THE EFFECTIVENESS OF THE INTERACTION AND TRUST ON THE INTELLIGENT DIGITAL ASSISTANTS USAGE

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Abstract - The growing volume of data and the need to access information instantly has guided people to use technology. Intelligent Digital Assistant (IDA) developed as a sufficient tool to cover the web search engine features and more to meet the users' dynamic needs. The IDA can be simply defined as a software that functions as a personal information manager such as Siri and Google Now. This is an explorative study that aims to identify the various factors that impact the usage of the IDA from two aspects which are interaction and trust regarding the future usage, in order to find out the most effective directions of development for the IDAs. The importance of this study is due to the increased numbers of the IDAs' usage users. As mentioned by Gautier and Pestanes [1], the usage time of these systems is converging to be one billion hours per month. The findings indicate that interaction and trust significantly and positively affect the IDA usage. The results show that ease of use and the less effort are positively associated with the IDAs adoption. However, giving an inappropriate answer or out of context dialogue affect the usage significantly but negatively. Therefore, quality and recognition accuracy are factors that should be developed to increase the rate of IDA's usage.

Index Terms - Intelligent Digital Assistants (IDAs), Artificial Intelligence (AI), Human-Computer Interaction (HCI), Natural Language Procession (NLP).

I. INTRODUCTION

The growing volume of data and the need to access information instantly has guided people to use technology. The web search engine was established to meet users' need to find the requested information. A web search engine is defined by Nasirian et al. [2] as "a software system that is designed to search for information on the World Wide Web". However, the 'Anatomy of a Search Engine' paper concludes that Google's search engine typically provides the best results due to its innovative PageRank algorithm [3]. Nevertheless, despite all the benefits of using search engines, they still have limited features and do not simulate the reality of fast technological development or perform all of the users' desired tasks. In regard to these limitations, Intelligent Digital Assistants (IDAs) have been developed to provide web search engine features and meet the users' dynamic needs more effectively. An IDA can be simply defined as software that functions as a personal information manager; but they are also "the realization of the science fiction dream of interacting with our computers by talking to them" [4].

1.1 Research problem statement

As Rousso and Schwartz [5] note, the purpose of developing the IDA is to simplify the search process and reduce the time for multitasking. Therefore, IDAs, which can also be called voice assistant systems, are expected to provide highquality services because they are capable of monitoring both environments and users. In addition, these systems offer new sorts of interactions which are more implicit and transparent kinds of exchanges with users. These new interaction types have caused new challenges in terms of quality evaluation [2], therefore, these challenges need to be addressed through investigation in 3 order to maintain the development of IDAs and increase their usage. Although much work about trust perspective has been done to date, more studies are needed in order to establish the impact of trust on IDA usage. In addition, no prior study has considered the effectiveness of interaction quality and trust on IDA usage in Saudi society, specifically in terms of the factors affecting usage.

1.2 Research aims and objectives

To address this gap, this study aims to propose some factors that could affect interactions and trust and measure the impact of these factors on IDA usage. This study intends to answer the following questions: (1) What are the potential factors affecting the usage of IDAs? and (2) What are the impacts of these factors on usage? This study is an explorative study to identify the range of factors that affect the usage of the IDA from two perspectives (interaction and trust) in terms of increasing or decreasing usage in the future, in order to find out the most effective directions for development of the IDA. Moreover, the study targets Saudi consumers in particular, measuring current IDA usage in Saudi Arabia and then investigating how it could be affected, by which factors and in which direction.

The importance of this study lies in the rapid growth in IDA usage with many people using voice assistant systems such as Siri and Google Assistant on their smartphones. Indeed, the usage time of these systems is now approaching one billion hours per month [6]. Moreover, mobile devices have become more personal by allowing users to be connected to the internet (online) all the time, and by assisting them with tasks in their work or even in their daily lives. This makes the

context in which IDAs are used a crucial factor to consider [7]. According to Kline [8], Apple has installed a large number of IDAs on smartphones, as has Google. However, while Microsoft offers IDAs on personal computers, smartphones and smart speakers, Alexa has them just on smart speakers. Yet, Newsroom [9] claims that interactions with IDAs on smartphones will account for 20% of user interactions by 2019. The increase in IDA user numbers underlines the importance of this study and makes it worthwhile. In addition, finding the right directions for improvement to keep up with users' needs and satisfy them will provide guidelines to help companies develop their IDAs and get the most advantage. The goal is to enhance the technology so that a digital assistant will not only be more effective in managing a large selection of tasks, but will likely be able to do so in a way that is surprisingly human.

II. LITERATURE REVIEW

2.1. What are Intelligent Digital Assistants?

Intelligent Digital Assistants are a software service, which can be coupled with specialised hardware tools, including a smart speaker, and are often presented on personal computing devices such as private smartphones, computers, tablets, or wearable technology (including virtual wristwatches). The concept of the IDA is also referred to by terms such as 'intelligent personal assistant', 'voice-enabled digital assistant', 'virtual digital assistant', 'intelligent virtual assistant', 'personal digital assistant', 'virtual assistant', 'Smart Assistant' or 'digital assistant' [10], [11]. As Bahceci [12] notes, Intelligent Digital Assistants (IDAs) can be used and implemented in a variety of operating systems, and they can be made more intelligent with the use of Artificial Intelligence (AI), Human-Computer Interaction (HCI) and Natural Language Processing (NLP).

Artificial intelligence has been defined as "a scientific field which strives to build and understand intelligent entities" [12, p. 5]. The early focus of HCI has been on delivering high usability by concentrating on how design interaction and implementation interface [2]. Bahceci [12] defined NLP as "a field in artificial intelligence and linguistics concerned with interaction between computers and human natural language". It can also be defined as the capability to analyse and synthesize voice output, voice input and parse natural language requests. In AI-based systems, HCI is a significant concept and becomes more critical in interactive systems [2]. The importance of HCI is that it has the potential to change everything around us through interactive computing services, using digital technology in order to make lives more convenient, exciting and efficient. In addition, NLP is essential to understand and improve voice-enabled commands, and also to interpret human natural language in Human-Computer Interaction. It is also used to match user voice input to executable commands. Therefore, HCI and NLP are essential elements of IDA systems and their functionality [13].

