Basic
VMBG	Virtual Message with Body Gestures
VMFE	Virtual Message with Facial Expressions

CHAPTER 1

1.1 Introduction

This chapter gives a brief summary of the experimental studies carried out in this research to explore the essence of different multimodal interaction metaphors on the usability, perception of trust and the performance of communication in e-government interfaces. The chapter also summarizes the main conclusions and short-feelings drawn from the obtained results.

In modern times, rapid advancement in ICT has encouraged many governments to integrate new technology into their national economic development strategies. These developments opened the door widely to offer more opportunities to obtain knowledge in different disciplines through virtual communication (e-government). The successes of governments or organizations are determined by their ability to capture intelligence, transform it into a deployable form and distribute it rapidly among the users. Most user interfaces heavily use visual stimuli to communicate information and this could result in overloading users‘ visual channel [1, 2] and missing important information [3]. The reviewed literature demonstrated the significance of incorporating both visual and auditory metaphors to enhance Human-Computer Interaction process. The inclusion of both visual and auditory metaphors in computer interfaces could contribute to enhancing the amount of information delivered by the particular sensory channel [4] and increasing the capacity of communicating information [5] addition to allowing different information to be conveyed using different interaction metaphors [6]. In e-government interfaces, multimodality has shown to be convenient in improving the users’ communication performance [7] and usability, and increase the trust between the user and the application [8]. Hence, the demands for further research to assimilate multimodal metaphors in e-government applications are even highlighted.

Communication through multimodal interaction may serve to ease a portion of the difficulties that e-governments often come across such as the lack of personal interaction.

This thesis investigates the use of multimodal interaction metaphors to provide an audio-visual presentation of the messaging information on e-government interfaces. While the main focus of the experimental work carried out within this investigation was on exploring the influence of non-speech sounds (auditory icons and earcons), speech sounds (recorded), alongside avatars as virtual communication with facial expressions and body gestures on the usability and communication performance and perception of trust in e-government portals. The main research question is whether or not; including these interaction metaphors can improve the ease of use and communication performance to increase users' trust in e-government interfaces. An additional question related to the contribution of each of these metaphors to the expected improvement. In addition, how would the users evaluate the use of these metaphors when incorporated into e-government interfaces? In the end, does it constitute a difference between avatar facial expressions and avatar full body motion in these interfaces? What follows is the explanation of the purposes and targets of this thesis, as well as the overall hypothesis, including the method used to accomplish the objectives. The concluding element of this chapter contributes towards the thesis and succinctly outlines its structure.

1.2 Aims and Objectives

In general, this research aims to look into multimodal interaction metaphors and its effect on the usability and communication performance and perception of trust in term of efficiency, effectiveness, communication performance, user satisfaction and perception of trust of a multimodal in e-government interface, as opposed to a typical text based interface. To build a host of empirically derived guidelines, to assist in the conception and implementation of multimodal e-government interfaces. The objectives of this research:

- To design a condition based on the delivery of the message in the e-government interfaces to identify the most ease of use.
- To identify the effects of multimodal in e-government interfaces using the experimental conditions evaluated by six groups of users.
- To measure the efficiency of the conditions by recording the time users spent in completing the required tasks.
- To test the effectiveness and the communication performance of the conditions by calculating the percentage of message tasks correctly completed by the users.
- To evaluate user satisfaction and trust by rating various aspects of the conditions tested.

1.3 Overall Hypothesis

This research formulated hypothesis to be examined as follows: In comparison with the usage of text with graph and by the addition, auditory to text in multimodal-based government interface as audio channel and avatar as a visual-audio channel to send messages. It is hypothesised that the role of multimodal interaction metaphors will undoubtedly play a pivotal role in enhancing the usability (with regards to its efficiency, effectiveness, user satisfaction and user trust) and develop user‘s communication performance in e-government interfaces.

1.4 Research Method

The research included a literature survey, an initial experimental study and two further experiments. Experimental observations and questionnaires formed the basis of the data aggregation operation. Experimental observations assisted in collecting the data linked to efficiency, effectiveness and communication performance. However, questionnaires were applied to acquire data linked to users’ satisfaction and users’ trust and ratings.

The literature survey method was based on:

1. Identifying the main researchers in the area and their work.
2. Identify experiments that are related or linked in this investigation.
3. Critically assessing this body of literature.
4. Identifying the main gaps in the literature that were used as a basis for this investigation.

5. The factor that we shall investigate in this study shall be different so as to shed light on human interaction from a new angle. The lack of interaction with humans may feel due to the absence of physical interaction with other people.

Overall experiments conducted in this research, participating users were of different ages, backgrounds and gender. Also, they were employees working at the e-government departments in kingdom of Saudi Arabia and undergraduates and postgraduates at the University of De Montfort.

For the statistical analysis, the nonparametric Kolmogorov-Smirnov test has been used to test the normal distribution of the results obtained in terms of the tasks attempted and answering time, mouse click, correctly entered task and the satisfaction. If normal distribution was found to be the scope of the data, then the evaluation of the significance of the difference between the two groups in regard to each of these parameters would be underpinned through the use of an independent t-test. The pertinence of this statistical test is apparent when two varying experimental conditions are tested by two independent groups of users.

1.5 Significance of the Research

This research considers the enhanced usability and acceptance of e-government in evolving countries in terms of communication performance, users‘ satisfaction and increase users' trust. It is undoubtedly a topic for not only researchers, but also professionals, decision makers and policy shapers in developing countries. The determinations and results of this survey will be valuable for leaders at both the organisational and national level; to facilitate them in making decisions which are correct, thereby enhancing their environments and developing the public sector in the modification process.

1.6 Modelling Framework of Multimodal Messaging in HCI

To explain the message model of multimodal user interface, we need a vocabulary of modelling primitives. So, we defined the metamodel where we formally described basic concepts of multimodal interaction [9]. The primary concept of our metamodel is a HCI modality, which we describe as a form of interaction designed to engage some of human capabilities, e.g. to produce some effects on users through the process of sending and receiving the message as a solution for the development of communication systems.

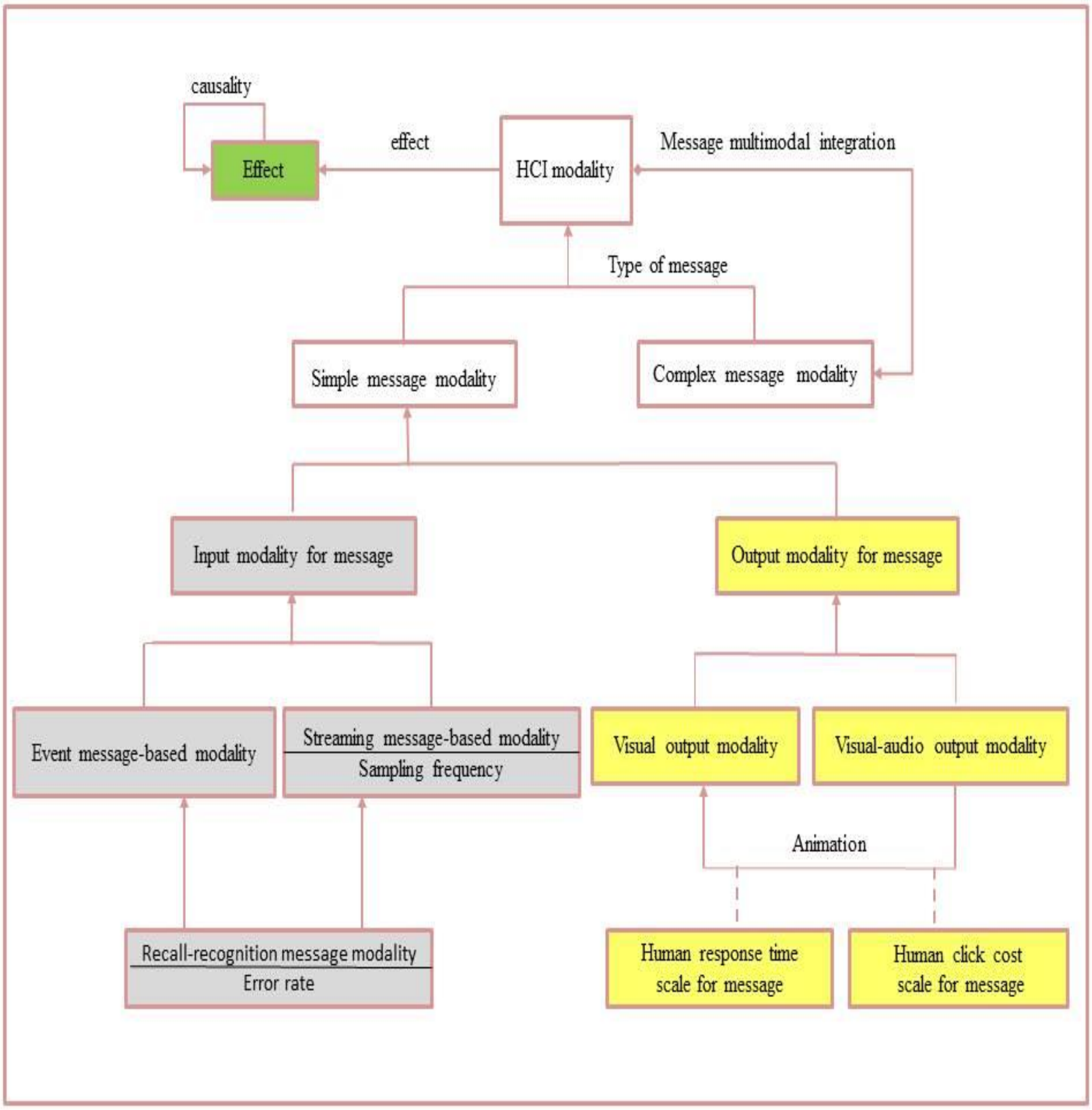


Figure 1-1 Simplified modelling framework of multimodal messaging in HCI

Figure 1-1 shows simplified description of HCI messaging modalities. This model is based on the composite software designed pattern. HCI modality can be simple or complex via the process of sending and receiving the message. A complex HCI modality integrates other modalities to create simultaneous use of them, while a simple modality represents a primitive form of interaction. We defined input and output types of simple HCI modality, using the computer as a reference point.

An input modality for message requires some user devices to transfer human output into a form suitable for computer processing. Input modalities are classified into event message-based and streaming message-based classes. Event message-based input modalities produce discrete events in reaction to user actions. For example, user input via a keyboard or mouse represent the event message-based input style. Streaming message-based modalities sample input signals with some resolution and frequency, producing the time-stamped array of sampled values. For example, a computer detects the user's voice or psychological signals such as avatar by sampling input signals with sensors such as a microphone or electrode. Sampled values can be used directly by the application. For example, speech and handwriting recognition conditions generate tokens, based on complex analysis of sampled data. Therefore, we introduced a special class of streaming modality, a recall-recognition modality, which adds additional processing over streaming data, searching for patterns. All recall-recognition based modalities introduce some recognition error. Output modality presents data to the user, and this presentation can be visual or visual-audio. Some modalities are inherently visual such as text and graph or visual-audio, such as speech or avatar represents animation of visual-audio pictures. To indicate what kind of human processing is necessary to produce aimed message presentation effect.

1.7 Contribution to Knowledge

This study produces a novel thinking in establishing relationships and communication, namely e-government and the multimodal Human-Computer Interaction. The research makes a significant contribution to the literature of e-government, specifically in detailing the method in which knowledge is connected to the user, and presents a cutting edge application field of multimodal metaphors. It is possible to summarise these contributions in the following points:

- Offering thesis a novel approach for the investigation and methodology employed in terms of combining multimodal metaphors to communicate messaging information in e-government interfaces. Three experimental studies were carried out to assess different blends of multimodal metaphors when incorporated in e-government interfaces. The achieved results appeared that the practice of these metaphors could play a pivotal role in the enhancement of the usability as well as in supporting users to attain well communication performance. It can be said, the hypothesis contributes to multimodal e-government by feeding different combinations of multimodal interaction metaphors that could be used in e-government interfaces to enhance usability and caller performance. These combinations include: a facially expressive avatar, complete with earcons and recorded speech, as well as a facially expressive avatar with auditory icons, graphics, earcons and recorded speech as well as full body gestures.

- The investigating users‘ evaluation when used by avatars of facial expressions and full body gesture in interactive e-government context, and suggests the adoption of specific expressions and gestures because of the positive effects on ease of use or on the usability of e-government interfaces particularly in terms of enhancing communication performance and users‘ satisfaction and increase users’ trust.

- Additionally, this thesis seeks to add considerably to the vast existing knowledge and practice of e-government as found in the Arab region by focussing on not only technical, but also organisational and environmental elements. It surveyed the literature in e-government experiences globally in order to grasp both the drivers as well as the specific features that may limit the acceptance of e-government in the Saudi Arabian kingdom. The study proposed to adopt a framework which is believed to aid Saudi Arabia, including its neighbouring countries within a similar context, facilitating for them the decision-making process, specifically in planning as well as implementing e-government effectively.

- To conclude, the thesis recommends a host of innovative guidelines which have been derived empirically for the sole purpose of designing more usable multimodal e-government interfaces. Interfaces those are capable of offering the most suitable communication medium for the users depending on the type of content being communicated.

Based on this idea, an organisation is developed under the name Khadeem. Khadeem is a premium quality service tailored to address the communication needs for both the public and private sector across the world. The philosophy of Khadeem is to serve as a global solution for governments and businesses, helping to improve their communication using a multimodal system. This will in turn enable a new way of interaction, and help build trust and customer satisfaction.

Figure 1-2 Khadeem logo

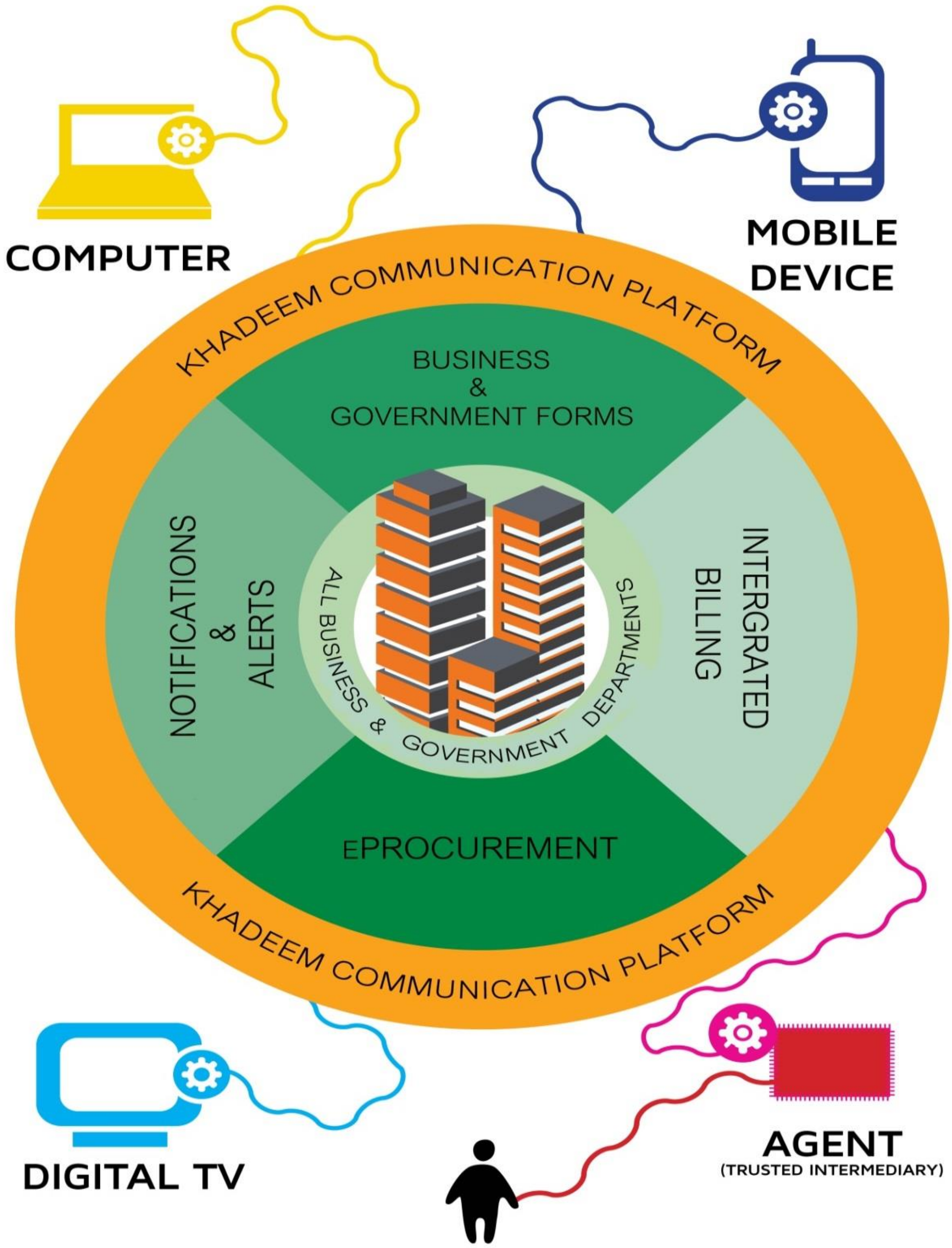


Figure 1-3 Khadeem platform

Offering next generation of customer experience strategies, this platform combines the world class communication technology. Success of an organisation is determined by its ability to capture intelligence, transform it into a deployable form and the ability to distribute it rapidly among users.

This product is used to help customers to take control of web and mobile channels, improves customer experience and transforms their organization.

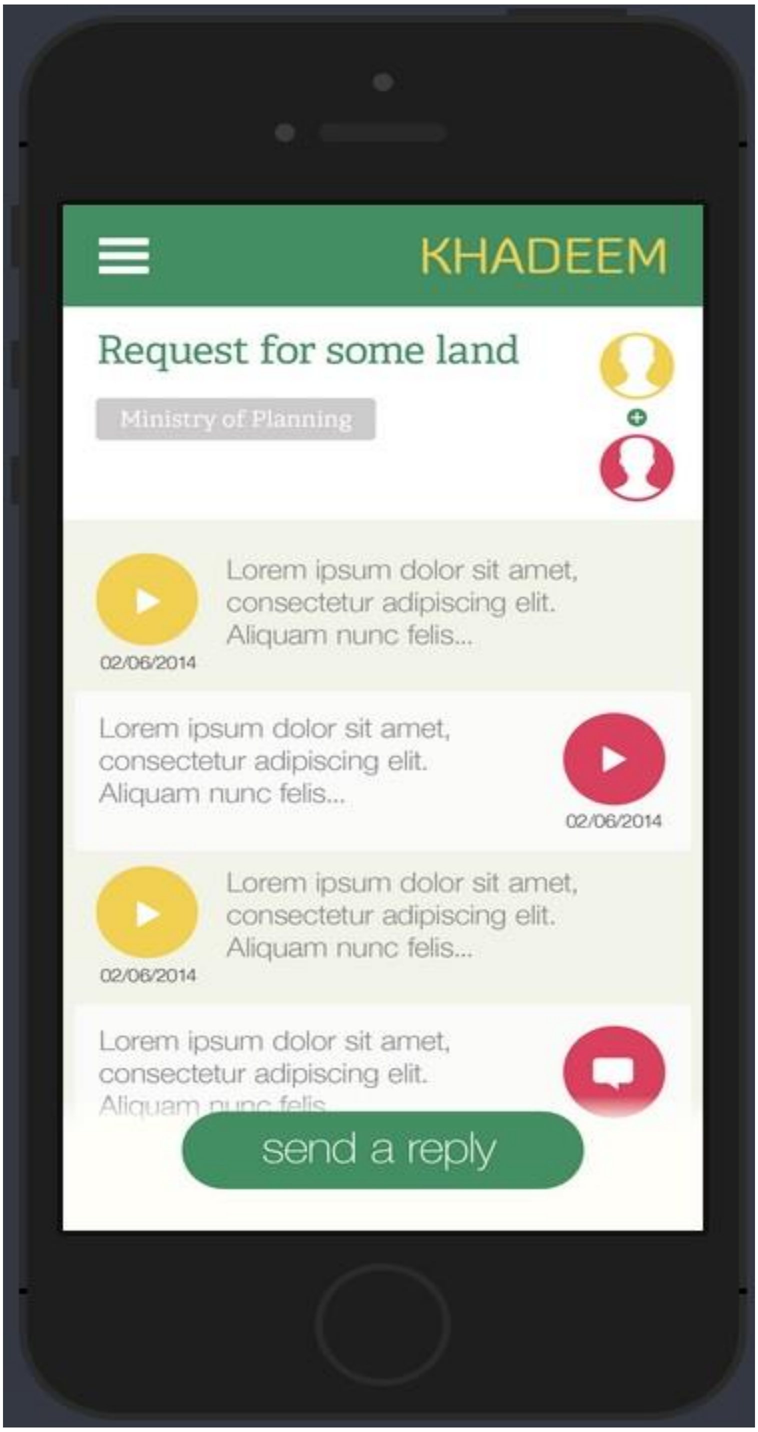


Figure 1-4 Khadeem App.

1.8 Thesis Outline

The thesis is organised into five chapters along with a series of appendices. This is inclusive of various sections describing these chapters.

Chapter 1: Introduction – Refers to the general background of the research and work undertaken in terms of the aims, objectives and the procedure surveyed in this thesis. Furthermore, it outlines the construction of the thesis, its significance and its contributing factors to the study area in multimodal e-government interfaces.

Chapter 2 **Literature Review** E-government, Trust and Communication, Multimodal Interactions
Chapter 3 Investigation into the Use of Multimodal E-government Interfaces **Experiment Phase I** A two-group study (n = 30) TOEGP vs. MMEGP **Experiment Phase II** A two group (n=30) NMEGP vs. AVEGP (Communication Performance), Efficiency, Effectiveness and User Satisfaction
Chapter 4 **Experiment Phase III** Investigating the Role of full body Avatars in Multimodal E-government Interfaces A two group study (n = 30) VMFE vs. VMBG Efficiency, Effectiveness (Communication Performance), User Satisfaction, User Trust
Chapter 5 **Conclusions and Empirical Guidelines** A summary of conclusions drawn and guidelines which have been empirically derived for the sole use of multimodal metaphors in e-government interfaces

Table 1-1: The outline of the methodology followed in this research study

Guidelines are described and summarized in all chapter Table 1-1 shows an illustrative summary of the methodology used to conduct this research study.

Chapter 2: Literature Review – This is largely a review of previous studies relative to multimodal e-government and separated into three primary parts; e-government, trust and communication, multimodal. The first part presents introductory information concerning e-government descriptions, profits, challenges and principles underlying e-government work. It also provides an insight into the main components of e-government environments and the technologies involved in the e-government process. The second part the types of communication and human trust importance in the government process. The last part provides the basic concepts of multimodal metaphors utilized in this research, namely, visual metaphors, speech and non-speech sounds in addition to avatars, covering previous research studies in order to shed light on the significance of these metaphors in enhancing the user to computer interaction in a variety of problem domains.

Chapter 3: Multimodal E-government Interfaces– This chapter consists of a report on experiments conducted to investigate the usability and communication performance of multimodal e-interfaces. It was performed empirically through the determination of two independent sets of users to prove two very different conditions of the experimental e-government condition: text with graph only TOEGP and multimodal MMEGP. The second experiment was conducted to investigate and compare the usability and communication performance of two different styles for incorporating initial avatars AVEGP whereas the NMEGP as virtual communication in e-government interfaces.

Chapter 4: Experimental Phase III: Investigating the Role of full body Avatars in Multimodal E-government Interfaces – The 5th chapter evaluates the influence of VMFE speak avatars with human-like facial expressions with three levels, whereas the VMBG interface was based on speaking avatars with human-like full body gestures when were used. Which is the better comparison among them in delivering the message? In addition to efficiency, effectiveness, communication performance and user satisfaction and user trust of the added full body gestures and messages to indicate the key features of the messaging content presented by the virtual communication with full body animation.

Chapter 5: Conclusions and Empirically Derived Guidelines – The final chapter provides a summarised account of empirical studies carried out in this research, procedures leading to conclusions and limitations that were drawn from the achieved results, and suggests a range of guidelines that might be employed in the actual design of multimodal e-government interfaces to enhance its usability and communication performance and increase trust.

Appendix: Includes the questionnaire used during the all experiments and analysis of the experimental e-government interfaces used in the three experiments conducted in this research.

CHAPTER 2 LITERATURE REVIEW: E-GOVERNMENT AND MULTIMODALITY

2.1 Introduction

This chapter shall attempt to evaluate and closely analyse not only the theoretical, but also the practical aspects of research conducted in this thesis. More particularly, these chapters' three main constituent divisions are: E-government, trust and communication and multimodality. The first section initially serves to provide introductory information about e-government definitions, benefits, challenges and the principles underlying e-government work. After which, it further goes on to deliver an insight into the main components of e-government environments and the technologies involved in the e-government process. The second part outlines the different types of communication and human trust importance in the government process. The last part provides the basic concept of multimodal metaphors utilized in this research, namely, visual metaphors, speech and non-speech sounds in addition to avatars, covering previous research studies in order to shed light on the significance of these metaphors in enhancing the user to computer interaction in a variety of problem domains. However the final section is not constrained to just the basic concept mentioned above, but moreover continues on to supplement these basic concepts with the use of multimodal interaction metaphors in e-government interfaces, and on the research studies, which highlight the usability enhancement due to the utilization of multimodality in e-government.

2.2 E-government

E-government is a combination of information communication technologies (ICT) that interact with each other to enhance the delivery of service to the user. E-government attempts to make use of the full spectrum of technologies including networks, devices and application to ultimately aid in their aim of improving the interactions between citizen and government and empowering via the enablement of efficient access to information, or more efficient government management. Benefits achieved as a result of this include business development and an industry with increased trust and transparency, less corruption, greater convenience, revenue growth, and cost reductions.

In addition thereto, the interaction between government and its citizens can be of any form, including but not exclusive to obtaining information, communicating, or making payments via the World Wide Web [10]. Before designing such system we have to consider many implication factors that are associated with implementing and designing e-government, again including but not exclusive to disintermediation of the central government and its respective citizens, impacts of factors of an economic, social, and political nature, vulnerability to cyber-attacks, and disruptions to the present circumstances in these areas [11]. An effective system can be implemented and produced entirely by understanding the function of government websites, expectations of the users' under the citizen-centric approach, and the roadblocks that might hinder these Web sites from providing the desired services through the Internet. An effective system has the potential to overcome challenges faced by the public sector [12]. Nevertheless, there are several developing countries whose e-government objectives are not fulfilled, due to the insufficient development of the e-government [13]. It is possible to make E-Government services more user-friendly through the involvement of prospective users in the requirements engineering stage. These prospective users, after trailing the e-government service, are able to act as a focus group to relay positive criticism back to the designers [14]. However, in contrast to many of the developed countries whose economy is flourishing off of the advancement in ICT, there are many other undeveloped countries where ICT still has very little or no impact on the lives of the inhabitants there. This great inequality in the impact of ICT around the world today is representative of the uneven progression of economic development. Additionally, it highlights the important role of government in the age of information [15].

In developed economies, there has been heavy pressure on the public sector to improve transparency in administrative procedures as well as decision making processes, in an attempt to ease the mind of the consumers and to bring the public in the loop regarding the way in which these systems operate. The public sector has also been under pressure to develop the efficiency of its services to both citizens and business enterprises. Given the limited capabilities and skills for the successful implementation of e-government, some economies are likely to adopt the experiences and theories of their counterparts in the developed world. However, when considering capabilities, there are substantial differences between both economies, as evident in their histories, cultures, technological infrastructures, and people including government employees, citizens and technical manpower [16].

2.2.1 E-government benefits

The user and the government are able to save both time and money, and strengthen the level of reliability of the citizen in government schemes if a government implements an e-government portal. A study of the impact that e-government has on competitiveness, growth, including jobs, has concluded that e-government provided both users as well as government agencies with at least seven tangible benefits [17].

- Improved quality of information provision
- Reduced work-process time
- Fewer administrative burdens
- Reduced operational costs
- An improved service level
- Increased work efficiencies
- Increasing loyalty and customer satisfaction

The government, gives rise to a "virtual office" available to everyone, 24 hours / 7 days a week. The interaction of this sort strengthens the public sector, creating a seamless relationship between the government and its citizens. The provision of online services greatly benefits the government as well as those who it engages in interaction with. This allows effective saving of not only operational, but also administrative costs. An e-government undoubtedly possesses the capacity for system integration to assist its citizens, as well as private and public institutions and potentially international organizations. It is possible for an interrelationship model to engage in interaction with external private or public organizations, with a view make processes automated, thereby assisting in the establishment of effective communication as well as mutual collaboration. There are various types of e-government, including:

1. Government to Citizens (G2C): This relationship provides citizens access to government services quickly and without much difficulty [18].

2. Government to Business (G2B): This allows businesses to interact with the government, thereby simplifying processes and reducing costs [19].

3. Government to Government (G2G): This caters to intra-governmental relationships – exemplified by the relationship between national, regional and local governmental organizations, or indeed with other foreign government organizations [18]. Communication via online conditions and cooperation facilitates governmental agencies and departments in sharing databases, resources, skills and capabilities, which ultimately enhances both the efficiency as well as the affectivity of processes [19].

4. Government to Employees (G2E): This refers to the interaction between a government and its employees. It is possible for employees to access specific information, explore any

training and e-learning offers available, and access other tools which may be of assistance to them in successfully conducting the responsibilities associated with their jobs [20].

2.2.2 E-government challenges

E-government systems are able to bring a multitude of different benefits to the government as governments are determined to provide e-government solutions and online products and services to all the citizens of their respective countries. What is apparent is that there has been a shift in the conventional methodology of public service delivery which will only increase with time, from a face-to-face and the telephone approach to communicating through the means of e-communication. However, it should be noted that not all the citizens are utilising these changes and therefore it is possible to suffer losses which are not only economic, but of an even greater impact [21]. Because the nature of the system in handling highly sensitive, confidential data, it is possible that national interests could be serious and adversely affected if the system happens to suffer from some illegitimate modification or from a failure of availability [22]. In addition, it was understood that concerning the quality, the local authority websites are deficient and do not contain useful and relevant information for the users. However, it is difficult to access this information, primarily due to the majority of the population lacking the skills or knowledge to effectively utilise computers or the internet [21].

A large proportion of the written literature based on human interaction tackles human interaction from an information system design angle or rather more specifically, in a way that associates it to design improvement. The factors that we shall investigate in this chapter shall be different so as to shed light on human interaction from a new angle in the present study. The lack of interaction with humans or the anxiety people may feel due to the absence of physical interaction with other people when fully moving communication and interaction with virtual world was the main factor [23]. Involvement of Technology has significantly contributed to the growth in human interaction by creating a gateway that goes beyond the physical boundaries. Nevertheless, some governments still exercise restraint and resist this kind of interaction for a number of reasons. Technology can serve either to group us together or to separate us as it can also increase citizen involvement in governmental affairs, dependent on how it is implemented [24]. E-government interaction is the type of interaction that occurs between two or more people via the channel of a computer network [24]. Chadhar and Rahmati suggest that one of the factors that influence Communication between Governments to Citizens (CG2C) is national culture. In individualist cultures, CG2C is more successful. On the other hand, technology such as CG2C is less likely to be used in collectivist cultures [25]. In face-to-face interaction, Loch et al. has investigated the role that social norms and technological enculturation on diffusing the Internet in the Arab world. The difference that differentiates their study from the previous studies is that they are studying "*face-to-face versus electronic meeting*". Their aim was narrowing down the general concept of social norms that measure culture-specific beliefs. According to their study, "*social norms are typically defined as social pressure on an individual to perform, or not to perform, some behavior. The closer the affinity of the individuals with their reference group, the more likely the individuals are to perform according to reference group expectations*" [26].

Levinson identified very little empirical information on the "*universal properties of interaction*". Levinson increases, the argument that popular means of human interaction like language and face-to-face interaction with different cultures are undertaken differently [27]. People of some cultures like to be physically in contact with each other and try to avoid any communication method that prevents them from such contact; whereas in some individualistic cultures that may not be so. In the context of this study, it has been identified that Saudi Arabia (a country with a more collectivist culture), belongs to the category where people prefer the physical interactions [23].

Decision making in government processes needs to have employees in the back-office for making decisions. These kinds of decisions that are left to people in the back office are usually systematic because they manage with what is provided in the system. Due to the fact that these employees are not directly interacting with the citizens they are unaware of any specific reasons for failing to provide the complete requirements. Even when human involvement is required in decisions, the communication nature (via e-services rather than face to face) may result in less empathic decision-making by those back-office employees responsible for making the decision. The presence of both Arabic and Islamic traditions, which form the main foundations of the culture in Saudi Arabia, underlines the importance of empathy consideration when engaging and interacting with others. Electronic service usage in general could therefore reduce or even disallow such considerations altogether [23].

Therefore, we see that these studies confirm that there are limitations or challenges not driven out so far. These limitations and challenges that could have been driven out in terms of communication or contact by e-government portals weren't because of the lack of both availability and use of tools such as emails telegram or fax. This is due to the main form of communication being through the use of text only which further augments the problem faced in the process of expression. This reinforces the need for the development of tools such as emails, telegrams and fax through the science of Human computer interaction in order for these tools to play their crucial role in the delivery of the message which in turn should successfully address the issues faced by the user under the current regulations. Understanding your users' has become a top priority for most organizations as they come to the realization that the more you know about them, the more successfully you can cater to their requirements. This study believes that technology is significantly shifting the nature of competition. Information technology has observed dramatic changes in the recent past. It is imperative for organisations possess the ability to effectively and efficiently access and use information, and this has become a fundamental source of competitive advantage. The organisation's success is determined by its ability to identify and capture intelligence, manipulating it into a deployable form as well as the ability to distribute it rapidly amongst the users.

2.2.3 The State of e-government in Saudi Arabia

To anticipate the enormous benefits of the concepts in e-government to the national economy, the KSA government places great importance on the transformation of e-Government. Realizing that it is crucial to cooperate and liaise interdepartmentally in order to develop into the information society and achieve established objectives, MCIT, in collaboration with the Ministry of Finance, Communication and Information Technology Commission, established the renown e-Government Program (YESSER) in 1426 H (2005G). One of Saudi Arabia's e-government solutions are called "YESSER". As the government of Saudi Arabia began to realise the importance of e-government; they started to learn from the experiences of other country projects [28]. To continue to be a World Trade Organization (WTO) member; it has to fulfil certain conditions. One of the conditions which the Saudi government must work on is e-government. In the "*UN E-Government Readiness Report 2005*", Saudi Arabia was ranked 80th. From that point onward, Saudi Arabia initiated the development of its services offered through alternate Saudi Ministries such as the Hajj Ministry which was responsible for facilitating the applications developed for both Hajj and Omra, while working hard to also attain the benefits available from the technological innovations of recent years. As a result, Saudi Arabia surged from 85th in the 2010 UN report to 41st in 2012 [29]. Some critics argue that the concept of e-government is not feasible. Some stress that online transaction systems are rarely used and that the advantages of e-government are limited to businesses rather than citizens. Furthermore, the extensive amount of money associated with implementation is also a criticising factor. All these factors and others negatively impact the perception of this tool. This will narrow our focus to the issues relating in particular to the kingdom of Saudi Arabia and its culture [28].

2.3 Communication

Communication is the process of conveying information through the exchange of thoughts, messages, or information, through speech, visuals, signals, writing, or behaviour [30]. It is the meaningful exchange of information between two or more people. Communication is just like any other sign-mediated interaction that follows combinatorial, context-specific and content-coherent rules. Communicative competence describes the capability to install inter subjective interactions, thereby identifying itself as an essential social interaction [31]. As illustrated in Figure 2-11the communication process requires a sender, a message, and a recipient, although there isn't a need for the receiver to be present or indeed aware of the sender's intent to communicate at the immediate time of communication. Thus it is possible for communication to take place across vast distances in time and space. It requires that the participating parties share an area of communicative commonality. The communication process is identified as complete once the receiver has fully understood the message which was sent by the sender [32].

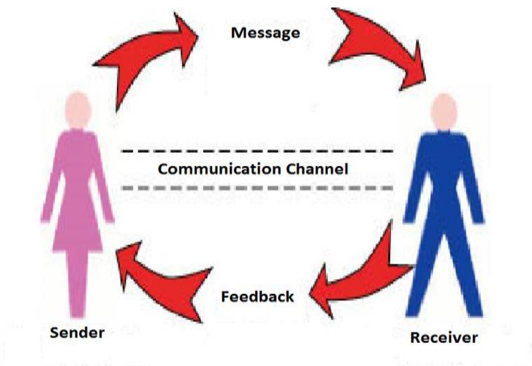


Figure 2-1: Communication process

While there are several different aspects unique to each of the different verbal communication methods, there are many general qualities of efficient presentations that are common to all. For example, good body language is an essential element necessary for clarifying and reaffirming the message that the sender/encoder is trying to get across to their audience. Eye contact, passionate gestures, smiling regularly, and nodding your head every now and then while you're engaging your audience all communicate confidence and passion and reassures the audience that the sender of the message is relatively experienced in the concept being communicated. An effective example to follow on how and where to position yourself during a presentation would be, as demonstrated in the "weather reporter" design. The weather reporter design requires ranking alongside the product of interest, bringing attention to the applicable party, and experiencing your audience while covering the specifics of your presentation [33].

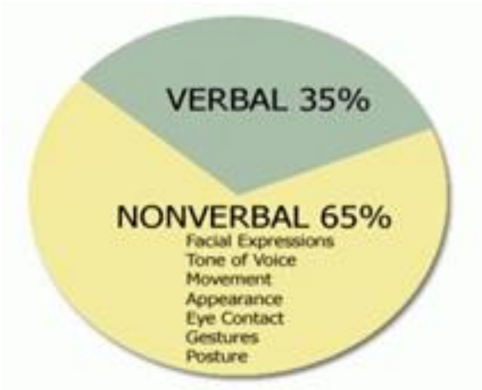


Figure 2-2: Type of communication in the life **[35]**

2.3.1 Verbal communication

Verbal communication or verbal language is one of the most natural forms of human-human interaction. And it has been used in many virtual systems [34]. Verbal behavior usually consists of speech and usually accompanied by an intricate mix of non-verbal communication such as gestures and facial expression [35]. However speech recognition accuracy is likely to be affected by background noise, human accents and the performance of the device trying to recognize speech. Learning and interpreting the subtle rules of syntax and grammar in speech is also a difficult task. These negative factors collectively limit the practical use of verbal language in e-government [34].

2.3.2 Nonverbal communication

Nonverbal communication refers to any communication which does not involve speech or words. It is a wordless message received through the medium of elements such as gestures, signs, symbols, body movements, facial expressions, colour, time, space, style of writing and choice of words. Non-verbal communication tends to accompany verbal communication [36]. In addition, non-verbal communication constitutes nearly two-thirds of all communication between people. Thus, non-verbal language must be considered as another factor of human-human communication which would enhance the effectiveness and the interactive performance of human-virtual communication if it was to be employed in an e-government system. However, to the best of our knowledge, very few works pay attention to this topic in the virtual reality community [34].

Generally, non-verbal communication accompanies verbal communication because it is a way of making communication more effective. The role of the non-verbal aspects of communication is very important as it exhibits an individual's characteristic of personality. A person who has a neat and tidy appearance, uses the tone of their voice appropriately to deliver their message while exhibiting positive body language and enthusiasm, is a lot more likely to leave a positive impression on their audience relative to their opposite counterparts. While communicating one has to keep in mind the importance of time, space, voice modulation and the objects he/she is using [36]. In addition Mehrabian suggests that whenever we communicate 7% of the message is translated through words that are spoken.

38% of the communication are in the tonality (how the words are said) and 55% of the communication are in the physiology or body language of the communicator [37].

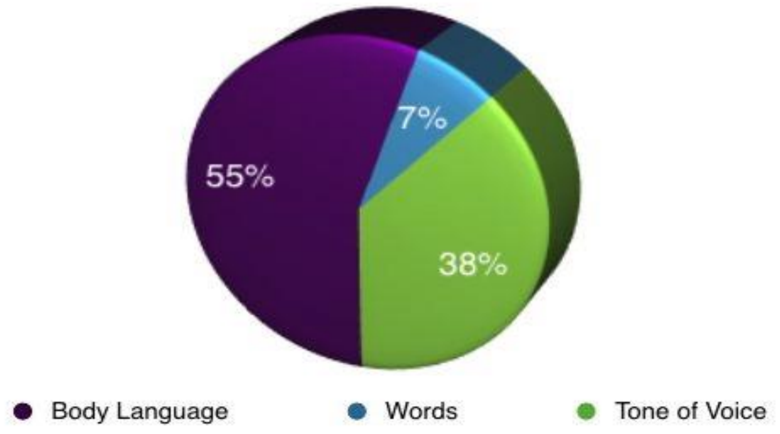


Figure 2-3: Communication theory model [37]

2.3.3 Saudi Arabia Communications

Saudi Arabia’s telecommunications market is undoubtedly expanding at a remarkable rate. Services are constantly being extended to accommodate for the growing market. The Ministry of Telecommunications and Information Technology is responsible for overseeing all modern communications technologies in the Kingdom. Lately, there has been a significant increase in the demand for broadband services, due to the society's needs, particularly after the government provided high levels of support for the high tech projects requiring digital infrastructure of a high standard. Additionally, e-government transactions now form the basis of many government services. As society’s use of the internet is widespread and ever-growing, this is a significant contributing factor to the continuous growth in demand for broadband. Due to many different factors such as the internet has become the major source of hundreds of thousands of applications including social networking, business, government applications and more. Providers are currently providing communication services through both fixed and mobile networks [38].

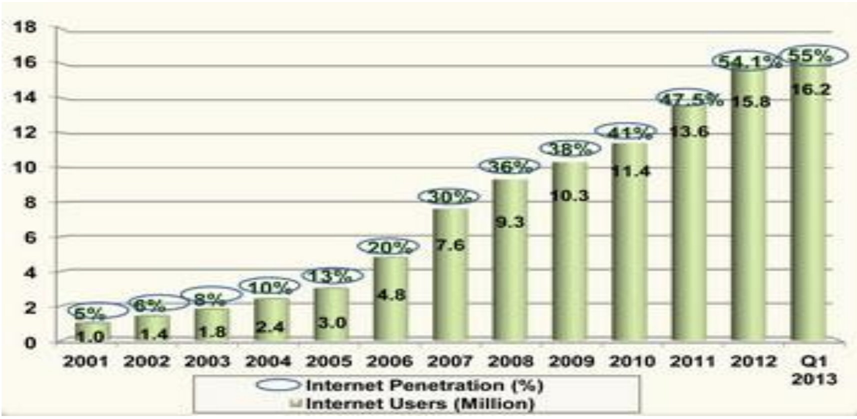


Figure 2-4: Internet Market Evolution (2001 – Q1 2013) in Saudi Arabia [38]

The estimated number of avid users of the internet in the kingdom of Saudi Arabia was 16.2 million at the end of Q1 of 2013, with a 55% population penetration. It is anticipated that the demand for Internet services will significantly increase over the next few years due to the wider availability of fibre-optic networks (FTTx) at extraordinarily high speeds, which were initially just available in the expanding large cities.

Therefore, it is imperative to adopt good communication because it can assist in understanding what another person is saying and helps the receiver of your message understand what you're saying clearly. It also allows them to express their own needs and concerns. When you are far away, it is often the case that there will be many things which require discussion. Some of these discussions, especially in Saudi Arabia, may be difficult and emotional due to the nature and cultural background of the inhabitants.

Effective communication is crucial in various circles of life. It helps to avoid any misunderstandings and it allows you to reach a more well-informed conclusion of what other people are thinking. Effective communication allows you to connect with people which in turn help to fulfil the human need for socialising. Communication ultimately helps you to get what you want through appropriate expression.