2.1.1. The IDAs system mechanism

The use of Intelligent Digital Assistants (IDAs) relies on two main actions: firstly, requests for information and secondly, the performance of tasks. However, IDAs can be used for more purposes based on the user's interest. For example, companies are using virtual assistants to increase productivity streamline methods [14]. However, by comparison with traditional digital devices and the internet services, IDAs have a different purpose that concentrates on natural language interaction, which is voice-enabled and includes a voice input and output and also the NLP [11]. In addition, according to George [14], IDAs rely on humans to develop the datasets and algorithms required in order to mimic human intelligence and "learn" how to answer questions and solve issues. Therefore, the execution of requests is based not only on the on crude input "ask" or command from the user, but also the user's individual information and the history of that user's utilization. However, some users are not aware of this, and this could lead to their dissatisfaction with the IDAs results. In contrast, the efficiency of the IDAs can be further increased by developing the NLP to provide the data that trains and optimizes the algorithms that power IDAs' systems are suggested (Ibid). Improving the NLP would help to decrease the user's dissatisfaction and show better results thereby increasing the intention to use the IDAs.

2.1.2. The IDAs' previous studies aspects

Just one study has considered the interaction and trust perspectives of IDAs [2]. However, its main focus was on the adoption of Artificial Intelligence (AI)-based technology. This study shows a strong relationship between the interaction and trust in terms of measuring the acceptance rate of the IDAs as a new technology, and the authors conclude that interaction quality significantly affects an individual's trust in and adoption of IDA technology. The reason that only one study has considered the trust and interaction aspects could be because IDAs are still new technology so more time could be needed for more in depth evaluation. Therefore, in this study, the interaction and trust will be considered separately in terms of measuring their impact on IDA usage. Then any common factors will be identified in order to find 10 out if there is any relationship between them which could affected usage in the future.

As supported by Kiseleva et al. [14], there is a need for assessment of IDAs effectiveness in helping users with tasks because of the significant changes in accessing information that have been introduced by IDAs through enabling dialogues. However, Bahceci [12] claims that it isn't viable to measure intelligence and technologies at the moment, mainly because of the fact

that the IDAs under discussion are under closed development. Nevertheless, it could be possible to measure and evaluate the IDAs from several different aspects due to the speed of progress and development and also the improvement of evaluation methods. For instance, the latest study by López et al. [16], measured the service and performance of IDAs by making some comparisons between them. This shows that the measurement of IDAs is starting to be under open development.

IDAs have been studied from different perspectives, notably security [17, 18], IDAs' capability [12], behaviour-based evaluation [19] and user satisfaction [14]. However, there seems to be a lack of studies measuring the effectiveness of the interaction perspective and trust perspective on the usage of IDAs. Furthermore, no studies have been found that considered the usage of IDAs in Saudi Arabia. Therefore, the next two sections will consider the concepts of interaction and trust in IDAs in more detail and these will then be measured based on Saudi society through the use of the online questionnaire.

2.2 The concept of trust

Intelligent Digital Assistants (IDAs) open an innovative world where people can ask a machine to perform tasks as if it were human. For example, when a user wakes up, they can ask their IDA "Hey, what's on my calendar for today?" or "Hey, turn on the living room lights". Ideally, these conversations should be between the users and their assistants only. However, it is questionable whether they actually are. New technology needs to be accepted by the users in order to be adopted, and trust is one of the most basic aspects that play an important role in adaptation. Trust is defined by Rousseau et al. [20, p. 395] as "a psychological state comprising the intention to accept vulnerability based on positive expectations of the intentions or behaviors of another". Moreover, ability, benevolence, and integrity are factors specified as a result of multidimensional trust, as supported by scholarly research about trust [21]. In general, trust is an essential component which reduces the perceived risks and uncertainties in social or monetary interactions, mainly when making decisions or adopting new technology (Ibid). Therefore, it is critical to explore technology adoption literatures which demonstrate examine factors that affect mobile phone application usage, including those that contain IDAs, in order to identify the factors affecting IDAs' usage, particularly those related to potential security and privacy concerns. Besides that, Chung et al. [10] confirms that security and privacy threats of these IDAs have not yet received enough attention.

2.2.1. Technology adoption

The success of a new technology relies on the users' acceptance. According to Bailey and Pearson [22], Management Information Systems (MIS) success criteria have consistently included variables such as the attitudes of the users, the impact of performance and actual system usage. The main, longstanding goal of an MIS is to develop the understanding of the factors which influence the successful development and implementation of primarily computer-based systems in corporations [23]. He added that perceived ease of use, attitude toward using the system and perceived usefulness are three factors that demonstrate users' motivation. These three factors could affect IDAs usage positively or negatively based on the results of some evaluations and measurements. In order to identify the factors that affect IDA's usage, users' attitude toward the IDAs, systems usage and the IDAs' ease of use needs to be evaluated.

For instance, perceived ease of use has been defined as "the degree to which an individual believes that using a particular system would be free of physical and mental effort", and it includes a causal impact on perceived usefulness (Ibid). In 1986, the first technology acceptance model (TAM) was introduced, providing a theoretical framework for the user's inclination toward new technology [24]. The TAM was developed in order to understand the process of user acceptance more clearly and to provide new theoretical insights into the successful design and execution of information systems. It also offered a theoretical basis for the test of user acceptance as a practical methodology which could empower system designers and implementers to evaluate proposed new systems prior to implementation (Ibid).

In addition, Venkatesh's study [25] tried to find the most influential factors that affect users' acceptance of a new technology. However, this does not mean that the same factors could indicate effective results for every new technology because each technology has different features which could require different evaluation factors. To measure the effectiveness of the factors that affect IDA usage, IDAs could be considered as mobile phone applications, and mobile phone acceptance patterns have been determined by many researchers [26]; however, Aldhaban [27] concludes that the lack of in-depth analysis of the factors that affect users' acceptance of technology has created a gap, and a holistic approach needs to be adopted in order to reflect users' perspectives as a whole on the product or service on their smartphone. At this stage, it may be helpful to adopt established theories such as the technology acceptance model, which focuses on the take-up and usage of information systems [28], and the unified theory of use and acceptance of technology.

According to Moorthy and Vu [29], the factors governing IDA usage can be understood through explaining theories of specific technology tendencies, as adoption patterns of a mobile phone. They add that important constructs were established and can predict the use of IDAs, such as behavioural intention for the use, facilitating the conditions and social influence.

However, these need to be streamlined to foresee factors impacting reception of specialized mobile technologies that utilize voice interaction. For instance, in the medical sector, individual behavioural intentions related to the acceptance of smartphones among medical specialists and medical caretakers was demonstrated. It was found that the users' attitude toward smartphone usage was the most significant predictor for their intention and indicated that there was no significance of individual factors [30]. However, the attitude toward uses of a technology is a function of perceived usefulness and perceived ease of use. The reasons for lack of importance of individual factors could be because individual factors such as education or experience are correlated with user attitude which cannot be notable for medical specialists and medical caretakers who likely don't perceive individual factors which influence their attitudes towards smartphone usage (Ibid).

In addition, Chin et al. [31] focused on the implications of privacy and security on users' perceptions and behaviours in the smartphone ecosystem. They concluded that running sensitive, private or financial tasks on a smartphones was viewed with apprehension by participants, which were 60 in total. As they noted, this was due to four fundamental factors: loss of data, network security communications misconceptions, fear of theft and worries about accidentally touching/clicking. These factors that affected privacy and security could also affect users' trust, and hence their IDA usage.

2.2.2. Privacy and security

Wang and Petrison [32] found that users' responses to threats of privacy depend on the sort of data requested. However, according to Malhotra et al, [33] previous privacy studies have found that the sensitivity of information affects the user's willingness to disclose personal data. Despite all the changes and development in technology, users still prefer not to use all types of personal information with the technology. As supported by Moorthy and Vu [29], people tend not to share their private information with their IDAs. This could be due to one of two main reasons. Firstly, it could be because all the dialogues are recorded. As explained by Hoy [4] the IDA records the user's voice and transfers the recording to a determined server for processing and interpreting it into a command; then, based on the command, the server will supply the IDA with appropriate information in order to relay it to the user, to complete different tasks with other devices, or even play the user's requested media. Therefore, as Chung et al. [10] note, this makes it possible for unauthorized entities to use the information to identify people, to maliciously access systems which implement user's voice recognition, or process data and assemble voice artefacts that might be used to impersonate users. The second reason could be due to privacy issues or security threats. IDA users have reported some data privacy issues such as unintentionally recorded voice [34]. This means that voices may be recorded by means of coincidence and transmitted to the cloud which raises the possibility of eavesdropping on private conversations unintentionally. Therefore, users don't have total control about sounds transmitted from the IDA to the cloud. Other security threats associated with IDAs include malicious voice commands [34]. For instance, in the case of some IDA services, misuse of users' voices could lead to dangerous outcomes. Some IDAs offer a voice training attribute, however it's troublesome to teach the device to recognise the voices of the users and their tones perfectly, so, in many cases, recognition is only partial [10]. In this manner, a malevolent individual may be able to trick the system into considering that the genuine proprietor is the individual talking, leading it to act on commands from a malicious user. As a result, these issues could affect IDAs' usage negatively or could make users more cautious of transmitting private information.

Hypothesis1: Perceptions of intelligent digital assistants' privacy invasion and perceived information sensitivity are positively associated with privacy concerns, and higher privacy concern is negatively associated with trust in IDAs. This leads current users to avoid using their IDAs due to privacy and security concerns.

However, several different forms of trust were identified by Rousseau et al. [20]. These include relational trust that builds up based on repeated interactions over time. In fact, one of the logical ways to build trust with any technology is through the usage and experiences with that technology, so if the technology meets the user's expectations with no major issues then a trust relation will start to develop and will improve over time based on the user's experience with the technology. However, in the case of IDAs, some problems were discovered which could negatively affect the usage decisions of new and existing users. For example, recent DDoS assaults on Dyn LLC exploited vulnerabilities in tens of millions of home-based gadgets with webcams and DVRs, infecting them with a Mirai botnet and then using them to assault Dyn's systems. Due to the fact that similar devices are used in the IDA ecosystem, there are risks that they might be compromised if they too contain security vulnerabilities [35]. As reported in the "Alexa, Can I Trust You?" paper, some IDAs power remotely-controlled speakers and can be used as a device to monitor young children [10].

However, this type of remotely controlled feature also has some security issues. For example, in one recorded case, a family in Washington described their horror at discovering that the child monitoring device they used in their 3-year-old son's room had been hacked, enabling a complete stranger to speak to their little child and say disturbing messages through the monitor

(Ibid). As a result of things like this, parents could be more sensitive about using IDAs to help keep their children safe. Moreover, the possibility of hacking could stop persons from using their IDAs in order to guard their security and privacy from such threats. However, despite all these issues, the number of IDA users is still increasing with usage in the USA, increasing two-fold between 2013 and 2015, with up to 65% of smartphone users now using IDAs [1]. This could be a result of a lack of awareness of security issues or perhaps a belief that the benefits of IDAs are greater than the existing risks. Another reason behind the increase could be the accuracy of the answers IDAs give to users' questions. For example, Google Assistant on smartphones had an accuracy rate of over 95 percent out of 5000 random questions [36].

Hypothesis2: Users are less willing to provide sensitive information on their IDA; however prior positive experience with the IDA is positively associated with trust in the IDA and also with increased intentions to disclose sensitive information via the IDA, but the extent of risk beliefs associated with recording dialogue information is negatively associated with trust in the IDA.

2.2.3. User satisfaction and trust

Moreover, when considering the effect of satisfaction on trust, Garbarino and Johnson [37] believe that both information and system quality are the factors that should be at a high level to avoid loss of trust. This means that they identify information quality and system quality as two factors that could be the most significant factors affecting trust. Indeed, these two factors are "hygiene" factors which should be at an acceptable level to meet users' expectations (Ibid) because if the quality of the given information or of the IDA system itself is not acceptable to users, this could affect IDA usage and, ultimately, lead users to stop using their IDAs altogether. According to Zhou [38], information quality is simply the perceived quality of the information supplied, whereas system quality is the perceived quality of the IDA system.