2.4 Trust

Trust played a pivotal role in social interaction. It is commonly understood that every aspect surrounding a person's life is based upon trust. Therefore; trust is undoubtedly a very rich concept, encasing a wide range of relationships; drawing together a variety of objects [39]. Trust is intimately linked to risk and expectations as it is used as a substitute for risk, but it also creates risk for the trustor [40]. As Baier states "*Trust involves the belief that others will, so far as they can look after our interests, that they will not take advantage or harm us. Therefore, trust involves personal vulnerability caused by uncertainty about the future behavior of others, we cannot be sure, but we believe that they will be benign, or at least not malignant, and act accordingly in a way which may possibly put us at risk*" [41]. Extensive studies have been carried out on the various concepts of trust in many disciplines, pre-dating the appearance of Internet or e-Government, but of course, each field has its own individual understanding. In general, researchers experience great difficulty in identifying a suitable definition of this concept. It is therefore commonly defined in a particular context [42]. Grandison and Sloman report that the reasons for the presence of a range of literature-based definitions of trust are twofold:

- Firstly, it should be identified that trust is undoubtedly an abstract concept, which is often found in place of interrelated concepts, including but not limited to, *safety, reliability and certainty*. Therefore, the ability to define the term clearly as well as identification of the distinction between the term and its related concepts have to date proved to be quite challenging for many researchers [43].
- Secondly, trust is a undoubtedly a multi-facet psychological concept, including, but not limited to, cognitive, emotional and behavioral dimensions [44].

In order to present a reference point for understanding trust, this study presents some general definitions from existing research [45].

Trusting in an event to occur, if an expectation in its occurrence is established, and it is observed to follow through to a resultant behavior which is perceived to possess superior negative motivational consequences if there is a lack of confirmation of the expectation itself, as opposed to the positive motivational consequences released upon confirmation [46]. A belief held, either by an individual or by a group that the verbal promise, words or written statement of another individual or group can be relied upon [47]. It has its place in a social system, so long as the constituents of that system are acting in accordance with it, and are confident in the anticipated futures established with each other being present or indeed their representations symbolically [48]. The willingness of parties to partake in being vulnerable to the implicit actions of a third party based on anticipating the performance of a particular action which is deemed to be important to the trustor, regardless of any need or ability to possess control over the other party [49]. Trust can be understood as an emotional state which is represented by the presence of an intention to accept being vulnerable based upon expectations of a positive nature pertaining to the behavior or intentions of another [50]. It is the well-founded belief in an entity's ability to demonstrate actions of a dependable, secure, and reliable nature within a context that has been pre-specified [43]. It is identified as an expectation of a subjective nature that an agent may hold of the future behavior pertaining to another party founded upon the past records of their previous encounters [51].

To put forth an example, if party A trusts party B for a service X, trust is the measurable belief of A in that B will behave dependably for a specified period within a specified context (with regard to service X) [52].

Due to the complexity of the concept, trust has been a source of attraction and considerable attention from a significant range of different perspectives, inclusive of:

- The economical approach; this is where the emphasis is centered on the actor's reputation as well as their transaction effects [53].

- The managerial approach whereby the focal point is on consumer persuasion strategies accompanied by building of trust [54].
- The human computer interaction approach, this is where the key focal point is directed towards the relationship between user interface engineering, as well as the usability of a system and the reactions of its users [55, 56].
- The sociological approach, this is where trust has been historically studied rigorously as both an interpersonal as well as a group phenomenon [57, 58].
- The technological approach, whereby the central focus is on adopting new technologies [59, 60].

2.4.1 E-government - Trust Perspective

Modern activities in governmental institutions could act not only as an important tool for radical institutional reform in both the private and the public sectors, but also for much greater efficiency in the provision of public sector services, if of course, it is implemented efficiently [61]. Therefore, it is apparent that around the world, governments have been working tirelessly to identify and capture the massive potential of information and communication technologies with the aim of simplifying and developing government processes. E-government, e-democracy and e-administration have undoubtedly become main subjects in developing the delivery of many public sector services [62]. The World Bank [45] defines e-Government as "*the use by government agencies of information technologies (such as Wide Area Networks, the Internet, and mobile computing) that have the ability to transform relations with citizens, businesses, and other arms of government. These technologies can serve a variety of different ends: better delivery of government services to citizens, improved interactions with business and industry, citizen empowerment through access to information, or more efficient government management. The resulting benefits can be less corruption, increased transparency, greater convenience, revenue growth, and/or* *cost reductions*”. Information and communication technology usage on a large scale has its advantages, but also causes certain challenges [63]. It is identifiable that to a great extent, efforts are dependent upon how well the citizens, i.e. the targeted users of such services, make use of them. A recognisable level of transparency is introduced through e-government, as well as a good scope to identify and develop a range of innovative ways of delivering services, despite the fact that some people still remain suspicious of government usage of IT. Wauters and Lorincz [64] expressed in a study conducted by themselves, that only a mere 124 million Europeans engage with e-Government provisions, and over 86 million of Europeans who are recorded as frequent users of the internet, do not partake in or make use of e-Government services. Ergo, these figures alone are suggestive of the fact that citizens who are not avid users of e-government are bound to have non-favourable attitudes towards using electronic services in relation with the governmental agencies. This change any statistical inferences made in relation to the use of e-government and its variability. Gatautis [65] identified that the efficient use of ICT is only realisable upon the presence of trust. Enhancement remains challenging in forming policy, especially considering that we are in a time when businesses and citizens are expectant of the higher levels of responsiveness and advanced features in government services, as well as administrative procedures which are streamlined in nature and a government that takes into account their knowledge and views when making decisions which affect the public. It is imperative to understand the characteristics of citizens before developing an effective e-Government strategy.

The trust associated with E-government trust is undoubtedly an abstract concept which forms the underlying basis of a complex assortment of relationships. Therefore; it is crucial that quantifying methods used in measuring trust in e-government should be reflective of this abstract nature.

There are two dimensions as it pertains to citizen trust associated with the usage of e-government systems; one is the trust displayed by citizens of the government itself; and the second is the trust of the Internet. Prior to trusting the e-government enterprises, it is important for citizens to have a firm belief in the competence of government and its resourcefulness in possessing not only the managerial, but also the technical resources necessary to implement and secure these systems. Citizens should intend to ‘engage in e-government’- a notion which incorporates the intentions not only to be recipient of information, but also to provide information through the use of on-line channels [66].

Confidence of citizens is defined as the ability of an agency in its capacity to provide online services and is vital for the widespread adoption of the various e-government initiatives. If citizens express a despondent trust in the ability of government to successfully implement e-government initiative, as well as deficient trust in internet usage, this will result in a condition whereby the citizens become adversaries to both government and technology [67]. The lack of trust as prevalent in both dimensions will undoubtedly lead to unfavourable outcomes in relation to the extent to which e-Government initiatives are accepted. It would therefore be disadvantageous and unfavourable for the successful implementation or, by extension, the underlying success of the various e-Government programs.

In cases where a government trust is limited, which contrasts with a high level of developed trust in the Internet, citizens may utilise technology as a tool in competing against the government [68]. E-Government implementation of services in such situations will lead to unpredictable and sporadic results. In such a scenario, the citizens will view the e-government initiatives with suspicion and cynicism.

Whereas, a high level of trust in the government, but a low level of trust on the Internet may result in a scenario where the citizens will endeavor to cooperate with the government efforts but the lack of their trust in technology will undoubtedly inhibit this cooperation.

Internet technologies are unfortunately poorly understood by large numbers of people, despite the fact that some of them utilise it as an omnipresent part of daily life. It is generally understood that the extent of the pervasiveness of new technologies is unclear. In particular, personal experiences which are negative, and failures or inadequacies in computerisation of a large nature which make headlines, may increase the level of distrust or play a paramount role in reducing the levels of trust in the Internet and by extension, the agencies that make use of them. However the citizens choose or are made to cooperate with the government, they are prevented from contributing to the e-Government initiatives (due to a lacking on their part in their trust in technology), therefore it will be difficult to realise the full potential [45]. Trusting in the ability of the government, as well as its commitment and motivation to the various e-government programs, and placing trust in the technologies which enable its success, will undoubtedly lead to a synergy of both the government and its citizens. On the upside, it is noticed that agency trust will have a significant impact technology adoption. The collaborative behavior can lead to a proactive effort by the government as well as its citizens towards the success of e-Government programs [66].

Evolution of services encompassing an electronic nature, specifically for the public sector, is more than just an organisational or technical modification. Ethical dimensions are involved, namely, the interaction between the state and its citizen interaction in a democracy, in which both trust and consent are at the very least of equal importance in comparison to legal authority. Together with face-to-face interactions amongst others amid mutually known actors, it may be possible for strangers engaging in virtual transactions and abstract systems to extend chains of interdependence into unfamiliar territory in which accustomed ways of trust establishment are absent and new mechanism reliabilities remain yet to be tested [45].

2.4.2 Factors of Trust in e-Government

As a number of features of online communication have the ability to both decrease or increase the level of citizens trust, it would be valuable to understand which factors and what levels will have desirable effect and which wouldn’t. This will then help with ensuring that these factors are executed in such a manner that ensures that citizens can place the optimal degree of trust in e-government.

Observed evidence connecting to the impact of various factors on e-government trust is both rare and sparse. The majority of existing studies has also included trust in much broader adoption models, for example the technology acceptance model and the diffusion of innovation theory [66]. In these models, it is evident that the most analyzed determinants were trusting of the Internet, trust of the government, perceived usefulness as well as perceived quality of the e-Government services.

The findings of multiple research studies [67, 69] indicate that is essential for both a system to be in place to enable online interaction with an organisation, as well as the organisation itself. Two other significant determinants of trust in e-government are therefore trusted in the technology and perceived organizational trustworthiness. In the same context, Avgerou et al, have made a noteworthy distinction between the different types of citizens’ trust in e-government [70]. The first centralises focus on the methodology in which ICT is associated with the trust of the citizens in government agencies for the period of time encompassing their service delivery; this is ultimately considered to be operated at the micro level. The second type concerns the potential contribution resulting from improved trust in government agencies and, by extension, increased trust in government in the broader, political sense, that is, which is considered to be operating at the macro level.

Trust of Citizen’s in e-government has some very unique features because of the impersonal nature of the online environments, as well as the extensive use of technology and the inherent uncertainty and risk which are hallmarks of using an open infrastructure [71]. The online environment disallows the natural benefits of face-to-face communications and the direct observation of the service provider's behavior, which undoubtedly happens to be an assurance mechanism on which humans have depended on for ages. There is potential for new service paradigms to emerge, based on trust, thereby converting passive citizen participation in public service delivery into active citizen participation [45].

2.4.3 Saudi Culture

A very important factor in information and communication technology is the Culture factor improvement. It affects all aspects "of our lives" (Hofstede, 1991; p.170). E-governments are not only a technical project, but rather it has many aspects that require time and a framework to deal with since they affect all aspects of business. It requires changes in the behavior of the individuals. All these requirements and more are challenging toward a successful development of e-service use. The major issues are often "*organizational dimensions including strategy, structure, people, technology and processes as well as the principal external forces such as citizens, suppliers, partners and regulators*" [72].

Many key issues in electronic services in developed countries are different from developing countries because of the various technological and social circumstances. Consequently, strategies and experiences from developing countries may not necessarily be appropriate for developing countries [73, 74]. Historically, developed countries were either colonizers or were colonies that obtained their independence much earlier than developing countries. They have had more time and a relatively much better chance to improve their services, follow up and uptake the latest business trends. Meanwhile, most developing countries were still in the foundational stages of basic infrastructure. In addition, bureaucracy and governance in developing countries is slow and can sometimes hinder adopting innovations. Citizen's participation in making decision enforces developed countries to adopt them [73]. There are many perspectives that form Saudi's culture, including both the dominant religion and the tribal system. Al-Shehry et al, have stated that in a country such as Saudi Arabia it is crucial to consider the cultural characteristics and the values of the environment [72]. The use of e-service is a very complex process and is often accompanied with many challenges. These can vary between technical, cultural, educational, economic, political and social factors. Additionally, Al-Shari et al, found that IT transfer is often hampered by technical, organizational and human problems in Saudi Arabia [75]. Therefore the components presented in this section as the two main drivers and influences on Saudi culture will be the Islamic and Arabic cultures.

A very strong predictor of resistance to systems is the cultural beliefs found within Arab populations. Some researchers are of the opinion that Arab societies (Egypt, Saudi Arabia, Jordan, Lebanon and the Sudan) participate in the negotiation of their technology issues within a cultural context. It is evident that the organisation and management style of Western and Arab business leaders and workers have faced cultural struggles which have, in turn, had a major influence on the process related to developing systems, which ultimately concluded in flawed approaches to the historic usage of computers use and policy [23]. There is immense stress placed upon the Arab culture in highlighting the importance of home values and its influence, traditionally, on the adoption of new technologies; culture directs the critical pathway of the community's social lives [76].

2.5 Usability Evaluation in e-Government Interfaces

One of the most important factors to evaluate Human-Computer Interaction [77] and software quality [78]. Is its usability in e-government interfaces? 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" [79]. Effectiveness is defined as the "accuracy and completeness with which users achieve specified goals" but in this case the effectiveness represents the ability of communication performance to achieve the objectives of communication, whereas efficiency is “the resources expended in relation to the accuracy and completeness with which users achieve goals” but in this case it can also be stated that the time cost to reach these objectives is the way in which efficiency can be calculated; and that satisfaction is the “freedom from discomfort, and positive attitudes towards the user of the product” it is otherwise identified as the interest towards the presented contents of message and their tendency to continue to communicate [79]. Thus, the time spent completing these tasks can be used as a measure of efficiency, and not the required tasks have been successfully completed or not can be used as an indicator of effectiveness [80]. However, a user’s response to a questionnaire comprising of statements in relation to the tested interface can be used as a measure of the user satisfaction level as well as their overall experience with interacting with the system. In addition, other usability attributes such as memorability can be considered which is measured by the users ‘ability to remember the features of the system and its functionalities’ [80].

2.5.1 Multimodal Interaction

Human senses provide different information using different channels in everyday interaction. The majority of computer systems use graphics and text to communicate with their users. This limits the sense that the user will use to just sight and can lead to an overload of the human visual channel during interaction [81] which can lead to a loss of information. Multimodal computer interfaces use multiple interaction modality to incorporate the different human senses in the interaction process [82]. These metaphors can be categorized into several categories like, visual (e.g. Text and graphics), auditory (e.g. Speech and non-speech sounds) and audio-visual such as avatars with facial expressions and body gestures. Multimodal metaphors can improve the Human-Computer Interaction by involving more than one channel to convey different information [6], thus reducing information overload [83]. By engaging the user with more than one mode of interaction they are a little more likely to remember and be interested in using the e-interface. This is because this technique makes the human computer interaction closer to natural human to human and human to environment interaction [84] and could overcome the lack of face-to-face communication in computer user interfaces [85].

The perceived absence of interaction with other humans or the unease that some people may feel at missing the physical interaction with other people by moving their business interactions completely over to the virtual world shall be another factor considered in this study. In such instances, the decision making process may be fully automated and reduce the sense of mankind that was present when the procedure of decision making was undertaken in the “real” world [23].

Contained in human interaction is not solely interactions of a physical nature, but online interaction is also included, exemplified in the case of discussion forums or email. Stromer-Galley outlines three reasons for this [24].

1. Burdensome: in practice, interaction is much harder to carry out than as desired. The time and energy expended by the candidate was found to have been better spent on a television interview.

2. Loss of control: the mutual outcome is a website of an interactive nature which contributes towards the loss of control over one’s website content. In reality, the majority of candidates does not view a chat forum or web board as being worth that risk.

3. Loss of ambiguity: the ability to remain ambiguous in positions involving policy is lost as a result of interaction.

2.5.2 Visual Metaphors

Visual metaphors are used in computer interfaces to represent information in textual and graphical format and communicated to users using their visual channel [86]. These metaphors have been practiced in the early eighties by the Xerox Star system and successfully adopted by Apple Macintosh operating system later on [87]. User interfaces with Macintosh computer systems enabled the users to use the mouse in treating iconic and pictorial representations of files and folders. For example, delete a file by dragging its icon to trash folder. The role of visual metaphors has been proven to possess a positive influence on computer system's usability in terms of offering simpler and easier user and the system interact. However, crowding the interfaces with overwhelming information (both graphical and textual) may play a part in confusing the users and scattering their concentration [88]. By including auditory metaphors, this could contribute towards reducing the visual load when receiving the communicated information [89]. With visual interaction, users need to keep directing their sight toward the output device. On the other hand, auditory information can be captured from all sides regardless of the head and body direction, allowing different information to be obtained by other channels (e.g. Visual) [6]. For example, non-speech sounds could be used to capture user attention to specific events while the user‘s visual channel is involved in performing a different task [90].

2.5.3 Speech Metaphors

The use of speech in Human-Computer Interaction began long ago and can be considered as the most suitable metaphor to communicate textual information using the human auditory channel [91]. In addition to communicating auditory feedback related to the current state of the system [92], Speech output has been shown to be useful to provide the users with the information they needed in different applications such as help disks [93], e-banking, e-news, and email [94] in addition to search engines, note-taking, and talking agents in e-commerce [95]. Furthermore, it is widely utilized as assistive technology for visually impaired users [91, 96].

Categories of speech sounds can include natural and synthesized speech [97]. Natural speech is a recorded human spoken speech using digital technology [97]. This type of speech is characterized by its naturalness and its ability to provide a human like interaction with computer systems. However, it needs to be pre-recorded, edited and stored as sound files prior to usage. With the volume of these files constantly increasing, there is a great need for storage spaces of a large nature, thus recorded speech is not at all as widely applied in those systems that involve a large vocabulary and is restricted to the communication of limited short spoken messages which cannot be generated automatically during the interaction process [98]. Conversely, synthetic speech is a simulation of human speech generated by speech synthesizers based on either of two techniques, namely concatenation or the alternative which is known as synthesis by role [92]. Under the former technique, the production of speech messages is through the concatenation of pre-recorded segments of voices from actual human beings, following its storage in a database system. Contrastingly, it is identifiable that the second technique, which can also be considered as speech of a formant nature, sees its basis upon the creation of artificial speech sounds through the avid use of rules pertaining to the generation of phonemes, thus making it possible to be utilised in the production of speech during run-time. Compared to concatenated speech, the formant speech is of poorer quality [99]. Although the speech synthesizer technology is a faster solution providing increased flexibility in order to produce speech sounds of high quality, the created speech still sounds computer generated and natural recorded speech is therefore recommended due to it increasing the probability of comprehension [100]; as well as it being received better by the user because it resembles human-human interaction more closely.

2.5.4 Non-Speech Metaphors

Another multimodal interaction metaphor that has seen heavy involvement in Human-Computer Interaction is Non-speech sound, which has been increasingly used to incorporate the auditory channel as found in the process of interaction. The use of non-speech sounds can effectively contribute towards enhancing the users' performance and improving the overall usability of the interfaces (see the following two subsections), as has been demonstrated. Compared to speech sounds, non-speech sounds give quicker communication and are able to be understood faster provided there has been sufficient training mainly because unlike speech sounds, non-speech sounds are language-independent [101]. It can be segregated into two types: earcons and auditory icons. This allows for their use globally without the need to record them again in different languages to accommodate for the difference between different speech patterns and vocabulary. Non-speech, metaphors can be segregated into two types: icons and auditory icons.

2.5.5 Earcons

Earcons are short sounds of musical nature used in Human-Computer Interaction for the communication of information about objects, operations and interaction in computer interfaces [102]. In other words, earcons are defined as abstract, synthetic tones that can be used in structured combinations to create sound messages to represent parts of the interface. These non-speech sounds are constructed from short sequences of musical notes [103] that can be combined to convey more complex information [90]. According to Blattner et al. [102], earcons can be simple (one-element) or compound (multi-elements). A single note or single pitches are examples of the one-element earcons. However, compound earcons can be different combinations of simple earcons. In order to discriminate different earcons within these combinations, sound attributes such as pitch, timbre, register, tempo, rhythm, duration and spatial location can be used [104]. The use of earcons in user interfaces is based on the linkage between the incorporated earcons and the information to be communicated meaning that the user has to rely only on his/her memory to interpret the delivered auditory message [95]. Earcons have been evaluated in different problem domains and demonstrated to be effectively utilizable to communicate information in sound [90]. It has been employed to enhance users' interaction with graphical components used in user interfaces such as scrollbars, buttons, menus, progress bars, and tool palettes. The auditory feedback provided to the users by earcons assisted in resolving usability problems associated with the use of these graphical widgets and contributed to reduce error rate, task completion time, error recovery time and without annoying or frustrating the users [2]. Interaction with mobile devices where structured musical sounds were made use of helped the users to overcome the lack of visual feedback due to the small screen size of these devices. Furthermore, the software development process has made use of earcons to communicate auditory messages related to program coding, execution and debugging [99, 101] in terms of variable values, compilation errors, their types and locations in the code. Earcons are also utilized as an assistive technology for users with visual impairments to access graphical representations, spreadsheets and numerical data tables and to enable them to draw line graphs of two dimensions as well after its data points are being communicated by musical notes. Audio Graph [79] is an experimental condition by which earcons have been successfully utilized to convey graphical information to users with visual impairments. In this system, coordinate locations and graphical shapes such as lines, squares, rectangles and circles are all communicated by musical sounds. The potential of usability enhancement due to the incorporation of earcons in multimodal user interfaces has been also demonstrated in other application domains such as stock control systems [105], knowledge management systems, email browsing [106] and search engines [94].

2.5.6 Auditory Icons

Auditory icons are non-speech sounds are likely to take out in way of life used to connect objects and activities in different computer interfaces [107] based on the mapping between these sounds and the information to be presented [108]. For example, a noise can be introduced as a glass breaking sound to represent an application error [109]. The following section highlights examples of systems where auditory icons has been evolved and use.

Auditory icons are representative of interface objects, attributes and operations along with a degree of visual feedback. Upon selecting a file, for instance, the file's icon is highlighted which is followed by the pre-recorded sound of hitting (selection) wood (file) which is played with the file size being communicated by the frequency of the sound. The ARKola, however, is a simulation system in which the auditory icons are communicated to monitor a nine-machine bottling factory. The system attaches each machine with a specific sound to indicate its status and at the same time all sounds are played together to communicate the overall ongoing processes in the factory. Auditory icons can moreover be successfully mixed along with other multimodal metaphors, including earcons or speech, to communicate information for mobile telephony users [103]. The implementation of environmental sounds in user interfaces demonstrates that it could be effectively employed to convey both simple and complex information. An important advantage of auditory icons is its ability to convey different information using single sounds [110]. For example, in a messaging system, a weighty sound can be played to indicate both the arrival and the size of the received message [107]. In addition, these sounds are well known to users and can provide natural mapping with the delivered data; therefore they can be easily learnt and remembered [110]. However, these mappings are sometimes difficult to establish. For example, copying had no equivalent environmental sound [108]. In addition, these sounds are well known to users and can provide natural mapping with the delivered data; therefore they can be easily learnt and remembered [103].

In comparison, earcons are more flexible as it can be used to represent any object, operation or interaction in computer interfaces [111] and can be designed in structured combinations to represent hierarchical information (such as menus and its components) that could be differentiated by pitch, timbre and other sound attributes [102]. On the other hand, earcons are more abstract sounds that do not have a direct, meaningful association with the data it represent [111]. Therefore, this association should be learned from scratch so that the users can easily remember its representation [82]. In summary, each of earcons and auditory icons has advantages and disadvantages. Combining both of them in a multimodal interface could be the best choice and this has been demonstrated by some experimental studies [79, 112].

2.5.7 Avatars

Another example of a multimodal interaction metaphor which could involve not only the auditory, but also the visual human senses is an avatar. It is effectively a computer-based character that has been utilized to virtually represent one party in an interactive context [113, 114] with the ability to communicate verbal and non-verbal information [115, 116]. Verbal communication refers to the use of speech and written messages, whereas a nonverbal one can be represented by facial expressions and body gestures [115]. In general, avatars can be classified as abstract, realistic and naturalistic. Abstract avatars are cartoon-like interactive characters with limited animation [117]. The help avatar embodied in Microsoft‘s office application is an apparent example of these avatars, designed to provide the users with helpful information during the preparation of their documents [116]. Realistic avatars offer a real representation of humans being generated based on captured static or video images and are used in several applications such as games, movies and teleconferences [118]. The drawback here is the cost associated with the hardware needed to implement this technology. However, the naturalistic avatars are humanoid in its appearance and widely utilized in collaborative virtual environments to represent the interacting users [119]. The use of avatars in virtual environments allows users in physically-isolated locations to interact with each other [120] in a virtual world wherein everyday human expressions can be utilised to express users‘ feelings and emotions [115] and this could also be useful in providing the users with an enhanced feeling of presence and engagement in a wide range of everyday social computer-mediated activities [119]. This could enhance the interaction between users who are communicating in these environments. A user‘s avatar can reflect his/her actions, attention and interactive behavior of the others, thus providing a high level of mutual awareness [119]. Virtual environments are implemented in web-based applications such as entertainment, edutainment, e-communication simulation and e-commerce [121]. Facial expressions with simple features can be displayed effectively and efficiently by avatars in user interfaces [122]. They found that the six universal facial expressions (as regarded by Ekman et al. [123]): happiness, surprise, anger, fear, sadness and disgust in addition to neutral, can be correctly recognised by users even when communicated with limited facial features [124]. Another study conducted by Fabri et al. [125] demonstrated that the addition of facially expressive avatars in the interface of an instant messaging tool improved users‘ involvement in the communication tasks and created a more enjoyable experience, providing them with higher senses of presence and togetherness with the other person they are communication with. Facial expressions were also explored as a therapeutic technology for autistic users. This category of users was found capable of understanding and using the facial expression shown by their avatars [125]; however, in this case, different users need different treatments, particularly those with severe autism due to significant differences in their social abilities [126].

When speech metaphor is integrated with expressive avatars, a more realistic and intelligible audio-visual interaction could be introduced by which both verbal and non- verbal information is communicated using spoken messages in company with relative facial expressions and body gestures [115]. In order to attain this integration, facial movements in terms of jaw, lips, teeth and tongue need to be synchronized in a normal manner so that the produced speech is correctly articulated. In addition to facial expressions, body gestures are used by humans to communicate non-verbally in a wordless manner where the movements of the body, head and hands can be used as an illustration tool to supplement our speech when we feel that it is unable to express what we would like to say [127]. Although different people have different cultures and traditions, most human body gestures have common interpretations across the world. For example, shaking the head from side to side denotes negation whilst nodding indicates agreement or confirmation. However, some gestures (such as the thumb-up) have different meanings in different countries. According to Pease [128], it is widely agreed that facial expressions and body gestures are mainly used to convey attitudes during interpersonal communication and in some case it could replace spoken and written messages.

Different studies were devoted to examining the effect of specific facial expressions and body gesture as well as to evaluate users‘ perception towards these modalities when used by speaking avatars in the interface. For example, Gazepidis and Rigas argued that incorporating talking virtual salesman with facial expressions and body gestures in e-commerce interfaces are more appealing to users compared to the textual presentation of products [85, 129]. Based on further empirical investigation [95, 127], it has been proposed that some facial expressions are more preferred than others and the same is true for body gestures. An evaluation was carried out concerning a selection of 13 expressions and 9 gestures with both interactive contexts absent and present; among them the expressions: happy, amazed, interested, neutral, thinking and positively surprised, and the gestures: chin stroking, hands clenching, open palms, hand steepling and head up were found to be the most positively viewed by users. Furthermore, these expressions and gestures resulted in enhancing users‘ attitude and their ability to remember the delivered information more accurately [127]. These results have been supported later by other experimental studies where the inclusion of positive (amazed, positively surprised and happy), negative (sad, disgusted and tired) and neutral (thinking and neutral) facial expressions significantly contributed to enhance the satisfaction of users as well as their understanding and remembrance of the presented knowledge achieving a higher level of usability [130]. Users' perceptions of avatars could be improved when human-like expressions and body gestures are embedded. A study performed by Cowell and Stanny [131] demonstrated that the facial expressions could promote an users' feeling of credibility and trust towards interface agents. Furthermore, animating an avatar's body in a way resembling human gestures could make it more friendly to users [132]. Additionally, even the presence of simple facial animation such as happiness and eye gaze could have a positive influence on the users. In particular, the happy expression was found to be useful in enhancing users'attitude, intentions and experience [133] as well as making them more pleasant, confident and responsive to the required tasks [134]. Garau experimentally investigated how important it is to implement a variety of eye gazes on the avatar's face to be utilized in different scenarios where the users are communicating to each other and found that it has the potential to enrich the quality of conversation as a communication process [135].

In order to maximize the benefits of multimodal interaction metaphors in Human-Computer Interaction, guidelines for the design and implementation of such metaphors were empirically derived as a result of a series of experimental studies. Part of these guidelines were dedicated to help interface designers in the creation and implementation of earcons and avatars whilst other, guidelines were concerned with the effective use of different combinations of multimodal metaphors such as speech with avatars [127], speech with earcons and auditory icons, and earcons with speech. Other guidelines however were introduced to provide general guidance for the design of multimodal user interfaces [9, 136].

2.6 Critical Summary

To summarize, the inclusion of multimodal interaction metaphors has shown to be very valuable in e-government interfaces. Although most of the current e-government interfaces provide a simple and an efficient interaction by means of text and graphics, there is a potential to cause overloading to users' visual channel [2, 81] particularly when the interface becomes crowded with more textual descriptions and graphical illustrations. In this case, this could lead to an overload of information and users 'retention of the delivered messaging information will be in question as some important information being communicated could be missed [137]. This loss of information can be prevented by overcoming the information overload caused by the continued use of the same mode of interaction to deliver the message from the system to the user in computer-human interactions. The way in which the information overload can be overcome is by using a variety of different modes of interaction through different channels such as the visual or the audio channels. This ends up incorporating the different human senses, such as sight and hearing in the Computer-Human interaction which more closely resembles Human-human interaction, making it more engaging and favourable. Also, users are not always satisfied with the computer-based communication because user satisfaction is a crucial factor for continual usage of e-government services and for the success or failure of e-Government projects. If users are not satisfied with the computer-based communication, then all the investment made in developing the computer-based communication will turn into a deadweight loss because it is no longer used by the client. The main challenge for satisfying users is determining what the key determinants of their satisfaction [138].

The reviewed literature highlighted the need to address the following issues relating to the design of multimodal e-government interfaces:

1. Information overload.
2. Missing the physical interaction with other humans to the virtual world.
3. Types of communication through e-government: by application forms or by email as a text format.
4. Convey information to users via a visual channel.
5. Lack of trust about these types of contacts with the government.
6. Can users ask for more information?
7. Feedback to government outside the boundaries of the systems.

Lack of face-to-face interaction:

Previous research demonstrated that using speech and non-speech (earcons and auditory icons) sounds could indeed contribute to reduce visual overload by conveying part of the presented information through the auditory channel and consequently allowing a large volume of information to be communicated using different channels. However, these multimodal interaction metaphors in e-government interfaces are not yet used and could not provide the social interaction for callers through government portals which would suggest that the majority of users prefer to use the traditional method of communication such as face to face instead of through an e-government interface. Most likely, the users will feel the lack of interpersonal face-to-face interaction when using the text with graphics to send messages to whoever the operator on the other side is. Moreover, the user will probably feel that this is still an inadequate mechanism to fully express what they want to due to the fact that the transfer of feelings through factors such as body gesture and tone that they need, to enhance the communication of their message is not available. The user is also unable to read the body language and tone of expression in the response of the person who they are communicating with, which over the years social interaction has been developed we have become heavily reliant upon.

Users' evaluation of facial expressions and body gestures:

The audio-visual inclusion of avatars with facial expressions and body gestures could benefit e-government interfaces when considering the enhancement of the users' motivation to increase trust, participation, engagement and satisfaction, including communicating and feeding back on their overall performance. Nevertheless, the views of users in relation to the use of the designated facial expressions as well as specific body gestures are in need of being recorded in order to render complete feedback of their perception about these metaphors obtainable when used in an e-government interface. This could contribute to identifying which facial expressions and body gestures are more pleasant to callers and consequently to generating more attractive facial expressions and body gestures to be used in e-government interfaces and within the messages or live mail which will be sent to them.

Further research on multimodal e-government:

The e-government literature also highlighted the dire need for further research to assimilate multimodal metaphors in applications used in e-government where there is a potential for usability and communication enhancements through the incorporation of these metaphors, both on their own and when combined with each other.

Therefore, the initiation of this research was fuelled by the motivation to carry out an investigation as to whether or not a combination of earcons, recorded speech and facially expressive, speaking avatars could successfully impact on system usability and communicating performance conveyed through the interface of e-government systems.

In addition to this, it is noticeable that a strong encouragement has been emphasised in evaluating three different modes for the inclusion of avatars in live mail as well as exploring users' opinions in regard to the facial expressions and body gestures demonstrated by these avatars during the presentation of the messaging content. The investigation used as part of this research could potentially prove to be useful in providing additional insight into the expediency of multimodal interaction metaphors in different computer applications including those used in e-government. Based on an extensive review of the literature, trust has been widely addressed as a reason behind the failure of e-communication use in Saudi Arab

CHAPTER 3
MULTIMODAL E-GOVERNMENT INTERFACES

3.1 Introduction

The chapter investigates the aspects of usability pertaining to an e-government interface that incorporates a mixture of model text with both metaphors and multimodal metaphors, examples of which include recorded speech sounds and avatars. E-government is a combination of information communication technologies that interact with each other to enhance the delivery of service to the user [9] . These forms of communication can be used in the delivery of e-government services to improve communication performance between users and government. In addition, governments undertake their first steps to implement e-government by investing billions to develop electronic-based transaction systems [139]. The main question asked in this study is whether or not the decision to include these metaphors can play a role in enhancing usability and communication performance with the user. A further question as it relates to the contributing role is to what extent each of these multimodal metaphors can play in the projected enhancement. An experimental condition for use by e-government with two interface conditions was created to serve as a basis for these investigations. The e-government software solution described uses an input interface to send messages and an output interface to receive messages. The studies used four groups of users, each interface condition being used by one of the groups. A comparison between the four groups was made, in which the level of usability and performance in communication emanating from these groups, in terms of effectiveness, efficiency and user satisfaction were considered.

3.2 Aims and Objectives

The main aim of these experiments in the first and second phases was to measure the impact of combining auditory such as recorded natural speech and avatar 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 improve communication performance with users. Specifically, these experiments are focused on testing the efficiency, effectiveness and communication performance and user satisfaction of a multimodal e-government interface and its impact on the user, as opposed to a typical text with the graphical based interface as visual channel. An additional aim was to explore these usability and communication performance factors with different task message complexities (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). In general, these experiments are focused on investigating the usability aspects and communication performance of e-government interfaces that combine text with graph as visual channel and graphs and recorded speech as audio channel and avatar as visual-audio channel to improve usability and communication performance between users and government applications. In other words, these studies are focused on exploring if there is a possibility for the addition of the aforementioned multimodal metaphors to provide an enhancement of a significant nature in terms of efficiency, effectiveness and also satisfaction to improve communication performance of the e-government interfaces users.

The following objectives had to be considered to fulfil the aims

1. Formulating the experimental hypotheses.

2. Creating three different experimental e-government condition conditions to be utilised in conducting this investigation of an empirical nature. Condition one, a Text Only E-Government Condition (TOEGP) was based on using text with graph metaphor as a visual channel to present general government information. The second interface was a Multimodal E-Government Condition (MMEGP) which offered multimodal delivery of the same general government information by the use of text and graphics and record speech as audio channel.

The third interface was a New Multimodal E-Government Condition (NMEGP) which offered multimodal delivery of the same general government information by the use of text, auditory channels such as icons and earcons as audio channels, as well as graphics. The fourth interface was an Avatar e-government Condition (AVEGP) as a visual-audio channel.

3. Testing all experimental e-government conditions independently, with the use of two different groups of users for each experiment.

4. Conducting a measure of the conditions' efficiency, through testing by recording the amount of time users spent in completing the required tasks.

5. Carrying out a measure of the effectiveness of the conditions tested by a calculation of the percentage of mouse clicks for communication performance of task messages and correctly completed the task by users. The MMEGP will be more effective than the TOEGP and the AVEGP will have a greater effect over the NMEGP when considering the percentage of tasks communication performance and successful completion by users.

6. Measuring user satisfaction with rating different aspects of the conditions tested.

3.3 Hypotheses

It was expected that the usability of e-government interfaces and the communication performance of users would be influenced by the addition, auditory to text in multimodal-based government interface as audio channel and avatar as a visual-audio channel to send messages. This leads to the following hypotheses:

H1: The MMEGP will be more efficient compared to the TOEGP and the AVEGP will be an increase in efficiency when compared to the NMEGP interface, considering the time spent by users in completing the required tasks.

H2: The MMEGP will have a greater efficiency over TOEGP and the AVEGP will have a greater efficiency over NMEGP, due to the increase in the complexity of the task message.

H3: The MMEGP will have a greater efficiency over TOEGP and the AVEGP will have a greater efficiency over the NMEGP message type.

H4: The MMEGP will be more efficient than the TOEGP and the AVEGP will have a greater efficiency over the NMEGP when considering the performance of both recognition and recall tasks when making use of the output interface.

H5: The MMEGP will have a greater efficiency over the TOEGP and the AVEGP will be more effective than the NMEGP, when using all interfaces, in terms of the percentage of tasks successfully completed by users to enter a message and the communication performance of users through mouse clicks.

H6: The MMEGP will be more effective than the TOEGP and the AVEGP will be more effective than the NMEGP, as the task complexity increases to enter the message.

H7: The MMEGP will be more effective than the TOEGP and the AVEGP will be more effective than the NMEGP message types.

H8: Users of the MMEGP will outperform TOEGP users and users AVEGP will outperform NMEGP, in terms of the recall and recognition of information presented in the output interface.

H9: MMEGP users will have greater levels of satisfaction over the users of TOEGP and AVEGP users will have greater levels of satisfaction over the users of NMEGP.

3.4 Experimental e-government Condition

An e-government condition was specially developed for these empirical investigations. The condition aimed to provide a selection of three different interface conditions; a multimodal condition, a text with the graphical interface condition and an avatar condition. All interface conditions of the experimental condition were engineered to provide the exact same information pertaining to software representation of a pre-determined message statement and each interface dived two interfaces Input and Output. The software, in the form of three message types common (Suggestion, Complaint and Comment), included explanations about Specific requests. There are three examples of common message types with different complexities (easy, moderate, complex). The complexity of these examples was gradually increased. In addition to question type, these studies also investigated the effect of two types of evaluation questions; recall and recognition for the usability of the e-government interfaces tested, as well as on users' performance of the output interface property. Therefore, a graphical metaphor was commonly used in both interface conditions to show software representations.

It can be noticed that the TOEGP use text only in communicating all types of information. On the other hand, the presentation of the communicating information in the MMEGP, NMEGP and AVEGP was based on a multimodal approaches, in which different interaction metaphors were used to support the delivery of different types of communication enhancement.

In summary, the TOEGP involved visual only metaphors (text with graph) as visual channel, whereas the MMEGP made use of visual (graphics), auditory (recorded) interaction metaphors as audio channel. In addition the NMEGP auditory recorded, icons and icons, audio interaction metaphors as audio channel, whereas the AVEGP as a visual-audio channel by avatar.

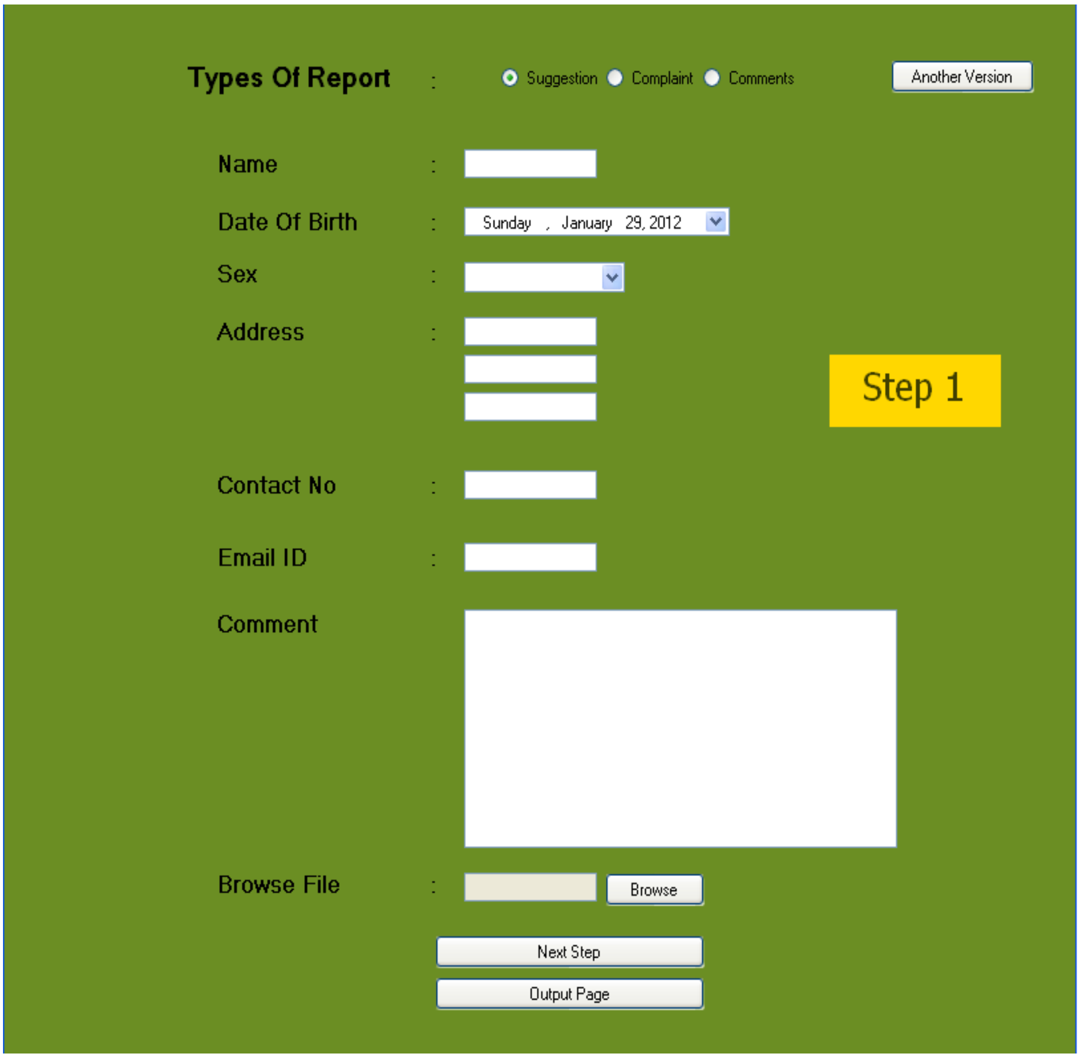


Figure 3-1: Text only e-government Condition (TOEGP) input interface

3.4.1 Text only e-government Condition (TOEGP)

Figure 3-1 and Figure 3-2 are examples screenshot depicting the visual channel e-government interface, in which the information required was provided to the user through a textual approach, communicated exclusively through the visual channel, bearing no reference to any use of the various human senses throughout the entire process of interaction. This interface is divided into two parts. The first part (Input Interface) and second part (Output Interface) were designed to include the following components: a text box to present the user information, a statement of the message related which kind of statement is choosing (suggestion, comment, and complaint).

Figure 3-2: Text only e-government Condition (TOEGP) output interface

3.4.2 Multimodal e-government Condition (MMEGP)

Figure 3-3 demonstrates an example screenshot depicting the multimodal e-government interface. The multimodal metaphors were created 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. Possibilities existed for the communication of information through the visual channel and by making use of the other human senses throughout the entire process of interaction, for example, recorded speech and images as audio channel. The interface is divided into two parts, the first part of (Input Interface) and the second part (Output Interface). These were designed to include the following components: a text box to present the user with information and a recorded speech box and images. There is a statement of the problem which is related to the kind of statement is choosing (suggestion, comment and complaint).

Figure 3-3: Multimodal e-government Condition (MMEGP) input interface.

Figure 3-4: Multimodal e-government Condition (MMEGP) output interface.

Guidelines for multimodal information presentation [5] and user interface design were followed. For example, the multimodal input and output was used to widen the bandwidth of information transfer [6]. Also, graphical displays, speech sound were combined to obtain an effective presentation [140] where speech can be used to transmit short messages interaction modalities [141].