Another aspect to consider is service quality and the extent to which a service meets the users' expectations [39]. For example, a recent study by Nasirian et al. [2] found that the most significant factors affecting users' satisfaction and usage intentions are service quality, system quality and information quality. They found that the main factor affecting trust is service quality, whereas the main factor affecting satisfaction is system quality. For instance, if an IDA did not provide good quality service by giving correct information, then that would affect the user's trust and could lead to them avoiding using the IDA; whereas if the system quality was good and provided immediate answers to the user's questions, then this would increase user satisfaction. Gaining both the users' trust and satisfaction at the same time doesn't just encourage them to use the IDA but also to use it more frequently.

Hypothesis3: Information quality, system quality, service quality and interaction quality of an IDA positively affect user's trust in the IDA.

2.2.4. Gender and trust

In addition to the above factors, gender also plays a role in trust. Perhaps due to the topic sensitivity, researchers have tended not to focus on gender differences in relation to trust, but a few studies in the MIS literature have compared the trust between men and women (e.g., [40]). Riedl et al. [41] focused on neural gender differences in online trust and explained the relationship between trust and gender. They found that trustworthiness is encoded in completely different brain ranges in women and men, in this way recognizing vital neurological differences between genders. In addition, their findings indicated that more brain regions appeared to be active in women than in men. As Kenning et al. [42] suggest, these discoveries may bolster the idea that women act upon their feelings more quickly than men do, since these areas included emotion-laden brain ranges, such as the amygdala and the insular cortex, which are activated by sudden emotional states. If, as these studies suggest, men and women handle trust-related data in completely different ranges within the brain, this may suggest that they treat trust-related data and choosing whether to trust based on different processes [43]. These discoveries moreover have provided significant findings for understanding trust in relation to men and women by providing neurological clarification for such behavioural differences.

Hypothesis4: Female gender is positively associated with trust, and trust in an IDA positively affects user's intention to use the IDA and increase its reliability and user dependency.

2.3. The concept of interaction

Interaction is one of the main aspects that needs to be considered in relation to IDAs, because without interaction there is no use for an IDA. The conversational and multimodal approach to voice-enabled systems has been accepted very well by users [44, 45]. In addition, IDAs use modern mechanisms for getting information, which are different compared to conventional web searches. According to Kiseleva et al. [15], the key difference between the IDA and a traditional web search is the conversational nature of the interaction with the user. For instance, the spoken form is used to request information from an IDA while the written form is used in a standard web search. Furthermore, comparison of users' behaviour when using IDAs found that they expected the device to maintain a particular context throughout a conversation (Ibid). For example, if a user asked about the weather in "Nottingham", a

specific city, then the IDA should understand that any second question could also be about Nottingham. The IDA is made distinctive by understanding these transitions, offering context-rich, task-based searches based on dialogues which are more complex when compared to web search [46].

According to Branco et al. [47] the key factors in gaining wider acceptance of multimodal systems, such as voice-enabled systems, and in developing better experiences for the user are the accurate recognition of spoken commands and the system's quality and speed of response. These factors are a result of an IDA's application evaluation, offering facilities such as e-mail management which provide an intelligent and multimodal interaction with a mobile or fixed device. However, they need to be improved over time to maintain user acceptance. The current quality of speech recognition, due to gigantic online processing, is one of the reasons for the increasing adoption of IDAs [47]. Moreover, the spoken dialogue mode of interaction could be seen as more natural in terms of communication and is normally speedier when compared to writing.

Systems of spoken dialogue understand voice commands as a form of a dialogue and respond to them, which make them closely related to IDAs [48]. However, interaction and understanding of user intention is also supported by IDAs, which makes them different from traditional spoken dialogue systems. Users now expect their IDAs to understand their intent and to maintain the dialogue's context [15]. Furthermore, users' interaction with IDAs are not purely based on speech - their responses can be typed as well. As supported by Hoy [4], IDAs can respond to far more questions and commands than earlier voice-activated technologies which also makes them different. The reason for this is that IDAs are always connected to the Internet, to a central computing system which receives each interaction in order to analyse the voice commands and provide the user with the proper response. As Hoy notes, this allows IDAs to create meaningful responses quickly due to advances in natural language processing known as 'computational linguistics'.

Hypothesis 4: Increasing the accuracy and quality of speech recognition in the IDA is positively associated with user satisfaction and user intention toward the IDA.

Hypothesis 5: The accuracy and quality of speech recognition in the IDA affects the users' attitudes toward the IDA.

Kiseleva et al. [15] have defined search dialogues success prediction as a new problem which is important for the evaluation and development of IDAs. While user satisfaction is often determined based on clicks in web search, the ongoing replacement of manual clicks with voice control, touch, gestures and direct voice responses has reduced their significance in search dialogues. Moreover, in order to understand the factors that affect the IDA usage in terms of interaction, the key elements of user satisfaction need to be considered. Consideration of the factors that influence user satisfaction could indicate the effectiveness of these factors in relation to IDA usage. According to Jiang et al. [48], users mostly use voice commands to communicate with IDAs, and it has been shown that user satisfaction is influenced negatively by speech recognition errors. Understanding user intent is important as an IDA needs to be able to understand the user's intent in order to carry out a specific task or give an answer [15]. In dialogue based interactions, users expect an IDA to keep the dialogue's context in order to fulfil their complex information needs; thus the expectations of users are more sophisticated in terms of needs when their interaction is with an IDA (Ibid).

Spoken dialogue systems have been well studied in the literature [49], [50]. Both Jiang al. [19] and Kiseleva et al. [15] proposed that certain interaction scenarios, including controlling the device, performing web searches, and structured search dialogues, can be used to measure user satisfaction based on their interaction with their IDAs. Kiseleva et al. [15] focused on the satisfaction of the user based on three usage scenarios, as well as measures such as completion of the task, effort taken and quality of speech recognition. In addition, they considered that some factors were themselves involved in more complex scenarios, such as complex information needs, automatic speech recognition (ASR), dialogue-based interaction and understanding user intent. Furthermore, the perceived task complexity was linked with effort, which indicated that the amount of effort required for completion of complex tasks may affect user satisfaction [51]. These factors were measured in each scenario to find out which had the greatest effect on user satisfaction. The scenarios were then used in order to understand what factors influence user satisfaction the most and which affect IDA usage, either positively or negatively.

2.3.1. The characteristic types of IDAs usage scenarios

2.3.1.1. 'Controlling a Device' Scenario

The direct access to on-device functionality is the main focus of this scenario [15]. For example, calling a person or contact, playing music, checking the calendar, opening an application, turning the wi-fi on or off and sending a text message are tasks grouped into same category; the reason is because they share the similarity that users seek to access them through the IDA (Ibid). These functions are normally offered by the hosting device rather than the IDA itself, but the IDA serves as a quick and efficient interface to access them. Additionally, the usefulness of this scenario is due to the fact that, without the IDA, it would ordinarily takes several steps to complete some of these actions (Ibid). For instance, when making a

phone call, the user would need to go through several steps: first, open the contact list, then identify the required person and, finally, call them. This could be time consuming, particularly if the user is not familiar with the device. However, nowadays IDA users can speak directly to their device to achieve these tasks. As long as the task context and the user's words can be correctly recognized by the IDA, the user's effort will be reduced.

2.3.1.2. 'Performing a Web Search' Scenario

The general web search scenario is another popular usage scenario [52]. One of this scenario's characteristics is the optionality of the input - it can be speech or even text. In addition, from a user satisfaction point of view, the 'right' answer is evident in this scenario; indeed, this point has been identified as a main contrast point compared with the information searching task. To satisfy a user, the IDA needs to understand a request correctly and then provide the user with access to the right functionality [15]. However, the users' intent can be ambiguous in web search scenarios which can lead the search result page (SERP) to incorporate different kinds of answers such as images and answer boxes which present diverse answers for a specific query based on location (Ibid). In addition, previous studies about web searches have concluded that user behaviour is affected by the types of answers [53]. However, according to Ingwersen and Järvelin [54], users show different behaviour for information seeking tasks.

2.3.1.3. 'Structured Search Dialogue' Scenario

This scenario is another mechanism by which the user's interaction with the information systems supported by some IDAs can be examined. In this scenario, individuals use their voice to engage in a conversation with the system, and the IDA needs to be able to maintain the context of dialogue as it develops. This scenario includes two task-types: 'simple' and 'mission' tasks. The simple task consists of a question and an answer, such as a weather-related query, whereas the mission task involves a series of interactions with the IDA in order to achieve a final goal, such as finding a suitable place for a holiday. The mission task is more complicated compared to the simple task, which can be similar to the first scenario web search, and it relies on the IDA understanding the need to keep context within the conversation. Completing a mission task successfully requires an IDA to respond correctly to a sequence of user instructions in order to reach the desired outcome, and the device's response at each step in the process can either satisfy or frustrate the user.

Hypothesis 6: The complexity of dialogues is positively associated with user effort, and greater user effort is negatively associated with user satisfaction and user intention towards the IDA.

Hypothesis 7: Ease of use and a reduction in the effort required to complete tasks are positively associated with IDA adoption; also overall user satisfaction is correlated with ease of use, confidence, dialogue, interaction control and error recognition.

III. METHODOLOGY

The quantitative approach was selected as the most appropriate approach for this study in order to test the research hypotheses and find answers to the research questions, considering the three main aspects (usage, interaction and trust), and also to determine their independent variables. Moreover, as quantitative methods can help us explore the interaction between the dependent and independent variables, this could indicate new significant paths for producers in terms of developing and improving IDAs.

It was decided that a sample of 200 participants would be most appropriate for this study. Concerning the sampling approach, factors such as gender were considered with the target of recruiting 100 male and 100 female participants. However, due to the randomness approach that was adopted when selecting participants in order to get more accurate data, the actual number of female participants was 151 with 49 male participants.

The questionnaire had 28 questions in total and was divided into 3 sections with a different focus for in each section. The first section focused on usage and had 9 questions related to users' identification (such as age and gender) and their prior use of IDAs (such as which IDA was used, how many times and where). The second had 10 questions and the main focus was on interaction; the questions in this section reflected the interaction of the users with the IDA based on three scenarios: a) the controlling device scenario, b) the web search scenario and c) the structured search dialogue scenario. These scenarios were explained simply and clearly in the questionnaire to make sure the questions were understandable. The questions in this section asked participants about their experiences of these types of interactions, for example, which scenario required more effort, and how good was the interaction quality and the capability of the IDA. The last section had 9 questions with the main focus on trust. Participants were asked how confident they felt when using their IDAs and to what extent did they count on getting correct answers from the IDA; this section also included questions that indicated the users' intentions about using IDAs in the future.

IV. ANALYSIS

4.1 Analysis techniques

Usage of IDA systems could be modelled as two observable parameters which shows the prior usage of the IDA and the intention to use it in the future.

However, in this study, usage of IDA systems is investigated based on two perspectives: trust and interaction. Since these parameters are not totally directly observable, reliability analysis was conducted to establish the most consistent parameters to estimate each of the above. Thus, each item represented in the aim of the study was evaluated from the resultant factors of the questionnaire. Once the survey questions had been studied to find appropriate parameters to represent trust and interaction, the reliability analysis was applied to find the most consistent parameters which could be used together to evaluate these unobserved parameters. After that, the consistent factors for evaluating each main parameter were identified. The evaluation was done by taking the average of the consistent factor and considering it as the latent parameter used for the regression model. Next, hypothesis tests were conducted using one-way analysis of variance if the assumptions of the one-way ANOVA were not violated. Analysis of variance can be used to compare the mean values of a parameter within several groups (categories) to see whether there is a significant difference between the mean value of the parameter in each group or not. This assumes that the residual of the model is normally distributed and the residual has almost homogenous and constant variance for all the predicted values. When assumptions of normal distribution were violated, then a non-parametric test was used as an alternative to one-way ANOVA.