Apart from the notes textbox, the same components used in the text and recorded speech box within the e-government interface, were replicated in the multimodal one. The notes in the text box were a combination of recorded speech. When placing the mouse cursor on a specific box in the condition, the user can enter information used. Attention was communicated by graphs whereas other information was explained by the recorded speech sounds. This way represents a different approach for previous condition implementations, as the user can keep looking at the displayed information, whilst listening to the delivered auditory message.

3.4.2.1 Implementation of recorded speech

Audio editor software can be used to allow users to speak about something through audio message formats which can be used to give complaints, suggestions or comments. Recorded speech sounds can be compared with text messages or a recorded message during the study. The efficiency and effectiveness of the messages can be recorded by the time factor and by the number of mouse clicks and miss as well as user satisfaction.

3.4.3 Avatar e-government Condition (AVEGP)

Figure 3-5, Figure 3-6 are examples screenshot illustrating the avatar e-government interface. In Figure 3-5, Figure 3-6, this condition uses an expressive avatar with facial expressions to provide virtual messages.

Figure 3-5: Avatar e-government Condition (AVEGP) input interface.

The interface provides command buttons to enable the message to be presented. It also provides two separate components for the message process. When the user clicks the button of a given message, this button starts the speaking expressive avatar. The interface is divided into two parts, the first part the Input Interface and second part the Output Interface. These were designed to include the following components: a text box to present the user with information and a speaking expressive avatar box. There is also a statement of the problem which is related to the kind of statement chosen (suggestion, comment, complaint).

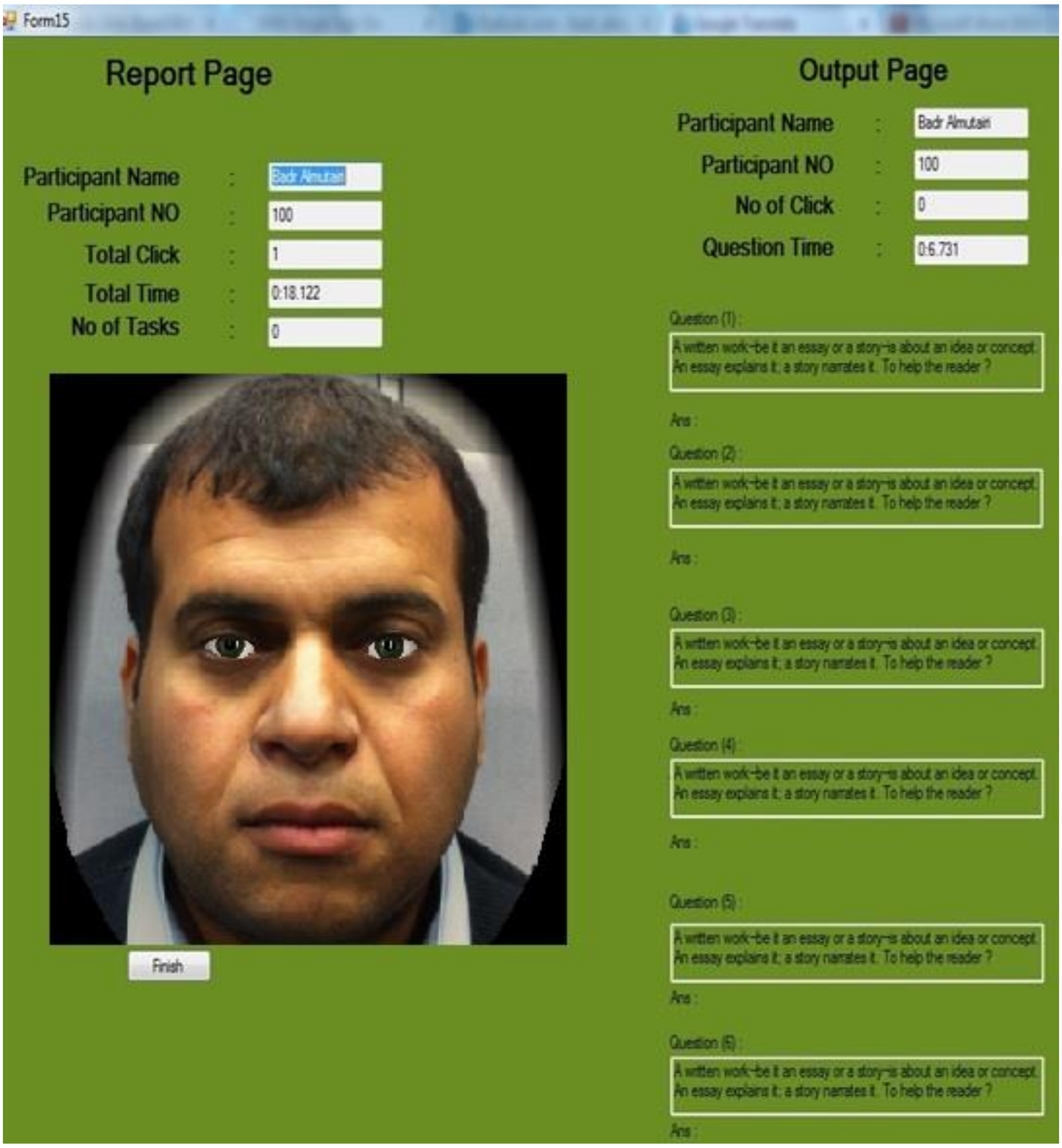


Figure 3-6: Avatar e-government Condition (AVEGP) output interface.

3.4.3.1 Implementation of Avatars

An avatar is a software or tool which can be used to allow users to speak about something through live message formats which can be used to give complaints, suggestions or comments. Use of the avatar is compared with visual-audio message or recorded message during this study. The efficiency and effectiveness of the messages can be determined by the time factor and by the number of mouse clicks as well as user satisfaction.

3.4.4 New Multimodal E-government Condition (NMEGP)

A Figure 3-7, Figure 3-8 are illustrative of an example screenshot concerning the new multimodal e-government interface. This way represents a different approach for previous condition implementations, as the user can keep looking at the displayed information, whilst listening to the delivered auditory message.

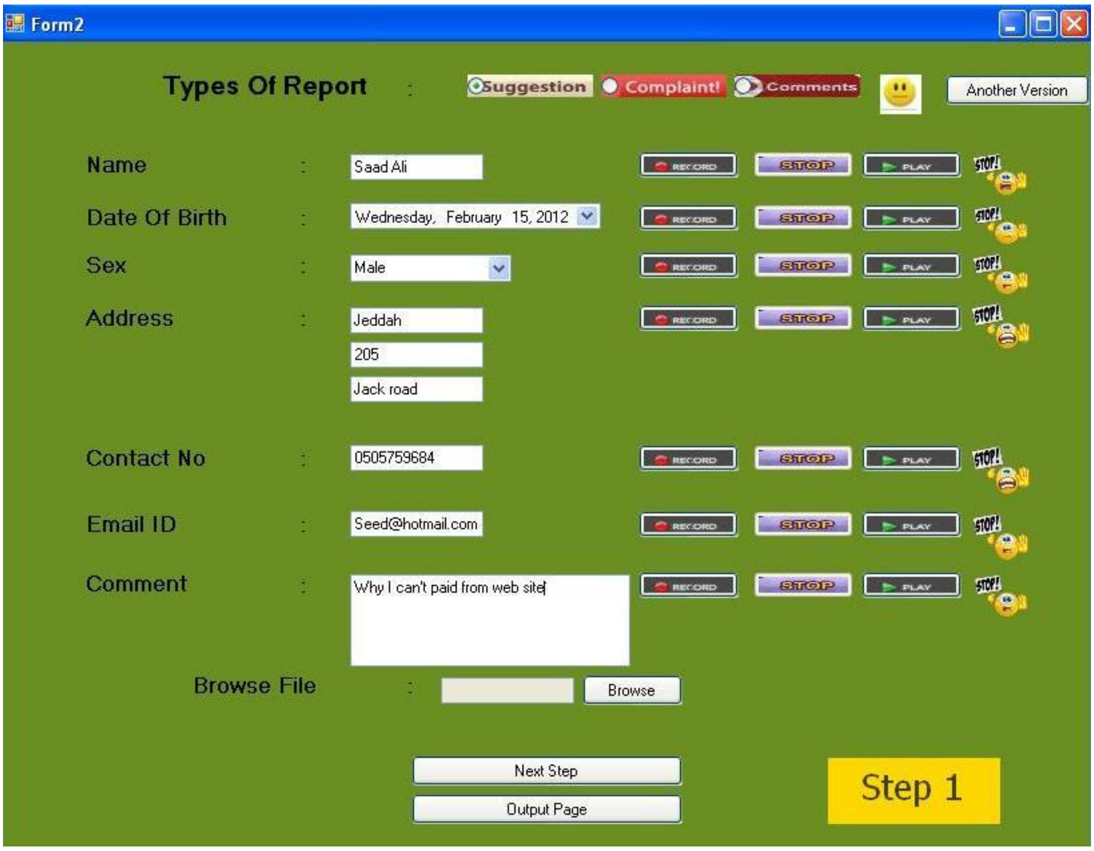


Figure 3-7: New Multimodal e-government Condition (NMEGP) input interface

Possibilities exist in the communication of information via the visual channel and through effective utilisation of the other human senses in the process of interaction, for example, recorded speech, earcons, icons and images as audio channel. The interface is divided into two parts, the first part of (Input Interface) and the second part (Output Interface) same approach for previous condition implementations just add another multimodal interaction metaphor such as earcons and icons.

Figure 3-8: New Multimodal e-government Condition (NMEGP) output interface.

3.4.4.1 Implementation of Earcons

Earcons were employed in the multimodal interface (NMEGP) to help convey multiplicity. Though, the use of auditory icons requires the existence attention between these sounds and the communicated information and this was available in the communicated message.

3.4.4.2 Auditory Icons

Auditory icons were employed in the multimodal interface (NMEGP) to help convey multiplicity. The following section highlights examples of systems in which the development and utilization of auditory icons have occurred.

3.5 Experimental Design

It was crucial, for the exploration of multimodal metaphors' effects and determining which interface would provide an enhancement to effectiveness, efficiency, and user satisfaction in the e-government process, that all interface conditions of the experimental conditions were evaluated empirically by four independent groups of users. A control was established by one group testing the text interface whilst others tested the text and multimodal interface, thereby establishing themselves as an experimental group. In the second phase; the multimodal interface play as (control) group verses an experimental condition with avatar interface. This design methodology, between the subjects tested, involves assigning dissimilar users to test varying experimental conditions and therefore it finds and utilise effect on interface e-government. N = 60 individual users participated in the experiment in total. They were equally allocated to all four groups.

3.5.1 Procedure

All groups of users followed the same procedure to keep consistency throughout the experiment. The experiment was started with an introduction to the questionnaire and allowed the users to answer the pre-experimental questions relating to user profiling, inclusive of personal information examples of which include gender, age and level of education. It was also a requirement that users should issue declarations of their previous experience in the usage of computers, internet and the use of e-government applications and to state their prior knowledge in the object orientation condition. Users use the input condition which was shown to all users in both groups, then move to the output condition which has two conditions, one for each group, in order to effectively introduce the e-government interface. Thereafter, users were instructed to start performing nine common tasks. After completing all input tasks, users were instructed to start performing three common output tasks. Users were then asked to answer the post-experimental part of the questionnaire. This highlighted their ratings assigned to satisfaction levels in consideration of the various aspects of the interface condition tested.

3.5.2 Tasks

All groups performed nine common in input condition tasks and three common in output condition tasks. These tasks were evenly associated with the condition examples and encompassed various types of information examples of which included complaint, suggestions and comments. Previous experimental studies demonstrated that the use of multimodal metaphors could be affected by tasks type [130] and task complexity [79, 142]. Therefore, it was intended for the tasks in this experiment to increase in difficulty in line with the design, which was realised through the equal division of the tasks into easy, moderate and difficult. The delivered information was communicated, either visually (in TOEGP) or in a multimodal approach (in MMEGP, NMEGP & AVEGP). The complexity of the task depended on two main factors; the number of requirements and the nature of the information delivered due to the implementation of each requirement. The more complex the task, the more requirements is postulated and thus more information is presented. As a result, difficult tasks involved communicating larger volumes of information, as opposed to moderate and easy tasks.

Upon completion of all tasks for an input interface, a request was made for each user to participate in answering a memory recall and recognition questions for the output interface. The aim of these questions was undoubtedly to carry out an evaluation of the information obtained from the message from users, due to the information supplied to the interface. In order to answer recall questions correctly, the user was requested to recall a portion of the information presented to them using just their memory as a reference. Four options were offered by the recognition questions, with the intent that the user should recognise the correct answer from amongst these. Each user entered nine task messages in total in the input interface and answered a total of six questions consisting of easy, moderate and difficult questions. Based on question type, these questions were divided into three recognition and three recall questions in the output interface. The questionnaire in Appendix gives more details about the requirements of the tasks and its relevant evaluation questions. Figure 3-5, Figure 3-6, Figure 3-7, Figure 3-8 are illustrates the multimodal metaphors used in the communication of important information required by the users of the NMEGP and AVEGP in order to answer the questions successfully.

3.5.3 Variables

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

Variable Code	Variable	Levels	State 1	State 2	State 3	State 4
IV 1	Communication method	4	TOEGP	MMEGP	NMEGP	AVEGP
IV 2	Message complexity	3	Easy	Moderate	Difficult	
IV 3	Message type	3	Suggest	Complain	Comment	

Table 3-1: Independent variables considered in the two experiments (Input interface)

Variable Code	Variable	Levels	State 1	State 2	State 3	State 4
IV 4	Communication method	4	TOEGP	MMEGP	NMEGP	AVEGP
IV 5	Message complexity	3	Easy	Moderate	Difficult	
IV 6	Message type	3	Suggest	Complain	Comment	
IV 7	Question type	2	Recognition	Recall		

Table 3-2: Independent variables considered in the two experiments (Output interface)

Variable Code	Variable	Measure
DV 1	Tasks messaging and question answering time	Efficiency
DV 2	Correctness of enter tasks and answers	Effectiveness and user‘s performance
DV 3	User satisfaction	Satisfaction

Table 3-3: Dependent variables considered in the two experiments

3.5.3.1 Independent Variables

Independent variables represent the factors manipulated in the experiment and assumed to be the cause of the results. These variables include:

IV 1: Communication method: the experimental e-government condition offered three different methods for the communication of the e-government input interface; text with graph in TOEGP and text with multimodal in MMEGP, NMEGP and AVEGP.

IV 2: Message complexity: this study investigated the usability and user communication performance related to three levels of complexity; easy, moderate and difficult presented in the input interface.

IV 3: Message type: this study investigated the usability and user communication performance related to three types of message; Suggestions, Complaints and Comments presented in the input interface.

IV 4: Communication method: the experimental e-government condition offered three different methods for the communication of the utilize e-government output interface; text in TOEGP and text with multimodal in MMEGP, NMEGP and AVEGP.

IV 5: Message complexity: this study explored not only the usability, but also the user performance in relation to three varying levels of complexity; easy, moderate and difficult, as given by the output interface.

IV 6: Message type: this study explored both the usability and the user performance in relation to three types of message; Suggestions, Complains and Comments, as given by the output interface.

IV 7: Question type: this study also investigated the effect of two types of evaluation questions; recall and recognition on the usability of the tested e-government interfaces as well as on users' performance from output interface. These variables are summarized in Table 3-2.

3.5.3.2 Dependent Variables

These are the variables being measured as a result of manipulating the independent variables. The dependent variables regarded in this study are shown in Table 5 and include the following:

DV 1: Enter tasks, messaging and question answering them: this variable was measured by the time taken by users to enter message tasks and to answer the questions, as required.

DV 2: Correctness of completed tasks and answered questions: collected by measuring and calculating the number of correctly answered message tasks and answered questions through mouse click as a percentage. In recall questions, partial or total correct answers were considered whilst in the recognition questions, the answer had to be totally correct.

DV 3: User satisfaction: collected through the measurement involving the observation of users' responses to the issued questionnaire on user satisfaction, developed at a 4-point like scale. A SUS scoring method [143] was used to measure and determine the satisfaction of each user in regard to overall attitude as well as user e-government experience with the e-government interface tested.

3.5.3.3 Controlled variables

These represent the external variables associated with the procedure of the experiment and could affect the results obtained. The controlled variables (known also as confounding variables) should be kept consistent throughout the experiment to avoid the dependent variables being influenced by them, and so ascertain that the only cause of the experimental results is the independent variables [144].

In this experiment, the controlled variables were:

CV 1: Required tasks: all users were required to carry out the same tasks

CV 2: Content message: the information presented about condition examples was similar in both interface conditions.

CV 3: Awareness of message: none of the users were aware of the required message.

CV 4: Procedure consistency: the experiment was carried out by the same experimenter on an individual basis with each user. Also, during the execution of the experiment, the same procedure was followed inclusive of the equipment and measurement tools.

CV 5: Familiarity with the interface: all the users experienced the exact same level of training and were using the tested interface for the first-time.

3.5.3.4 Usability and communication performance definition

The usability one of the most important factors to evaluate Human-Computer Interaction [77] and software quality [78]. 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" [79]. Effectiveness is defined as the "accuracy and completeness with which users achieve specified goals" but in this case the effectiveness represents the ability of communication performance to achieve the objectives of communication, whereas efficiency is "the resources expended in relation to the accuracy and completeness with which users achieve goals" but in this case it can also be stated that the time cost to reach these objectives is the way in which efficiency can be calculated; and that satisfaction is the "freedom from discomfort, and positive attitudes towards the user of the product" it is otherwise identified as the interest towards the presented contents of message and their tendency to continue to communicate [79].

3.6 Empirical Data and Analysis

This section discusses the results and analysis of Text Vs Audio and Audio Vs Audio-visual conditions comparisons. Two experiments were derived from these results: Phase I and Phase II. This part describes the results of the four groups which are TOEGP Vs MMEGP and NMEGP Vs AVEGP who's efficiencies were analysed (time required by users to enter message tasks and answer the required questions), effectiveness (percentage of mouse clicks to enter messages and correctly entered tasks and answered questions in terms tasks completed successfully), and user satisfaction (based on a rating scale). For the statistical analysis, the nonparametric Kolmogorov-Smirnov test [145] has been used to test the normal distribution of the results obtained in terms of the tasks attempted and answering time, mouse click, correctly entered task and the satisfaction. If normal distribution was found to be the scope of the data, then the evaluation of the significance of the difference between the two groups in regard to each of these parameters would be underpinned through the use of an independent t-test. The pertinence of this statistical test is apparent when two varying experimental conditions are tested by two independent groups of users. In addition use the Mean Difference that it is a measure of statistical dispersion equal to the average absolute difference of two independent values drawn from a probability distribution [146]. Otherwise, as a non-parametric equivalent of the independent t-test, a Mann-Whitney test was used [144]. Also, a Chi-square test was used for analysis statistically the categorical data [147]. These statistical analyses were carried out at $\alpha = 0.05$ and if p-value was found to be less than 0.05, a significant difference was detected.

The first phase is descriptive of an exploration of an empirical nature that was conducted in order to sufficiently investigate the aspects of usability inherent in an e-government interface that incorporates a combination of typical text with graph by TOEGP group and multimodal metaphors such as speech sounds (recorded) by MMEGP group. The second phase that has been conducted to explore and compare the role of avatars with AVEGP group when incorporated into the delivery of messages in e-government interfaces, to provide a new kind of communication and multimodal metaphors such as speech sounds recorded, earcons and icons by NMEGP group [148]. In addition to texts and recorded speech communication metaphors, animated, speaking avatars were employed in two different modes of presentation which are: facial expressions and naturally recorded speech. A detailed description of the research aims and objectives, hypotheses, experimental conditions, the design of the experiment, results and discussion is provided in the following sections.

3.6.1 Users Sampling

The studies involved 60 volunteer users, all of whom were using the experimental condition for the first time. They were equally and randomly assigned (N = 15) to each of the experimental conditions. The e-government interface, 'text with graph' was used for the control group by TOEGP and the text with multimodal interface for the experimental group by MMEGP. On the other hand the text with graph and other multimodal interface was used for the control group by NMEGP and the text to graph and multimodal with an avatar interface for the experimental group by AVEGP. The participation of this number of users in all groups is sufficient to provide a usability evaluation [80]. A large number of users have not been involved in the studies because of the need to investigate and carry out an initial experiment to obtain an overall impression and understanding about the procedure and the test criteria feasibility. The participants were selected based on their existing knowledge of government services and e-government interfaces. It was therefore the case that a large proportion of the users contained in both groups had significant experience, indicating a perceived level of competence in their ability to communicate any information required in the successful completion of tasks.

3.6.2 Data Collection

The process of collecting data utilised experimental observations and questionnaires. For each task, each user was required to complete nine message tasks and to answer six questions. The time spent to complete the message tasks and to answer each of the six questions was observed to help in measuring the efficiency. However, to collect the data related to effectiveness, the correctness of user‘s answers were checked and the total number of successful users, who completed the message tasks and answer questions was counted for each user. The questionnaire section pertaining to the pre-experimental aspect revolved around gathering data of a personal nature concerning the gender, age and level of education of users. Additionally, it assisted in obtaining significant user data pertaining to previous experience in computers, internet and e-government. The post-experimental section of the questionnaire was largely focused on assessing user satisfaction and the perception of trust within the e-government condition subjected to testing. Responses arising from this questionnaire were fundamentally used in the calculation of the satisfaction score for all users, not only in the experimental, but also in the control groups.

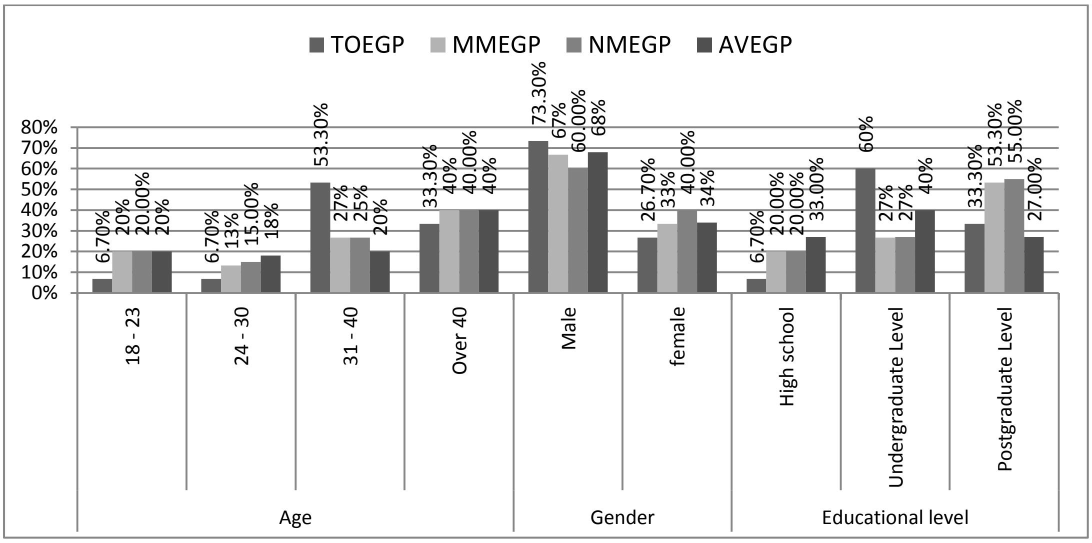


Figure 3-9: Users' profile in terms of age, gender, education level in all control and experimental groups

3.6.3 User Profiling

Information on a users' personal and educational information as well, as their previous knowledge and experience was collected and analysed on the basis of their responses to the pre-experimental questions (see Appendix). Figure 3-9 shows the age ranges in the control group by TOEGP contained 53.3% within 31 – 40, 33.3% over 40, 6.7% 24 – 30 and 6.7% 18 – 23 years old. On the other hand, in the control group in NMEGP was 26.7% within 31 – 40, 40% over 40, 15% 24 – 30 and 20% 18 – 23 years old. In the experimental group via MMEGP, 40% were over 40, 27% 31 – 40 and 13% 24 – 30 and 20% 18 – 23 years old. On the opposite side, in the experimental group by AVEGP; 40% were over 40, 20% 31 – 40 and 18% 24 – 30 and 20% 18 – 23 years old. Most participants were male (73.3% in the control group by TOEGP and through NMEGP was 60% and 67% in the experimental group in MMEGP and 68% via AVEGP). Predominantly, the education level was found to be postgraduates, with 33.3% in the control group by TOEGP also through NMEGP 55%, in contrast, 53.3% in the experimental by MMEGP and 27% via AVEGP. However, undergraduates represented 60% in the control group and 26.7% in the experimental between TOEGP and MMEGP groups. In addition, 20% were from high school in the control group and 33% in the experimental among NMEGP and AVEGP groups. Also, as can be noted from Figure 3-10, most participants are expert users of computers in the control group, 80% very frequently in group TOEGP and 86.7% frequently in the experimental group MMEGP. Fifth per cent of the control group NMEGP use computers from home and 40% in the experimental group AVEGP. 33.3% of the control group use computers for work and 46.7% in the experimental. On the other hand for more than fifteen hours a week compared to 60% in both the experimental group MMEGP and control group TOEGP, with respect to the weekly use of Internet.

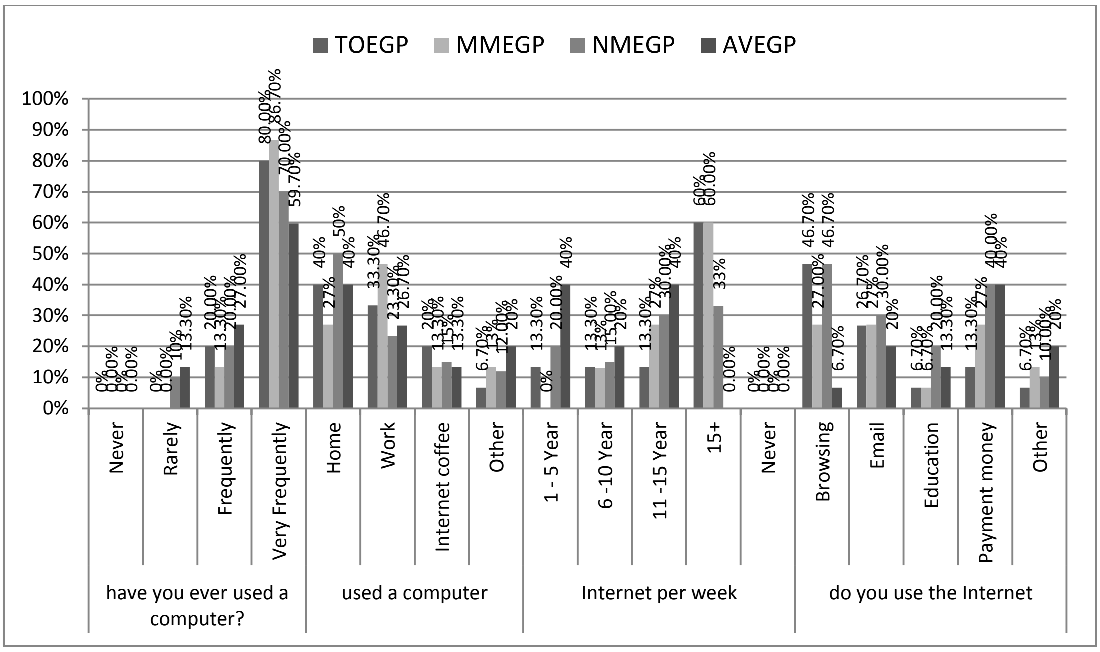


Figure 3-10: Prior experience for users in all control and experimental groups

Over 46% use the Internet for browsing in the control group and 26.7% in the experimental. In addition, less than 13.3% of the sample users were using the Internet for education. 20% in both the experimental group among AVEGP and control group in NMEGP were using it for email. Finally, Figure 3-11 demonstrates that all groups, to a large extent, were equivalent in terms of users‘ individual characteristics and prior experience.

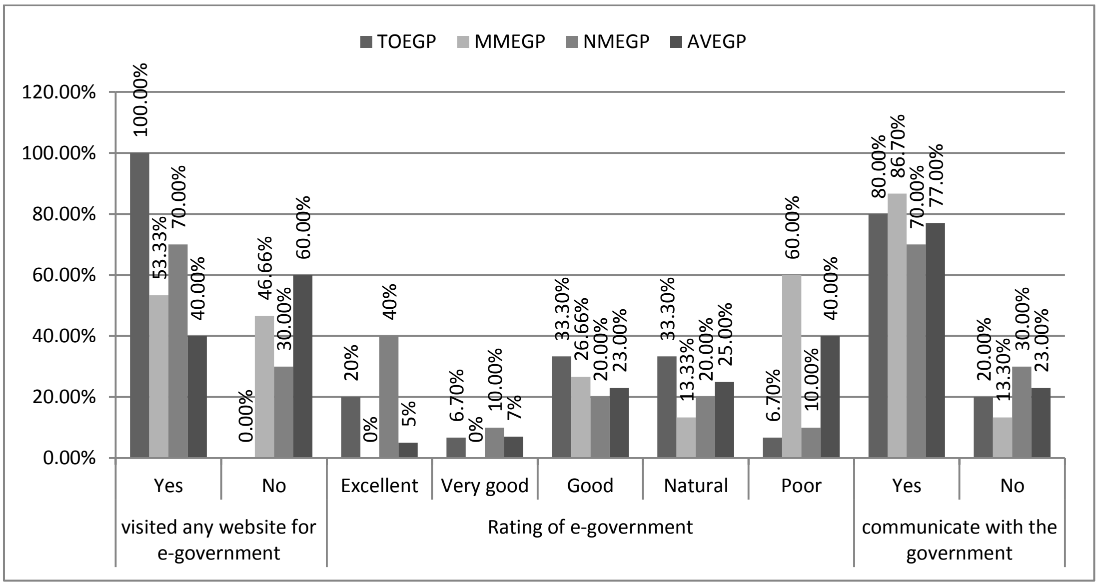


Figure 3-11: Learn how to use e-government for users in all control and experimental groups

Figure 3-11 shows that the experimental group was slightly less experienced in e-government applications than the control group in TOEGP. Therefore, any differences between the two experimentally obtained results could be attributed to the trials carried out by the participants.

3.6.4 Efficiency

The time spent to enter message tasks and answer the required questions was used as to evaluate efficiency. This 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.

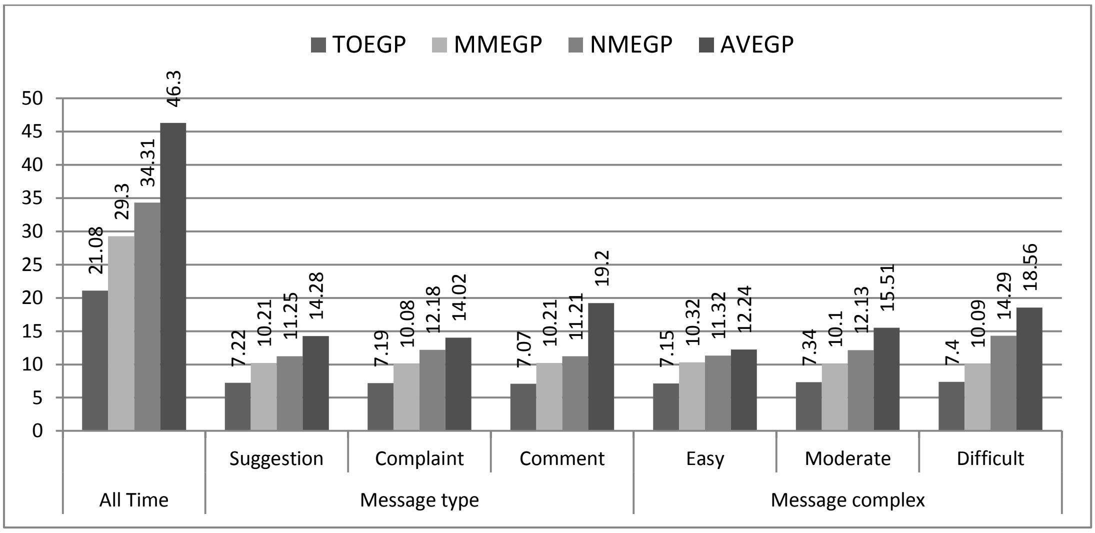


Figure 3-12: Mean values of time taken by users in all groups to enter all tasks, grouped by message complexity and message type for the Input interface.

The control group in TOEGP spent a total of 21.08 minutes, but note that the experimental group by MMEGP spend more time, 29.3 minutes, because they must enter both text and record speech for each task, so tasks take more time. Figure 3-12shows the mean values of the time taken by all users. On the opposite side the control group via NMEGP spent an overall of 34.3 minutes, but note that the experimental group through AVEGP spends more time, 46.3 minutes, because they must enter both text and avatar visual-audio for each task.

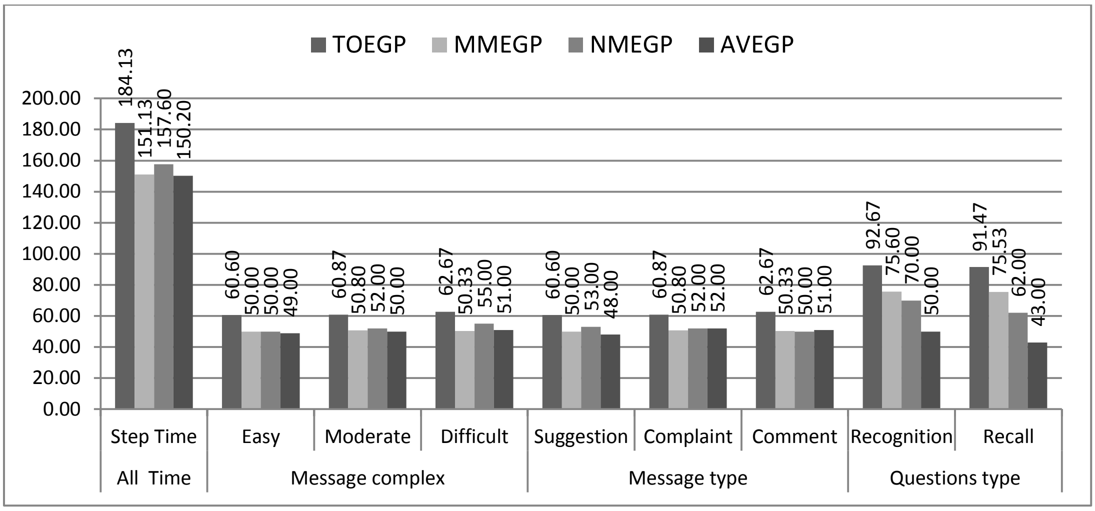


Figure 3-13: Mean values of time taken by users in all groups to enter all tasks, grouped by message complexity and message type for the (output interface).

What for the note in the experimental groups Figure 3-13 was the faster time taken to complete the tasks. It can be said the use of recorded speech was more efficient, as tasks took less time - unlike other groups which took more time to read the tasks.

3.6.4.1 All Tasks

Figure 3-12 and Figure 3-13 shows the mean values of the time taken by users in all groups to enter message tasks using the input interface and answer questions using the output interface. The results are grouped by the message complexity for the input and output interfaces, message types in both interfaces, input and output and question type for the output interface. In Figure 3-12 the message tasks time was lower in the control group for all tasks messages, as well as for each message complexity and message type for the input interface. The raw data for the task time can be found in the Appendix. Each user had to enter nine message tasks using the input interface. The mean time taken to, enter all message tasks in the input interface using MMEGP was more than that for the TOEGP. The total time taken by users of the TOEGP in the control group for the input interface was on average 21.08 minutes per user.

In comparison, users of the MMEGP in the experimental group of the input interface spent a total of 29.30 minutes per user on average. Tasks in which both text and record speech must be entered took more time. Figure 3-12 shows the mean values for the time taken by all users. The t-test calculations showed a significant difference in answering time between both groups ($t(-23)$, $p = 0 < 0.05$). Experimental observations revealed that users in the control group took less time because only a text input was required - unlike the other experimental group which required record speech, as well as text. When answering six questions for the output interface, as shown in Figure 3-13, users of the MMEGP were 151.13 seconds faster than their counterparts who used the TOEGP. The t-test calculations showed a significant difference in answering time between both groups (t (6), p = < 0.05). Experimental observations revealed that users in the experimental group took less time to complete tasks. Users who listened to instructions for tasks took less time; unlike the other group which took more time to read the task.

On the other hand, the mean time taken to, enter all message tasks in the input interface using AVEGP was more than that for the NMEGP. The total time taken by users of the NMEGP in the control group for the input interface was on average 34.31 minutes per user. In comparison, users of the AVEGP in the experimental group of the input interface spent a total of 46.30 minutes per user on average. Tasks in which both text and avatar must be entered took more time. Figure 3-12 shows the mean values for the time taken by all users. The t-test calculations showed that the difference in answering time between both groups was significant (t (23), MD (-17), p = 0 < 0.05). Experimental observations revealed that users in the control group took less time because these users only had to focus on the audio- unlike the other experimental group which required avatar video, as well as text. Once answering six questions for the output interface, as shown in Figure 3-13, users of the AVEGP were 150.20 seconds slightly faster than their counterparts who used the NMEGP. The t-test calculations showed that the difference in answering time between both groups was significant (t (-1.77), MD (-106), p = 0.00 < 0.05). Experimental observations revealed that users in the experimental group took less time to complete tasks. Users who listened and followed the instructions for tasks took less time; unlike the other group which took more time to listen to the instructions for the task.

3.6.4.2 Question Type

Figure 3-13 shows the answering time grouped by the question type. The questions were designed to be of two different types; recall and recognition with six questions each. Overall, the answering time in the experimental group was lower for both types of questions, as opposed to the control group. Answering the recall questions took less time in comparison with the recognition questions. In responding to the recall questions, users of the MMEGP in the experimental group spent 75.53 seconds (on average) less than the users of the TOEGP in the control group. However, the variation between the two groups was substantially reduced to 17.07 seconds, with respect to answering recognition questions. According to t-test results, the difference between the two groups in answering time was found to be statistically significant for the recall questions (t (3), MD (17), $p < 0.05$) whereas no significant difference has was identified for the recognition questions (t (2), MD (16) $p > 0.05$).

The other side of, the answering time in the experimental group was lower for both types of questions, as opposed to the control group. Answering the recall questions took less time in comparison with the recognition questions. In responding to the recall questions, users of the AVEGP in the experimental group spent 43 seconds (on average) less than the users of the NMEGP in the control group. However, the variation between the two groups was substantially reduced to 20 seconds, with respect to answering recognition questions. According to the t-test results, the difference between the two groups in answering time was found to be statistically significant for the recall questions (t (13), MD (53), $p < 0.05$) whereas no significant difference was identified for the recognition questions (t (13), MD (52), $p < 0.05$).

In summary, the users in the control group using text in the input interface in order to spend less time entering information, compared to users of the MMEGP. On the other hand, the users in the experimental group were significantly aided by the addition of the multimodal metaphors in the MMEGP which enabled them to spend less time than the users of the TOEGP in responding to the required questions given by the output interface. It can also be said that using recorded speech was less efficient than using only text in the input interface.

In addition users in the control group who used recorded speech in the input interface, spent less time entering information, compared to users of the AVEGP. On the other hand, the users in the experimental group were significantly aided by the addition of the multimodal metaphors in the AVEGP which enabled them to spend less time than the users of the MMEGP in responding to the required questions given by the output interface. It can also be said that using the avatar was less efficient than using earcons and recorded speech in the input interface. During the recall and the recognition tasks, we can see that the message receivers respond faster to questions, compared to the experimental groups using the output interface.

3.6.4.3 Message Complexity

Figure 3-12 shows the message time grouped by the complexity of tasks. These tasks were designed to increase in difficulty and were equally divided into three easy, three moderate and three difficult tasks. In overall, the message time for the control group was lower for all complexity levels. Also, the variance in messaging time between the two groups increased with an increasing level of task complexity. For easy tasks, the mean message time in TOEGP was 7.15 minutes less than that for the MMEGP. The variance between both tasks, however, was slightly larger (7.34 minute) for responding to moderate tasks. For difficult tasks, the variance was considerably higher, 7.40 minutes in favour of the TOEGP. The statistical tests revealed that users of the TOEGP needed significantly less time than the users of the MMEGP to enter message tasks for each of the easy ($t(-11)$, $p = 0.00 < 0.05$), moderate ($t(-4)$, $p = 0.00 < 0.05$) and difficult ($t(-10)$, $p= 0.00 < 0.05$) tasks.

Figure 3-13 shows the message time grouped by the complexity of tasks for the output interface. These questions were designed to increase in difficulty and were equally divided into two easy, two moderate and two difficult tasks. In overall, the answering time in the experimental group was lower for all complexity levels. Also, the variance in answering time between the two groups increased with an increasing level of question complexity. For easy questions, the mean answering time for MMEGP was 50.00 seconds less than for TOEGP. The variance between both tasks was slightly larger (50.80 seconds) for responding to moderate questions. For difficult questions, the variance was 50.33 seconds in favour of the MMEGP. The statistical tests revealed that the users of the MMELP needed significantly less time than the users of the TOEGP to answer each of the easy (t (5), $p < 0.05$), moderate (t (-4), $p < 0.05$) and difficult (t (6), $p < 0.05$) questions.

Opposite side, the message time for the control group was lower for all complexity levels. The difference in messaging time between the two groups increased with an increasing level of task complexity. For easy tasks, the mean message time in the NMEGP was 11.32 minutes less than that for the AVEGP. The variance between both tasks, however, was slightly less (12.13 minute) for responding to moderate tasks. For difficult tasks, the variance was considerably higher, 14.29 minutes in favour of the NMEGP. The statistical tests revealed that users of the MMEGP needed significantly less time than the users of the AVEGP to enter message tasks for each of the easy (t (11), MD (34), $p < 0.05$), moderate (t (-0.93), MD (1.5), $p < 0.05$) and difficult (t (9.4), MD (36.20), $p < 0.05$) tasks.

The answering time in the experimental group was lower for all complexity levels. The adjustment in answering time between the two groups increased with an increasing level of question complexity. For easy questions, the mean answering time for AVEGP was 49 seconds less than for NMEGP. The variance between both tasks was slightly less (2 seconds) for responding to moderate questions. For difficult questions, the variance was 4 seconds in favour of the AVEGP. The statistical tests revealed that the users of the AVEGP needed significantly less time than the users of the NMEGP to answer each of the easy (t(11.8), MD (0.13), $p < 0.05$), moderate (t (-9), MD (1.5), $p < 0.05$) and difficult (t (0.5), MD (-3), $p < 0.05$) questions.

In summary, these results demonstrate that users of the input interface in the control group in TOEGP take less time because they were only required to enter text, in comparison to the experimental group by MMEGP which were required to enter text and record speech. While the users of the output interface, which used multimodal metaphors, gradually reduced their answering time, users used more time when the required evaluation questions became more difficult. In the control group via NMEGP, take less time because they only had to focus on the audio, in comparison to the experimental group through AVEGP which were required to generate avatar visual-audio and focus on the audio and animation input. The users of the output interface, which used multimodal metaphors, gradually reduced their answering time but these users required more time when the evaluation questions became more difficult.

3.6.4.4 Message Type

Figure 3-12 shows the message time grouped by the message type. The tasks were designed to be of three different types; nine task each. Overall, the message time in the control group was lower, for all types of tasks, as opposed to the experiment group using the input interface. In responding to message tasks, users of the MMEGP, in the experimental group, spent 10.21 minutes to complete suggestions and comments but less time for complaints, just 10.8 minutes. The users of the TOEGP, in the control group, spent less time than the experimental group where the suggestion time was (t (-16), MD (-8), $P = 0.00 < 0.05$) and complaint time (t (-10), MD (-3), $P = 0.00 < 0.05$) and the comment time was (t (-14), MD (-3), $P < 0.05$). Note from the T- test and Mean Definition (MD) test for all message types. The reduced time for the control group is due to the fact that users are only required to enter text in the control group but the experimental groups are required to enter text and record speech when using the input interface. On the other hand, a variation between the task times for the three message types was observed for users of the MMEGP in the experimental group who spent 50.38 seconds (on average) less than the users of the TOEGP in the control group. According to t-test results, the difference between the two groups for tasks time was found to be statistically significant for the experiment group using the output interface. The users time for suggestions was (t (6), MD (11), P = 0.00 < 0.05) and for complaints was (t (4), MD (11), P = 0.00 < 0.05) and for comments was (t (5), MD (12), P = 0.00 < 0.05). There was a positive T- test and MD for all message types for the experimental group for the output interface.

Other side in responding to message tasks, users of the AVEGP, in the experimental group, spent 14.3 minutes to complete suggestions and 19.20 minutes for complaints. The users of the NMEGP, in the control group, spent less time than the experimental group where the suggestion time was (t (5), MD (-4), P = 0.00 < 0.05) and the complaint time (t (-0.9), MD (-3.9), P = 0.00 < 0.05) and the comment time was (t (21), MD (-8.9), P < 0.05). Note the negative T- test and Mean Definition (MD) test was conducted for all message types. The reduced time for the control group is due to the fact that users are only required to enter text and record speech, but users of the experimental groups are required to generate text and avatar video, when using the input interface.

On the other hand, a difference between the task times for the three message types was observed for users of the AVEGP in the experimental group who spent 50 seconds (on average) slightly less than the users of the MMEGP in the control group. According to the t-test results, the difference between the two groups for tasks time was found to be statistically significant for the experiment group using the output interface. The users' time for suggestions was (t (11.8), MD (0.13), P = 0.00 < 0.05) and for complaints were (t (-8), MD (1.5), P = 0.00 < 0.05) and for comments was (t (0.52), MD (-3), P = 0.00 < 0.05).

There was a positive T- test and MD for all message types for the experimental group for the output interface.

Overall on the whole, these experimental findings indicate that the addition of the multimodal metaphors to the MMEGP helped users much more when using the output interface. For the input interface, the results indicated for TOEGP took less time this is due to required enter messages only text in the control group, but the experimental group to require enters messages were text and speech record. The addition of the multimodal metaphors to the AVEGP helped users much more when using the output interface. For the input interface, the results indicated that users of the NMEGP took less time; this is because users were required the enter text and record speech. The control group just had to focus on the audio, but the experimental group was required to enter text and avatar video, and the users had to focus on hearing and animation.

3.6.4.5 Each User

Figure 3-14 show the time consumed to enter message tasks in each group. Apart from the 9th tasks which needed longer times using the TOEGP, the control group needed shorter times than the experimental group to enter messages for all the tasks.

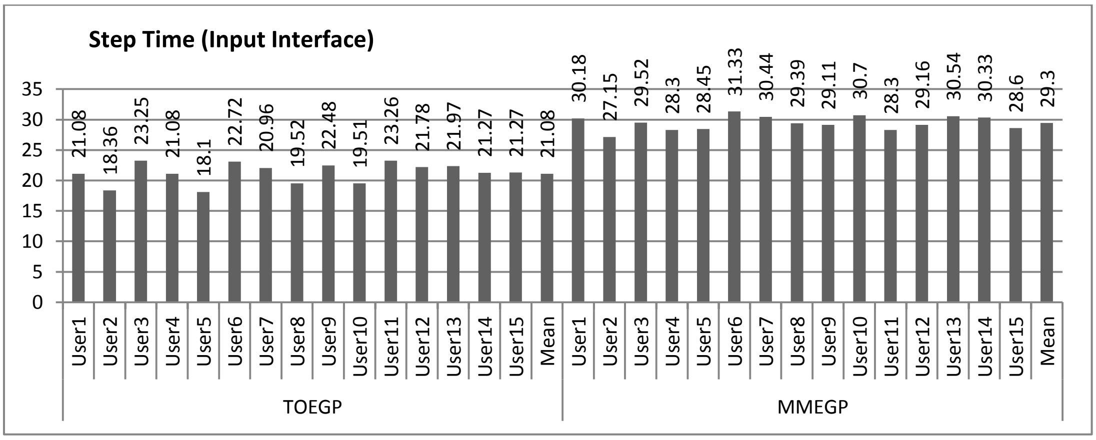


Figure 3-14: Mean values of time taken by the users in both groups to enter messages for each tasks in the input interface

Additionally, the mean time taken to enter a message task was 29.30 minutes in the experimental group, compared to 21.08 minutes in the control group. It was noticed that the difference between the two groups for message times varied across the nine tasks for the input interface. These variances could be attributed to the differences in complexity and type of tasks.

Significant differences were obtained for the control group. Nevertheless, the results obtained could not be considered as conclusive for clarifying the role that the text played in shortening the message time when used in the input interface. The reason behind this can be attributed to the design of the required tasks because the control group just entered text but the experimental group entered text and recorded speech in the input interface. These tasks were not designed to explore the individual role of these multimodal metaphors. In a few words, the multimodal metaphors used in the MMEGP did not assist in reducing the message time for most users undertaking the required tasks for the input interface.

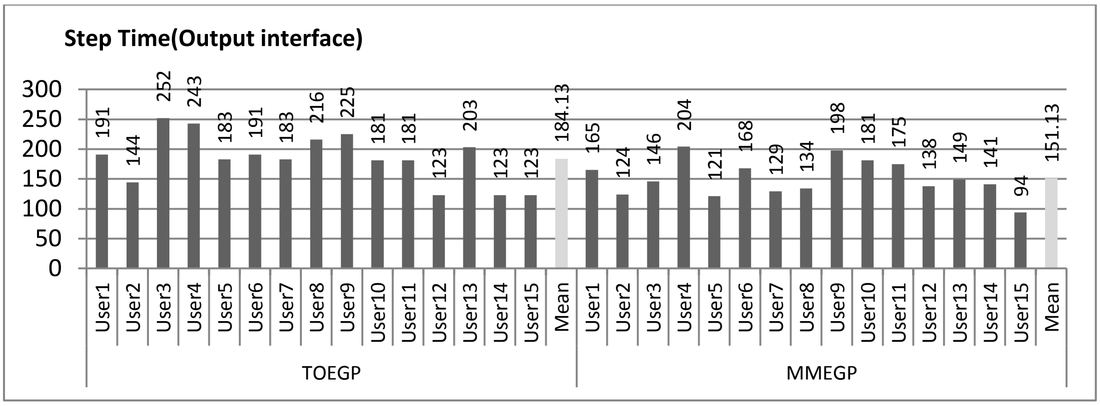


Figure 3-15: Mean values of time taken by the users in both groups to enter messages for each task in the output interface

Figure 3-15 shows the total time spent by each user in both groups to enter messages for all the six tasks. A larger proportion of time was spent by users of the TOEGP, compared to users of the MMEGP. The minimum and maximum message times taken by the control group TOEGP were 123 seconds (User 12) and 252 seconds (User 3), correspondingly. In the experimental group, the minimum time taken was slightly lower (94 seconds by User 15), whereas the maximum time (204 seconds by User 4) was less than that in the control group. On average, the users of the MMEGP were 151.13 seconds faster than their counterparts who used the TOEGP.

However, Figure 3-16 shows the time consumed to enter message tasks for each group. The control group by NMEGP needed shorter times than the experimental group in AVEGP to enter messages for all the users.

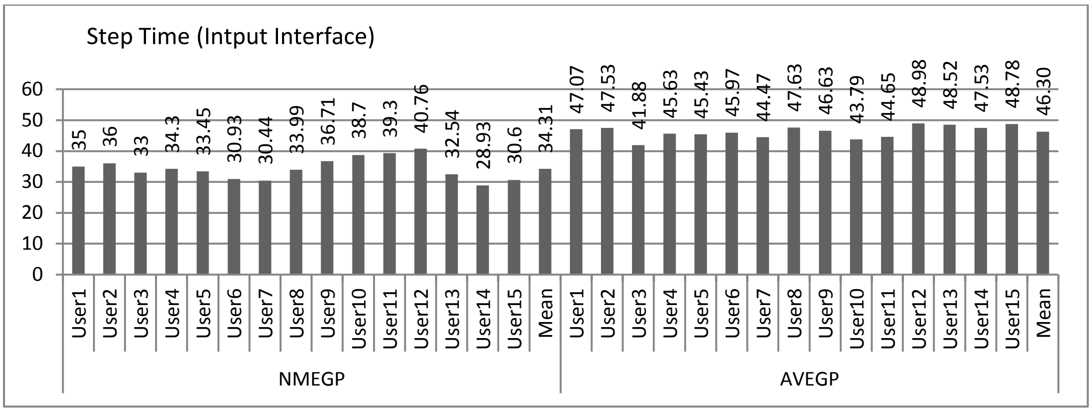


Figure 3-16: Mean values of time taken by the users in both groups to enter messages for each of the tasks in the input interface.

Moreover, the mean time taken to enter a message task was 46.30 minutes for the experimental group, compared to 34.31 minutes for the control group. It was noticed that the difference between the two groups for message times varied across the nine tasks for the input interface. These variances could be attributed to the differences in complexity and the type of task or because of the new effects which were added attracted the attention of users. Major differences were obtained for the control group. Even so, the results obtained could not be considered as conclusive for clarifying the role that the text and record speech played in shortening the message time when used in the input interface. The control and experimental groups are equal in terms of the complexity of the required tasks - the control group enter text and record speech and the experimental group enter text and generate the avatar animation in the input interface. These tasks were designed to explore the individual role of these multimodal metaphors. In a few words, the multimodal metaphors used in the

NMEGP and AVEGP assist in reducing the message time for most users undertaking the required tasks for the input interface.

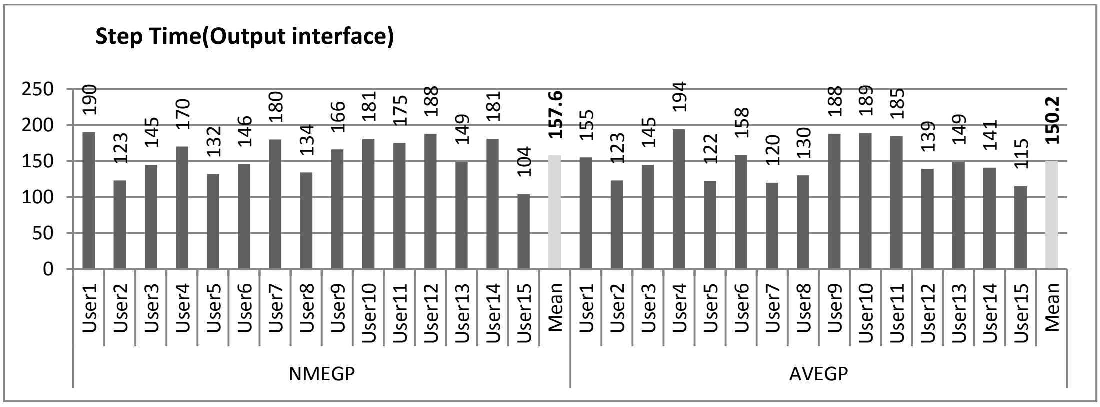


Figure 3-17: Mean values of time taken by the users in both groups to enter messages for each task in the output interface.

Figure 3-17shows the total time spent by each user in both groups to enter messages for all the six tasks. Little proportion of time was spent by users of the NMEGP, compared to users of the AVEGP. The minimum and maximum message times taken from the control group were 104 seconds (User 15) and 190 seconds (User 1), correspondingly. In the experimental group, the minimum time taken was slightly lower (115 seconds by User 15), whereas the maximum time (194 seconds by User 4) was less than that in the control group. On average, the users of the AVEGP were 150.20 seconds faster than their counterparts who used the NMEGP.

3.6.5 Effectiveness

The number of mouse clicks to assess the communication performance of users from all experimental groups and correctly entered messages in terms tasks completed successfully, test results were used to evaluate effectiveness. This 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.

3.6.5.1 All Tasks

This measure was considered for all the tasks for each group per user.

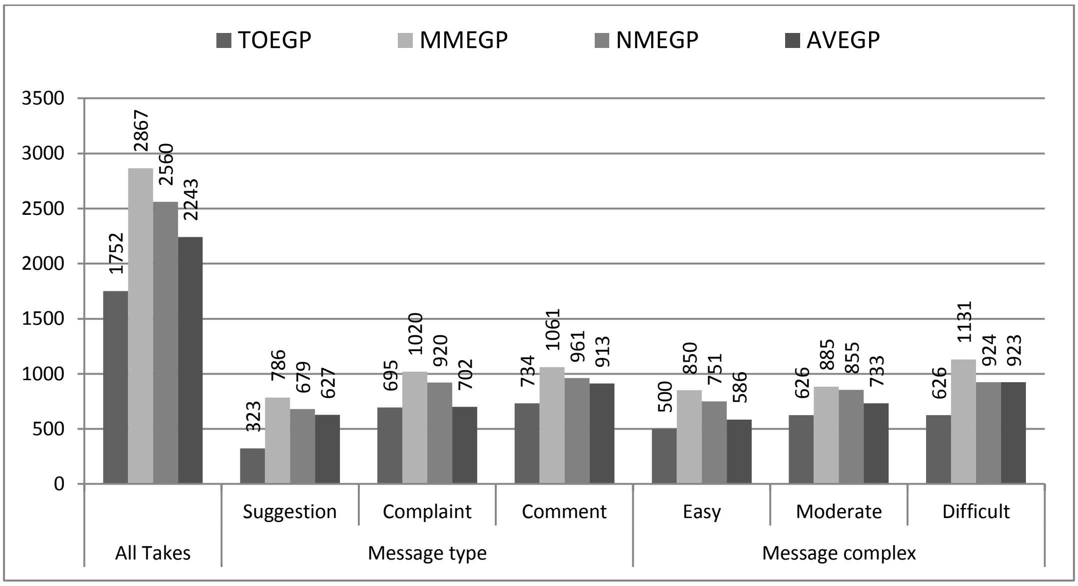


Figure 3-18: The mean number of mouse clicks performed by users in all groups to enter messages for all the tasks for the input interface.

Figure 3-18 shows the percentage of mouse clicks to enter messages for all tasks for the TOEGP and MMEGP. The users of the TOEGP used less mouse clicks of 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 which was required to enter text and recorded speech. In Figure 3-18, the users of the TOEGP performed better than the users of the MMEGP when considering 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 revealed a significant difference in mouse clicks between MMEGP and TOEGP (t (16), MD = -2.9, $p < 0.05$). As a result, the MMEGP users outperformed the users of the TOEGP, who send the messaging information via the text channel only.

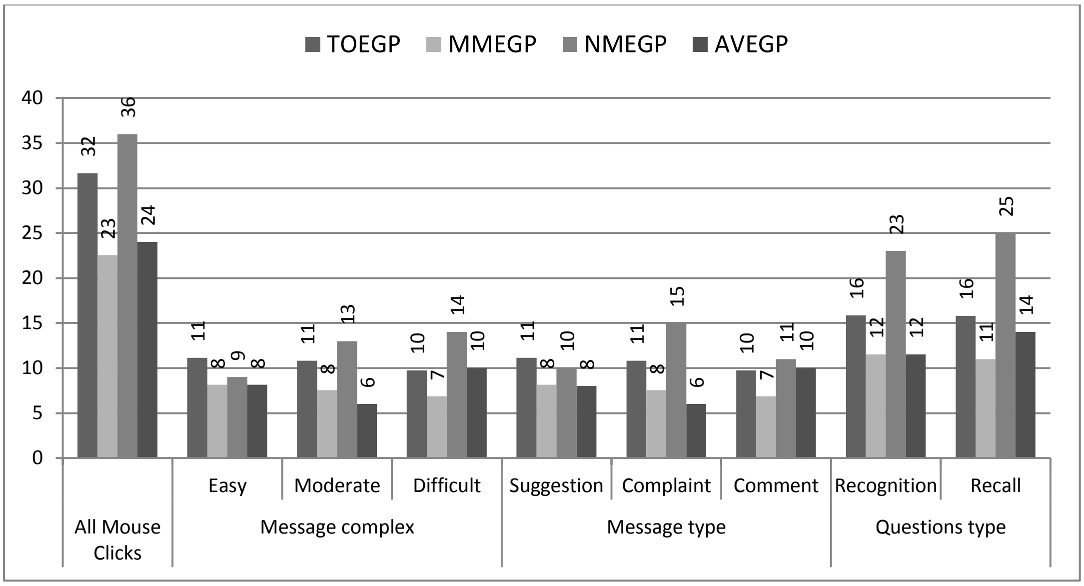


Figure 3-19: The mean number of mouse clicks by users in both groups to enter message for all the tasks in the output interface.

The 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. Figure 3-19 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 was (23) 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, $p < 0.05$). As a result, TOEGP outperformed the users of the MMEGP when received the messaging information via text with metaphors. The incorporation of more than one communication metaphor of different natures 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 reducing 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.

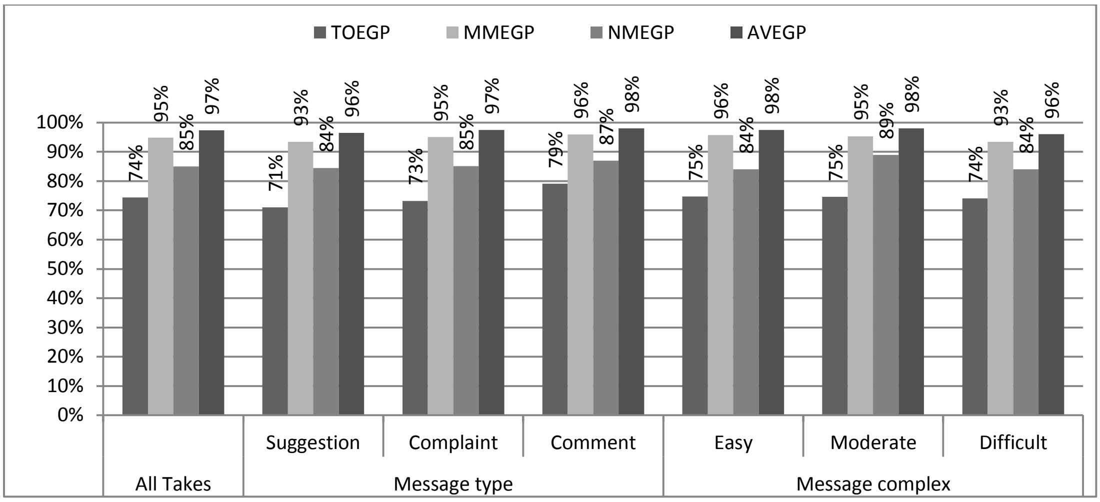


Figure 3-20: Percentage of correctly completed tasks by correctly entered for users in by groups for the input interface.

By analysing the correctly entered measure we can find what percentage of users entered the correct message in the input for all tasks. Figure 3-20 shows the percentage of test result messages correctly entered for all tasks in the TOEGP and MMEGP. Users of the MMEGP are 94.82% correct and TOEGP users are 74.47% correct, in terms of the correctly entered measure for the input interface.

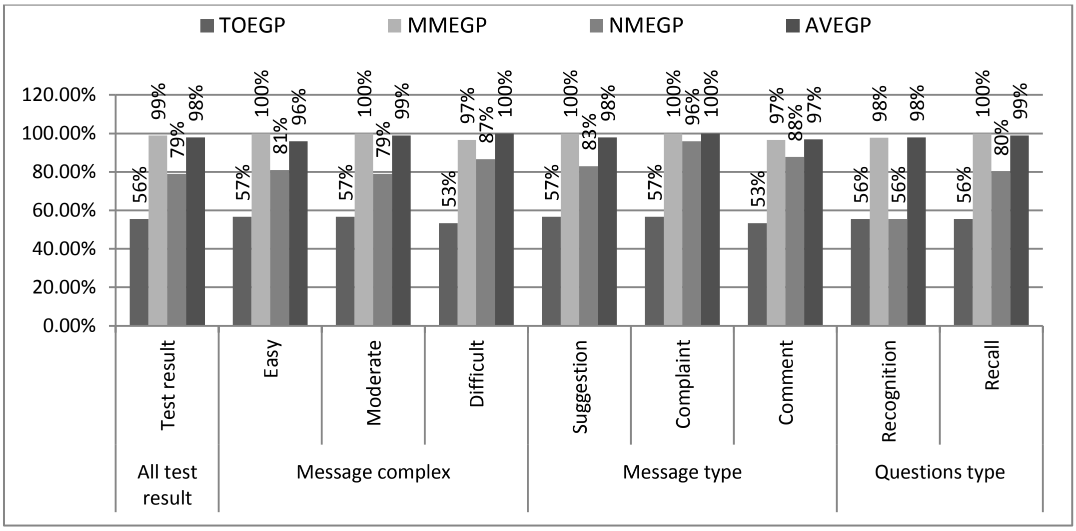


Figure 3-21: Percentage of correctly completed tasks by correctly entered for users in all groups for the output interface.

On the other hand, when looking at Figure 3-21, the users of the MMEGP complete more tasks successfully than 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.

Conversely the users of the AVEGP used less mouse clicks the users of the NMEGP. The reason for this is the enhanced input interface used by users when using the new avatar tool. The mean number of mouse clicks for the NMEGP was (2560) more than that for the AVEGP (2243), for all messages. As a result, the AVEGP users outperformed the users of the NMEGP, who send the messaging information via the text channel and avatar. The users of the NMEGP exceeded AVEGP users in terms of the number of mouse clicks used to enter messages for all tasks. The new multimodal metaphors applied when using avatar in the AVEGP assisted in reducing the number of mouse clicks used for the required tasks in the input and output interfaces. The users of AVEGP performed better than users of the NMEGP in terms of the number of mouse clicks used for all messages. The mean number of mouse clicks used in the NMEGP was (36) less than that used in the AVEGP (24), for all messages in the output interface. The t-test results showed that the difference in mouse clicks between NMEGP and AVEGP was significant (t (-1.77), MD = -1.40, $p < .05$). As a result, AVEGP outperformed the users of the NMEGP when receiving the messaging information via text with the new metaphors. The incorporation of more than one communication metaphor of different natures in the AVEGP helped users in the experimental group to discriminate between the different types of information delivered by each of the avatar more than when using the recorded speech extracts, thus enabling them to understand this information in a short time period and reducing the number of mouse clicks. In summary, the new multimodal interaction metaphors used in the AVEGP were more effective in communicating and considerably assisted the users in the experimental group to achieve a higher effectiveness rate, when using the input and output interfaces.

By analysing the correctly entered measure we can find what percentage of users entered the correct message for all tasks. Shows the percentage of test result messages correctly entered for all tasks in the AVEGP and NMEGP. Users of the NMEGP are 85.47% correct and AVEGP users are 97.33% correct, in terms of the correctly entered measure for the input interface.

In addition, when looking at the users of the AVEGP complete more tasks successfully than NMEGP users, in terms of the number of correctly entered messages for tasks using the output interface. The AVEGP 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.

3.6.5.2 Question Type

The question type was considered to measure the percentage of correct answers to recall and recognition questions, in both control and experimental groups correctly entered test. Figure 3-19 and Figure 3-21users of the MMEGP performed better than those of the TOEGP in both recall and recognition questions, but the difference between the two groups was smaller in the latter type. For recall questions, the percentages of correctly answered questions in the experimental group were 11 clicks less than that of the control group. However, the number of mouse clicks for correctly answered recognition questions in the experimental group was 12 clicks less than that of the control group. Using the MMEGP, users in the experimental group used a smaller number of mouse clicks in recall and recognition questions respectively when using the output interface. Alternatively, the users of the MMEGP in the experimental group exhibited a 100% correctness rate in answering recall questions and a 97.7% correctness rate in answering recognition questions for the correctly entered measure for the output interface. The results of the T-test showed a significant difference in the number of correct answers between the MMEGP and TOEGP, for both types of questions, in terms of the number of mouse clicks; recall ($T = 6$, $MD = 5$, $p < 0.05$) and recognition ($T = 6$, $MD = 4$, $p < 0.05$). On the other hand, the results of the Chi - square test showed a significant difference in the number of correct answers between the MMEGP and TOEGP, for both types of questions correctly entered; recall ($X^2 = 26$, $p < 0.05$) and recognition ($X^2 = 23$, $p < 0.05$). A further analysis (see Figure 3-19, Figure 3-21) indicated that the experimental group significantly outperformed the control group in answering both recall and recognition questions in terms of the number of mouse clicks and correctly entered for the output interface.

On the other hand the users of the AVEGP performed better than those of the NMEGP for both recall and recognition questions, but the difference between the two groups was smaller in the latter type. For recall questions, the percentages of correctly answered questions in the experimental group were 14 clicks less than that for the control group, which were 25 clicks. However, the number of mouse clicks for correctly answered recognition questions in the experimental group was 12 clicks less than that for the control group, which were 23 clicks. Using the AVEGP, users in the experimental group used a slightly smaller number of mouse clicks in recall and recognition questions, respectively, when using the output interface. On the other hand, the users of the AVEGP, in the experimental group, exhibited a 100% correctness rate in answering recall questions and a 90% correctness rate in answering recognition questions for the output interface. The results of the T-test showed a significant difference in the number of correct answers between the AVEGP and NMEGP, for both types of questions, in terms of the number of mouse clicks; recall ($T = -6$, $MD = -3$, $p < 0.05$) and recognition ($T = 4$, $MD = 1.5$, $p < 0.05$). On the other hand, the results of Chi-square test showed no significant difference in the number of correct answers between the NMEGP and AVEGP, for both types of questions correctly entered; A further analysis (see

Figure 3-19, Figure 3-21) indicated that the experimental group significantly outperformed the control group in answering both recall and recognition questions, in terms of the number of mouse clicks and correctly entered answers for the output interface.

In summary, the advantage of using multimodal metaphors was more apparent when users answer questions to recall activities, compared to when users answer questions to recognition activities. Nevertheless, the experimental groups in MMEGP and AVEGP performed significantly better than the control groups, in terms of the overall results for both types of questions and in the number of mouse clicks and correctly entered in the output interface.

3.6.5.3 Message Complexity

Figure 3-18 illustrates the percentage of mouse clicks made by users in both groups to enter messages, grouped by message complexity (easy, moderate and difficult tasks) for the input interface. The total number of tasks in each complexity level was 9 tasks. The experimental group outperformed the control group in all levels of complexity, particularly when completing the easy tasks. This is shown by the number of mouse clicks performed by users. Additionally, the difference in users ‘performance increased in the experimental group, as the complexity of tasks increased. For easy task, the users of the MMGEP scored 95.69% for correctly answered tasks, more than that achieved by the TOEGP users. However, the difference was larger (20%) approximately, with respect to moderate tasks. The largest difference (20%) was noted in users ‘responses to difficult tasks, where the users in the experimental group performed more mouse clicks compared to users in the control group. This is due to the fact that the users in the experimental group were required to perform more mouse clicks. Using the MMGEP, the users in the experimental group correctly answered 96%, 95% and 93% of easy, moderate and difficult tasks, respectively. Conversely, the TOEGP users as the control group participants, were successful in their response to 75% of easy tasks, 75% of moderate tasks, and 74% of difficult tasks. The T-test results demonstrated a variance incorrectly answered messages between the MMGEP and TOEGP that reached a statistical significance for easy tasks ($T = -11$, $MD = -4$, $p < 0.05$), while it was found to be significant in moderate tasks ($T = -10$, $MD = -3$, $p < 0.05$) and difficult tasks ($T = -10$, $MD = -8$, $p < 0.05$). This result is in favour of the control group, which exhibited a value in the T test and MD test, as well as ($a < 0.05$) for the input interface.

Figure 3-19 shows the mean number of mouse clicks performed by users in both groups in order to correctly answer message when using the output interface, grouped in terms of complexity. The control group outperformed the experimental group at all levels of message complexity, chiefly for the difficult tasks. This is shown by the low number of mouse clicks performed by users. The results of the T-test showed that the difference in correctly entered messages between MMGEP and TOEGP reached a statistical significance for easy tasks ($T = 5$, $MD = 3$, $p < 0.05$), while it was found to be significant for moderate ($T = 2$, $MD = 3$, $p < 0.05$) and difficult tasks ($T = 5$, $MD = 3$, $p < 0.05$). This result is in favour of the experimental group, which exhibited a value in the T test and MD test, as well as for the output interface ($a < 0.05$).

Figure 3-20 shows the percentage of correctly entered messages, grouped by message complexity, for the TOEGP and MMEGP interfaces. Users of the MMEGP, when entering easy messages, scored 96%, higher than TOEGP users, 75% in terms correctly entered message measure. The Chi-square test shows results for easy ($X^2 = 23$, $p < 0.05$), moderate ($X^2 = 24$, $p < 0.05$) and difficult ($X^2 = 26$, $p < 0.05$) tasks because the three variables were non-parametric with three levels. Multimodal interaction metaphors increase the numbers of correctly entered messages, as shown by the Chi-square test.

Figure 3-21 shows the percentage of correctly entered messages for tasks of different complexity in the TOEGP and MMEGP. When the message complexity is easy, it should be noted that users of the MMEGP showed a success rate of 100%, higher than TOEGP users (57%). The Chi-square test gave outcomes: easy ($X^2 = 12.8$, $p < 0.05$), moderate ($X^2 = 12.8$, $p < 0.05$) and difficult ($X^2 = 14$, $p < 0.05$). The use of multimodal interaction metaphors gave a better rate of success, as shown by the Chi-square test.

Nevertheless the control group in NMEGP outperformed the experimental group by AVEGP at all levels of complexity, particularly when completing the easy tasks. This is shown by the number of mouse clicks performed by users. What is more, the difference in users' performance increased in the experimental group, as the complexity of tasks increased. For easy task, the users of the AVEGP required 586 clicks for correctly entered message tasks, less than that achieved by the NMEGP users, which were 751 clicks. However, the difference was largest 152 clicks, with respect to moderate tasks. The largest difference (108 clicks) was noted in users' responses to difficult tasks, where users in the experimental group performed less mouse clicks compared to users in the control group - the reverse of the results of the first experiment. This is due to the fact that users using the new avatar tool in the experimental group perform less mouse clicks. The results of the T-test showed that the difference in correctly answered messages between the MMGEP and AVEGP reached a statistical significance for easy tasks ($T = 11$, $MD = 0.13$, $p > 0.05$), while it was found to be significant in moderate tasks ($T = -8$, $MD = 1.5$, $p > 0.05$) and difficult tasks ($T = 9$, $MD = -3$, $p > 0.05$). This result is in favour of the experiment group, for the input interface.

The mean number of mouse clicks performed by users in both groups in order to correctly answer messages when using the output interface, grouped in terms of complexity. The control group outperformed the experimental group at all levels of message complexity, chiefly for the moderate tasks. This is shown by the low number of mouse clicks performed by users. The results of the T-test showed that the difference in correctly entered messages between NMGEP and AVEGP reached a statistical no significance for easy tasks ($T = 0.52$, $MD = 0.13$, $p > 0.05$), while it was found to be significant for moderate ($T = 13$, $MD = 34$, $p < 0.05$) and no significance difficult tasks ($T = 0.00$, $MD = 34$, $p > 0.05$). This result is in favour of the experimental group.

The percentage of correctly entered messages grouped by message complexity for the NMEGP and AVEGP in input interface. Users of the AVEGP, when entering easy messages, scored 97%, higher than MMEGP users, 84% in terms correctly entered message measure. The Chi-square test shows results, significance for easy ($X^2 = 5$, $p < 0.05$), no significance for moderate ($X^2 = 5$, $p > 0.05$) and significance for difficult ($X^2 = 8$, $p < 0.05$) tasks. The new multimodal interaction metaphors increase the numbers of correctly entered messages, as shown by the Chi-square test.

The percentage of correctly entered messages for tasks of different complexity in the NMEGP and AVEGP in output interface. When the message complexity is easy, it should be noted that users of the AVEGP showed a success rate of 100%, higher than NMEGP users (81%). The Chi-square test gave outcomes: easy ($X^2 = -1$, $p < 0.05$), moderate ($X^2 = -1$, $p < 0.05$) and difficult ($X^2 = 0.0$, $p < 0.05$). The use new of multimodal interaction metaphors gave a better rate of success, as shown by the Chi-square test.

In brief, all groups of users accomplished equivalent levels of accuracy in response to different complexity tasks. However, the contribution of new multimodal metaphors such as an avatar, to improved user performance was more obvious for the high complexity tasks.

3.6.5.4 Message Type

The number of mouse clicks performed by user entered messages, for message type tasks, for both groups. The number of mouse clicks is between 323 to 1061 for both groups when using the input interface. Users of the TOEGP performed better than those using the MMEGP for different message type tasks, but the difference between the two groups was bigger in terms of the total number of clicks needed for each type. In the comments tasks, the percentage of correctly entered messages in the experimental group was 1061 higher than that in the control group (734). As mentioned earlier, this was due to the differences in the requirements between the two groups were more at the experimental group In terms of the input message. The results of the T-test showed a significance in the number of mouse clicks between the MMEGP and TOEGP for both message types which favours the control group using the input interface; Suggestion ($T = -16$, $MD = -3$, $p < 0.05$) was significantly and Complaint ($T = -16$, $MD = -324$, $p < 0.05$) was significantly and Comment ($T = -7$, $MD = -350$, $p < 0.05$) was significantly. A further analysis (see Figure 3-18) indicated that the control group significantly outperformed the experimental group in its ability to perform fewer mouse clicks when using the input interface, as shown by a value in the T test, as well as MD test.

Figure 3-19 shows that the mean number of correctly answered comment tasks for the experimental group was 7 clicks less than that for the control group (10 clicks). This result indicates that it is easier to answer questions when using the enhancement. The experimental group took less time and performed fewer clicks. The results of T-test showed a significant difference in the time taken to enter messages for answers to the questions between the MMEGP and TOEGP for both types of message: Suggestion ($T = 5$, $MD = 5$, $p < 0.05$), Complaint ($T = 2$, $MD = 3$, $p < 0.05$) and Comment ($T = 5$, $MD = 12$, $p < 0.05$). An additional analysis (see Figure 3-18) indicated that the experimental group significantly outperformed the control group in answering the questions of different message type when using the output interface. This is shown by a value in the T test result, as well as MD test which shows the differences more clearly.

Figure 3-21 shows the percentage of correctly entered messages for the different task types for the TOEGP and MMEGP. Users of the MMEGP had a 93% success rate for suggestion type messages which was higher than TOEGP users (71%). In addition, the complaint and comment similar result in terms of correctly entered messages for message type tasks e in the input interface. The Chi-square test gave results; Suggestion ($X^2 = 12.857$, $p < 0.05$), Complaint ($X^2 = 12.857= 3$, $p < 0.05$) and Comment ($X^2 = 14$, $p < 0.05$). The Chi-square test is effective at differentiating between the two groups, in terms of testing the degree of successful entry of messages. In addition, it has been shown by previous findings that the success rate was higher in the experimental group.

Figure 3-21 shows that users of the MMEGP had a message success rate 100% for the suggestion type, higher than TOEGP user (57%). For the complaint message type, MMEGP users had a success rate of 100% and TOEGP user 57%, in terms of the correctly entered messages when using the output interface. The Chi-square test demonstrates the results; Suggestion ($X^2 = 13$, $p < 0.05$), Complaint ($X^2 = 13$, $p < 0.05$) and Comment ($X^2 = 14$, $p < 0.05$). As was mentioned earlier, the Chi-square test effectively differentiates between the two groups in terms of testing the degree of accuracy of entering messages. It has been shown by previous findings that the experimental group had a higher success for entering messages.

Though the number of mouse clicks is between 627 to 961 for both groups when applying the input interface. Users of the AVEGP performed better than those using the NMEGP for different message type tasks, but the difference between the two groups was bigger in terms of the total number of clicks needed for each type. In the complaint tasks, the number of correctly entered messages in the control group was 920 higher than that in the experimental group 720. As mentioned earlier, this is due to the fact that the users when using the new avatar tool in the experimental group require less mouse clicks in terms of the input message. The results of the T-test showed a significance in the number of mouse clicks between the NMEGP and AVEGP for both message types which favours the experimental group using the input interface; Suggestion ($T = 6$, $MD = 159$, $p < 0.05$) was significantly and Complaint ($T = -9$, $MD = 317$, $p < 0.05$) was significantly and Comment ($T = 21$, $MD = 147$, $p < 0.05$) was significantly. A further analysis (see Figure 3-18) indicated that the experimental group significantly outperformed the control group in its ability to perform fewer mouse clicks when using the input interface.

Figure 3-19 shows that the mean number of correctly answered complaint tasks for the experimental group was 6 clicks less than that for the control group, 15 clicks. This result indicates that it is easier to answer questions when using the enhancement. The experimental group took less time and performed fewer clicks. The results of T-test showed a significant difference in the mouse clicks taken to enter messages for answers to the questions between the NMEGP and AVEGP, for both types of message: Suggestion no significance ($T = 52$, $MD = 13$, $p > 0.05$), Complaint significance ($T = 13$, $MD = 34$, $p < 0.05$) and Comment no significance ($T = 0.0$, $MD = 36$, $p > 0.05$). An additional analysis (see Figure 3-19) indicated that the experimental group some time significantly outperformed the control group in answering questions of different message type when using the output interface.

Figure 3-20 shows the percentage of correctly entered messages for the different task types for the NMEGP and AVEGP. Users of the AVEGP had a 96% success rate for suggestion type messages which was higher than NMEGP users (84%). In addition, the complaint and comment had a similar result in terms of the correctly entered messages for message type tasks in the input interface. The Chi-square test gave results; Suggestion ($X^2 = 11$, $p < 0.05$), Complaint ($X^2 = 3$, $p < 0.05$) and Comment ($X^2 = 4$, $p > 0.05$). The Chi-square test is effective at differentiating between the two groups, in terms of testing the degree of successful entry of messages. In addition, it has been shown by previous findings that the success rate was higher in the experimental group.

Figure 3-21 shows that users of the AVEGP had a message success rate 99% for the suggestion type, higher than NMEGP users (85%). For the complaint message type, AVEGP users had a success rate of 97% and NMEGP users 96%, in terms of the correctly entered messages when using the output interface. The Chi-square test demonstrates the results; Suggestion ($X^2 = -1$, $p < 0.05$), Complaint ($X^2 = -1$, $p < 0.05$) and Comment ($X^2 = 0.0$, $p > 0.05$). As was mentioned earlier, the Chi-square test effectively differentiates between the two groups in terms of testing the degree of accuracy of entering messages. It has been shown by previous findings that the experimental group had a higher success for entering messages.

In summary, the contribution of new multimodal metaphors such as avatars reduces the number of mouse clicks, users use to enter messages for the different type tasks in the input interface. In addition, it helps users to input messages correctly. Also, use of new multimodal metaphors reduces the number of mouse clicks used when using the output interface. Nevertheless, the experimental group in AVEGP performed significantly better than the control group by NMEGP, in terms of the overall results achieved for the different message types. However the contribution of multimodal metaphors had the effect of increasing the number of mouse clicks, users used to enter messages for the different type tasks in the input interface in NMEGP. On the other hand, multimodal metaphors help user to input messages correctly. In addition, use of multimodal metaphors reduced the number of mouse clicks when using the output interface. Nevertheless, the experimental group via MMEGP performed significantly better than the control group by TOEGP in terms of the overall results achieved for the different message types.

3.6.5.5 Individual Users

Figure 3-22 shows the total number of mouse clicks used to enter the correct answers for both the control and experimental groups for each user.

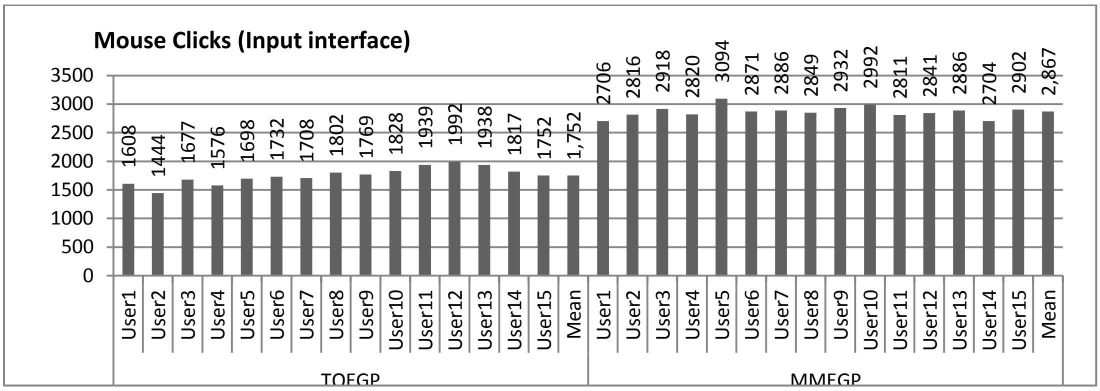


Figure 3-22: The mean number of mouse clicks used to enter the correct answers for individual users, in both groups, when using the input interface.

All users of the MMEGP to use more mouse clicks than users of the TOEGP. User 14 of the MMEGP used 2704 clicks and User 5 used 3094 clicks. The reasons for this difference are clear, as I mentioned earlier, as users of the experimental group are required to record speech as well as enter the text. On the other hand, the TOEGP users are not required to record speech as well as enter the text. On average, the number of mouse clicks per user for the experimental group was 2867, compared to 1752 clicks for the control group. In short, the use of multimodal metaphors for communicating messages is more helpful for users in the experimental group, than users in the control group, in terms of the tasks required to enter messages when using the input interface.

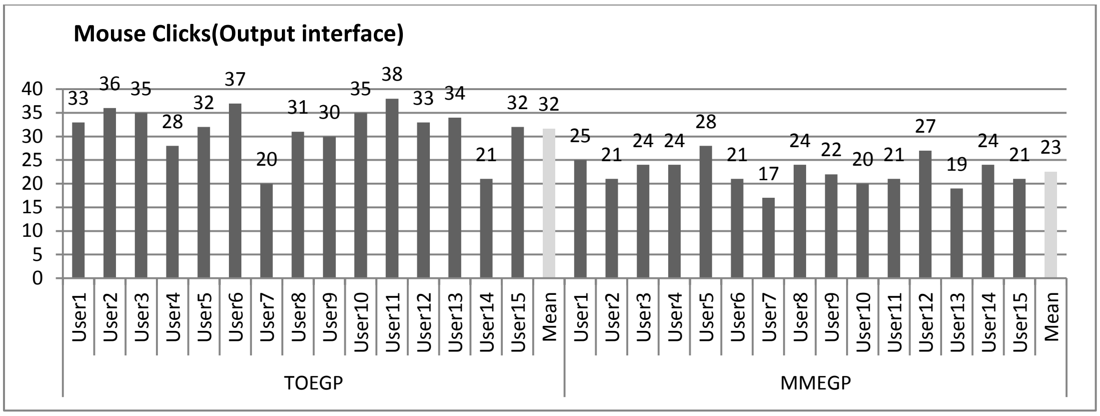


Figure 3-23: The mean number of mouse clicks used to enter correct answers for individual users in both groups for the output interface.

Users in the experimental group used less mouse clicks, compared to users in the control group, for the output interfaces. On average, correct answers per user in the experimental group required 23 clicks, compared to 32 clicks in the control group. In a word, the use of multimodal metaphors in communicating the message enables users in the experimental group to outperform their counterparts in the control group in answering the required questions correctly, in terms of the number of mouse clicks used when using the output interface.

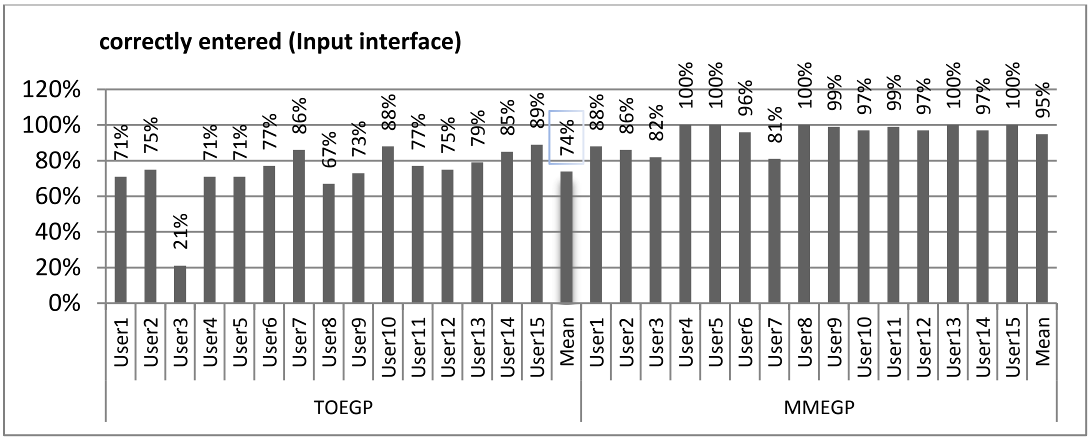


Figure 3-24: Percentage of correctly entered messages achieved by individual users in both groups, for the input interface.