The non-parametric Kruskal-Wallis test is an extension for the Mann-Whitney U-test when the number of levels exceeds two. Instead of testing the mean values of each group, it works with the rank of each value of the dependent variable. It checks the null hypothesis that each group in the test has the same distribution with equal median. However, for the hypothesis tests which included both discrete factors, the chi squared test of association was done to check the null hypothesis that the factors are independent. In addition, Pearson correlation was calculated to check the null hypothesis that the parameters had zero correlation (There is no correlation between those two parameters). Moreover, two-way analysis of variance was also conducted to check whether the effect of the parameter found in one-way ANOVA remained consistent if the group was controlled by another categorical parameter. Furthermore, post-hoc tests were used for those factors which were deemed significant as a result of one-way ANOVA to check which of them were significantly different from each other. After finding all the parameters which affect IDA usage, multiple regression analysis was conducted. This was done step by step, adding and removing parameters which were not significant to find the model which had the maximum R-squared value. Assumptions of the multiple regression model were investigated and the residual of the model checked to confirm the assumption of normality of the residual and the homogeneity of variance. Moderation analysis was done after implementing the multiple regression model and finding the best model. The moderator analysis was conducted to see if there was any significant effect for the moderators (interaction) in the model. In each step one interaction parameter was added and the percentage change in R-squared value checked. The significance level of the added moderator was also considered. This was done by checking if the added moderator was significant at 5% significance level or not to see if it could be considered as a parameter which significantly improved the model and added more explanation about the dependent variable (increased the R-squared value of the model). If the moderator was significant it means it moderated between two independent parameters. In addition, steps were taken to consider all the interaction parameters and find all the effective moderators. All the categorical variables were converted to dummy variables in the moderation analysis and their interaction with each other and with the main parameters was checked to identify the potential factors which could explain the variation of the usage. All the analysis for the reliability analysis, hypothesis test, multiple regression and moderator analysis was done using SPSS. Finally, structural equation modelling was performed to consider the correlation between the covariates and to estimate the equation for each parameter avoiding a high correlation between parameters in each equation. This helped to avoid multicollinearity in the data used in the equation. A multiple weighted regression model was used in the analysis in order to confirm the results obtained in the earlier moderation analysis, covarying the parameters and the error terms of the equations if there was a significant covariance between them. Covariance between the parameters showed to what extent the variation of one parameter is associated with the variation of the other. The results obtained will be compared with previous parts below to see if they were consistent and to check whether the same individual effect on the dependent variable or the effect of the parameters were not shown clearly due to the existence of multicollinearity in the independent parameters. Multicollinearity occurs when two independent parameters have a high correlation and one of the parameters could be predicted using the other one. In such cases, structural equation modelling can be used to consider all the relationships and use all the equations together in one model to find the effect of all the parameters in each equation. This step will be done using SPSS AMOS to graphically construct the structures for the equations.

4.2 Summary of the Results

4.2.1. Reliability analysis

Reliability analysis using Cronbach's Alpha is done to calculate the internal consistency of the parameters in order to find the appropriate subscales for usage,

interaction and trust.

4.2.1.1. Usage

Appropriate parameters that represent the IDA usage were found in section 1 of the questionnaire: 3 parameters (questions 6, 7 and 8). The reliability analysis for these 3 factors showed a moderate consistency. The standardized Cronbach's alpha is 0.623, a value considered a questionable consistency (Table 4.1). Some researchers deem this questionable reliability, while others call it moderate reliability. The inter-item correlation for these 3 parameters shows that the correlation is significantly different from zero which means there is a correlation between the parameters (Table 4.2).

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.514	.623	3

Table 4.1 Reliability statistics for three parameters of usage

Inter-Item Correlation Matrix

	How many times did you use the IDA this month?	How was your experience with the IDA?	How easy was the work with the IDA's system?
How many times did you use the IDA this month?	1.000	.277	.227
How was your experience with the IDA?	.277	1.000	.562
How easy was the work with the IDA's system?	.227	.562	1.000

Table 4.2. Inter-Item Correlation Matrix for three parameters of usage

The subscales for evaluating the IDAs usage	
Usage of IDA	1. How many times did you use the IDA this month? 2. How was your experience with the IDA? 3. How easy was the work with the IDA's system?

Table 4.3. Subscales of Usage of IDA

4.2.1.2. Interaction

In section 2, there were 6 factors that looked appropriate for evaluating the interaction parameter. The reliability analysis showed acceptable consistency with Cronbach's alpha of 0.739 (Table 4.4). The inter-item correlations were all significantly different from zero.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.739	.756	6

Table 4.4. Reliability Statistics of 6 subscales of Interaction with IDA

The subscales for evaluating the interaction	
Interaction	1. How was the IDA's system quality? (such as the system's time response and voice recognition) 2. How satisfied are you with the interaction control? (the control that you had upon the system actions) 3. How satisfied are you with your experience? 4. When you use the IDA, do you put in a lot of effort to find answers to your questions? 5. When you start a scenario, are you usually able to complete the scenario and get the required information? 6. How well did the IDA recognize what you said?

Table 4.5. Subscales of the interaction with the IDA

4.2.1.3. Trust

To evaluate the trust of the IDA users, 8 factors (questions) from section 3 were used initially. The reliability for these 8 factors shows acceptable consistency with Cronbach's alpha equal to 0.709 (which is between 0.7 and 0.8). The scales for SPSS state that we delete each factor from the 8 factors for Cronbach's alpha is presented in Table 4.6. The results are as follows:

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.709	.718	8

Table 4.6. Reliability statistics of 8 subscales of the trust in the IDA

From the results, it is clear that if the 8th factor was removed, the Cronbach's alpha would increase to 0.747 which is an acceptable internal consistency. However, although the consistency is acceptable, the inter-item correlation for the 8th parameter with other parameters is very low (not significantly different from zero and no correlation between the parameters) and in some cases is negative which means that increasing one factor is associated with decreasing another factor. In such cases, the factor which has negative correlation needs to be recoded and then the reliability analysis repeated. Therefore, the 8th item will be removed from the parameters. As a result of removing the 8th parameter the Guttman's Lambda2 and Lambda3 will be both more than 0.7. Hence, the internal consistency is acceptable for the remaining 7 parameters. Nevertheless, the inter-item correlation of the 6th item is low and its correlation with the 4th item is 0.099 which is not significantly different from zero and has no correlation between the parameters (p-value = 0.164 > 0.05). This suggests that removing this parameter too would increase the internal consistency (Table 4.8).