Figure 3-24 shows the percentage of correctly entered messages achieved by each user in both groups for the TOEGP and MMEGP. The experimental group outperformed their counterparts in the control group, in terms of the number of messages entered correctly when using the input interface. The most successful result was in the experimental group, where users 4, 5, 13, 15 achieved 100%. The most successful result was in the control group, where user 15 achieved a success rate 89%. User 4 had the worst success rate (21%). The average test result of correctly entered messages for users in the experimental group was 95%, compared to 74% for users in the control group.

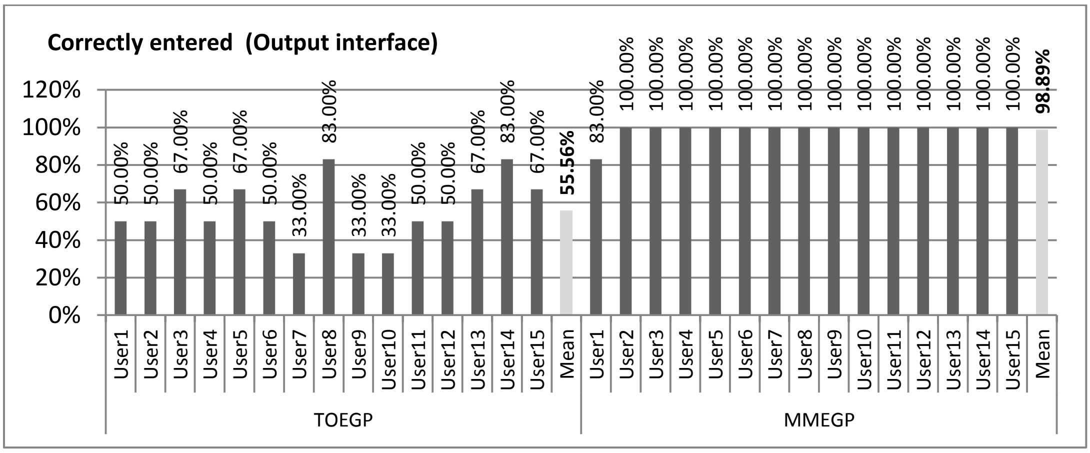


Figure 3-25: Percentage of correctly entered messages for individual users in both groups using the output interface.

However, Figure 3-25 shows the percentage of correctly entered messages achieved by each user for both groups (TOEGP and MMEGP) when using the output interface. The highest results in the experimental group were 100% (users 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15) and the lowest result was 83% (user 1). The highest result in the control group was 83% (users 8, 14). The lowest result (users 7, 9, 10) was 33%. On average, the correctly entered messages sper user in the experimental group was 98.89%, compared to 55.56% in the control group. This means that user in the experimental group performed more successfully when using multimodal metaphors, as the metaphors helped to communicate the messages to the users.

However in the Figure 3-26 all users of the NMEGP used more mouse clicks than users of the AVEGP. User 2 of the NMEGP used 2516 clicks and User 4 used 2820 clicks. The reasons for this difference are clear, as I mentioned earlier, as users of the experimental group are required to record speech as well as enter the text. On the other hand, on average, the number of mouse clicks per user for the AVEGP experimental group was 2243, compared to 2667 clicks for the control group. In short, the use of new multimodal metaphors for communicating messages is more helpful for users in the experimental group, than users in the control group, in terms of the tasks required to enter messages when using the input interface.

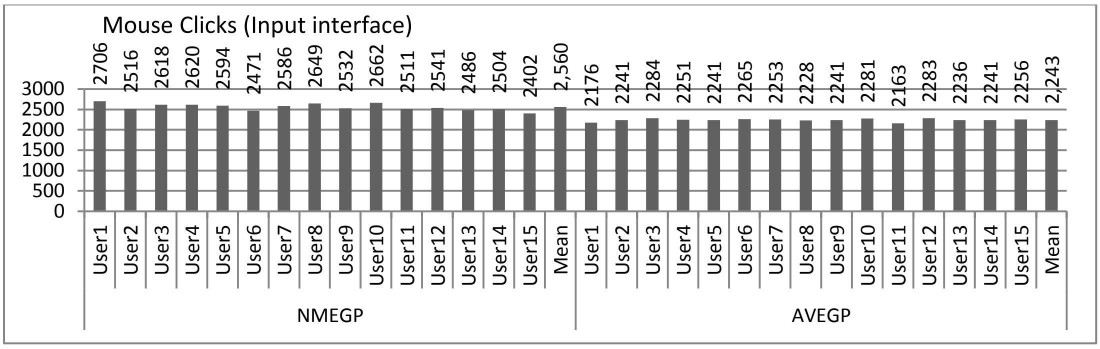


Figure 3-26: The mean number of mouse clicks used to enter the correct answers for individual users, in both groups, when using the input interface.

Users in the experimental group used less mouse clicks, compared to users in the control group, for the output interfaces. On average, correct answers per user in the experimental group required 24 clicks, compared to 36 clicks in the control group.

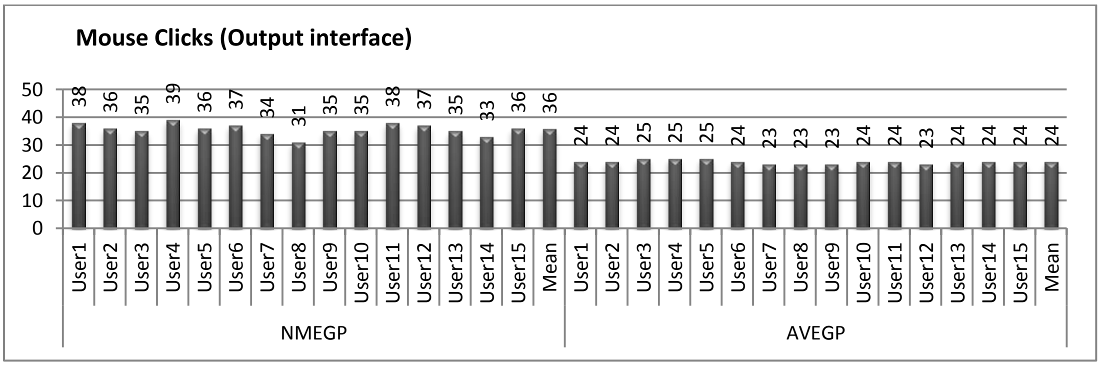


Figure 3-27: The mean number of mouse clicks used to enter correct answers for individual users in both groups for the output interface.

In a word, the use of new multimodal metaphors as an avatar in communicating the message enables users in the experimental group to outperform their counterparts in the control group in answering the required questions correctly, in terms of the number of mouse clicks used when using the output interface.

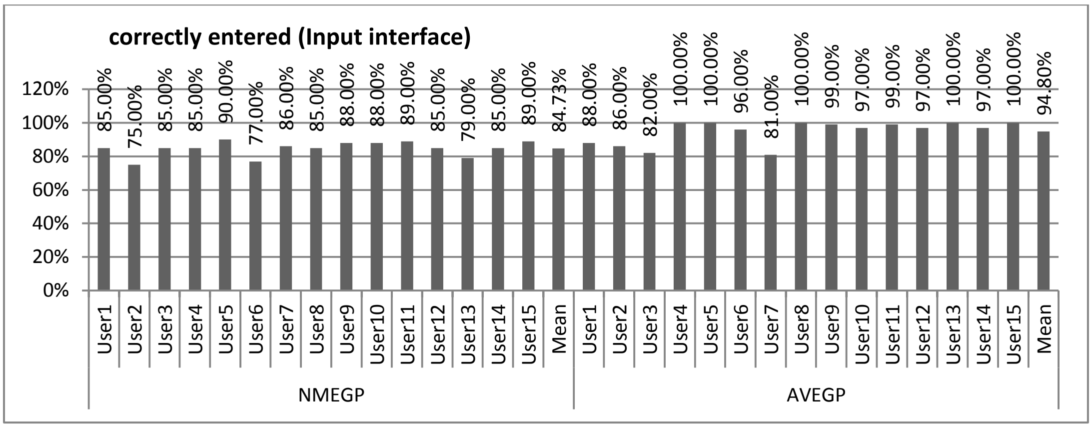


Figure 3-28: Percentage of correctly entered messages achieved by individual users in both groups, for the input interface.

Figure 3-28 shows the percentage of correctly entered messages achieved by each user in both groups for the NMEGP and AVEGP. The experimental group outperformed their counterparts in the control group, in terms of the number of messages entered correctly when using the input interface. The most successful result was in the experimental group, where users 6, 8, 9, 11, 12, 15, achieved 100%. The most successful result was in the control group, where users 6, 14 achieved a success rate 100%. User 9 had the worst success rate (71%). The average test result of correctly entered messages for users in the experimental group was 97%, compared to 85% for users in the control group.

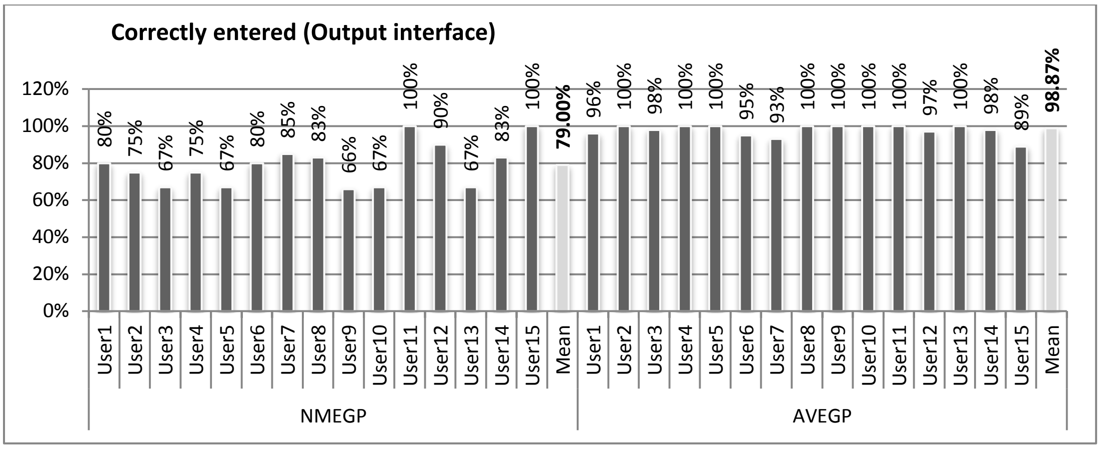


Figure 3-29: Percentage of correctly entered messages for individual users in both groups using the output interface.

However, Figure 3-29 shows the percentage of correctly entered messages achieved by each user for both groups (NMEGP and AVEGP) when using the output interface. The highest results in the experimental group were 100% (users 2, 4, 5, 8, 9, 10, 11, 12, 13) and the lowest result was 93% (user 7). The highest result in the control group was 100% (users 11, 15). The lowest result (user 9) was 66%. On average, the correctly entered messages for users in the experimental group were 97.73%, compared to 81.27% in the control group. This means that users in the experimental group performed more successfully when using new multimodal metaphors, as the avatar helped to communicate the messages to the users.

3.6.6 User Satisfaction

User satisfaction in considering different aspects of the applied e-government condition 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. These questions considered the following areas: (Q1), complexity (Q2), the quality of the communication channel (Q3), difficult to use (Q4), ease of communication (Q5), degree of confusion (Q6), satisfaction (Q7), nervousness (Q8), ease of identification of the information message (Q9), and overall satisfaction (Q10).

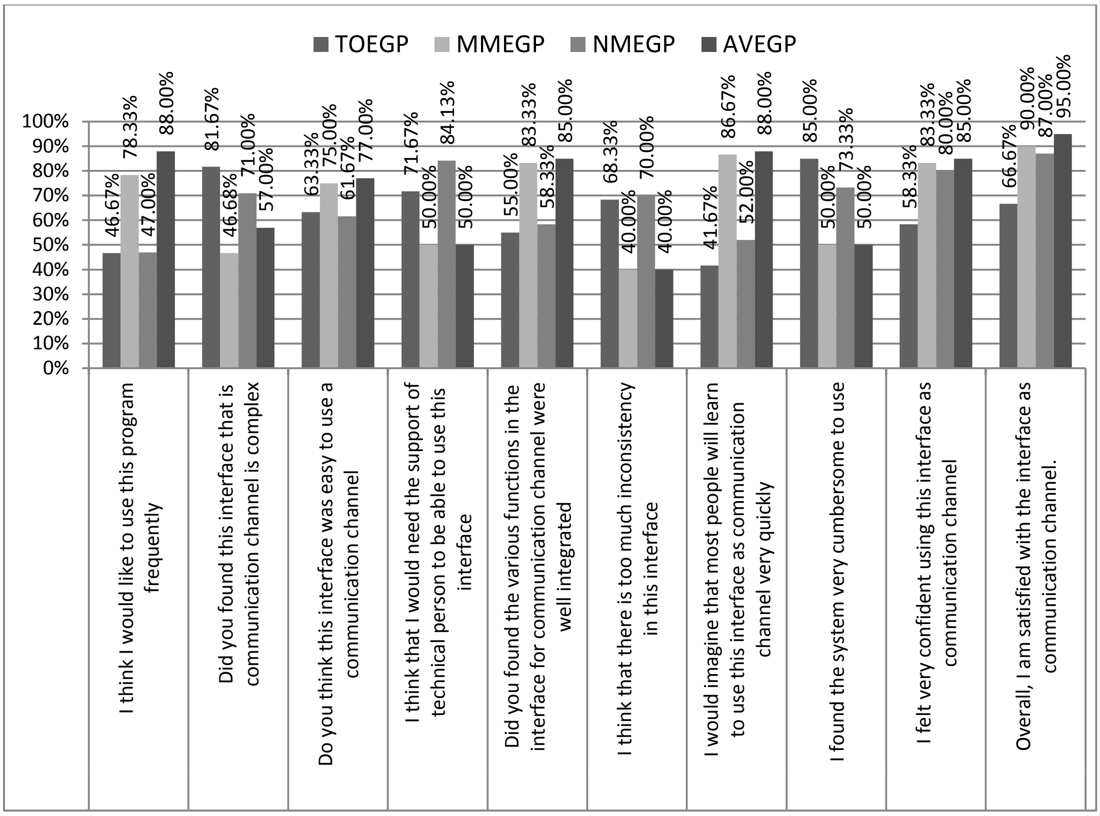


Figure 3-30: Percentage of users agreeing to each statement of satisfaction, for both TOEGP and MMEGP groups.

The four-point Liker scale ranging from 1, the value of strong disagreement, to 4, the value of strong agreement was used for each statement. Each user's overall satisfaction score was calculated using the SUS (System Usability Scale) method [143]. The mean satisfaction score for the users in the experimental group was 90%, compared to 66.67% for the users in the control group. In other words, the MMEGP was more satisfactory for users than the TOEGP.

Figure 3-30 shows the percentage of users agreeing to each statement as it relates to questionnaire on satisfaction (refer to the Appendix for users' responses to the satisfaction questionnaire). In the initial statement (Q1), 78.33% of users in the experimental group agreed that the e-government interface tested was easy to use. The next statement (Q2) asked the users whether they found the interface to be complex to use. In this regard, users of the

MMEGP expressed a lower level of disagreement 47% than the users of the TOEGP 82%. A high level of agreement was observed for Q1, but a low level of agreement was observed for Q3, where only 11% of the users in each group thought there was good communication during the interaction with the tested interface. However, users found the MMEGP to be less difficult (Q4). 83% of users in the experimental group found the communication to be easy (Q5). Conversely, users found the MMEGP to be less confusing (Q6 and Q7). All of the MMEGP users believed that most people will learn the use the tool quickly, compared to 42% who agreed with this statement in the TOEGP group. Also nervousness levels (Q8) were higher in the control group (85%) - 50% in the experimental group. Additionally, users' agreement in the experimental group was evidently higher, in comparison to the control group, in terms of the aspects connected to the communication channel (Q9). Overall, there was a general satisfaction shown from the entire cohort of experimental group users in relation to their satisfaction with the tested interface (Q10) whereas fewer (67%) were satisfied with the control group. In brief, the use of multimodal metaphors to convey the message results in positive views of users. Therefore, the multimodal e-government interface can be considered more satisfactory than a text-based one.

However, in the statement (Q1), 88.33% of users in the experimental group agreed that the e-government interface tested was easy to use. The next statement (Q2) asked the users whether they found the interface to be complex to use. In this regard, users of the AVEGP expressed a lower level of disagreement 56.67% than the users of the NMEGP 71.67%. A high level of agreement was observed for Q1, but a low level of agreement was observed for Q3, where only 14% of the users in each group thought there was good communication during interaction with the interface. However, users found the AVEGP to be less difficult (Q4). 83% of users in the experimental group found communication to be easy (Q5). Conversely, users found the AVEGP to be less confusing (Q6 and Q7). All of the AVEGP users believed that most people will learn to use the tool quickly, compared to 51.67% who agreed with this statement in the NMEGP group. Also nervousness levels (Q8) were higher in the control group (73.33%) - 50% in the experimental group. Additionally, users' agreement in the experimental group was higher, in comparison to the control group, in terms of the aspects connected to the communication channel (Q9). Overall, all users in the experimental group were satisfied with the tested interface (Q10), whereas fewer (87%) were satisfied with the control group. In brief, the use of new multimodal metaphors to convey the message results in positive views from users. Therefore, the new multimodal e-government interface with avatar can be considered more satisfactory than recorded speech only.

3.6.7 Discussion

The current study investigated the usability of a multimodal e-government interface to improve communication performance, as opposed to a text based version. The results from the study have been used in the comparison of the two interfaces in terms to analyse effectiveness, efficiency and user satisfaction. Also of focus to the studies were the factors affecting the role of multimodal interaction metaphors, like the message type (suggestion, complaint, comment) the message complexity level (easy, moderate and difficult) and the question type (recall and recognition).

Connection Properties: Discussion of the results originates from the three angles identified below, with a view to acquire an insight into the significance of the contributions made by the use of multimodal metaphors pertaining to user effectiveness, efficiency and satisfaction.

1. Time taken to, enter message task and to answer question type for both input and output interfaces.

2. The number of correctly entered message tasks for both input and output interfaces.

3. User satisfaction and experience with both of the e-government interfaces tested.

Although the text interface presented simpler classical interactions, results obtained showed that the use of multimodal metaphors (recorded speech) did not significantly improve the efficiency and effectiveness of the response from users using the e-government input interface between both groups TOEGP and MMEGP. It was significantly through correctly entered messages measure. On the other hand, multimodal metaphors improved users' efficiency and effective when used in the output interface, compared to a text based approach for communicating the message content. However the use of new multimodal metaphors (avatar) did not significantly improve the efficiency of tasks, but they were more effective for users using the e-government input interface between both groups NMEGP and AVEGP. On the other hand, new multimodal metaphors with avatar improved users' efficiency and effective when used in the output interface, compared to the recorded speech and earcons approach for communicating the message content.

3.6.7.1 Message and Question Answering Time

The first hypothesis assumed that the multimodal e-government interface will be more efficient than the text based one regarding the efficiency of users to enter messages and to answer the required tasks in both input and output interfaces. The experimental results, as shown in Figure 3-12, demonstrate that using the multimodal interaction metaphors results in an increase in the time needed by users in the experimental group to enter messages in the input interface. There was a significant reduction in the time needed by users in the experimental group to respond to the evaluation questions in the output interface, as shown in Figure 3-13. The main reason behind this is that the requirements in the experimental group were more than those in the control group. The inclusion of different multimodal communication metaphors in the MMEGP assisted user concentration pertaining to the information presented via the auditory channel, while simultaneously using the visual channel to aid in the understanding of this information through output interface. On the other hand, experimental observations revealed that users in the control group took less time because they were only required to enter text, unlike users in the other experimental group which were required to record speech as well as enter text [147]. Therefore, users in the control group were significantly aided by the addition of these metaphors in the MMEGP, in terms of spending less answering time than users of the TOEGP when using the output interface. These results suggest that the use of recorded speech can significantly improve efficiency than the use of text only metaphors in presenting information. In this experiment, thus accepting what has been hypothesized in H1 in terms output interface. But is not acceptable in the input interface.

With regard to message complexity, it was estimated, as stated in H2, that the MMEGP is more efficient than the TOEGP with an increasing level of complexity. As shown Figure 3-13, there was a difference in answering message time in favour of the experimental group, when the required questions become more difficult for the output interface. On the other hand, for less complex tasks, the control group took less time to enter messages (see Figure 3-12) in the input interface. Multimodal metaphors could be used to extend the ability of user's to process both verbal (auditory) and non-verbal (visual) information proved through the use of the output interface. Consequently, the experimental outcome indicated that multimodal metaphors improved users' efficiency, as users of the MMEGP responded significantly faster to the required easy, moderate and difficult evaluation questions. This supports H2 for the output interface. In brief, the experimental evidence shows that the efficiency of the multimodal metaphors can have an influence imposed on it by the level of complexity ingrained within the communicated messages.

When considering the message type, it was predicted in the third hypothesis that the MMEGP would have greater levels of efficiency for both groups. For the most part, these experimental findings were indicative of the fact that adding multimodal metaphors to the MMEGP helped users when using the output interface. When users use the input interface for TOEGP, they are only required to enter text in the control group but in the experimental group they are required to enter text and recorded speech when using the input interface.

The fourth hypothesis predicted that the MMEGP have greater levels of efficiency for both recognition and recall questions than the output interface. The experimental findings were largely indicative of the fact that adding multimodal metaphors, as demonstrated in the MMEGP, played a pivotal role in the contribution to memory recall activities. Figure 3-13 shows the answering time grouped by the question type. The questions were designed to be of two different types; recall and recognition. Overall, the answering time for the experimental group was lower for both types of questions, as opposed to the answering time for the control group. The recall questions took a short time to answer in comparison with the recognition questions. Overall, H4 was supported for recall and recognition questions measure and it can be said that the effect of the multimodal metaphors on answering time is limited to memory recall activities.

On the other hand the third hypothesis assumed that the new multimodal e-government interface will be more efficient than the record speech based one regarding the efficiency of users to enter messages and to answer the required tasks in both input and output interfaces. The experimental results, as shown in Figure 3-12, demonstrate that using the new multimodal interaction metaphors results in an increase in the time needed by users in the experimental group to enter messages in the input interface. There was a significant reduction in the time needed by users in the experimental group to respond to the evaluation questions in the output interface, as shown in Figure 3-13. The main reason behind this is that they must generate avatar visual-audio for each task and most users watch the avatar more than once to show the message, so tasks take more time in the input interface. The inclusion of different multimodal communication metaphors in the AVEGP assisted user concentration pertaining to the information presented via the visual-audio channel, while simultaneously using the auditory channel to aid in the understanding of this information through output interface. On the other hand, experimental observations revealed that users in the experimental group took less time because they were concentrating on the avatar as visual-audio channel. Therefore, users in the experimental group were significantly aided by the addition of these metaphors in the AVEGP, in terms of spending less answering time than users of the NMEGP when using the output interface. These results suggest that the use of the avatar can significantly improve efficiency than the use of earcons and recorded speech metaphors in presenting information. In this experiment, thus accepting what has been hypothesized in H1 and H2 and H3, in terms output interface. However, the hypothesis is not true for the input interface.

The fifth and sixth hypothesis predicted that the AVEGP would have higher levels of efficiency for both recognition and recall questions than the output interface. The experimental findings were largely indicative of the fact that adding multimodal metaphors, as demonstrated in the AVEGP, played a crucial role in the contribution to memory recall activities. Figure 3-13 shows the answering time grouped by the question type. The questions were designed to be of two different types; recall and recognition. Overall, the answering time for the experimental group was lower for both types of questions, as opposed to the answering time for the control group. The recall questions took a short time to answer in comparison with the recognition questions. Overall, H4 was supported for recall and recognition questions measure and it can be deduced that the alleged effect on answering time as a result of the multimodal metaphors is limited to activities concerning memory recall.

3.6.7.2 Correctness of messages

It was probable that MMEGP users will outperform TOEGP users in relation to the number of correctly entered messages and correctly answered questions. As shown in Figure 3-18, the TOEGP was better than the MMEGP for reducing the number of mouse clicks used. This was due to the requirement for the control group only to enter text in the input interface. A key requirement for the experimental group was the recording of speech and entering of text in the output interface. Multimodal metaphors also helped users to differentiate between the various types of provided information. Information retention was improved as each metaphor assisted users in remembering information for extended periods of time. The multimedia principle is responsible for this effect, where other human senses are involved coupled with the audio channel in the process of interaction. This effect can assist in the extension of the communication performance capacity and, following on from that, the ability of the users in perceiving and understanding the information presented. As the experimental group users were able to retain the communicated information for an extended period of time (in comparison with the control group), this allowed them to score a considerably greater number of correct answers than the control group equivalents. In addition, the correctly entered test shows 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. These findings confirmed the assumptions made in H5, in terms of the output interface but opposed the hypothesis for the input interface

In terms of message complexity, it was hypothesized that the MMEGP will be more effective than the TOEGP with the increasing difficulty of the tasks required to enter the messages and questions in both interfaces. In this regard, the obtained results (refer to Figure 3-12, Figure 3-13) were similar to those observed for efficiency and therefore supported H2. Although the TOEGP outperformed the MMEGP, in terms of the success rate to enter messages of difficult tasks for the input interface, the influence of the multimodal metaphors reached a significant level in for the output interface. These findings confirm the effect of multimodal metaphors, with increased complexity tasks and demonstrate that users' performance can be improved by the incorporation of these metaphors in e-government interfaces. In other words, the complexity level of the presented message content can influence the effectiveness and the efficiency of the tested multimodality in e-government interfaces. This has been experimentally proved for the output interface.

For message type, H7 suggested that the MMEGP will be more effective than the TOEGP when users are required to enter message and questions in both interfaces. In this regard, from the results obtained (refer to Figure 3-18, Figure 3-19), it can be found that users of the TOEGP performed better than those of the MMEGP in both group for different message type tasks but the difference between the two groups was larger in terms of the total number of mouse clicks. As mentioned earlier, this was because the requirements of the experimental group were greater, in terms of the input message tasks. On the other hand, the correctly answered message tasks in the experimental group required less clicks than those for the control group. The experimental group took less time and fewer clicks.

In view of the question type, the experimental results proved H8. Users of the MMEGP accomplished a substantially larger number of correct answers than users of the TOEGP in both recall and recognition questions. In order to successfully answer the recall questions, users had to correctly retrieve from their memory part of the communicated messaging content. The results of this experiment indicated that multimodal metaphors enabled users to understand the questions better, without distracting their attention away from the presented content. The correctly entered test measure (Figure 3-20) shows the low correctness rate of recall and recognition questions for the TOEGP (56% compared to 98% for the MMEGP). This demonstrates that users' memory was not aided when they used the text interface, in comparison to the multimodal interface. In short, the results recommend the use of multimedia metaphors to facilitate the performance of users in each activity for recall and recognition tasks in the MMEGP.

However users AVEGP will outperform users of NMEGP in terms of the number of correctly entered messages and correctly answered questions. As shown in Figure 3-20, Figure 3-21the AVEGP was better than the NMEGP for reducing the number of mouse clicks used. This was the result of using the avatar in the input interface for the experimental group, in comparison to using recorded speech to convey messages for the control group. New multimodal metaphors also assisted users in differentiating between the various types of information provided. The metaphors, each of them provided them with the ability to increase their retention of the information. This effect is due to the multimedia principle of the involvement of other human senses, in addition to the visual-audio channel, as presented in the process of interaction. This effect can help to extend the capacity of working memory and as a result increase the users' ability to perceive and understand the information presented. As the experimental group users were able to retain the communicated information for an extended period of time (in comparison with the control group), this allowed them to score a considerably greater number of correct answers than the control group equivalents. In addition, the test for correctly entered messages shows the new multimodal interaction metaphors used in the AVEGP 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. These findings confirmed the assumptions made in H4, in terms of the output interface but opposed the hypothesis for the input and output interfaces. In view of the question type, the experimental results proved H5 and H6. Users of the AVEGP accomplished a substantially larger number of correct answers than users of the NMEGP in both recall and recognition questions. In order to successfully answer the recall questions, users had to correctly retrieve from their memory part of the communicated messaging content. The results of this experiment indicated that new multimodal metaphors enabled users to understand the questions better, without distracting their attention away from the presented content. The correctly entered test measure

(Figure 3-21) shows the low correctness rate of recall and recognition questions for the NMEGP (98% compared to 100% for the AVEGP). This demonstrates that users' memory was not aided when they used the record speech interface, in comparison to the new multimodal interface. In short, the results recommend the use of new multimedia metaphors to facilitate the performance of users in each activity for recall and recognition tasks in the AVEGP.

3.6.7.3 User Satisfaction

On the whole, it was anticipated that users of the MMEGP would have a greater level of satisfaction than the users of the TOEGP. Consistent with this assumption, a significant leverage of satisfaction was displayed in the multimodal presentation of the message content in the MMEGP over the text interface in the TOEGP. It is evident that the use of recorded speech is both interesting and attractive for the users participating in the experimental group, due to the fact that they expressed approval in relation to the audio-visual communication featured in the message content. Although both of the e-government interfaces tested were considered easy to use, neither was considered too confusing or nerve-racking. The results obtained were not demonstrative of a remarkable difference between both groups of users regarding these satisfaction features (refer to Q1 to Q6 in Figure 38. However, a larger difference was observed for statements related to communication (refer to Q7 to Q10 in Figure 3-30). These results were derivatives of two independent groups and, in order to formulate an informed comparison, users participating in those two groups were restricted in being presented for both interface conditions. However, it should be noted that users participating in the experimental group might have had previous experience with and exposure to typical government interfaces (refer to Figure 3-11), and this may have possibly served as a valid point of comparison. Naturally, users in the experimental group believed that their communication with the government was improved and aided by the multimodal metaphors. It was easier for them to identify the messaging information, which was communicated by earcons and speech, respectively. On its own, this result proves to be inconclusive; due to the basis of the result being on a subjective user rating system, coupled with the fact that the typical difference in mean is not great enough (even in the instance where the overall satisfaction results reached a statistical significance). As the satisfaction, efficiency and effectiveness results are similar to each other, it is strongly argued that assistance was provided to the experimental group users through the use of the multimodal metaphors. Therefore, it can be confidently deduced that the e-government assisted by multimodal metaphors, has a higher probability of generating both an agreeable and satisfying user experience. Connections are made with this experience and its ability to finalise and complete message tasks quickly and accurately. To summarise, the general outcomes of this experimental study suggests the significance of the multimodal interaction metaphors tested in the development and enhancement of the users' messaging performance along with e-government interface usability in relation to effectiveness, efficiency and user satisfaction.

On the other hand, AVEGP users would experience greater levels of satisfaction than NMEGP users. Consistent with this assumption, a significant leverage of satisfaction was displayed in the multimodal presentation of the message content in the AVEGP over the record speech interface in the NMEGP. It is evident that the use of the avatar approach is both interesting and attractive for the users participating in the experimental group, due to the fact that they expressed approval in relation to the audio-visual communication featured in the message content. Although both of the e-government interfaces tested were considered easy to use, neither was considered too confusing or nerve-racking. The results obtained were not demonstrative of a remarkable difference between both groups of users regarding these satisfaction features (refer to Q1 to Q6 in Figure 3-30). However, a larger difference was observed for statements related to communication (refer to Q7 to Q10 in Figure 3-30). These results were derivatives of two independent groups and, in order to formulate an informed comparison, users participating in those two groups were restricted in being presented for both interface conditions. However, it should be noted that users participating in the experimental group might have had previous experience with and exposure to typical government interfaces (refer to Figure 3-11), and this may have possibly served as a valid point of comparison. Naturally, users in the experimental group believed that their communication with the government was improved and aided by the multimodal metaphors. It was easier for them to identify the messaging information, which was communicated by the avatar. On its own, this result proves to be inconclusive; due to the basis of the result being on a subjective user rating system, coupled with the fact that the typical difference in mean is not great enough (even in the instance where the overall satisfaction results reached a statistical significance). As the satisfaction, efficiency and effectiveness results are similar to each other, it is strongly argued that assistance was provided to the experimental group users through the use of the multimodal metaphors. Therefore, it can be confidently deduced that the e-government assisted by multimodal metaphors, has a higher probability of generating both an agreeable and satisfying user experience. Connections are made with this experience and its ability to finalise and complete message tasks quickly and accurately. To summarise, the general outcomes of this experimental study suggests the significance of the multimodal interaction metaphors tested in the development and enhancement of the users' messaging performance along with e-government interface usability in relation to effectiveness, efficiency and user satisfaction.

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. In other words, we 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 in term to use this interface in the future. It is therefore proposed to include multimodal metaphors in e-government interfaces and this need to be taken in mind when designing such interfaces.

The e-government interface is gaining the 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. That is why these studies will focuses on the investigation of usability which is an important factor in the improvement of e-government interfaces for the provision of high quality government services.

In addition, the multimodal metaphors play a key role in enhancing usability along with messaging performance in the AVEGP. In some measure, the results of the experiment (see Figure 3-12, Figure 3-13and Figure 3-18, Figure 3-19, Figure 3-20 and Figure 3-21) indicated that the interaction between the sender and receiver for messages was good. However, this evidence is not sufficient to determine how the avatar contributed to improving the results. This study investigated users' attitude towards facial expressions that can be incorporated in avatars when employed as virtual message. But we need further studies to identify whether the improved interaction between the sender and receiver is significant. Therefore, preparations have been made for the successive experiment (as outlined in Chapter 4) to consider full body gestures, the usability (in relation to effectiveness, efficiency and user satisfaction) of virtual message in e-government interfaces, as well as to obtain users' feedback in relation to the use of specific gestures full body used in these interfaces.

3.7 Summary

Examine the impact of new multimodal interaction metaphors for ease of use, in terms of efficiency, effectiveness and user satisfaction and the communication performance of the e-government interfaces. These studies have been implemented by developing fourth different conditions of the experimental e-government condition. The first experiment was used first condition was based on the use of text with graph by TOEGP to present the messaging content between the sender and receiver. The second condition was concerned with using a combination of new multimodal metaphors (recorded speech and text with graph) via MMEGP to supply the same messaging content. In addition was used third condition was based on the use of recorded speech and earcons and icons and text with graph by NMEGP to present the messaging content between the sender and receiver. The fourth condition was concerned with using a combination of new multimodal metaphors (avatar) via AVEGP to supply the same messaging content. Together, an empirical evaluation of e-government conditions was then carried out by two independent groups of users. By performing common tasks and answering a set of message evaluation questions. The results obtained from these experiments 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. In other words, we conclude that the new 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. The e-government interface is gaining the popularity among the providers of e-government services. Its importance from the users' point of view has become the main concern for e-government service providers. This is why this chapter has focused on investigating the usability which is an important factor for the improvement of e-government interfaces for the provision of high quality government services.

CHAPTER 4
INVESTIGATING THE ROLE OF FULL BODY AVATARS IN MULTIMODAL E-GOVERNMENT INTERFACES

4.1 Introduction

Chapter 3 verified how the use of avatars to send messages outperformed the use of audio in terms of enhancing the usability of e-government interfaces and improving communication performance. On the other hand, the role of avatar was found to be limited to decide how the avatar contributed to improving the results or of the message arrives in its correct form. This study investigated users' attitudes toward facial expressions that can be incorporated in avatars when employed as virtual messengers. However, we need to identify whether the improved interaction between the sender and receiver is more significant and measure how to increase users trust. This chapter therefore investigates whether the addition of avatar with full body gestures, when comparing to facially expressive avatars with three conditions could contribute to supporting the influence of avatar type of messaging. This investigation could help in revealing the role that avatar body gestures could play in multimodal e-government interfaces.

4.2 Aims and Objectives

One of the main aims of this experiment was the evaluation of the usability (in relation to effectiveness, efficiency and user satisfaction) and communication performance, as well as the perception of trust in e-government interfaces, incorporating the use of full body animated avatars in virtual message presentation. In particular, it is focused on the evaluation of both the effectiveness and efficiency of visual-audio in communicating supportive auditory messages associated with the live message presented by a full-body animated avatar. Furthermore, this experiment is targeted at measuring users' satisfaction and users' trust in relation to the applied e-government interface. Additionally, this experiment is directed at evaluating the users' performance in responding to the required experimental messaging activities.

To secure the accomplishment of the aforementioned aims, the achievement of the following objectives are critical:

1. Development of an e-government condition (experimental) which enables the employment of avatars with full body gestures in a analogous way to that applied in the previous experiment to communicate specific features of presented content messaging. This condition has been referred to as Avatar enhanced Virtual Message with Body Gestures Condition (VMBG).
2. Independent testing of the two experimental e-government conditions by two variant groups of users.
3. Measurement of the tested conditions efficiency by the time users spent in completing the required tasks.
4. Measuring the effectiveness (as well as users' performance) through the calculation of the number of tasks successfully answered by users as a percentage, in a bid to measure and determine the effectiveness of the tested e-government condition, and users' communicating performance.
5. Measurement of user satisfaction by their responses to questionnaires prepared in order to determine and assess users' attitudes as it relates to the application of the e-government condition.
6. Measurement of users' trust by their responses to questionnaires prepared in order to determine and assess users' attitudes as it relates to the application of the e-government condition.

4.3 Hypotheses

Theoretically, it was suggested that adding an avatar in VMBG would impact the stage involving usability, as well as users' communication abilities when using the VMBG e-government condition. The following hypotheses were derived based on this assumption:

H1: The addition of the avatar will enhance the effectiveness of the VMBG in terms of tasks correctly completed and communication performance of both interfaces input and output.

H2: Positive views will be expressed by users of the VMBG towards the use of avatar in terms convenience, disappointment? Cooperation, focus and understanding.

H3: Users of the VMBG will successfully remember the key features of the content of messaging when communicating by avatar.

H4: On overall, users will be satisfied with the VMBG.

H5: On overall, users will be trusted with the VMBG.

4.4 Experimental condition

The AVEGP condition used in previous experimental work better verified performance compared to NMEGP regarding both usability and users' accomplishment levels. This was noticeable in all tasks. However, AVEGP was found to be as usable with respect to both efficiency and effectiveness in all tasks. The need for the AVEGP condition to be further enhanced was established by these experimental outcomes, in order to investigate if adding visual-audio or sound and image stimuli could enhance users 'performance in all tasks. Consequently, the e-government condition of an experimental nature VMBG enlisted in order to conduct this investigation, having replicated and extended the VMFE by involving the avatar to capture the users' attention towards the most important parts of the message information when delivered by full-body animation as a virtual message.

It should be noted that the VMFE uses speaking avatars with human-like facial expressions when communicating all types of information. On the other hand, the information communicated in the VMBG interface was based on speaking avatars with human-like full body gestures, in which different interaction metaphors were used to support the delivery of different types of communication enhancement.

In summary, the VMFE used speaking avatars with human-like facial expressions, whereas the VMBG interface was based on speaking avatars with human-like full body gestures. Which is better comparison among them in delivering the message and using avatars in this way, it is possible to imitate, to a great extent, the typical interaction involving face-to-face communication which traditionally occurs between the sender and the receiver of the message and it would be appropriate in the VMBG.

4.5 Virtual Message with Facial Expressions Condition (VMFE)

Figure 4-1, Figure 4-2 illustrates an example screenshot of the avatar e-government interface.

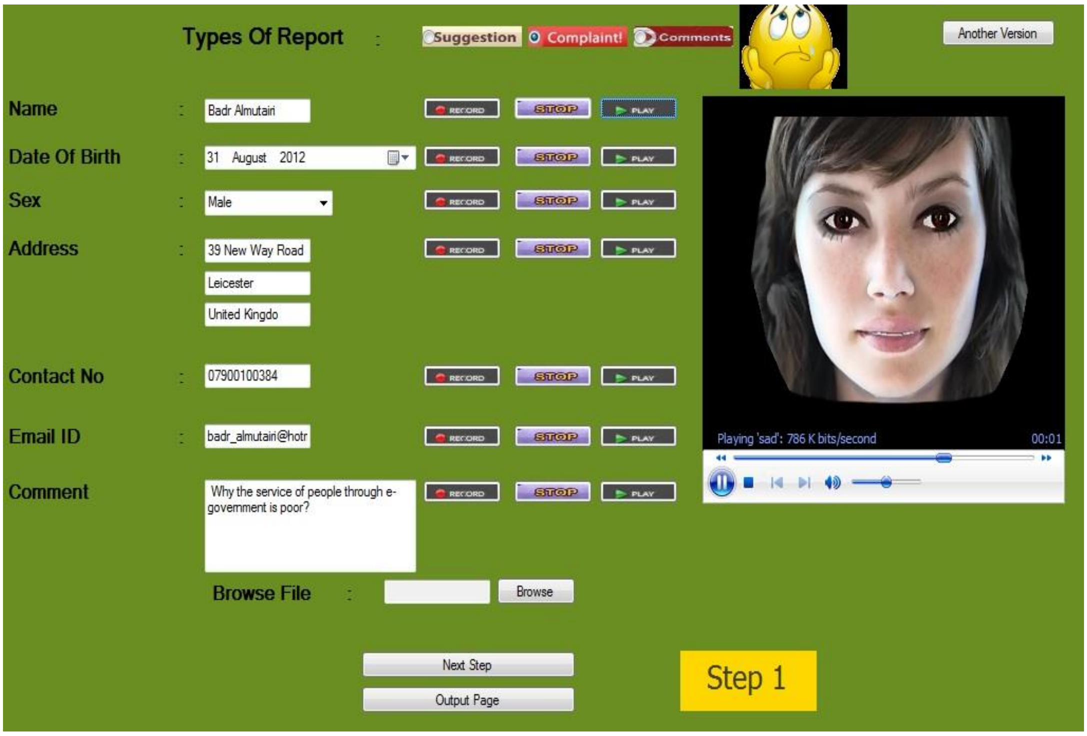


Figure 4-1: Virtual Message with Facial Expressions Condition (VMFE) input interface

This condition, in Figure 4-1Figure 4-2 uses an expressive avatar with facial expressions to enhance the virtual message. The interface provides command buttons to enable the message to be presented. It also provides two separate components for the message process, namely the speaking expressive avatar.

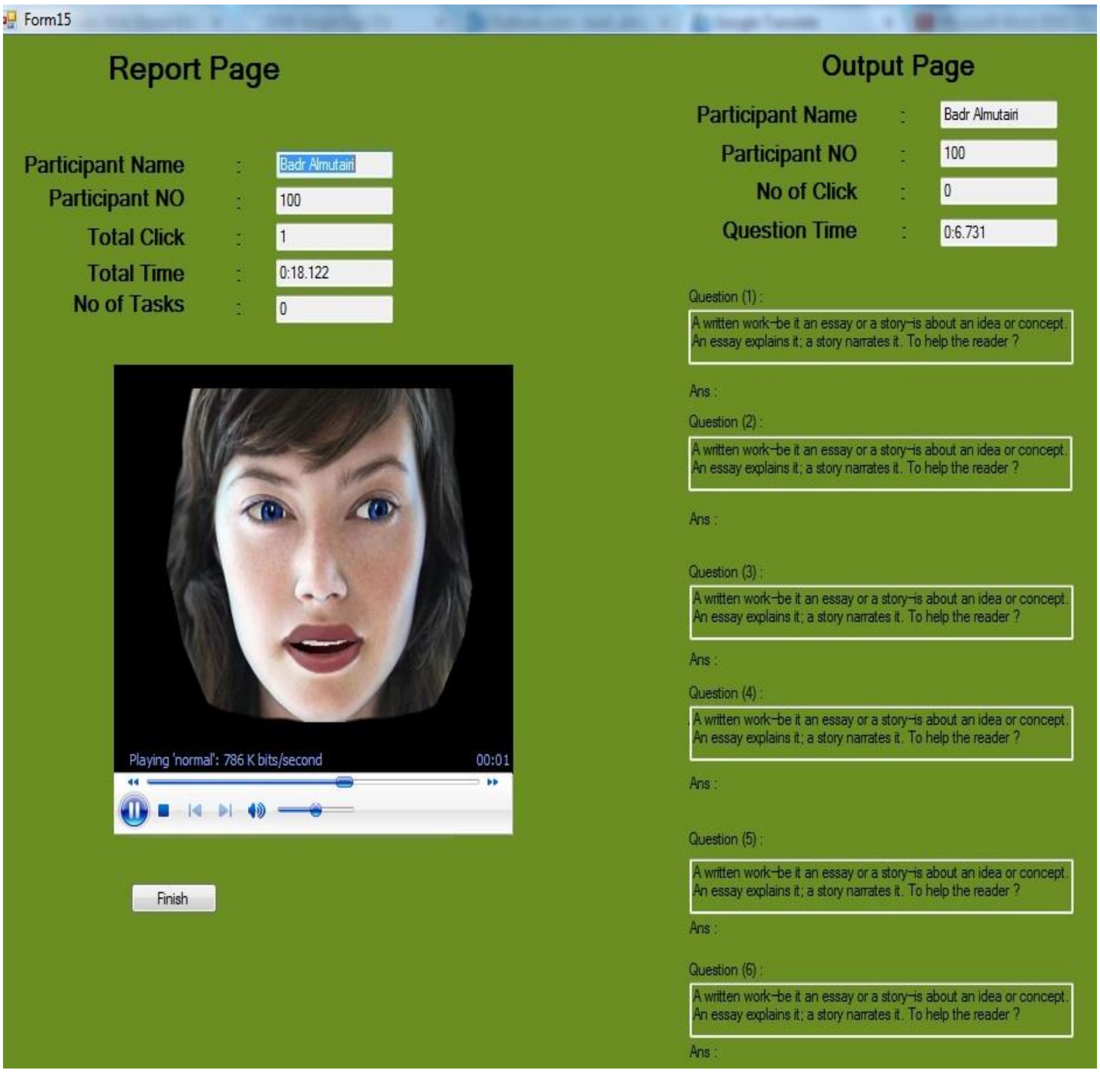


Figure 4-2: Virtual Message with Facial Expressions Condition (VMFE) output interface

When the user clicks the button of a given message, this button starts a speaking expressive avatar. The interface is divided into two parts, the first part for (Input Interface) and second part (Output Interface). These were designed to include the following components: a text box to present the user with information and a speaking expressive avatar box. There is a statement of the problem which is related to the kind of statement chosen (suggestion, comment, complaint).

4.6 Virtual Message with Body Gestures Condition (VMBG)

Figure 4-3Figure 4-4 illustrates an example screenshot of the multimodal e-government interface. This condition employed the speaking and expressive avatar with full body gestures to virtually message the experimental e-government interface. Through this interface anyone can send a message from the e-government interface which is easy to use and enhances the understanding of incoming massages. It was provided by the interface of VMBG condition. Also the same procedure for to send message and asking and answering questions was followed about it.

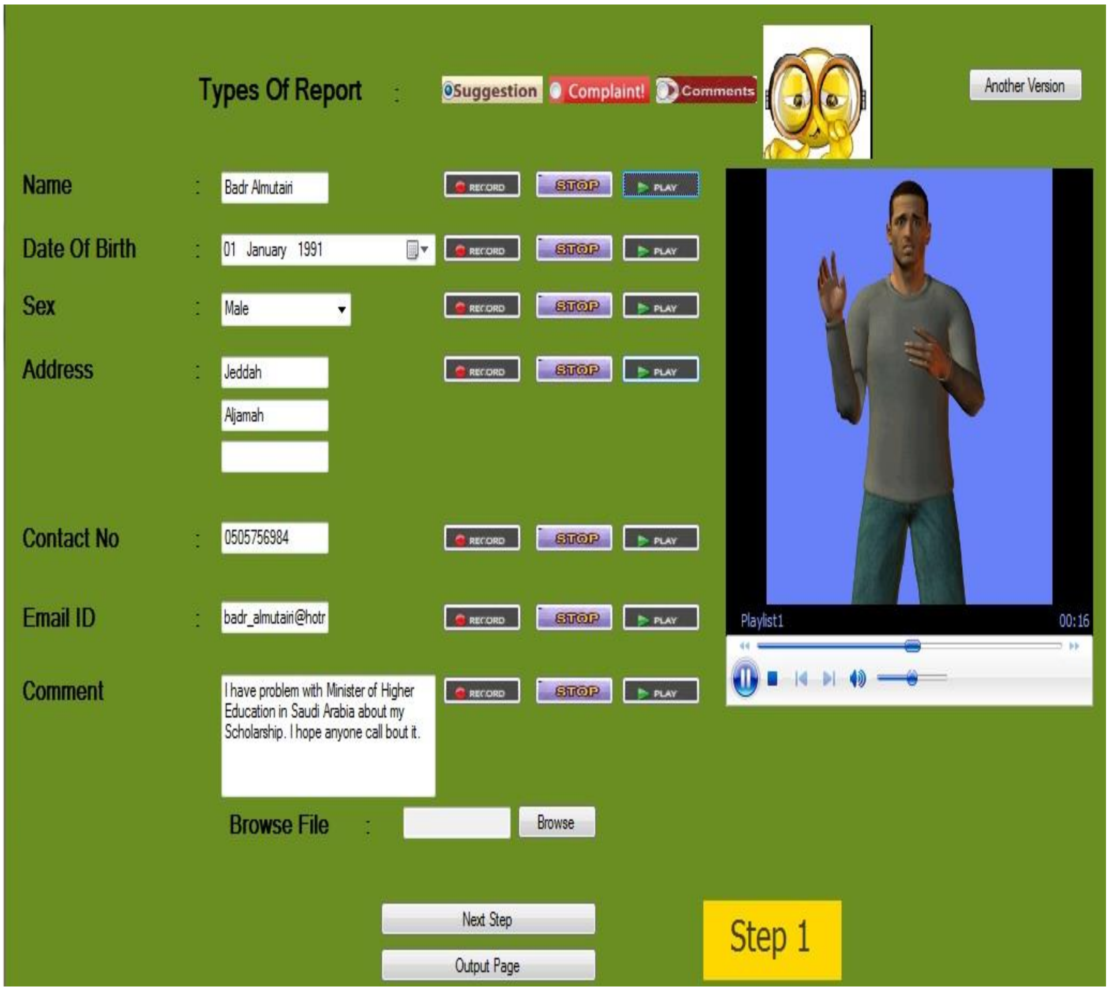


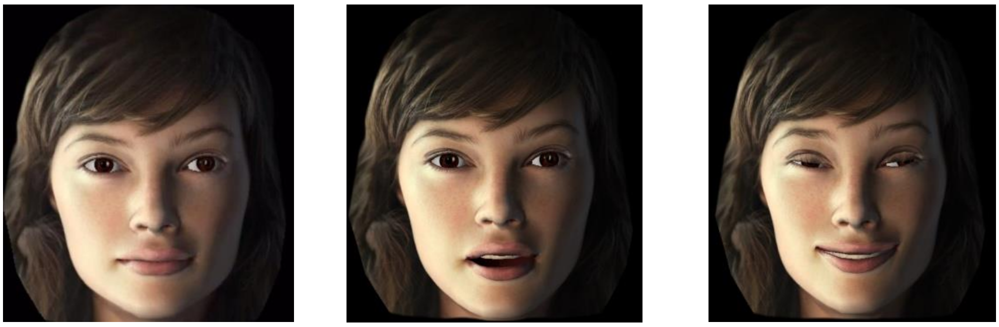
Figure 4-3: An example screenshot of VMBG condition input interface for e-government

Figure 4-4: An example screenshot of VMBG condition output interface for e-government

This approach could be considered as closest to the real message situation because the virtual message was designed to simulate the same body movements usually performed by humans.

4.7 Implementation of Avatars Facial expressions and Avatars full-body

The concept of an avatar can be explained as a multimodal interaction metaphor potentially involving both auditory and visual human senses. It is essentially a computer-based character that has been manipulated to virtually represent one party in an interactive context [113] with the ability to communicate both non-verbal as well as verbal information [115]. Verbal communication refers to the use of speech and written messages whereas nonverbal one can be attained by facial expressions [115].



Neutral Surprise Glad

Figure 4-5: Avatars Facial expressions with three levels used in the experimental e-government conditions

In general, avatars can be classified as abstract, realistic and naturalistic. Avatar is software or tools can be used to allow users to speak about something through live message formats which can be used to give complaints, suggestions or comments. Figures 39, 40 shows examples of Avatar facial expressions and full-body used in the experiment.

The main difficulty that has been confronted through the development of the experimental conditions was in generating the Avatars full-body files needed for Poser files.

Neutral Hands down Hands behind Open Hand Walking

Contemplate Paws opposite Chin Stroking Opposite legs Indicate

Figure 4-6: Avatars full-body used in the experimental e-government conditions

This process took a long time mainly when the number of frames becomes bigger; infrequently, the engine was hanging. Poser Tools were developed to resolve this problem. After that, the avatars full-body files for these parts were joined together using the tools to produce the final presentation and avatar files for each message.

Type of Avatar	Forms	Result	Type of message
Facial Expressions	Glad	Positive	suggestions
	Neutral	Neutral	comments
	Surprise	Negative	complaints
Body Gestures	Hands down, Hands behind, Open Hand, Walking, Paws opposite, Chin Stroking	Positive	suggestions
	Neutral, Contemplate,	Neutral	comments
	Opposite legs, Indicate, Hands down, Hands behind, Open Hand, Walking, Paws opposite, Chin Stroking	Negative	complaints

Table 4-1: Facial expressions and body gestures with three levels used in the third experiment classified according to respectively

Three facial expressions were commonly used in VMFE, whereas 10 body gestures were used in VMBG condition. These expressions and gestures are normally used by people in daily life. In Table 10, facial expressions were classified into three groups; positive, neutral and negative while body gestures were categorized into positive, neutral, and negative [128, 149]. Such as Neutral, Hands down, Hands behind, Open Hand, Walking, Contemplate, Paws opposite, Chin Stroking, Opposite legs, Indicate. When we use body gestures these help us to better explain messages of this evidence on the ability of Avatar Full Body up better than the message with facial expressions, which were limited. More technical details about the development of the experimental e-government conditions are available in Appendix.

4.8 Experimental Design

The thorough design methodology was followed in carrying out this experimental investigation. This design guarantees user sharing in the use of all evaluative systems; so, it brings down the effect of any external factors which may influence user performance from one behaviour to another. Therefore, two groups of users were associated with the assessment of the experimental e-government conditions: VMFE and VMBG. 30 users in total, on an individual basis, have participated in the experiment. This experiment data was collected of three main parts. The first part was the pre-experimental questions for the profiling of users. The second part investigated the users' evaluation (positive or negative or neutral) when using facial expressions or full body gestures in the experiment. Every of these expressions and gestures was shown to users as still images on the screen. In the third part of the experiment, the experimental conditions were demonstrated to users and then used to present the experimental interactively. This element was aimed at getting the users' perceptions of the same expressions and gestures when communicated in an interactive and comparing the experimental e-government conditions in terms of efficiency and effectiveness as well as users' satisfaction and communication performance and perception of trust. In addition, this experiment was used to acquire an overall feedback from users concerning the usefulness of the implemented multimodal metaphors, their preferred experimental condition.

4.9 Variables

Three types of variables were considered in this experiment which were: independent, dependent and controlled variables. The variables controlled in this experiment were similar to those considered in the first experiment (refer to section 3.6.3).

4.9.1 Independent Variables

Independent variables represent the factors manipulated in the experiment and are assumed to be the cause of the results for the presentation of the e-government input interface; avatar facial expression in VMFE and avatar full body gesture in VMBG. (refer to section 3.6.3).

4.9.2 Dependent Variables

These are the variables being measured as a result of manipulating the independent variables. The independent variables regarded in this study are shown in Table 13 and include the following:

Variable Code	Variable	Measure
DV 1	Tasks messaging and question answering time	Efficiency
DV 2	Correctness of enter tasks and answers	Effectiveness and user‘s performance
DV 3	User satisfaction	Satisfaction
DV 4	User trust	perception of trust

Table 4-2: Dependent variables considered in the third experiment

DV 1, DV 2 and DV 3 had taken by users to enter message tasks and to answer the questions, as required in the previous experiment.

DV 4: Perception of trust: While completing the task, users were coached evaluation of its agreement with the relevant data to a trust perception measuring facets of trust (competition of user expectations, user incompetency, previous experience effects, user trustworthiness, user honesty), using a Liker scale. A full explanation of the trust items can be located in Appendix.

4.10 Users Sampling

30 volunteer users in total participated in this study, all of whom were using the experimental condition for the first time. They were both equally and randomly assigned (N = 15) to the experimental conditions. (Refer to section 3.6.1)

4.11 Data Gathering

The process of gathering data was largely based on experimental observations as well as questionnaires. For each task, each user was required to complete nine message tasks and to answer six questions. The time spent to complete the message tasks and to answer each of the six questions was observed to help in measuring the efficiency. However, in order to collect the data related to effectiveness, the correctness of user‘s answers were checked to measure the performance of communications and the total number of successful users who completed the message tasks and answer questions was counted for each user. The pre-experimental section of the questionnaire was dedicated to gathering personal data about users such as age, gender and education. It also helped to obtain data related to users' prior experience in computers, Internet and e-government. Finally, the post-experimental part of the questionnaire was aimed at assessing the users' satisfaction and users' trust with the e-government condition tested. Users' responses to this questionnaire were used to calculate the satisfaction score for each user in both the control and the experimental groups. The perception of trust was influenced by five key statements pertaining to user beliefs on the message honesty, trustworthiness and competency, as well as the matching of expectations and the effect of previous experience. A comprehensive description of pre-experimental, post-task and post-experimental items can be found in the Appendix.

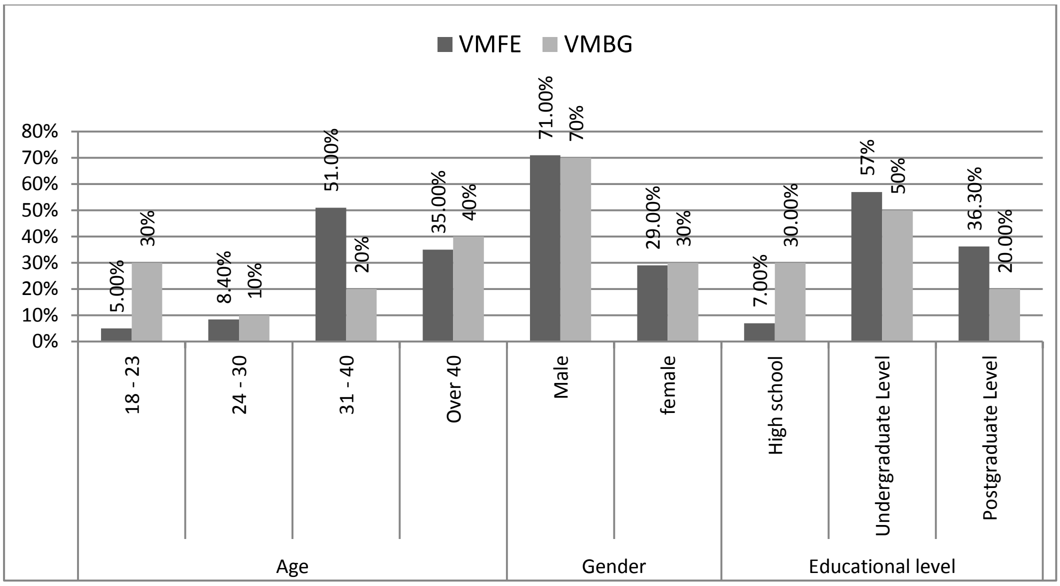


Figure 4-7: Users' profile in terms of age, gender, education level in both control and experimental groups

4.12 User Profiling

The users' personal and educational information, as well as their previous computing knowledge and experience was collected and analyzed on the basis of their responses to the pre-experimental questions (refer to Appendix). Figure 4-7 shows that the age range in the control group was 51 % within 31 – 40, 35% over 40, 8.4% 24 – 30 and 5% 18 – 23 years old. In the experimental group, 40% were over 40, 20% 31 – 40 and 10% 24 – 30 and 30% 18 – 23 years old. The majority of the participants were male (71% in the control group and 70% in the experimental group). The education level was found to be predominantly postgraduates by 36.3% in control group and 20% in the experimental but undergraduates represented 57% in control group and 50% in the experimental. In addition, 7% were from high school in the control group and 30% in the experimental.

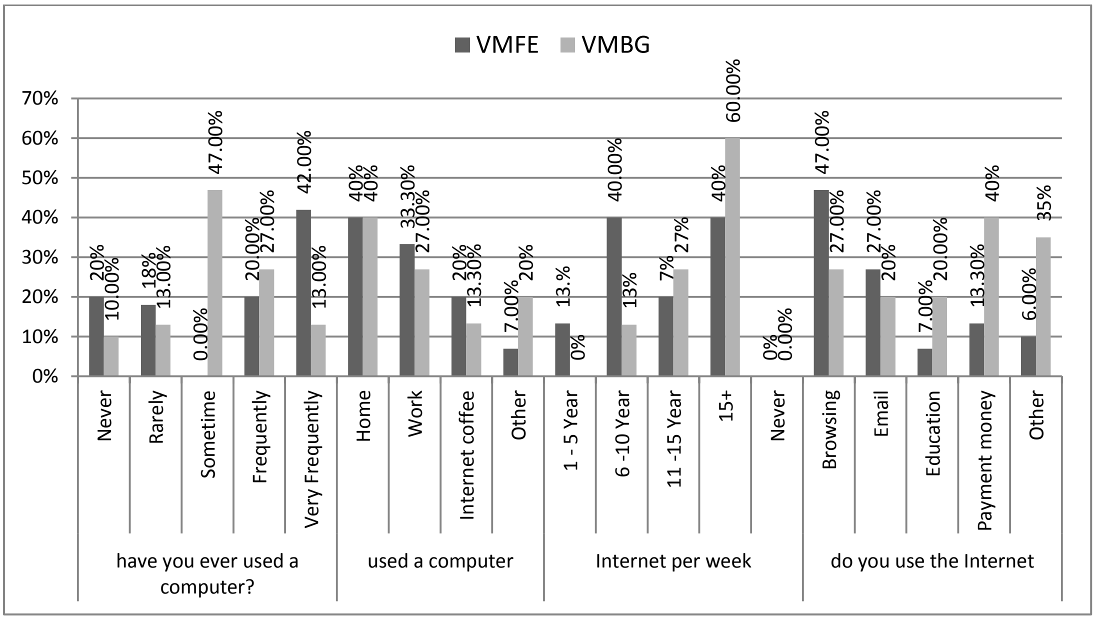


Figure 4-8: Prior experience for users in both control and experimental groups

Figure 4-8, show that most participants are expert users of computers in the control group, 42% very frequently and 13% frequently in the experimental group. Forty percent of the control group use computers from home and 40% in the experimental group. 33.3% of the control group use computers from work and 27% in the experimental. The weekly use of the Internet in the control group is less than fifteen hours a week, compared to hours in both the experimental group and control group. Over 47% use the Internet for browsing in the control group and 7% in the experimental. In addition, less than 7% of the sample users were using the Internet for education. 20% in the experimental group and 27% control groups were using it for email. Finally, Figure 4-8 demonstrates that both groups, to a large extent, were equivalent in terms of users' individual characteristics and prior experience.

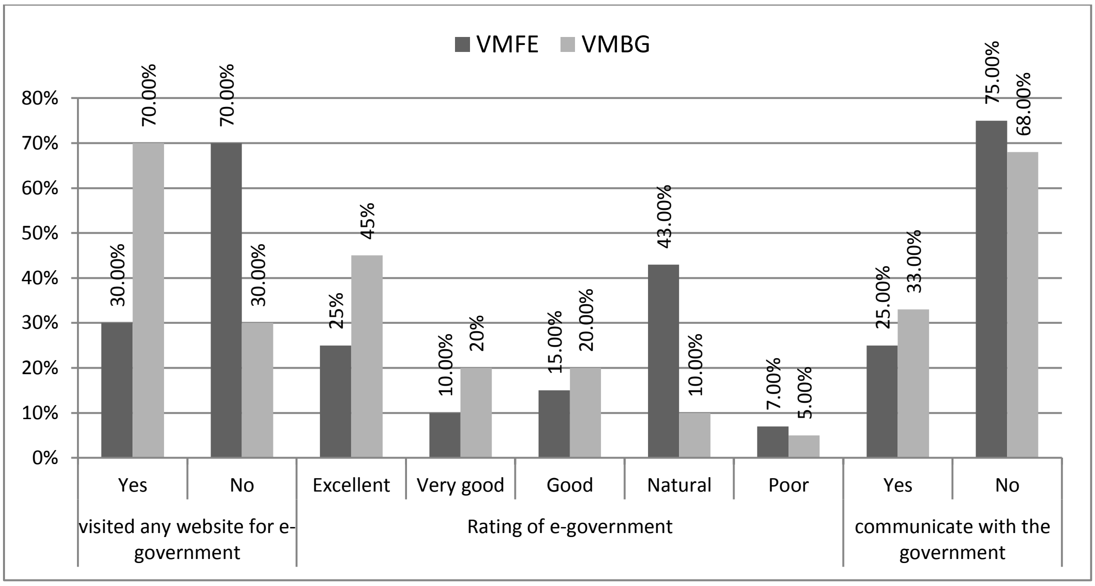


Figure 4-9: Learn how to use e-government for users in both control and experimental groups

Figure 4-9 shows that the experimental group was more experienced in e-government applications in comparison with the control group. Therefore, any differences between the two experimentally obtained results could be attributed to the treatment of the participants.

4.13 Results and Analysis

Both groups' results were analysed in terms of efficiency (time users needed to enter message tasks and answer the required questions), effectiveness (percentage of correctly entered tasks and answered questions), and user satisfaction and user trust (based on a rating scale). For the statistical analysis, the nonparametric Kolmogorov-Smirnov test [145] has been used to test the normal distribution of the results obtained in terms of the tasks attempted and answering time, mouse click, correctly entered task and the satisfaction. If normal distribution was found to be the scope of the data, then the evaluation of the significance of the difference between the two groups in regard to each of these parameters would be underpinned through the use of an independent t-test. The pertinence of this statistical test is apparent when two varying experimental conditions are tested by two independent groups of users. In addition use the Mean Difference that it is a measure of statistical dispersion equal to the average absolute difference of two independent values drawn from a probability distribution [146]. Otherwise, as a non-parametric equivalent of the independent t-test, a Mann-Whitney test was used [144]. Also, a Chi-square test was used for analysis statistically the categorical data [147]. These statistical analyses were carried out at $\alpha = 0.05$ and if p-value was found to be less than 0.05, a significant difference was detected.

4.14 Efficiency

The time taken to perform 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. The control group spent a total of 35 minutes but note that the experimental group spends less time, 28.38 minutes Figure 4-10 shows the mean values of the time taken by all users.

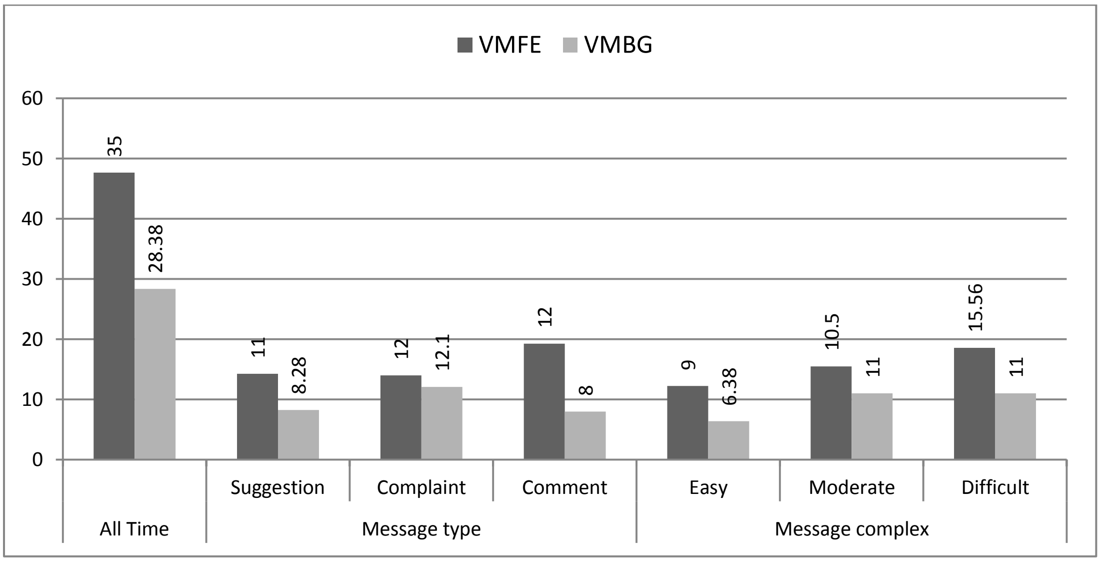


Figure 4-10: Mean values of time taken by users in both groups to enter all tasks, grouped by message complexity and message type for the (Input interface)

The experimental group Figure 4-11 took slightly less time to complete the tasks. Found in use the avatar full body improved efficiency, as tasks took less time - unlike the other groups which took more time to listen and watch from the avatar facial expression interface and read the tasks in the output interface.

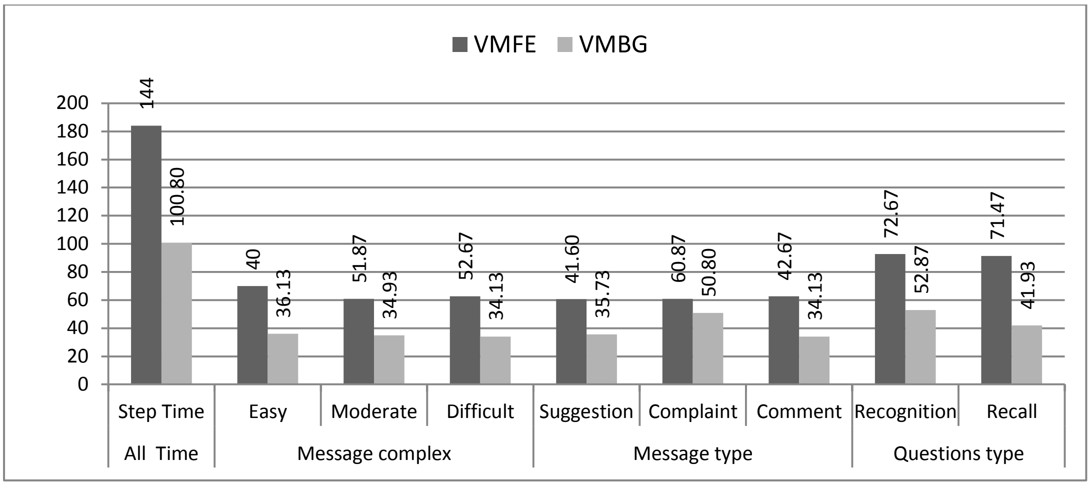


Figure 4-11: Mean values of time taken by users in both groups to enter all tasks, grouped by message complexity and message type for the (output interface).

4.14.1 All Tasks

Figure 4-10, Figure 4-11 shows the mean values of the time taken by users in both groups to enter message tasks for the input interface and answer questions for the output interface. The results are grouped by the message complexity for the input and output interfaces, message types for both interfaces and input and output and question types for the output interface. In Figure 4-10, the message tasks time was lower in the experimental group for all tasks, messages, as well as for each message complexity and message type for the input interface. The raw data for the task times can be found in the Appendix. Each user had to enter nine message tasks using the input interface. The mean time taken to, enter all message tasks in the input interface using VMFE was more than that for the VMBG. The total time taken by users of the VMBG in the experimental group for the input interface was on average 28.38 minutes per user. In comparison, users of the VMFE in the control group of the input interface spent a total of 35 minutes per user on average. Tasks in which both text and avatar with facial expression must be entered took more time. Figure 4-10 shows the mean values of the time taken by all users. The t-test calculations showed that the difference in answering time between both groups was significant (t (-11), MD (46), p < 0.05). Experimental observations revealed that users in the experimental group took less time. These results were positing previous experiments term of the time factor. Because these users used the same tool avatar, but was more interactive when used avatar full body gesture in VMBG.

When answering six questions for the output interface, as shown in Figure 4-11, users of the VMBG were 100.80 seconds slightly faster than their counterparts who used the VMFE. The t-test calculations showed that the difference in answering time between both groups was significant (t (5.6), MD (44.80), p = 0.0 < 0.05). Experimental observations exposed the fact that users in the experimental group took less time to complete tasks. Users who listened and showed and followed the instructions by the full body avatar for tasks took less time; unlike the other group which took more time to listen and showed by the avatar facial expression to the instructions for the task.

4.14.2 Message Complexity

Figure 4-10 shows the message time grouped by the complexity of tasks. These tasks were designed to increase in difficulty and were equally divided into three easy, three moderate and three difficult tasks. Overall, the message time for the experimental group was lower for all complexity levels. In addition, the difference in messaging time between the two groups increased with an increasing level of task complexity. For easy tasks, the mean message time in the VMBG was 6.38 minutes less than that for the VMFE. The variance between both tasks, however, was slightly less minutes for responding to moderate tasks. For difficult tasks, the variance was considerably higher, 4 minutes in favour of the VMBG. The statistical tests revealed that users of the VMBG needed significantly less time than the users of the VMFE to enter message tasks for each of the easy (t(-11), MD (-5), $p < 0.05$), moderate (t(-27.9), MD (-107), $p < 0.05$) and difficult (t t(-36.7), MD (-11), $p < 0.05$) tasks.

Figure 4-11 shows the message time grouped by the complexity of tasks for the output interface. These questions were designed to increase in difficulty and were equally divided into two easy, two moderate and two difficult tasks. On overall, the answering time in the experimental group was lower for all complexity levels. Moreover, the difference in answering time between the two groups increased with an increasing level of question complexity. For easy questions, the mean answering time for VMBG was 36 seconds less than for VMFE. The variance between both tasks was slightly fewer 4 seconds for responding to moderate questions. For difficult questions, the variance was 18.5 seconds in favour of the VMBG. The statistical tests revealed that the users of the VMBG needed significantly less time than the users of the VMFE to answer each of the easy (t(12), MD (44), $p < 0.05$), moderate (t(13), MD (45), $p < 0.05$) and difficult (t(13), MD (48), $p < 0.05$) questions.

In summary, these results demonstrate that users of the input interface and output interface, in the experimental group, take less time in comparison to the control group. The main reason is the optimization process to send the message by the avatar full body.

4.14.3 Message Type

Figure 4-10 shows the message time grouped by the message type. The tasks were designed to be of three different types; nine task each. Overall, the message time in the experimental group was lower, for both types of tasks, as opposed to the time for the control group using the input interface.

In responding to message tasks, users of the VMBG, in the experimental group, spent 8.2 minutes to complete suggestions and 12 minutes for complaints. The users of the VMBG, in the experimental group, spent less time than the control group where the suggestion time was (t (-17), MD (-7), P = 0.0 < 0.05) and the complaint time (t (-19), MD (-6), P = 0.0 < 0.05) and the comment time was (t (-31), MD (-11), P < 0.05). Note results demonstrate from T-test and Mean Definition (MD) test was conducted for all message types. The reduced time for the experimental group is due to the fact that users are used to generate text and avatar full body, when using the input interface.

On the other hand, a variation between the task times for the three message types was observed for users of the VMBG in the experimental group who spent 35 seconds (on average) slightly less than the users of the VMFE in the control group. According to the t-test results, the difference between the two groups for tasks time was found to be statistically significant for the experimental group using the output interface. The users' time for suggestions was (t (12), MD (44), P = 0.00 < 0.05) and for complaints was (t (13), MD (45), P = 0.00 < 0.05) and for comments was (t (13), MD (48), P = 0.00 < 0.05). Through T- test and MD for all message types were in the experimental group for the output interface.

On the whole, these experimental findings indicate that the addition of the multimodal metaphors to the VMBG helped users much more when using the output interface. For the input interface, the results indicated that users of the VMBG took less time; this result conversely on the previous experimental in terms of the efficiency.

4.14.4 Question Type

Figure 4-11 shows the answering time grouped by the question type. The questions were designed to be of two different types; recall and recognition with six questions each. Overall, the answering time in the experimental group was lower for both types of questions, as opposed to the control group. Answering the recall questions took less time in comparison with the recognition questions. In responding to the recall questions, users of the VMBG in the experimental group spent 41.9 seconds (on average) less than the users of the VMFE in the control group. However, the variation between the two groups was substantially reduced to 20 seconds, with respect to answering recognition questions. According to the t-test results, the difference between the two groups in answering time was found to be statistically significant for the recall questions (t (12.7), MD (69.5), $p < 0.05$) whereas significant difference was identified for the recognition questions (t (13), MD (69.8), $p < 0.05$).

In summary, during the recall and the recognition tasks, we can see that the message receivers respond faster to questions, compared to the experimental group using the output interface and the assistant behind it is to use avatar full body.

4.14.5 Each User

Figure 4-12 show the time taken to enter message tasks for each group. Apart from the 9th tasks which needed a long time to complete by the VMFE group, the experimental group needed shorter times than the control group to enter messages for all the tasks.

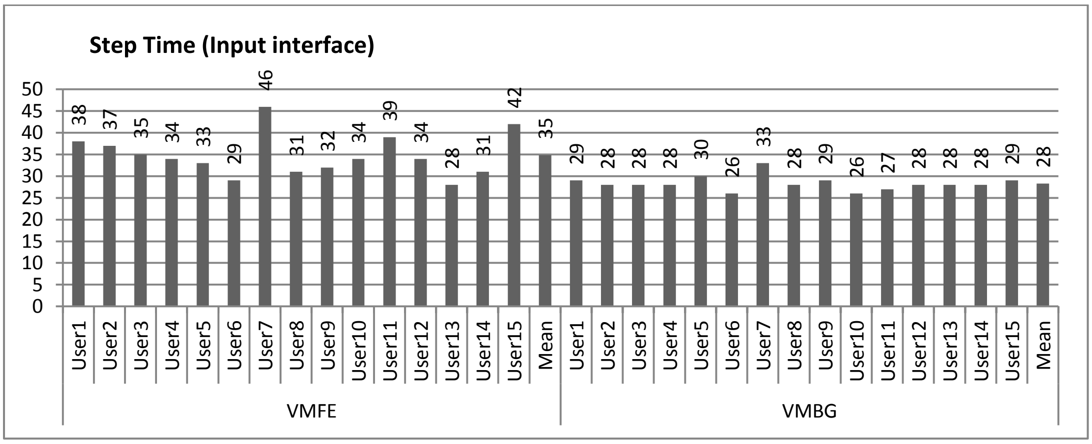


Figure 4-12: Mean values of time taken by the users in both groups to enter messages for each of the tasks in the input interface

Moreover, the mean time taken to enter a message task was 28.38 minutes for the experimental group, compared to 35 minutes for the control group. It was noticed that the difference between the two groups for message times varied across the nine tasks for the input interface. These variances could be attributed to the differences in complexity and the type of task or because of the new effects which were added attracted the attention of users.

Major differences were obtained for the experimental group. Still so, the results obtained could not be considered as conclusive for clarifying the role that the full body avatar played in shortening the message time when used in the input interface. The control and experimental groups are equal in terms of the complexity of the required tasks - the control group enter text and avatar facial expression and the experimental group enter text and avatar full body gesture in the input interface. These tasks were designed to explore the individual role of these multimodal metaphors. In a few words, the multimodal metaphors used in the VMFE and VMBG assist in reducing the message time for most users undertaking the required tasks for the input interface.

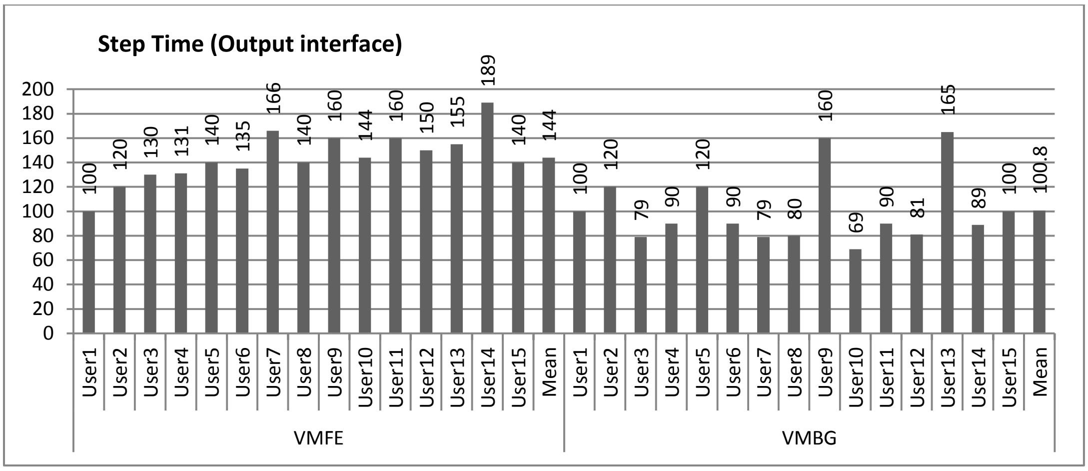


Figure 4-13: Mean values of time taken by the users in both groups to enter messages for each task in the output interface.

Figure 4-13 shows the total time spent by each user in both groups to enter messages for all the six tasks. Little proportion of time was spent by users of the VMFE, compared to users of the VMBG. The minimum and maximum message times taken by the control group were 100 seconds (User 1) and 189 seconds (User 14), correspondingly. In the experimental group, the minimum time taken was slightly lower (69 seconds by User 10), whereas the maximum time (165 seconds by User 13) was less than that in the control group. On average, the users of the VMBG were 100.80 seconds faster than their counterparts who used the VMFE.

4.15 Effectiveness

The correctness of user‘s answers were checked to measure the performance of communications and the total number of successful users, who completed the message tasks and answer questions was counted for each user. The number of correctly entered messages were used as a measure of 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.

4.15.1 All Tasks

This measure was considered for all the tasks for each group per user. Figure 4-14 shows the percentage of mouse clicks to enter messages for all tasks for the VMFE and VMBG. Users of the VMBG used less mouse clicks that users of the VMFE. The reason for this is the enhanced input interface used by users when using the new avatar tool as full body and improved the performance of communications. The mean number of mouse clicks for the VMFE was (1965) more than that for the VMBG (1669), for all messages. The t-test results revealed that the difference in mouse clicks between VMFE and VMBG was significant (t (22.9), MD = -450, $p < 0.05$). As a result, the VMBG users outperformed the users of the VMFE, who send the messaging information via the text channel and avatar full body.

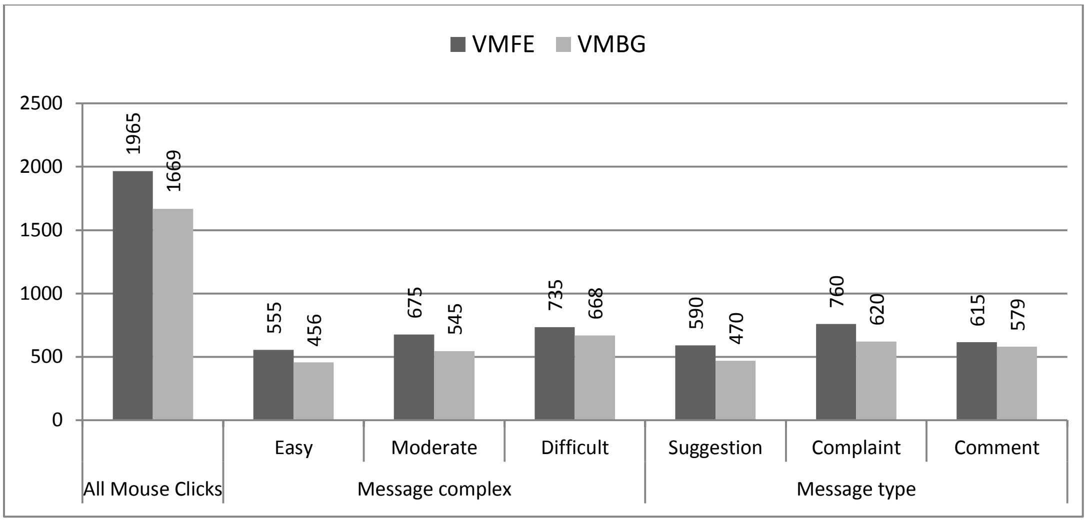


Figure 4-14: The mean number of mouse clicks performed by users in both groups to enter messages for all the tasks for the input interface.

Users of the VMFE exceeded VMBG users in terms of the number of mouse clicks used to enter messages for all tasks. The new multimodal metaphors applied when using avatar full body in the VMFE assisted in reducing the number of mouse clicks used for the required tasks and improved the performance of communications in the input and output interfaces. In Figure 4-15, users of VMBG performed better than users of the VMFE in terms of the number of mouse clicks used for all messages. The mean number of mouse clicks used in the VMFE was (32) less than that used in the VMBG (21), for all messages in the output interface. The t-test results showed that the difference in mouse clicks between VMFE and VMBG was significant (t (5.6), MD = 7.7, $p < 0.05$). As a result, VMBG outperformed the users of the VMFE when receiving the messaging information via text with the new metaphors. The assimilation of more than one communication metaphor of dissimilar natures in the VMBG assisted users in the experimental group to discriminate between the different types of information delivered by each of the avatar full body more than when using the avatar extracts, thus enabling them to understand this information in a short time period and reducing the number of mouse clicks and improved the performance of communications. In summary, the new multimodal interaction metaphors used in the VMBG were more effective in communicating and considerably helped the users in the experimental group to achieve a higher effectiveness rate, when using the input and output interfaces.

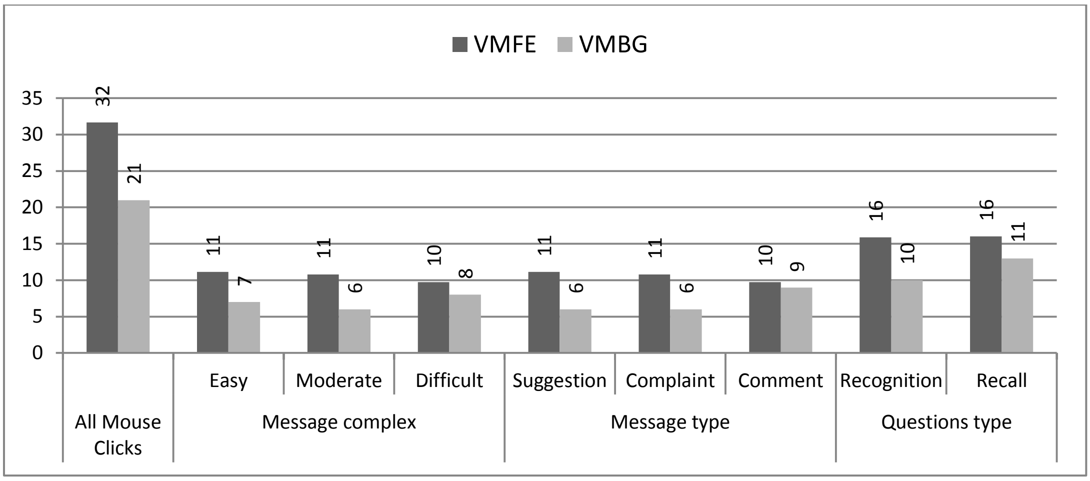


Figure 4-15: The mean number of mouse clicks performed by users in both groups to enter messages for all the tasks for the output interface.

By analysing the correctly entered measure we can find what percentage of users entered the correct message for all tasks. Figure 4-16shows the percentage of test result messages correctly entered for all tasks in the VMFE and VMBG. Users of the VMFE are 78% correct and VMBG users are 99% correct, in terms of the correctly entered measure for the input interface.