Reliability Statistics

Lambda	1	.640
	2	.755
	3	.747
	4	.653
	5	.742
	6	.746
N of Items		7

Table 4.8. Reliability Statistics of 7 subscales of the trust in the IDA

By removing the 6th parameter, the standardized Cronbach's alpha would be 0.77 with the Spearman-Brown coefficient of 0.745, which shows acceptable consistency. The results of Cronbach's alpha and Guttman reliability scale for the remaining parameters are shown in Table 4.9 and 4.10:

Reliability Statistics

Lambda	1	.626
	2	.758
	3	.751
	4	.745
	5	.746
	6	.743
N of Items		6

Table 4.9. Reliability Guttman Statistics of 6 subscales of the trust in the IDA

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.751	.770	6

Table 4.10. Reliability cronbach's alpha of 6 subscales of the trust in the IDA

Subscales for evaluating the trust factor	
Trust	1. Are the IDAs reliable for you? 2. How confident are you when using the IDA's system? 3. To what extent do you count on getting answers for your questions from the personal assistant? 4. Is the IDA's answers met your expectation and what you are looking for? 5. How was the IDA's service quality? (did the service met your expectations) 6. Are you aware about the IDAs' privacy and security policies?

Table 4.11. Subscales of trust in the IDA

4.2.2. Hypothesis Tests

In this section hypothesis testing is done to investigate the association between the parameters. The null hypothesis will be written from the aforementioned hypothesis and then checked to see if it can be rejected in favour of the alternative hypothesis. Based on the analysis results the table below presents each independent parameters' association and effect of them on the dependent variable:

Independent	Dependent	P-value	Result
Experience	Trust	0.000**	Effected
Recording dialogue	Trust	0.290	No effect
Sensitive information	Trust	0.000**	Effected
Sensitive information	Usage	0.000**	Effected
System quality	Trust	0.000**	Effected
Interaction quality	Trust	0.000**	Effected
Service quality	Trust	0.000**	Effected
Female	Trust	0.235	No effect
Female	Usage	0.260	No effect
Female	Reliability	0.308	No effect
Ease to use	Adaption to use	0.000**	Effected
Efforts	Usage	0.027*	Effected
Ease	Satisfaction	0.000**	Effected
Confidence	Satisfaction	0.000**	Effected
Recording dialogue	Satisfaction	0.246	No Effect
Interaction control	Satisfaction	0.000**	Effected
Recognition quality	Satisfaction	0.000**	Effected
Recognition quality	Usage	0.000**	Effected
Dialogue complexity	Effort	0.000**	Effected
Effort	Satisfaction	0.001**	Effected

** P value is less or equal with 0.001

* P value less than 0.05

Results of the hypothesis tests based on One-way ANOVA

Parameter	Effective parameter	Non-effective parameter
Trust	1.Prior experience** 2. Users will to divulge private information in IDA** 3. system quality** 4. service quality** 5. interaction quality**	1.Recording dialogue information 2. gender
Usage	1.ease of use** 2. Users will to divulge private information in IDA** 2.effort to complete task* 3. recognition**	1.gender
Overall Satisfaction	1.ease of use** 2.confidence** 3. Interaction control** 4. voice recognition** 5.effort**	1.dialuge recording
Intention to use in future	--	1. recognition 2.effort
Recognition	1.efforts.	--

** These parameters were highly significant < 0.001

* These parameters were significant at 5% significance level.

Note: The above parameters were found significant in One-way ANOVA, however, divulge private information was seen that is non-significant when controlling it by recognition for Usage, but it was significant for trust.

DISCUSSION AND CONCLUSION

The main finding of the analysis show that trust and interaction are two significant parameters which positively affect IDA usage; thus, if the proficiency of the factors that affect them are increased then IDA usage will increase. Moreover, based on the structural equation modelling for usage, interaction and trust are highly significant (P-value < 0.000). These parameters have positive coefficient which shows a positive trend and have positive and significant effect on IDA usage. For instance, increasing the score of the trust or the interaction parameter (by increasing the efficiency of any factor of the subscale of these parameters) will increase IDA usage. This means improving system quality, interaction quality and recognition quality which are subscales of interaction. For instance, increasing 1 score of the interaction parameter lead to an increase of 0.458 in IDA usage. Moreover, all the factors are correlated which means increasing the score of any factor will increase the score of other factors in the parameter.

In addition, increasing users' trust towards the IDA will lead to increased usage. For instance, improving the IDAs' capability to meet users' expectations, improving service quality and clarifying privacy and security policies would build trust and make users more likely to use their devices. Specifically, increasing 1 score in the trust subscales will lead to an increase in usage of 0.477. Moreover, by considering the role of satisfaction in trust, both information and system quality are factors that should be of high quality to avoid loss of trust [37]. However, the latent variable

analysis indicates that the effect of trust on IDA usage is slightly greater than that of interaction: the slope for trust is higher and increasing 1 level in the trust parameter had more effect compared with increasing 1 level in interaction. This indicate that developers should focus on developing users' trust in order to increase usage and not lose users.

5.1. Parameters and the dependent variables

The result of the analysis presents each independent parameters' association and their effect on the dependent variable. For instance, trust (dependant variable) is affected by user experience, sensitive information and system quality, interaction quality and service quality but not by recording dialogue or gender (independent variables). As Teo et al. [55] note, both information quality and system quality have a relationship with trust and interaction quality has a significant impact on building trust [2]. In addition, considering satisfaction as a dependant variable, it is affected by ease of use, user confidence, interaction control, recognition quality, and effort but not by recording dialogue. Branco et al. [47] found that satisfaction has a significant correlation with ease of use, confidence, interaction control and error recognition. Moreover, when usage is an independent variable, it is affected by recognition quality and sensitive information but not by gender. Additionally, adaption to use is a dependant variable affected by ease of use and effort is affected by dialogue complexity. Davis [23] claims that ease of use is a motivating factor in technology adaption and Kelly [49] links perceived task complexity with effort. In addition, although divulging information has a significant effect on trust (with the lowest estimated standardized weight (0.205) compared with other trust factors), it has no significant effect on usage. Bansal, Zahedi and Gefen [56] found that trust plays an important role in intention to disclose information.

5.2. The parameters

Three significant parameters are found based on the moderation analysis and structural equation modelling: receiving inappropriate answers or out of context dialogue, producing results faster and the parameter of the 4th query giving the required answer in the web search scenario. In addition, three moderators are used in the model, because by adding these moderators the R squared of the model improved by 5% (from 0.35 to 0.40).