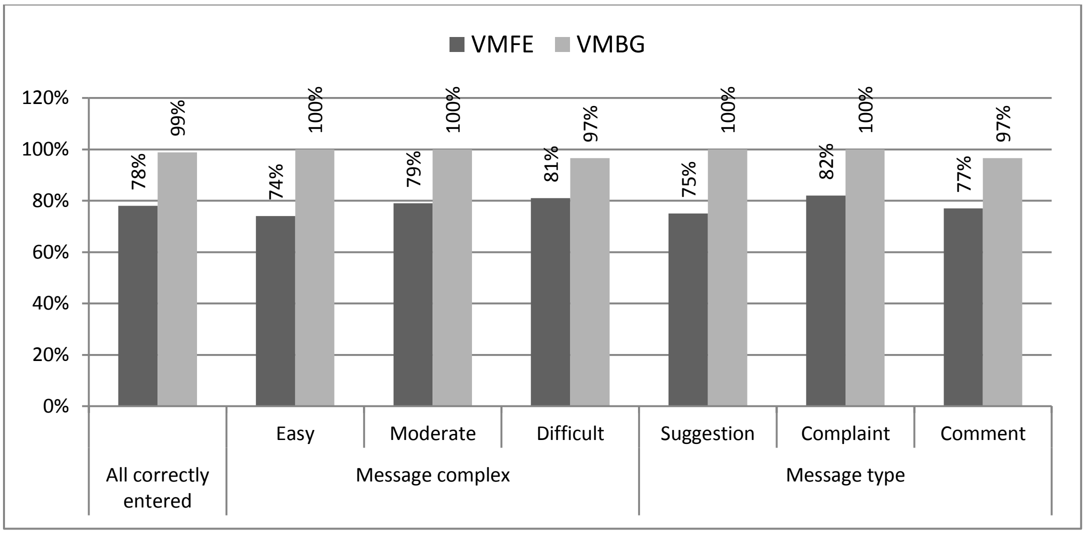


Figure 4-16: Percentage of correctly completed tasks by users in both groups for the input interface.

Also, when looking at Figure 4-17, users of the VMBG complete more tasks successfully than VMFE users, in terms of the number of correctly entered messages for tasks using the output interface. The VMBG 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.

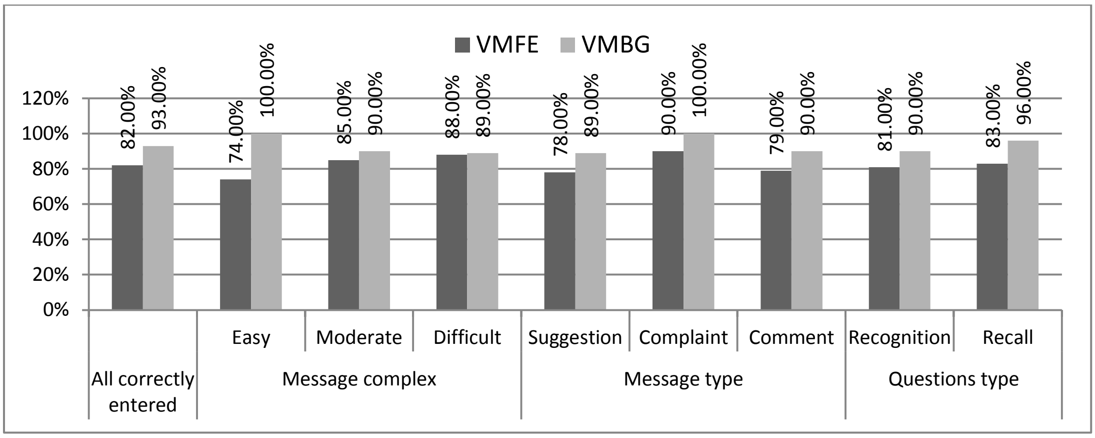


Figure 4-17: Percentage of correctly completed tasks for users in both groups for the output interface.

4.15.2 Message Complexity

Figure 4-14 shows the number of mouse clicks achieved by users in both groups to enter messages, grouped by message complexity (easy, moderate and difficult tasks) for the input interface. The total number of tasks in each complexity level was 9 tasks. The experimental group outperformed the control group in all levels of complexity, particularly when completing the easy tasks. This is shown by the number of mouse clicks performed by users. What is more, the difference in users‘ performance increased in the control group, as the complexity of tasks increased. For easy tasks, the users of the VMBG required 555 clicks for mouse click to entered message tasks, less than that achieved by the VMFE users, which were 456 clicks. However, the difference was 130 clicks, with respect to moderate tasks. The largest difference (67clicks) was noted in users‘ responses to difficult tasks, where users in the experimental group performed less mouse clicks compared to users in the control group - the reverse of the results for the first experiment in chapter 3. However the similar results for the second experiment in chapter 3. This is due to the fact that users using the new tool avatar full body in the experimental group perform less mouse clicks and improved the performance of communications. The results of the T-test showed that the difference in enter messages between the VMFE and VMBG reached a statistical significance for easy tasks

($T = -3.7$, $MD = -85.9$, $p > 0.05$), while it was found to be significant in moderate tasks

($T = -4.7$, $MD = -107$, $p > 0.05$) and difficult tasks ($T = -24.6$, $MD = -297$, $p > 0.05$). This result is in favour of the experiment group, for the input interface.

Figure 4-15 shows the mean number of mouse clicks performed by users in both groups in order to enter messages when using the output interface, grouped in terms of complexity. The experimental group outperformed the control group for all levels of message complexity, chiefly for the easy tasks. This is shown by the low number of mouse clicks performed by users. The results of the T-test showed that the difference in entered messages between VMFE and VMBG reached a statistical no significance for easy tasks ($T = 6$, $MD = 3$, $p > 0.05$), while it was found to be significant for moderate ($T = 8.8$, $MD = 4.8$, $p < 0.05$) and no significance difficult tasks ($T = 13$, $MD = 48$, $p > 0.05$). This result is in favour of the experimental group.

Figure 4-16 shows the percentage of correctly entered messages, grouped by message complexity, for the VMFE and VMBG in input interface. Users of the VMBG, when entering easy messages, scored 100%, higher than VMFE users, 79% in terms correctly entered message measure. The Chi-square test shows results, significance for easy ($X^2 = 24$, $p < 0.05$), significance for moderate ($X^2 = 25$, $p > 0.05$) and no significance for difficult ($X^2 = 21$, $p < 0.05$) tasks. The new multimodal interaction metaphors increase the numbers of correctly entered messages, as shown by the Chi-square test.

Figure 4-16 shows the percentage of correctly entered messages for tasks of different complexity in the VMFE and VMBG in output interface. When the message complexity is easy, it should be noted that users of the VMBG showed a success rate of 100%, higher than VMFE users (74%). The Chi-square test gave outcomes: easy ($X^2 = 12$, $p < 0.05$), moderate ($X^2 = 45$, $p < 0.05$) and difficult ($X^2 = 14$, $p < 0.05$). The use new of multimodal interaction metaphors such as avatar full body gave a better rate of success, as shown by the Chi-square test.

In brief, it can be said that both groups of users accomplished equivalent levels of accuracy in response to different complexity tasks. However, the contribution of new multimodal metaphors such as an avatar full body for improved user performance was more obvious for the high complexity tasks.

4.15.3 Message Type

Figure 4-14 shows the number of mouse clicks performed by users to measure the performance of communication, for message type tasks, for both control and experimental groups. The number of mouse clicks is between 470 to 760, for both groups when using the input interface. Users of the VMBG performed better than those using the VMFE for different message type tasks, but the difference between the two groups was bigger in terms of the total number of clicks needed for each type. For the comment tasks, the number of clicks entered for messages in the control group was 615 higher than that in the experimental group 579. As mentioned earlier, this is due to the fact that users when using the new avatar full body tool in the experimental group require less mouse clicks to enter the input message and improved the performance of communication. The results of the T-test showed a significance in the number of mouse clicks between the VMFE and VMBG for both message types which favours the experimental group using the input interface; Suggestion ($T = -48$, $MD = 304$, $p < 0.05$) was significantly and Complaint ($T = -0.39$, $MD = -7.2$, $p < 0.05$) was significantly and Comment ($T = -6$, $MD = -179$, $p < 0.05$) was significantly. A further analysis (see Figure 4-15) indicated that the experimental group significantly outperformed the control group in its ability to perform fewer mouse clicks when using the input interface.

Figure 4-15 shows that the mean number of mouse clicks for correctly answered complaint tasks for the experimental group was 6 clicks less than that for the control group, 11 clicks. This result indicates that it is easier to answer questions and increase the performance of communication when using the enhancement. The experimental group took less time and performed fewer clicks. The results of T-test showed a significant difference in the mouse clicks taken to enter messages for answers to the questions between the VMFE and VMBG, for both types of message: Suggestion significance ($T = 3$, $MD = 3$, $p < 0.05$), Complaint significance ($T = 8.8$, $MD = 4.8$, $p < 0.05$) and Comment no significance ($T = -0.40$, $MD = -0.20$, $p > .69$). An additional analysis (see Figure 4-15) indicated that the experimental group some time significantly outperformed the control group in answering questions of different message type when using the output interface.

Figure 4-16 shows the percentage of correctly entered messages for the different task types for the VMFE and VMBG. Users of the VMBG had a 100% success rate for suggestion type messages which was higher than VMFE users (75%). In addition, the complaint and comment had a similar result in terms of the correctly entered messages for message type tasks in the input interface. The Chi-square test gave results; Suggestion ($X^2 = 26$, $p < 0.05$), Complaint ($X^2 = 12$, $p < 0.05$) and Comment no significance ($X^2 = 12$, $p > .10$). The Chi-square test is effective at differentiating between the two groups, in terms of testing the degree of successful entry of messages. In addition, it has been shown by previous findings that the success rate was higher in the experimental group.

Figure 4-17 show that users of the VMBG had a message success rate of 89% for the suggestion type, higher than for VMFE users (78%). For the complaint message type, VMBG users had a success rate of 100% and VMFE users 90%, in terms of the correctly entered messages when using the output interface. The Chi-square test demonstrates the results; Suggestion ($X^2 = 12$, $p < 0.05$), Complaint ($X^2 = 12$, $p < 0.05$) and Comment ($X^2 = 14$, $p > 0.05$). As was mentioned earlier, the Chi-square test effectively differentiates between the two groups in terms of testing the degree of accuracy of entering messages. It has been shown by previous findings that the experimental group had a higher success for entering messages.

In summary, the contribution of new multimodal metaphors such as avatars full body reduces the number of mouse clicks users use to enter messages to measure the performance of communication for the different type tasks in the input interface. In addition, it helps users to input messages correctly. Also, use of new multimodal metaphors reduces the number of mouse clicks used when using the output interface. Nevertheless, the experimental group performed significantly better than the control group, in terms of the overall results achieved for the different message types.

4.15.4 Question Type

The mean number of mouse clicks and percentage of correct answers to recall and recognition questions, in both control and experimental groups, was considered. In Figure 4-14 and Figure 4-15 users of the VMBG performed better than those of the VMFE for both recall and recognition questions, butut the difference between the two groups was smaller in the latter type. For recall questions, the number of mouse clicks in the experimental group was 11 clicks less than that for the control group, which were 16 clicks. However, the number of mouse clicks recognition questions in the experimental group was 10 clicks less than that for the control group, which were 16 clicks. Using the VMBG, users in the experimental group used a slightly smaller number of mouse clicks in recall and recognition questions, respectively, when using the output interface. On the other hand, the users of the VMBG, in the experimental group, exhibited a 96% correctness rate in answering recall questions and a 97% correctness rate in answering recognition questions for the output interface. The results of the T-test showed a significant difference in the number of correct answers between the, for both types of questions, in terms of the number of mouse clicks; recall (T = 2.5, MD = 1.8, $p < 0.05$) and recognition (T = 8.6, MD = 5.8, $p < 0.05$). On the other hand, the results of Chi-square test showed significant difference in the number of correct answers between the VMFE and VMBG, for both types of questions correctly entered; A further analysis indicated that the experimental group significantly outperformed the control group in answering both recall and recognition questions, in terms of the number of mouse clicks and correctly entered answers for the output interface.

In summary, the advantage of using new multimodal metaphors was more apparent when users answer questions to recall activities, compared to when users answer questions to recognition activities. Nevertheless, the experimental group performed significantly better than the control group, in terms of the overall results for both types of questions and in the number of mouse clicks and correctly entered answers in the output interface.

4.15.5 Individual Users

Figure 4-18 shows the number of mouse clicks achieved by users in both groups to enter messages for both the control and experimental groups.

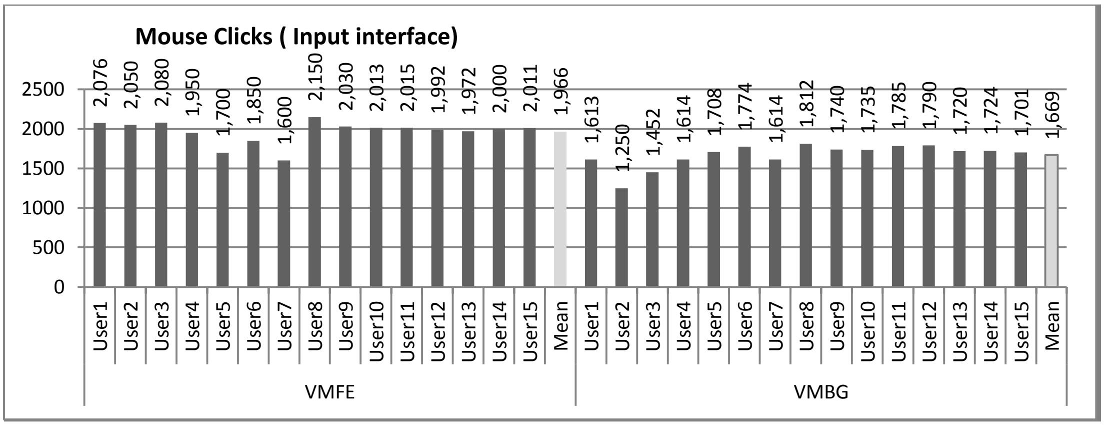


Figure 4-18: The mean number of mouse clicks used to enter the correct answers for individual users, in both groups, when using the input interface.

It is worth mentioning that all users of the VMFE used more mouse clicks than users of the VMBG. User 7 of the VMFE used 1600 clicks and User 8 used 2150 clicks. It shows the difference between the highest and the less frequently used. On the other hand, on average, the number of mouse clicks per user for the VMBG experimental group was 1669, compared to 1966 clicks for the control group. In short, the use of new multimodal metaphors such as avatar full body for communicating messages is more helpful for users in the experimental group, than users in the control group, in terms of the tasks required to enter messages when using the input interface.

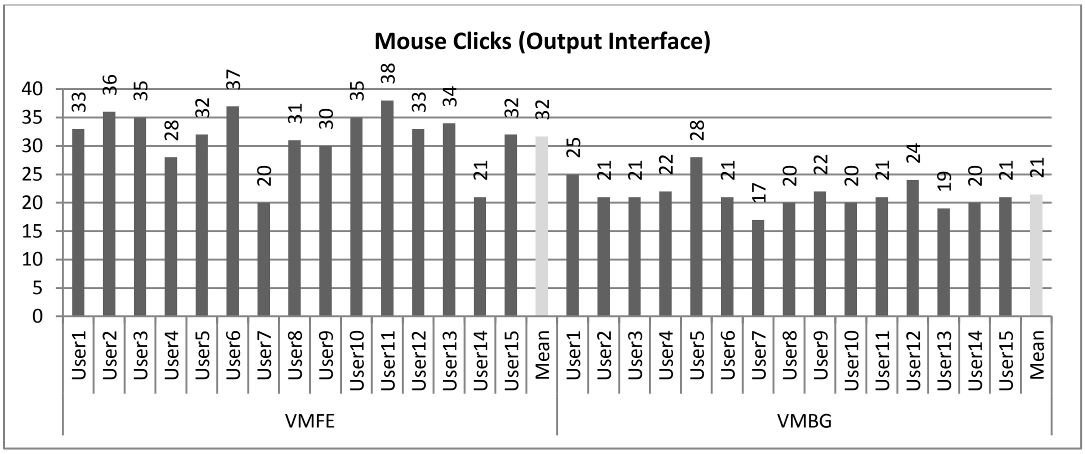


Figure 4-19: The mean number of mouse clicks used to enter the correct answers for individual users in both groups for the output interface.

Users in the experimental group used less mouse clicks, compared to users in the control group, for the output interfaces. On average, per user in the experimental group required 21 clicks, compared to 32 clicks in the control group. In a word, the use of new multimodal metaphors as avatar full body in communicating the message enables users in the experimental group to outperform their counterparts in the control group in answering the required questions correctly, in terms of the number of mouse clicks used when using the output interface.

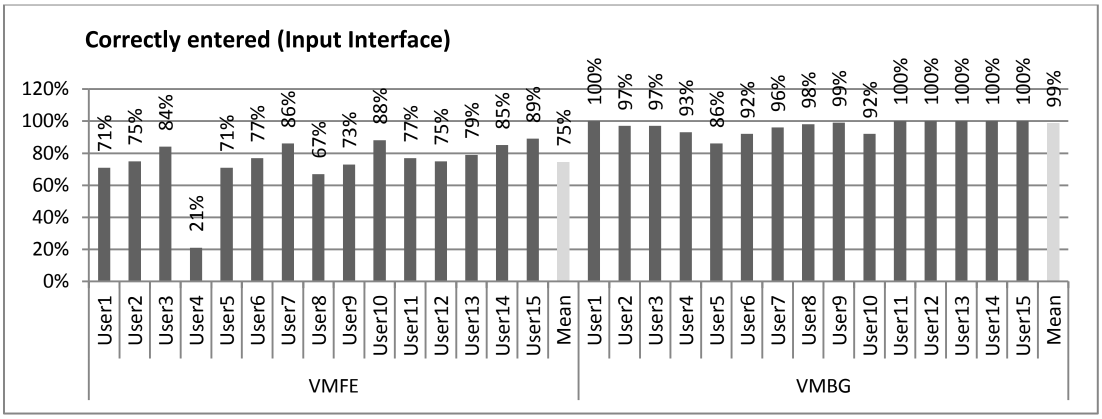


Figure 4-20: Percentage of correctly entered messages achieved by individual users in both groups, for the input interface.

Figure 4-20 shows the percentage of correctly entered messages achieved by each user in both groups for the VMFE and VMBG. The experimental group outperformed their counterparts in the control group, in terms of the number of messages entered correctly when using the input interface. The most successful result was in the experimental group, where users 1, 11, 12, 13, 14, 15, achieved 100%. The most successful result was in the control group, where user 15 achieved a success rate 89%. User 5had the worst success rate (86%). The average test result of correctly entered messages for users in the experimental group was 99%, compared to 75% for users in the control group.

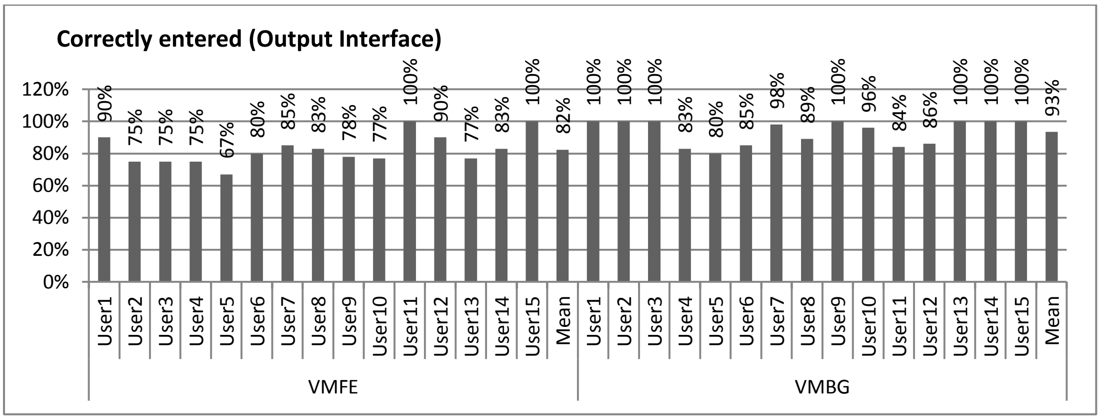


Figure 4-21: Percentage of correctly entered messages for individual users in both groups using the output interface.

However, Figure 4-21 shows the percentage of correctly entered messages achieved by each user for both groups (VMFE and VMBG) when using the output interface. The highest results in the experimental group were 100% (users 1, 2, 3,9,13, 14, 15) and the lowest result was 83% (user 4). The highest result in the control group was 100% (users 11, 15). The lowest result (user 5) was 67%. On average, the correctly entered messages for users in the experimental group was 93%, compared to 82% in the control group. This means that users in the experimental group performed more successfully when using new multimodal metaphors, as the avatar full body helped to communicate the messages to the users.

4.16 User Satisfaction

Users' responses and scale, ranging (Refer section 3.7.6).

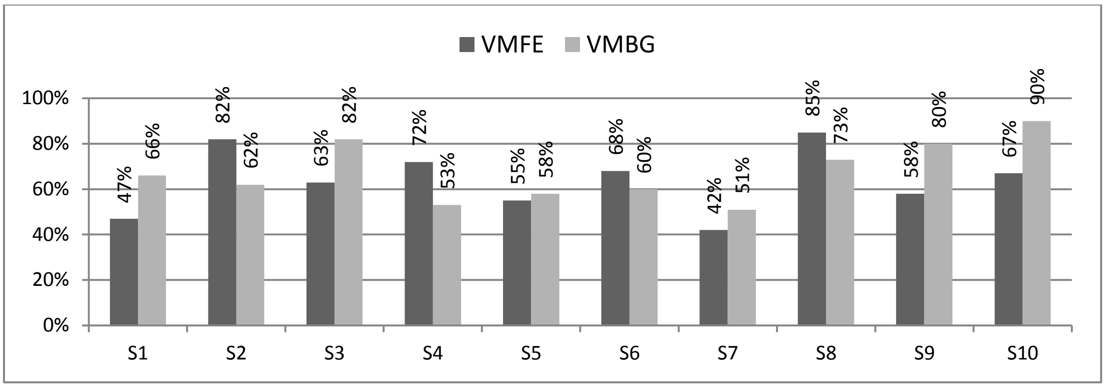


Figure 4-22: Percentage of users agreeing to each statement of satisfaction, for both VMFE and VMBG groups.

The mean satisfaction score for the users in the VMBG was more satisfactory for users using the VMFE. Figure 4-22 shows the percentage of users agreeing to each statement in the satisfaction questionnaire. Refer to Appendix for users' responses to the satisfaction questionnaire. In the initial statement (Q1), 66% of users in the experimental group agreed that the e-government interface tested was easy to use. The next statement (Q2) asked the users whether they found the interface to be complex to use. In this regard, users of the VMBG expressed a lower level of disagreement 61.7% than the users of the VMFE 81.7%. A high level of agreement was observed for Q1, but a low level of agreement was observed for Q3, where only 18.5% of the users in each group thought there was good communication during interaction with the interface. However, users found the VMBG to be less difficult (Q4). 58% of users in the experimental group found communication to be easy (Q5). Conversely, users found the VMBG to be less confusing (Q6 and Q7). All of the VMBG users believed that most people will learn to use the tool quickly, compared to 41.7% who agreed with this statement in the VMFE group. Also nervousness levels (Q8) were higher in the control group (85%) - 73% for the experimental group. Additionally, users' agreement in the experimental group was higher, in comparison to the control group, in terms of the aspects connected to the communication channel (Q9). Overall, all users in the experimental group were satisfied with the tested interface (Q10), whereas fewer (66.7%) were satisfied in the control group. In brief, the use of new multimodal metaphors to convey the message results in positive views from users. Therefore, the new multimodal e-government interface with avatar full body can be considered more satisfactory than avatar facial expression only.

4.17 Perception of Trust

If party A trusts party B for a service X, trust is the measurable belief of A in that B will behave dependably for a specified period within a specified context (with regard to service X) [52]. Therefore a number of features of online communication have the ability to both decrease or increase the level of citizens trust, it would be valuable to understand which factors and what levels will have desirable effect and which wouldn't. This will then help with ensuring that these factors are executed in such a manner that ensures that citizens can place the optimal degree of trust in e-government.

Conditions (n=30) / Statement	VMFE		VMBG	
	Agree	**Disagree**	**Agree**	**Disagree**
(Q1) The interface features offered matched my expectations	9 (60%)	6 (40%)	12 (80%)	3 (20%)
(Q2) I believe that this interface gave me the impression that it was honest	10 (67%)	5 (33%)	13 (87%)	2 (13%)
(Q3) I would rely on my previous experience more than interface contents.	11 (73%)	4 (27%)	13 (87%)	2 (13%)
(Q4) I felt this interface was unprofessional and incompetent	8 (53%)	7 (47%)	7 (47%)	8 (53%)
(Q5) I felt that this interface was trustworthy	10 (67%)	5 (33%)	14 (93%)	1 (7%)

Table 4-3: Frequency of the agreement and disagreement of participants in each statement related to the users' perception of trust.

Table 4-3 shows the frequency of the user agreement and disagreement with the trust statements for using the VMFE and VMBG experimental systems. Participants generally responded favourably to VMBG when questioned on the five trust aspects as outlined in the previous experiment and this shows when using multimodal approach and then increase trustworthy. From table 13, it is identifiable that 60% of VMFE users were in agreement that the system's features offered matched with what their expectations, in comparison to 80% of VMBG users. It was also noted that 87% of VMBG users possessed a belief that the system portrayed an honest impression overall, in comparison to 67% of the users of VMFE. Furthermore, 87% of VMBG users intended place a greater reliance on their prior experience than the actual content provided by the system compared to 73% of the users of VMFE. In addition to this, 53% of the users of VMFE felt this interface was incompetent and unprofessional, in comparison with 47% of the users of VMBG who were in agreement with this statement. Only 20% of VMFE users felt the system to be trustworthy, whereas approximately 87% of VMBG users believed in the trustworthiness of the condition. In summary, the responses of users identified multimodal approach effects were demonstrated in all aspects of user trust and Figure 4-23 shows that.

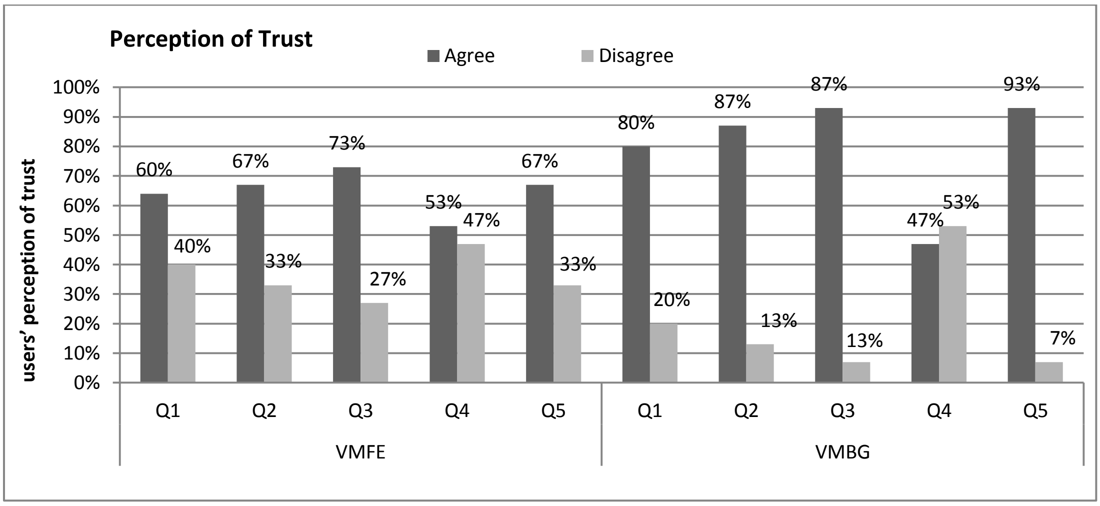


Figure 4-23: Percentage of users agreeing and disagreement to each trust statement, for both VMFE and VMBG groups.

In addition, results obtained from the chi-square test suggested that the difference between TOEGP and VMBG was insufficient with regard to Statements S1 ($X^2 = 20$, df= 1, $p < 0.05$) and S2 ($X^2 = 12$, df= 1, $p < 0.05$) and S3 ($X^2 = 9$, df= 1, $p < 0.05$) and S4 ($X^2 = 50$, df= 1, $p < 0.05$) and S5 ($X^2 = 11$, df= 1, $p < 0.05$) and use chi-square test because all the data were of the type categorical data. In brief, multimodal interaction has a considerable effect on aspects of Perception of Trust.

4.18 Discussion

The current study investigated the usability and communication performance of a new multimodal e-government interface with a full body avatar, as opposed to a simpler facial expression avatar. The results obtained have been used to compare the two interfaces in terms of efficiency, effectiveness and user satisfaction and Perception of Trust and the performance of communication. The study also focused on the factors that can affect the role of multimodal interaction metaphors, such as the message type (suggestion, complaint, comment) the message complexity level (easy, moderate and difficult) and the question type (recall and recognition) connection Properties:

The results are discussed from the following fourth points to get an insight into what contribution has been made by the use of multimodal metaphors, in terms of user efficiency, effectiveness, satisfaction and Perception of Trust.

1. Time taken to enter message task and to answer question type for both input and output interfaces.

2. Number of mouse clicks to measure performance of communication and correctly entered message tasks complete successful for both input and output interfaces.

3. User satisfaction and experience with both of the e-government interfaces tested.

4. User trust and experience with both of the e-government interfaces tested

The results obtained showed that the uses of new multimodal metaphors (avatar full body) significantly improve the efficiency of tasks and they were more effective for users using the e-government input interface. In addition, new multimodal metaphors with avatar full body improved users' efficiency and effective when used in the output interface, compared to the avatar facial expression approach for communicating the message content.

4.18.1 Message and Question Answering Time

The third hypothesis assumed that the new multimodal e-government interface will be more efficient than the avatar facial expression based one regarding the efficiency of users to enter messages and to answer the required tasks in both input and output interfaces. The experimental results, as shown in Figure 4-10, demonstrate that using the new multimodal interaction metaphors results in an increase in the time needed by users in the control group to enter messages in the input interface. There was a significant reduction in the time needed by users in the experimental group to respond to the evaluation questions in the output interface, as shown in Figure 4-11. The main reason behind this is that they used the full body avatar which enhanced the process for each task when they sent messages, so tasks took less time when using the input interface. This result was in contradiction to the results shown in Chapter 3. The inclusion of different multimodal communication metaphors in the VMBG helped the users to concentrate better on information presented through the full body avatar, while at the same time using the visual-audio channel and the auditory channel to understand this information through the output interface. In addition, experimental observations revealed that users in the experimental group took less time because they were concentrating on the full body avatar. Therefore, users in the experimental group were significantly aided by the addition of these metaphors in the VMBG, in terms of spending less time answering questions than users of the VMFE when using the output interface. These results suggest that the use of the full body avatar can significantly improve efficiency than the use of the avatar facial expression metaphors when presenting information. In this experiment proves what has been hypothesized in H1 and H2 and H3, in terms input and output interfaces.

The fifth and sixth hypothesis predicted that the VMBG would be more efficient for both recall and recognition questions than the output interface. On the whole, the experimental findings indicated that the addition of the new multimodal metaphors such as the full body avatar, as applied in the VMBG, contributed to memory recall activities. Figure 4-11 shows the answering time grouped by the question type. The questions were designed to be of two different types; recall and recognition. Overall, the answering time for the experimental group was lower for both types of questions, as opposed to the answering time for the control group. The recall questions took a short time to answer in comparison with the recognition questions. Overall, the H4 was supported for recall and recognition questions, measure and it can be said that the effect of the multimodal metaphors of answering time is limited to memory recall activities.

4.18.2 Correctness of messages

It was likely that users VMBG will outperform users of VMFE in terms of the number of mouse clicks to measure performance of communication and correctly entered message tasks complete successfully. As shown in Figure 4-14, Figure 4-15, Figure 4-16 and Figure 4-17 the VMBG was better than the VMFE for reducing the number of mouse clicks used and improved the performance of communication. This was due to the use of the full body avatar in the input interface for the experimental group, in comparison to the sole use of avatar facial expressions to convey messages to the control group. New multimodal metaphors also assisted users in distinguishing between the various types of information provided. The metaphors, each of them, enabled the retention of information for a lengthier period of time. The multimedia principle concerning the involvement of other human senses was pivotal in creating this effect in the interactive process, along with the visual-audio channel. This effect can contribute to the extension of working memory capacity, and following on from this, the ability of the users in perceiving and understanding the information presented to them. As the experimental group users were able to remember the communicated information for a lengthier period of time (in comparison with the control group), they were able to attain a considerably greater number of mouse clicks than their control group counterparts. In addition, the test for correctly entered messages shows the new multimodal interaction metaphors used in the VMBG were more effective in communicating performance and considerably assisted the users in the experimental group to achieve a higher effectiveness rate, as opposed to the control group. These findings confirmed the assumptions made in H4, in terms of the output interface and the hypothesis for the input and output interfaces.

In view of the question type, the experimental results proved H5 and H6. Users of the VMBG accomplished a substantially larger number of correct answers than users of the VMFE in both recall and recognition questions. In order to successfully answer the recall questions, users had to correctly retrieve from their memory part of the communicated messaging content. The results of this experiment indicated that new multimodal metaphors enabled users to understand the questions better, without distracting their attention away from the presented content. The correctly entered test measure (Figure 4-17) shows the low correctness rate of recognition questions for the VMFE 55% compared to 100% for the VMBG. This demonstrates that users' memory was not aided when they used the record speech interface, in comparison to the new multimodal interface. In short, the results recommend the use of new multimedia metaphors to facilitate the performance of users in each activity for recall and recognition tasks in the VMBG.

4.18.3 User Satisfaction

On the whole, it was expected that users of the VMBG would be more satisfied than the users of the VMFE. Consistent with this assumption, the multimodal presentation of the message content in the VMBG was shown to be significantly more satisfying than the avatar facial expression interface in the VMFE. It seems that using the avatar full body approach is interesting and attractive for users in the experimental group, as they expressed a more positive attitude towards the audio-visual communication of the message content. Although both of the e-government interfaces tested was easy to use, neither was confusing or nervous? The results obtained demonstrate a remarkable difference between both groups of users regarding these satisfaction features (refer to Q1 to Q10 in Figure 38). Naturally, users in the experimental group thought that their communication with the government was improved and aided by the multimodal metaphors. It was easier for them to identify the messaging information, which was communicated by the avatar full body. As the satisfaction, efficiency and effectiveness results are similar to each other, the argument that users in the experimental group were helped by the new multimodal metaphors becomes much stronger. The multimodal aided e-government is more likely to result in an agreeable and satisfying experience for the user. This experience is linked with the ability to complete message tasks correctly and quickly. In summary, the general results of this experimental study suggest the importance of the new multimodal interaction metaphors tested in enhancing users' messaging performance and the usability of e-government interfaces in terms of efficiency, effectiveness and user satisfaction.

4.18.4 Perception of Trust

As noted in the previous experiment and experimental group of experiment show when using the new multimodal approach it found growth Perception of Trust. In addition, achieved the aims and the hypothesis in this experiment it found that positive attitudes directed at the avatar's nonverbal communications were expressed by experimental group participants. The results proposed that users tend to be more comfortable with nonverbal communication by the avatar full body obverse the avatar facial expression interface. In particular, trust was improved, because the participants who took part in this experiment felt that e-government interfaces with the use of audio-visual metaphors with the avatar full body was more trustworthy than the avatar facial expression e-government interfaces. In particular, it is deducible that effect of prior experience can be reduced through the introduction of new multimodal metaphors during the message evaluation phase, thereby positively influencing the perception of trust.

The results obtained show that multimodal metaphors enhance usability as well as messaging performance in the VMFE. To some extent, the experimental results (see Figure 4-10 and Figure 4-11and Figure 4-14, Figure 4-15, Figure 4-16 and Figure 4-17) Pointed out that the interaction between the sender and the receiver of the messages were great. In addition, this mark is sufficient to determine how the avatar full body contributed to improving the results. This study investigated users' attitude towards avatar full body that can be incorporated in avatars when employed as virtual message. Therefore, this experiment illuminates the importance of using avatars, in terms the usability (efficiency, effectiveness and user satisfaction) and user trust of utilizing as virtual message between the sender and receiver in e-government interfaces.

4.19 Summary

This chapter examines the impact of new multimodal interaction metaphors for ease of use, in terms of efficiency, effectiveness and user satisfaction and user trust and the communication performance of the e-government interfaces. This study has been implemented by developing two different conditions of the experimental e-government condition. The first condition was based on the use of the avatar facial expression with text to present the messaging content between the sender and receiver. The second condition was concerned with using a combination of new multimodal metaphors (avatar full body and text) to supply the same messaging content. Together, e-government conditions were then empirically evaluated by two independent groups of users. The first group (control) tested the avatar facial expression with a text interface by performing common tasks and answering a set of message evaluation questions. The second one (experimental) tested the new multimodal interface by performing common tasks and answering a set of message evaluation questions.

The results obtained from this experiment confirm that multimodal metaphors do in fact help to improve the usability and Perception of Trust 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, satisfying, and has a positive influence on perception of trust. In other words, we conclude that the new 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 and user trust. It is therefore proposed to include multimodal metaphors in e-government interfaces, and this need to be taken in mind when designing such interfaces.

The e-government interface is gaining the popularity among the providers of e-government services. Its importance from the users' point of view has become the main concern for e-government service providers. This is why this chapter has focused on investigating the usability and the perception of trust which is an important factor for the improvement of e-government interfaces for the provision of high quality government services and enhancing the performance of communication.

CHAPTER 5
CONCLUSIONS AND EMPIRICALLY DERIVED GUIDELINES

5.1 Introduction

This chapter presents a brief review of the experimental studies carried out in this research program to explore the effect of different multimodal interaction metaphors on the usability and the perception of trust and the performance of communication in e-government interfaces. The chapter also summarizes the main conclusions and short-fallings drawn from the obtained results. A set of empirically derived guidelines for the inclusion of multimodal metaphors in interface of e-government applications are also included and discussed. These guidelines could contribute to the design of more usable e-government interfaces to enable better communication performance. In the final part, the chapter concludes with a discussion of recommended future work.

5.2 Main Conclusions

This section presents the main conclusions and limitations drawn from the experiments carried out in this research program.

The results obtained from the first experiment showed that the multimodal metaphors were significantly more usable than the text metaphor in the presentation of the messaging content. Using a combination of graph and recorded speech was more efficient in terms of reducing the time needed by users to answer the required evaluation questions (refer to Section 3.6 and Figure 3-12 and Figure 3-13). These multimodal metaphors were also found more effective in terms of communication performance and significantly helped users to respond correctly to a higher number of tasks, particularly when these tasks were of higher complexity (refer to Section 3.6.5 and Figure 3-18, Figure 3-19, Figure 3-20 and

Figure 3-21). Additionally, users of the multimodal e-government interface were significantly more satisfied than their counterparts who used the text e-government interface (see Section 3.6.6 Figure 3-30). These findings, however, indicate that e-government audio interfaces are unable to convey the style of the individual sender and their animation during the delivery the message. They also have a limited ability to increase interaction between the sender and receiver. Therefore, the next experiment was designed to examine the role of avatars with specific facial expressions as a virtual live mail message in e-government interfaces.

In the second experiment, the obtained results demonstrated that utilizing an animation of facially expressive avatar is more usable (in terms of efficiency, effectiveness and satisfaction) and communication performance than using recorded speech, earcons and images (refer to Sections 3.6.4). Also, designing the interface of e-government in a way that combines avatar animated virtual communication and the presented messaging content in interface component to measure different types; recall and recognition was shown to be more attentive and attractive (see section 3.6.4) as well as more useful and preferable. However, no difference in terms of usability and communication performance from the perspective of existence when was using facially expressive avatar when incorporated in separate components within e-government interfaces. Additionally, the results from the second experiment helped in determining features from facial expressions used in the tested e-government designs. As a result, further investigation was needed to explore if the addition of extended avatar could support the influence of full-body animated virtual communication to increase interaction between the sender and receiver to improve appearance.

The third experiment gave empirical evidence that the addition of avatar body gestures could indeed help with capturing users‘ attention to key features of the messaging content when delivered by the voice and body gestures of virtual communication. This visual-audio could be effective as supportive visual-audio messages to strengthen the contribution of full body animated virtual communication and hence to enable the users to perform well in different types (i.e. Positive, neutral, and negative) of messaging evaluation tasks were classified into three groups; positive, neutral, and negative while body gestures (see Section 4.8). Were shown to be satisfactory and perception of trust for them as shown in Section (4.18 and 4.19)

5.3 Empirically Derived Guidelines

Main results and conclusions of the discussed experiments, assisted in developing a set of empirically derived guidelines for the design of more usable e-government interfaces that could help callers in enhancing their communication performance in regard to the messaging content used in this research. These guidelines could contribute to the current literature in both areas; e-government and multimodal interaction. This section presents an overall discussion of the guidelines derived from this research.

5.3.1 Practice of Recoded Speech Sounds

Recorded speech was intensively used in this research program and primarily utilized as the voice of virtual communication. These sounds have shown to be a fundamental component in interactive multimodal e-government interfaces when these interfaces incorporate the use of recorded speech sounds speaking in communicating the messaging content. The obtained results demonstrated the significant contribution of recorded speech in enhancing the interaction process, particularly in terms of delivering clear and understandable spoken auditory messages. Most of the participants in all experiments (see Section 3.6) express positive attitudes towards the tested e-government conditions which implicitly mean that they were satisfied with the use of recorded natural speech sounds. These results support the findings of previous research (refer to Section 2.5.3) which confirmed that the recorded natural speech is advantageous over that generated by the speech synthesizers. Contrary to synthesized speech, recorded speech can be prepared to fit the needs of e-government. For example, different tones could be used to stress users‘ attention to specific key words or statements in the delivered message content. When recording speech sounds to be used as a voice of virtual communication. Also, it is recommended to leave short pause intervals among the speech of the virtual communication as it could attract the callers and possibly could be used later on to insert supportive auditory sounds of non-speech nature to capture users‘ attention to specific important parts of the presented content as demonstrated in the first experiment (see Section 3.6). Furthermore, using recorded speech sounds is suggested to prevent splitting users‘ attention away from that content where users can keep looking at graphical representation and at the same time listen to spoken auditory explanations. This will result in reducing working memory load and offering more resources for cognitive processing of the presented messaging content [150]. In brief, using recorded natural speech is recommended when designing e-government interfaces.

5.3.2 Practice of Avatar’s Facial Expressions

The second experiment investigated users‘ views in regard to facial expressions of interactive e-government context. Based on the obtained results (see Section 3.5.3), designers of avatars for e-government should bear in mind to incorporate positive facial expressions such as complaints, suggestions or comments. These expressions were found to be the most liked and best rated by the users (see Figure 3-5 and Figure 3-6). The implementation of these expressions of virtual communication during the presentation of the messaging content could make the e-government environment more interesting and enjoyable to callers. Still, there is a need to use these expressions by avatars in e-government interfaces. These expressions could be used to change the rhythm of the presentation and to attract users to think in the presented messaging information.

5.3.3 Practice of Avatar's Body Gestures

The third experiment also investigated users‘ views with respect to 10 body gestures when used by the virtual communication during the presentation of the messaging content of interactive e-government context. Based on the experimental results (see Figure 4-3, Figure 4-4 and Figure 4-6), some of these gestures such as Neutral, Hands down, Hands behind, Open Hands, Walking, Contemplate, Paws opposite, Chin Stroking, Opposite legs and Indicate are suggested to be used by virtual communication in e-government interfaces. When we use body gestures these help us to better explain messages of this evidence on the ability of Avatar Full Body up better than the message with facial expressions, which were limited. These gestures were preferred by users and could be used in e-government applications to attract callers and to enhance their interaction with the delivered message content. In particular, Neutral, Hands down, Hands behind, Open Hand, Walking, Contemplate, Paws opposite, Chin Stroking, Opposite legs and Indicate were the best rated gestures (refer to see Section 4.15) and could be performed by the virtual communication to support the presentation of messaging content in e-government interfaces.

5.3.4 Integration of Virtual Message in E-government Interface

Another guideline for the use of human-like avatars in e-government is related to interface component in which this avatar should be placed. The results from the third experiment in this research program (see Sections 4.16, 4.17, 4.18 and 4.19) provided an empirical basis for the necessity of combining full body animation of the virtual message in the same interface constituent. Placing the messaging content (textual) in the background of the virtual caller with full body animation in the same scene, as applied in the VLBG (refer to Section 4.7) is suggested to be adopted in the design of e-government interfaces in order to maximise the benefit of body gestures (such as *walking* and *pointing*) particularly in directing callers‘ visual attention to the related displayed messaging information. On the other hand, incorporating talking head of facially expressive virtual message content in separate interface components could result in overloading users' working memory by spending more mental effort in searching for the information related to the spoken message. This guideline is consistent with the results of other experiments in the literature which confirmed the importance of integrating different information elements in one place in the interface.

5.3.5 Practice of Non-speech Auditory Sounds

The use of non-speech sounds along with speech sounds has shown to be beneficial in enhancing Human-Computer Interaction in different domains (see Section 2.5.4, Section 2.5.5 and Section 2.5.6). Earcons and auditory icons, as demonstrated by the results of the first experiment in this thesis (see Section 3.2) can also be added to support and complement the role of virtual communication with Audio channel in e-government interfaces to communicate some key aspects of the messaging content without annoying or confusing the caller. For example, well-known environmental sounds such as a *bell, door opening* or *bottle opening* can be used to inform the caller that an important statement or definition is about to be explained by the virtual communication whereas a *door closing* or *can drop-in* sound can indicate the end of that information. Also, different numbers of musical tones can be used to convey simple and short auditory signals related to the importance level of specific key words in the presented massaging discipline. These sounds could convey single meaning and could be used consistently throughout the interface to prevent audio-visual distraction or confusion of the users. Also, it is recommended to add these sounds in the pause intervals in virtual communication, speech so that its duration suits these pauses. In other words, these sounds should be communicated in a way which does not overlap with the virtual communication speech to enable the caller to remember and interpret it before continuation of the virtual communication speech. Lastly, sufficient training could be provided so that users can easily and quickly remember the features communicated by these sounds.

5.4 Future Work

This unit proposes possible experimental work that could be carried out as a continuation of this research.

5.4.1 More Facial Expressions and Body Gestures

The second and third experiments in this research investigated facial expressions and 10 body gestures when used by the virtual communication during the presentation of messaging content. Further experiments can be undertaken to examine additional facial expressions and body gestures of interactive e-government state. The best and worst rated among these expressions and gestures can also be evaluated. The expected outcomes could contribute in producing wider and broader guidelines for the use of facial expressions and body gestures in e-government interfaces.

5.4.2 Interactive Virtual Communication in Mobile Government Service

Currently, mobile devices and wireless technology are widely used and could offer flexible and convenient mobile government services [151]. These portable devices are continuously developed particularly in terms of screen size and resolution as well as other multimedia features. Therefore, there is potential to explore the usefulness of incorporating avatars with facial expressions and body gestures as virtual agents in mobile government service. The idea is in a position to serve as the global gateway solution for governments and businesses to improve their communication using a multimodal system. Aim to provide a comprehensive range of quality problem solving solutions and services that enables a new way of interaction, aiming to build both trust and user satisfaction.

5.4.3 Smart Virtual Communication

The virtual communication investigated throughout this thesis was obviously used in the presentation of the messaging content. While users in the first, second and third experiments were able to textually task and use multimodal tools and got performance of communication by virtual communication, these features were programmed in advance to suit research necessities. Therefore, some of the participants expressed the desire of more interactivity in their rapport with the virtual communication. For example, it can be speech recognition technology to enable the relevant questions posed orally by users. In this situation, the virtual communication could have intelligent capabilities such as retrieval of the required explanations and automatic generation of relevant verbal and non-verbal responses.

5.4.4 Effect Metaphor

Results were obtained from the second and third experiments in this research program demonstrated that the use of full body animation of facially expressive virtual communication outperformed the use of only the talking head of facially expressive one. It would be worthy to conduct an experimental study to explore the usability and communication performance of two facially expressive virtual communications with full body animation when used in a dramatic style to share the presentation of the messaging content displayed in the background of the same interface component. This exploration could involve the gender of both virtual communication (i.e. Which is better to use? Two males, two females or mixed?).

5.4.5 Epilogue

This thesis has reported on the usability, communication performance and perception of trust aspects of e-government interfaces that utilise multimodal interaction metaphors in the messaging content presentation. The thesis has also carried out an investigation into these metaphors' effects on users' caller outcomes. The results obtained from the three experiments have provided empirical evidence that earcons, auditory icons, recorded speech along with avatars encompassing facial expressions and body gestures could indeed assist with the improvements to the usability and communication performance of users in e-government interfaces when utilised to communicate the incorporated messaging content. The experimental findings and the guidelines which were empirically derived will be helpful in the design of more usable e-government applications, with significant contributions to the research literature available involving both the multimodal interaction and the e-government fields. Practical advice has also been identified on how best to create content which may be valued by users when considering the process of sending information. However, further research highlighted earlier in this chapter could be conducted to reinforce multimodal metaphors potential in the enhancement of Human-Computer Interaction specific to e-government domain.

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APPENDICES

Questionnaire:

Investigation for using multimodal interaction metaphors
to increase users trust to e-government

البحث في استخدام الاستعارات التفاعلية للوسائط المتعددة
لزيادة ثقة المستخدمين في الحكومة الإلكترونية

Can you answer all the questions as truthfully as possible

Thank you for completing the following questionnaire

الرجاء الإجابة على جميع الأسئلة قدر الإمكان
نشكركم على استكمال الاستبيان التالي

Badr Almutairi PhD student at De Montfort University

Under Supervision of Proof Dimitris Rigas

بدر المطيري طالب دكتوراه في جامعة دي مونتفورت
تحت إشراف البروفيسور ديميتريس ريغاس

Personal Information

المعلومات الشخصية

<u>Part 1 الجزء الأول</u>

Please choose one answer for each flowing question:

الرجاء اختيار إجابة واحدة لكل من الأسئلة التالية

1. What is your age? ما هو عمرك

- Under 18 (أقل من 18)
- 18 – 23 (من 18 إلي 23)
- 24 – 30 (من 24 إلي 30)
- 31 – 40 (من 31 إلي 40)
- Over 40 (أكثر من 40)

2. What is your gender? ما هو جنسك

- Male (ذكر)
- Female (أنثى)

3. What is your education level? ما هو مستواك التعليمي

- High School (ثانوي)
- Undergraduate level (جامعي)
- Postgraduate level (دراسات عاليا)
- Other .... (أخرى)

4. Have you ever used a computer? هل سبق لك استخدام جهاز كمبيوتر

- Never (أبد)
- Rarely (نادر)
- Sometimes (بعض الأحيان)
- Frequently (كثيراً)
- Very Frequently (كثيراً جداً)

5. At which of the following places you use a internet?

في أي من الأماكن التالية عادةً تستخدم الانترنت ؟

- **Home** (المنزل)
- **Work** (العمل)
- **Internet coffee** (في مقهى الانترنت)
- **Other** (أخرى)

6. How many hours do you use the Internet per week?

كم عدد ساعات استخدام الإنترنت في الأسبوع ؟

- 1 - 5
- 6 - 10
- 11 -15
- 15+
- Never (أبد)

10. What are the main reasons you do use the Internet?

ما هي الأسباب الرئيسية لا ستخدم الانترنت ؟

- Browsing (التصفح)
- Email (البريد الالكتروني)
- Education (التعليم)
- Payment (أموار مالية)
- Other (أخرى)

12. Have you ever visited any website for the ministries education, finance, foreign affairs, health, labour, social services and environment for any service?

هل قمت بزيارة أي موقع حكومي إلكتروني في أي وقت مضى للوزارات تعليم أو المالية أو الشؤون الخارجية أو الصحة أو العمل أو الخدمات الاجتماعية أو البيئة من أجل أي خدمة؟

- Yes (نعم)
- No (لا)

13. How do you rate your overall experience of this e-government?

كيف تقيم تجربتك العامة لهذه الحكومة الإلكترونية؟

- Excellent (ممتازة)
- Very good (جيدة جداً)
- Good (جيدة)
- Natural (طبيعة)
- Poor (ضعيفة)

14. Do you think the Internet is good way to communicate with government?

هل تعتقد أن الانترنت هو وسيلة جيدة للتواصل مع الحكومة؟

- Yes (نعم)
- No (لا)

Part 2 الجزء الثاني **"Input interface"**

" واجهة الإدخال "

"Please open program and choose V1 and enter this number "No. 000" in new box and enter all information in the tasks are coming in the condition"

الرجاء فتح البرنامج وأدخل الاسم وهذا الرقم ( ) ثم اختيار الإصدار ألأول ثم إدخال جميع المعلومات في المهام المقبلة

Task 1: المهامه 1

1- Choose "Suggestion" (أقترح) أختار
2- Enter Name " Seed Ali " (سعد علي) إدخال الاسم
3- Choose data of birth " 03 / 01 / 1980 " أختار تاريخ الميلاد
4- Choose gender " Male " (ذكر) أختار الجنس
5- type address " Riyadh, King Abdullah road 115 " أكتب العنوان (الرياض، 115 طريق الملك عبدالله)
6- Type Contact " 0555606030 " إدخال الرقم
7- Type Email " seed@hotmail.com " إدخال ألا يميل
8- Type Comment " Why I can't paid post through web site " أكتب ملاحظة (لماذا لا أستطيع دفع رسوم البريد من خلال الموقع الكتروني)
9- Click next step button انقر على زر الخطوة التالية

Task 2: المهامه 2

1- Choose Suggestion (أقترح) أختار
2- Enter Name " Yousf AlZahrane " (يوسف الزهراني) إدخال الاسم
3- Choose data of birth " 11 / 01 / 1973 " أختار تاريخ الميلاد
4- Choose gender " Male " (ذكر) أختار الجنس
5- Type address " Jeddah, Jake road 265 " أكتب العنوان (جدة، 265 طريق جاك)
6- Type Contact " 0505707013 " إدخال الرقم
7- Type Email " Yousf_1973@hotmail.com " إدخال ألا يميل
8- Type Comment " I found my box post broking, I suggest open port on main door of home than drop letter easy way. " أكتب ملاحظة (أنا وجدت صندوق البريد مكسور، أقترح وضع فتحة من خلال الباب الرئيسي للمنزل لإدخال البريد) Click next step button انقر على زر الخطوة التالية

Task 3: المهامه 3

1. Choose Suggestion (أقترح) أختار
2. Enter Name " Amirah Nasser Almutairi " (أميرة ناصر المطيري) إدخال الاسم
3. Choose data of birth " 01 / 06 / 1972 " أختار تاريخ الميلاد
4. Choose gender " Female " (أنثى) أختار الجنس
5. Type address " Riyadh, Abu Baker street 81, second floor apartment 4 " أكتب العنوان (الرياض، 81 شارع أبو بكر, الدور الثاني، شقة 4)

6. Contact " 0504131534 " إدخال الرقم
7. Type Email " Amirah_Husain_1411@gmail.com " إدخال ألا يميل
8. Type Comment " Dear All, I send letter through post express before one week from Jeddah to Riyadh but until now don't received No action if don't mind check again, Why don't put tracking systems on web site "
   أكتب الملاحظة (السلام عليكم، أرسلت رسالة من خلال البريد السريع قبل أسبوع من جدة إلى الرياض ولكن حتى هذه ألحظة لم يصل شي إرجاء التأكد مرة أخرى، لماذا لا تضعوا نظم تتبع البريد على موقعكم (
9. **9.** Click next step button انقر على زر الخطوة التالية

Task 4: المهامه 4

1. Choose complaint (مشكلة) أختار
2. Enter Name " Mohammed Nasser" (محمد ناصر) إدخال الاسم
3. Choose data of birth " 01 / 11 / 1980" أختار تاريخ الميلاد
4. Choose gender "Male " (ذكر) أختار الجنس
5. Type address "Riyadh, King Fahd road 105" أكتب العنوان (الرياض، 105طريق الملك فهد)
6. Type Contact " 0555606030" إدخال الرقم
7. Type Email " moh11@hotmail.com " إدخال ألا يميل
8. Type Comment "To may concert I lost my post was coming from USA this week please check again"
   اكتب الملاحظة " إلى من يهمه الأمر أنا فقدت بريدي القادم من أمريكا هذا الأسبوع الرجاء التأكد مرة ثانية من وصول الشحنة "
9. **9.** Click next step button انقر على زر الخطوة التالية

Task 5: المهامه 5

1. Choose complaint (مشكلة) أختار
2. Enter Name " Noore Marshod " (نوري مرشود) إدخال الاسم
3. Choose data of birth " 21 / 12 / 1966 " أختار تاريخ الميلاد
4. Choose gender " Female "(أنثى) أختار الجنس
5. Type address " Jeddah, Alharam road 365 " أكتب العنوان (جدة، 365 طريق الحرم)
6. Type Contact "0505707013" إدخال الرقم
7. Type Email " noore1234@hotmail.com" إدخال ألا يميل
8. Type Comment "Dear All, I received my post but I found empty No any latter can you check again and sort this problem"
   اكتب الملاحظة " ألإخوة الأفاضل، استقبلت رسالة لي ولكن وجدتها فارغة لا يوجد فيها شي، ممكن أن تتأكدون مرة ثانية وكيف أستطيع أن أجد محتوى الرسالة "
9. Click next step button انقر على زر الخطوة التالية

Task 6: المهامه 6

1. Choose complaint (مشكلة) أختار
2. Enter Name “ Abdurrahman Saud Alharbi “ (عبد الرحمن سعود إدخال الاسم (الحربي
3. Choose data of birth “ 30 / 12 / 1978 “ أختار تاريخ الميلاد
4. Choose gender “ Male “ (ذكر) أختار الجنس
5. Type address “ Dammam, Alkobr street 81 “ أكتب العنوان (الدمام ، 81 شارع الخبر)
6. Type Contact “ 0504137364 “ إدخال الرقم
7. Type Email “Abdurrahman_Saud_Alharbi@gmail.com “ إدخال ألا يميل
8. Type Comment “To whom it may concern, I send letter through post express before one week from Jeddah to Riyadh but until now No received if don’t mind check again, I'd ask what happened about that and I attach with this message receipt “
   اكتب الملاحظة " إلى من يهمه الأمر أرسلت رسالة من خلال البريد السريع قبل أسبوع من جدة إلى الرياض ولكن حتى هذا ألحظة لم تصل من فضلكم تتأكدوا مرة ثانية أريد أن أسال ماذا حدث عليها وتجدون الإيصال مرفق مع الرسالة "
9. Click next step button انقر على زر الخطوة التالية

Task 7: المهامه 7

1. Choose comment (ملاحظة) أختار
2. Enter Name “ Hyat Saalm “ (حياة سالم) إدخال الاسم
3. Choose data of birth “ 15 / 11 / 1982 “ أختار تاريخ الميلاد
4. Choose gender “ Female “ (أنثى) أختار الجنس
5. Type address “Abha, Main road 95 “ أكتب العنوان (أبهاء ، 95 الطريق الرئيسي)
6. Type Contact “ 0504137364 “ إدخال الرقم
7. Type Email “ 2020A@hotmail.com “ إدخال ألا يميل
8. Type Comment “please sure of offers that link to the mailbox is the same up to the e-mail Please select one type of transmitter. “
   اكتب الملاحظة (الرجاء التأكد من العروض الإعلانات التي تصل إلى البريد المنزل هل هو نفس ما يصل إلى البريد الإلكتروني الرجاء اختيار نوع واحد من طرق الإرسال الإعلانات)
9. Click next step button انقر على زر الخطوة التالية

Task 8: المهامه 8

1- Choose comment (ملاحظة) أختار
2- Enter Name “ Khalid Mahmud Algahtani “ (خالد محمد إدخال الاسم (القحطاني
3- Choose data of birth “ 21 / 09 / 1966 “ أختار تاريخ الميلاد
4- Choose gender “ Male “(ذكر) أختار الجنس

5- Type address " Medina, Alharm Alnboi road 171 "
أكتب العنوان (المدينة المنورة، 171 طريق الحرم النبوي)
6- Type Contact " 0504607014 " إدخال الرقم
7- Type Email " khalid_mahmud@gmail.com " إدخال ألا يميل
8- Type Comment "Many of letters was came to mailbox not for me why I don't put this letters in yellow bag in mailbox than it can post man know this letters for other person "
اكتب الملاحظة " كثير من الرسائل كانت تأتي إلى بريدي وهي ليست لي لماذا لا نضاع هذه الرسائل في صندوق باللون الأصفر بجانب صندوق البريد لكي يعرف ساعي البريد أن هذه الرسائل لأشخاص آخرين "
9- Click next step button انقر على زر الخطوة التالية

Task 9: المهامه 9

1. Choose comment (ملاحظة) أختار
2. Enter Name " Martin Rose" (مارتين روز) إدخال الاسم
3. Choose data of birth "01 / 06 / 1972" أختار تاريخ الميلاد
4. Choose gender " Female "(أنثى) أختار الجنس
5. Type address " Riyadh, Abu Baker street 81"
أكتب العنوان (الرياض،81 شارع أبو بكر الصديق)
6. Type Contact "0504131534" إدخال الرقم
7. Type Email Martin_rose_1411@gmail.com إدخال ألا يميل
8. Type Comment "Dear brothers in the Saudi Post noted recently delayed mail, when compared with the Hereafter, companies find it faster to access. I think the problem is in the process of transmission and reception, or be related to other parts of the problem ... Greetings "
اكتب الملاحظة " الإخوة الأعزاء في البريد السعودي لاحظت تأخر البريد في الأونة الأخيرة ، بالمقارنة مع الشركات الأخرى، حيث تجد أنها أسرع في توصيل البريد. أعتقد أن المشكلة هي في عملية الإرسال والاستقبال، أو تكون ذات صلة بأجزاء أخرى من عمليات توصيل الشحنات... تحياتي "
9. Click next step button انقر على زر الخطوة التالية

Part الجزء الثالث **"Output interface"**
" واجهة الإخراج "

- First step Go to the first message then read the text then answer flowing questions:
الخطوة الأولى الذهاب إلى الرسالة الأولى ثم قراءة النص ثم الإجابة عن الأسئلة التالية
1- Read question then chose one from answers. قرأ السؤال ثم اختار واحد من الأجوبة
2- Read question then write right answer in white box below

Part 4 الجزء الرابع **Satisfaction: الرضاء**

For each statement below, please indicate your agreement rate using the following rating scale.
1=Strongly Disagree 2=Disagree 3=Agree 4=Strongly Agree

اقرأ السؤال ثم كتابة الجواب الصحيح في المربع الأبيض أدناه

S1	I think I would like to use this program frequently أعتقد أنني أود أن استخدام هذا البرنامج بشكل متكرر	1	2	3	4
S2	Do you found this interface that is communication channel is complex هل وجدت هذه الواجهة معقدة كقناة التواصل	1	2	3	4
S3	Do you think this interface was easy to use as communication channel هل الواجهة سهلة الاستخدام في التواصل	1	2	3	4
S4	I think that I would need the support of technical person to be able to use this interface هل تعتقد أنك في حاجة إلى الدعم التقني لكي تكون قادرا على استخدام هذه الواجهة	1	2	3	4
S5	Did you found the various functions in this interface for communication channel were well integrated هل وجدت الوظائف المختلفة في واجهة التواصل جيدة ومتكاملة	1	2	3	4
S6	I think that there is too much inconsistency in this interface أعتقد أن هناك الكثير من التناقض في هذه الواجهة	1	2	3	4
S7	I would imagine that most people will learn to use this interface as communication channel very quickly أتصور أن معظم الناس سوف يتعلم كيفية استخدام واجهة التواصل بشكل سريع	1	2	3	4
S8	I found the system very cumbersome to use لقد وجدت النظام مرهقة جداً للاستخدام	1	2	3	4
S9	I felt very confident using this interface as communication channel شعرت بثقة كبيرة باستخدام واجهة التواصل	1	2	3	4
S10	Overall, I am satisfied with the interface as communication channel عموما ، أنا راض عن واجهة التواصل	1	2	3	4

Part 5 الجزء الخامس **Trust: الثقة**

For each statement below, please indicate your agreement using the following scale.
Agree or Disagree.

Statement	Agree	Disagree	Agree	Disagree
(Q1) The interface features offered matched my expectations				
(Q2) I believe that this interface gave me the impression that it was honest				
(Q3) I would rely on my previous experience more than interface contents.				
(Q4) I felt this interface was unprofessional and incompetent				
(Q5) I felt that this interface was trustworthy				

Thank you for your time.

Frequency Table for Users' Responses to the Pre-experiment Questions in first experiment

Age

SN	Age	Control group (TOEGP)		Experimental group (MMEGP)	
		N	%	N	%
1	18 - 23	1	6.7	3	20.0
2	24 - 30	1	6.7	2	13.3
3	31 - 40	8	53.3	4	26.7
4	Over 40	5	33.3	6	40.0
5	Total	15	100.0	15	100.0

Gender

SN	Gender	Control group (TOEGP)		Experimental group (MMEGP)	
		N	%	N	%
1	Male	11	73.3	10	66.7
2	female	4	26.7	5	33.3
3	Total	15	100.0	15	100.0

Education

SN	Educational level	Control group (TOEGP)		Experimental group (MMEGP)	
		N	%	N	%
1	High school	1	6.7	3	20.0
2	Undergraduate Level	9	60.0	4	26.7
3	Postgraduate Level	5	33.3	8	53.3
4	Total	15	100.0	15	100.0

Have you ever used a computer?

SN	used a computer	Control group (TOEGP)		Experimental group (MMEGP)	
		N	%	N	%
1	Never	-	-	-	-
2	Rarely	-	-	-	-
3	Frequently	3	20.0	2	13.3
4	Very Frequently	12	80.0	13	86.7
5	Total	15	100.0	15	100.0

At which of following places you use an Internet

SN	use an Internet	Control group (TOEGP)		Experimental group (MMEGP)	
		N	%	N	%
1	Home	6	40.0	4	26.7
2	Work	5	33.3	7	46.7
3	Internet coffee	3	20.0	2	13.3
4	Other	1	6.7	2	13.3
5	Total	15	100.0	15	100.0

How many hours do you use the Internet per week?

SN	Internet per week	Control group (TOEGP)		Experimental group (MMEGP)	
		N	%	N	%
1	1 - 5	2	13.3	-	-
2	6 - 10	2	13.3	2	13.3
3	11 - 15	2	13.3	4	26.7
4	15+	9	60.0	9	60.0
5	Never	-	-	-	-
6	Total	15	100.0	15	100.0

What are the main reasons you do use the Internet?

SN	do you use the Internet	Control group (TOEGP)		Experimental group (MMEGP)	
		N	%	N	%
1	Browsing	7	46.7	4	26.7
2	Email	4	26.7	4	26.7
3	Education	1	6.7	1	6.7
4	Payment money	2	13.3	4	26.7
5	Other	1	6.7	2	13.3
6	Total	15	100.0	4	26.7

Have you ever visited any website for e-government?

SN	visited any website for e-government	Control group (TOEGP)		Experimental group (MMEGP)	
		N	%	N	%
1	Yes	15	100.0	13	86.7
2	No	-	-	2	13.3
3	Total	15	100.0	15	100.0

How do you rate your overall experience of this e-government?

SN	Rating of e-government	Control group (TOEGP)		Experimental group (MMEGP)	
		N	%	N	%
1	Excellent	1	6.7	2	-
2	Very good	5	33.3	5	13.3
3	Good	8	53.3	4	33.3
4	Natural	-	-	4	26.7
5	Poor	1	6.7	15	26.7
6	Total	15	100.0	2	100.0

Do you think the Internet is a good way to communicate with the government?

SN	communicate with the government	Control group (TOEGP)		Experimental group (MMEGP)	
		N	%	N	%
1	Yes	12	80	14	93.3
2	NO	3	20	1	6.7
3	Total	15	100.0	15	100.0

Raw data for users' to perform message in part 2 of the questionnaire in first experiment

Input interface

		Mouse Clicks	**Step Time**	**Test result**
Control group (TOEGP)	User1	1608	21.08	0.71
	User2	1444	18.36	0.75
	User3	1677	23.25	0.20
	User4	1576	21.08	0.71
	User5	1698	18.1	0.71
	User6	1732	22.72	0.77
	User7	1708	20.96	0.86
	User8	1802	19.52	0.67
	User9	1769	22.48	0.73
	User10	1828	19.51	0.88
	User11	1939	23.26	0.77
	User12	1992	21.78	0.75

	User13	1938	21.97	0.79
	User14	1817	21.27	0.85
	User15	1752	20.91	0.89

		Mouse Clicks	Step Time	Test result
Experimental group (MMEGP)	User1	2706	30.18	0.88
	User2	2816	27.15	0.86
	User3	2918	29.52	0.82
	User4	2820	28.3	1
	User5	3094	28.45	1
	User6	2871	30.93	0.96
	User7	2886	30.44	0.81
	User8	2849	28.99	1
	User9	2932	28.71	0.99
	User10	2992	30.7	0.97
	User11	2811	28.3	0.99
	User12	2841	28.76	0.97
	User13	2886	30.54	1
	User14	2704	29.93	0.97
	User15	2902	28.6	1

Output interface

		Mouse Clicks	Step Time	Test result
Control group (TOEGP)	User1	33	195	50%
	User2	36	144	50%
	User3	35	252	67%
	User4	28	243	50%
	User5	32	183	67%
	User6	37	191	50%
	User7	20	183	33%
	User8	31	216	83%
	User9	30	225	33%
	User10	35	181	33%
	User11	38	181	50%
	User12	33	123	50%
	User13	34	203	67%
	User14	21	123	83%
	User15	32	123	67%

		Mouse Clicks	Step Time	Test result
Experimental group (MMEGP)	User1	25	165	83%
	User2	21	124	100%
	User3	24	146	100%
	User4	24	204	100%
	User5	28	121	100%

	User6	21	168	100%
	User7	17	129	100%
	User8	24	134	100%
	User9	22	198	100%
	User10	20	181	100%
	User11	23	175	100%
	User12	27	138	100%
	User13	19	149	100%
	User14	24	141	100%
	User15	21	94	100%

Raw data for users' to perform message in part 3 of the questionnaire in first experiment

Satisfaction

A Likert scale of four was used to rate the responses as follows: strongly agree, agree, disagree and strongly disagree, with the highest rate having (4) degrees and the lowest grade scoring one (1).

	Control group (TOEGP) (N =15)														
	U1	U2	U3	U4	U5	U6	U7	U8	U9	U10	U11	U12	U13	U14	U15
S1	3	2	3	3	2	2	1	4	3	2	1	3	2	4	3
S2	2	3	1	2	3	2	4	2	3	4	3	3	2	2	2
S3	3	2	4	3	2	3	1	2	3	4	2	2	3	3	3
S4	3	4	1	1	2	1	4	2	2	3	2	1	1	3	1
S5	3	2	3	3	2	2	1	3	3	3	1	3	3	4	2
S6	2	4	2	2	2	1	4	1	3	3	1	1	2	2	2
S7	4	1	4	3	3	4	1	3	3	3	2	1	3	3	3
S8	1	3	1	2	3	3	4	1	3	3	4	4	1	2	1
S9	3	2	3	3	2	4	1	3	3	2	2	3	3	4	3
S10	3	2	4	3	2	3	4	4	3	3	1	3	3	3	2

	Experimental group (MMEGP) (N =15)														
	U1	U2	U3	U4	U5	U6	U7	U8	U9	U10	U11	U12	U13	U14	U15
S1	3	4	1	4	1	4	2	1	1	1	1	1	1	1	4
S2	1	1	2	2	4	1	1	4	4	4	4	4	4	4	2
S3	2	4	3	3	1	4	2	1	1	1	1	1	1	1	3
S4	3	4	1	1	2	1	4	2	2	3	2	1	1	3	1
S5	2	3	3	3	1	4	3	1	1	1	1	1	1	1	3
S6	3	1	2	1	4	1	3	4	4	4	4	4	4	4	1
S7	3	4	3	4	1	2	1	1	1	1	1	1	1	1	4
S8	3	1	4	1	3	1	3	4	4	4	4	4	4	4	1
S9	2	4	3	3	1	4	3	1	1	1	1	1	1	1	3
S10	3	4	2	3	4	4	3	4	4	4	4	4	4	4	3

Frequency Table for Users' Responses to the Pre-experiment Questions in Second experiment

Age

SN	Age	Control group (NMEGP)		Experimental group (AVEGP)	
		N	%	N	%
1	18 - 23	3	20.0	3	20.0
2	24 - 30	2	15	3	20.0
3	31 - 40	4	25	3	20.0
4	Over 40	6	40.0	6	40.0
5	Total	15	100.0	15	100.0

Gender

SN	Gender	Control group (NMEGP)		Experimental group (AVEGP)	
		N	%	N	%
1	Male	10	66.7	9	60.0
2	female	5	33.3	6	40.0
3	Total	15	100.0	15	100.0

Education

SN	Educational level	Control group (NMEGP)		Experimental group (AVEGP)	
		N	%	N	%
1	High school	3	20.0	4	33
2	Undergraduate Level	4	26.7	6	40
3	Postgraduate Level	8	53.3	4	27
4	Total	15	100.0	1	100

Have you ever used a computer?

SN	used a computer	Control group (NMEGP)		Experimental group (AVEGP)	
		N	%	N	%
1	Never	-	-	2	13.3
2	Rarely	-	-	7	46.7
3	Frequently	2	13.3	4	26.7
4	Very Frequently	13	86.7	2	13.3
5	Total	15	100.0	15	100.0

At which of following places you use an Internet

SN	use an Internet	Control group (NMEGP)		Experimental group (AVEGP)	
		N	%	N	%
1	Home	4	26.7	6	40.0
2	Work	7	46.7	4	26.7
3	Internet coffee	2	13.3	2	13.3
4	Other	2	13.3	3	20.0
5	Total	15	100.0	15	100.0

How many hours do you use the Internet per week?

SN	Internet per week	Control group (NMEGP)		Experimental group (AVEGP)	
		N	%	N	%
1	1 - 5	-	-	6	40.0
2	6 - 10	2	13.3	3	20.0
3	11 - 15	4	26.7	6	40.0
4	15+	9	60.0	-	-
5	Never	-	-	-	-
6	Total	15	100.0	15	100.0

What are the main reasons you do use the Internet?

SN	Do you use the Internet	Control group (NMEGP)		Experimental group (AVEGP)	
		N	%	N	%
1	Browsing	4	26.7	1	6.7
2	Email	4	26.7	3	20.0
3	Education	1	6.7	2	13.3
4	Payment money	4	26.7	6	40.0
5	Other	2	13.3	3	20.0
6	Total	4	26.7	15	100.0

Have you ever visited any website for e-government?

SN	Visited any website for e-government	Control group (NMEGP)		Experimental group (AVEGP)	
		N	%	N	%
1	Yes	13	86.7	8	53.3
2	No	2	13.3	7	46.7
3	Total	15	100.0	15	100.0

How do you rate your overall experience of this e-government?

SN	Rating of e-government	Control group (NMEGP)		Experimental group (AVEGP)	
		N	%	N	%
1	Excellent	-	-	-	-
2	Very good	2	13.3	-	-
3	Good	5	33.3	4	26.7
4	Natural	4	26.7	2	13.3
5	Poor	4	26.7	9	60.0
6	Total	15	100.0	15	100.0

Do you think the Internet is a good way to communicate with the government?

SN	Communicate with the government	Control group (NMEGP)		Experimental group (AVEGP)	
		N	%	N	%
1	Yes	14	93.3	13	86.7
2	No	1	6.7	2	13.3
3	Total	15	100.0	15	100.0

Raw data for users' perform message input interface

		Mouse Clicks	Step Time	Test result
Control group (MMEGP)	User1	1608	21.08	0.71
	User2	1358	18.36	0.75
	User3	1677	23.25	0.84
	User4	1576	21.08	0.21
	User5	1698	18.1	0.71
	User6	1732	22.72	0.77
	User7	1708	20.96	0.86
	User8	1802	19.52	0.67
	User9	1769	22.48	0.73
	User10	1837	19.51	0.88
	User11	1828	23.26	0.77
	User12	1939	21.78	0.75
	User13	1992	21.97	0.79
	User14	1938	21.27	0.85
	User15	1817	20.91	0.89

		Mouse Clicks	Step Time	Test result
Experimental group (AVEGP)	User1	2176	47.07	1
	User2	2241	47.53	0.97
	User3	2284	41.88	0.97
	User4	2251	45.63	0.93
	User5	2241	45.43	0.86
	User6	2265	45.97	0.92
	User7	2253	44.47	0.96
	User8	2228	47.63	0.98
	User9	2241	46.63	0.99
	User10	2281	43.79	0.92
	User11	2163	44.65	1
	User12	2283	48.98	1
	User13	2236	48.52	1
	User14	2241	47.53	1
	User15	2256	48.78	1

Raw data for users' perform message output interface

		Mouse Clicks	Step Time	Test result
Control group (MMEGP)	User1	33	191	0.5
	User2	36	144	0.5
	User3	35	252	0.67
	User4	28	243	0.5
	User5	32	183	0.67
	User6	37	191	0.5
	User7	20	183	0.33
	User8	31	216	0.83
	User9	30	225	0.33
	User10	35	181	0.33
	User11	38	181	0.5
	User12	33	123	0.5
	User13	34	203	0.67
	User14	21	123	0.83
	User15	32	123	0.67

		Mouse Clicks	Step Time	Test result
Experimental group (AVEGP)	User1	24	43	1
	User2	24	43	1
	User3	25	53	1
	User4	25	53	0.83
	User5	25	49	1
	User6	24	44	1
	User7	23	41	1
	User8	23	42	1
	User9	23	40	1
	User10	24	43	1
	User11	24	45	1
	User12	23	40	1
	User13	24	50	1
	User14	24	43	1
	User15	24	43	1

Satisfaction

Raw data for users' to perform message in part 3 of the questionnaire in second experiment

A Likert scale of four was used to rate the responses as follows: strongly agree, agree, disagree and strongly disagree, with the highest rate having (4) degrees and the lowest grade scoring one (1).

	Control group (MMEGP) (N =15)														
	U1	U2	U3	U4	U5	U6	U7	U8	U9	U10	U11	U12	U13	U14	U15
S1	2	2	3	2	1	2	1	1	3	2	1	1	2	4	1
S2	4	3	4	2	3	4	4	2	3	4	3	3	4	4	2
S3	3	2	2	3	2	3	1	2	3	4	2	2	3	3	3
S4	3	4	1	4	2	4	4	4	2	3	2	1	3	3	3
S5	1	2	3	1	2	2	1	3	3	1	1	3	3	4	3
S6	4	4	4	4	3	1	4	1	3	3	3	1	2	2	2
S7	2	1	3	3	3	1	1	1	1	3	2	1	1	1	1
S8	4	3	4	2	3	3	4	4	3	3	4	4	4	2	4
S9	3	2	3	3	2	1	1	3	3	2	2	3	3	1	3
S10	3	2	1	3	2	3	4	4	3	3	1	3	3	3	2

	Experimental group (AVEGP) (N =15)														
	U1	U2	U3	U4	U5	U6	U7	U8	U9	U10	U11	U12	U13	U14	U15
S1	1	1	1	1	3	2	1	3	1	1	2	1	1	1	1
S2	4	2	2	1	2	3	4	3	2	2	3	2	2	3	2
S3	1	3	3	1	4	1	2	3	4	3	2	3	3	1	3
S4	4	2	4	1	2	4	4	4	3	3	3	4	4	4	4
S5	1	2	1	1	4	2	2	3	3	3	3	3	3	1	3
S6	4	3	2	1	3	4	4	2	3	2	4	2	2	4	2
S7	1	3	3	1	4	2	2	4	2	1	4	1	1	1	1
S8	4	3	4	1	2	4	4	2	2	3	4	2	2	4	3
S9	3	2	3	3	4	2	2	3	4	4	4	3	3	4	4
S10	4	3	2	3	3	4	4	3	3	3	4	4	4	4	4

Third Experimental: Investigating the Role of full body Avatars in Multimodal E-government Interfaces

Age

	Age	Control group (VMFE))		Experimental group (VMBG)	
		N	%	N	%
1	18 - 23	1	5	4	30
2	24 - 30	1	9	2	10
3	31 - 40	5	51	3	20
4	Over 40	8	35	6	40
5	Total	15	100.0	15	100.0

Gender

SN	Gender	Control group (VMFE))		Experimental group (VMBG)	
		N	%	N	%
1	Male	11	73.3	9	60.0
2	female	4	26.7	6	40.0
3	Total	15	100.0	15	100.0

Education

SN	Educational level	Control group (VMFE))		Experimental group (VMBG)	
		N	%	N	%
1	High school	1	6.7	5	30
2	Undergraduate Level	9	57	6	50
3	Postgraduate Level	5	36.3	4	20
4	Total	15	100.0	15	100.0

Have you ever used a computer?

SN	used a computer	Control group (VMFE))		Experimental group (VMBG)	
		N	%	N	%
1	Never	2	20	2	10
2	Rarely	2	18	2	13
	Sometime	-	0	6	47
3	Frequently	3	20.0	3	27
4	Very Frequently	8	42.0	2	13
5	Total	15	100.0	15	100.0

At which of following places you use an Internet

SN	use an Internet	Control group (VMFE))		Experimental group (VMBG)	
		N	%	N	%
1	Home	6	40.0	6	40.0
2	Work	5	33.3	4	26.7
3	Internet coffee	3	20.0	2	13.3
4	Other	1	6.7	3	20.0
5	Total	15	100.0	15	100.0

How many hours do you use the Internet per week?

SN	Internet per week	Control group (VMFE))		Experimental group (VMBG)	
		N	%	N	%
1	1 - 5	2	13	0	0
2	6 - 10	6	40	2	13
3	11 - 15	1	7	4	27
4	15+	6	40	9	60
5	Never	-	-	-	-
6	Total	15	100.0	15	100.0

What are the main reasons you do use the Internet?

SN	do you use the Internet	Control group (VMFE))		Experimental group (VMBG)	
		N	%	N	%
1	Browsing	7	47	1	27
2	Email	4	27	3	20.0
3	Education	1	7	2	13.3
4	Payment money	2	13	6	40.0
5	Other	1	6	3	20.0
6	Total	15	100.0	15	100.0

Have you ever visited any website for e-government?

SN	visited any website for e-government	Control group (VMFE))		Experimental group (VMBG)	
		N	%	N	%
1	Yes	4	30	12	70
2	No	11	70	3	30
3	Total	15	100.0	15	100.0

How do you rate your overall experience of this e-government?

SN	Rating of e-government	Control group (VMFE))		Experimental group (VMBG)	
		N	%	N	%
1	Excellent	5	25	6	45
2	Very good	1	10	3	20
3	Good	2	15	3	20
4	Natural	6	43	2	10
5	Poor	1	7	1	5
6	Total	15	100.0	15	100.0

Do you think the Internet is a good way to communicate with the government?

SN	communicate with the government	Control group (VMFE))		Experimental group (VMBG)	
		N	%	N	%
1	Yes	3	25	4	33
2	No	12	75	11	67
3	Total	15	100.0	15	100.0

Raw data for users' perform message input interface

		Mouse Clicks	Step Time	Test result
Control group (VMFE))	User1	2076	38	0.71
	User2	2050	37	0.75
	User3	2080	35	0.84
	User4	1950	34	0.21
	User5	1700	33	0.71
	User6	1850	29	0.77
	User7	1600	46	0.86
	User8	2150	31	0.67
	User9	2030	32	0.73
	User10	2013	34	0.88
	User11	2015	39	0.77
	User12	1992	34	0.75
	User13	1972	28	0.79
	User14	2000	31	0.85
	User15	2011	42	0.89

		Mouse Clicks	Step Time	Test result
Experimental group (VMBG)	User1	1613	29	1
	User2	1250	28	0.97
	User3	1452	28	0.97
	User4	1614	28	0.93
	User5	1708	30	0.86
	User6	1774	26	0.92
	User7	1614	33	0.96
	User8	1812	28	0.98
	User9	1740	29	0.99

	User10	1835	26	0.92
	User11	1785	27	1
	User12	1790	28	1
	User13	1720	28	1
	User14	1724	28	1
	User15	1710	29	1

Raw data for users' perform message output interface

		Mouse Clicks	Step Time	Test result
Control group (VMFE))	User1	33	100	0.90
	User2	36	120	0.75
	User3	35	160	0.75
	User4	28	180	0.75
	User5	32	170	0.67
	User6	37	177	0.80
	User7	20	166	0.85
	User8	31	254	0.83
	User9	30	160	0.78
	User10	35	174	0.77
	User11	38	298	1
	User12	33	250	0.90
	User13	34	165	0.77
	User14	21	189	0.83
	User15	32	199	1

		Mouse Clicks	Step Time	Test result
Experimental group (VMBG)	User1	25	100	1
	User2	21	120	1
	User3	21	79	1
	User4	22	90	0.83
	User5	28	120	.080
	User6	21	90	0.85
	User7	17	79	0.98
	User8	20	80	0.89
	User9	22	160	1
	User10	20	69	0.96
	User11	21	90	0.84
	User12	24	81	0.86
	User13	19	165	1
	User14	20	89	1
	User15	21	100	1

Satisfaction raw data for users' to perform message in part 3 of the questionnaire in third experiment

	Control group (VMFE)) (N =15)														
	U1	U2	U3	U4	U5	U6	U7	U8	U9	U10	U11	U12	U13	U14	U15
S1	2	2	2	3	2	1	1	1	2	3	1	1	4	1	4
S2	3	4	4	2	4	3	4	2	3	4	3	3	4	2	4
S3	2	3	3	2	2	3	1	2	3	4	2	2	3	3	3
S4	3	4	1	4	2	4	4	4	2	3	2	1	3	3	3
S5	2	1	1	3	2	1	2	3	1	3	3	1	4	3	3
S6	4	4	4	4	3	1	4	1	3	3	3	1	2	2	2
S7	1	2	3	3	1	3	1	1	3	1	1	2	1	1	1
S8	4	3	4	2	3	3	4	4	3	3	4	4	4	2	4
S9	2	3	2	3	3	1	1	3	2	3	2	3	3	3	1
S10	2	3	3	1	2	3	4	4	3	3	1	3	3	2	3

	Experimental group (VMBG) (N =15)														
	U1	U2	U3	U4	U5	U6	U7	U8	U9	U10	U11	U12	U13	U14	U15
S1	3	1	1	1	2	1	3	1	1	1	1	2	1	1	1
S2	2	4	2	1	3	2	3	4	3	2	2	3	2	2	2
S3	1	3	3	1	4	1	2	3	4	3	2	3	3	1	3
S4	2	4	4	1	2	4	3	4	4	4	3	4	3	4	4
S5	2	1	1	4	1	2	3	2	3	3	3	3	3	3	1
S6	4	3	2	1	3	4	4	2	3	2	4	2	2	1	4
S7	3	1	3	1	4	2	4	2	2	1	4	1	1	1	1
S8	4	3	4	1	2	4	4	2	2	3	4	2	2	4	3
S9	2	3	3	3	4	2	3	2	4	4	4	4	4	3	3
S10	3	4	3	2	3	4	4	3	3	4	4	4	4	4	3

Raw data for users' trust to perform message in part 3 of the questionnaire in first experiment

Trust

	Control group (VMFE) (N =15)														
	U1	U2	U3	U4	U5	U6	U7	U8	U9	U10	U11	U12	U13	U14	U15
Q1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
Q2	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Q3	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
Q4	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Q5	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0

	Experimental group (VMBG) (N =15)														
	U1	U2	U3	U4	U5	U6	U7	U8	U9	U10	U11	U12	U13	U14	U15
Q1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Q2	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Q3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
Q4	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
Q5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0