5.2.1. The first parameter with related moderator

The first parameter (receiving inappropriate answer or out of context dialogue) has a high negative effect on IDA usage. The results indicate that users who get inappropriate answers will have less usage by equal -0.188 score compared with other users. As Branco et al. [47] note system prompts can annoy users if they are inappropriate or out of context. For example, over-confirmation, such as when a user chooses a recipient and create a message, and is then asked "Who would you like to send it to?" Moreover, the first moderator is interaction score for users who receive inappropriate answers; this has a negative slope which means that although the parameter of interaction itself has positive effect on the usage, its moderator with inappropriate answers has negative effect. Increasing the score for interaction of those who get inappropriate answers by 1 will reduce usage score by -0.777, ($p = 0.002$).

In addition, the interaction between the parameter of users who get inappropriate answers or out of context dialogue and the parameter of interaction (interaction is a continuous parameter that has 6 subscales) is also shown to be significantly negative. For instance, the interaction parameter has positive effect on usage (+0.288), but for those who receive inappropriate answers, the interaction also has negative effect since -0.486 + 0.288 = -0.198. Therefore, it is recommended that improvements are required in the algorithm of the IDA to optimize the output answer such that the device notifies the user if it doesn't fully recognize a query rather than returning an inappropriate answer.

5.2.2. The second parameter with two related moderators

The producing results faster parameter has positive effect on IDA usage, and users who value this use their IDAs more than other users. Hence, producing results faster will increase the usage score by 0.241. Comparing IDA usage in Saudi Arabia and in the USA, 35.5% of users in Saudi use IDAs to get results faster and 30% in the USA [1]. Thus, getting faster result is an important aspect to consider when developing IDAs. Moreover, the second moderator is producing results faster but getting inappropriate answers which increases the R squared by 1.3%. This moderator has negative coefficient, by increasing 1 score for producing results faster for those who get inappropriate answers the usage score will reduce by -0.387. Despite the importance of getting results faster, inappropriate answers still affect usage negatively which indicates that keeping the dialogue context is very significant to keep people using their IDAs. In addition, the third moderator is using Google Now and producing results faster which change the R squared by 1.2%; this has a positive effect on usage, the estimated coefficient is (+0.204, $p = 0.048$). Indeed, in the USA 19 out of 53 participants used Google Now [1], as did almost half of the Saudi participants (81 out of 200), which make producing results faster a distinguishing characteristic of Google Now compared to Siri, Alexa or Cortana.

5.2.3. The third parameter

Users who say that the 4th query usually leads them to the required answer in the web search have significantly higher usage than other users by a score of

0.513, p = 0.006. The reason behind this could be that those users are more familiar with IDAs and know that they will get to the right answer by keeping the dialogue in context (rather than stopping if they did not get the desired answer at first) because the IDA becomes more intelligent the more it is used by the user. Therefore, adding a tutorial session for new IDA user so they can learn how to use it correctly would avoid losing them later and increase IDA usage.

5.3. Overall satisfaction

For overall satisfaction, trust and interaction are highly significant and both have positive effect on overall satisfaction. Overall satisfaction has a positive relationship with usage; since it was highly correlated with interaction, it was not used in the equation of usage, but the relationship of satisfaction and usage is positive. The result of implementing one- way ANOVA in the structural equation model for overall satisfaction vs scenarios, shows that the satisfaction of the users who spend more time in each of these scenarios is different. Another main finding is that those who say they spend more effort on the Controlling Device scenario are more satisfied than other groups. Moreover, using post-hoc testing shows that users who say they use the controlling device scenario more are significantly more satisfied compared with both other groups. It is surprising that 58 of the participants spent more effort in the controlling device scenario as this is the easiest, lacking the complexity of the web search or the structured search dialogue [15]. However, this could be because those users just use their IDAs for this scenario and have less experience in controlling their devices.

In addition, 68% of the users used the IDA only 1 to 5 times in the month which indicates that they did not go through all the scenarios and mainly used the controlling device scenario for calling people, opening applications or playing music. In addition, the satisfaction of this group is due to the ease of the controlling scenario which require less effort compared to the other scenarios. Their low scores for effort overall are consistent with high levels of satisfaction and strong negative correlation between satisfaction and effort (Ibid). Therefore, in order to increase user satisfaction, user effort needs to be reduced by improving IDAs in terms of recognising users' speech correctly and mapping the requests to the right functionalities.

5.4. IDAs' future usage

In terms of future IDA usage, 65% of users who were not aware of their IDA's privacy and security policies decided not to use them anymore once they realised their dialogues were recorded. Other users indicated that they would not use them due to slow response times and recognition problems. By comparison with the expectations of USA users which suggest an annual increase of 29% in IDA usage [1], Saudi users show different results regarding their intention to use the IDA in future. This could be due to the different cultures as the adaptation level of each technology differs between societies and communities. However, in order that the IDA privacy and security policy does not affect usage negatively, producer companies should increase user awareness about the use of their information, making it clear that data is treated confidentially and this will not harm them. In addition, as Branco et al. [47] reported, the majority of participants were deterred by slow response times and recognition problems. These have been issues since 2006, and IDAs require intensive improvement in these areas to keep up with the market.

RECOMMENDATIONS

Based on the findings, developers should focus on improving IDA systems so users receive fewer inappropriate answers or out of context dialogue (due to voice recognition problems or system quality issues such as slow response times) as these affect IDA usage negatively. In addition, quality and recognition accuracy are factors that should be developed to keep the IDAs' usage rate increasing. As supported by Branco et al. [47] the critical factors to better user experience and for acceptance of a multimodal system are accurate recognition of the spoken components, the speed of the system feedback and quality. Moreover, it is recommended that IDA producers should do more to make users aware about the possible usage of their data in order to avoid losing users.

IMPLICATIONS

The implications of this study are about measuring how the factors that were found to affect usage can lead IDAs' systems to be developed further. A possible solution to solve this issue would be by examining the efficiency of the IDAs system after making some improvements considering each factor that leads to an increase or decrease in IDA usage. Evaluation of the system after the improvement would reflect the development paths based on each factor and would bring advantages to both users and producers by creating a more comprehensive picture about the most effective development path to satisfy users and increase their usage.

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