AI-Based Voice Assistant Systems: Evaluating from the Interaction and Trust Perspectives

Full Paper

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Abstract

Artificial Intelligence (AI) technologies are one of the new technologies with new complicated features, that are emerging in a fast pace. Although these technologies seem to be extensively adopted, people do not intend to use them in some cases. Technology adoption has been studied for many years, and there are many general models in the literature describing it. However, having more customized models for emerging technologies upon their features seems necessary. In this study, we developed a conceptual model involving a new system quality construct, i.e., interaction quality, which we believe can better describe adoption of AI-based technologies. In order to check our model, we used a voice assistant system (VAS) technology as an example of this technology, and tested a theory-based model using a data set achieved from a field survey. Our results confirm that interaction quality significantly affects individual's trust and leads to adoption of this technology.

Keywords:

Artificial Intelligence, Voice Assistant System, Interaction Quality, Trust, Technology Adoption.

Introduction

Artificial intelligence (AI) is the exhibition of intelligence by machines (Russell and Norvig 1995), and started in the 1950s as an inquiry into the nature of intelligence (Simon 1995). It used computers as a revolutionary tool to simulate and exhibit intelligence, thereby providing a means for examining it in utmost detail (Simon 1995). AI has a lot of applications in many industries, for example autonomous vehicles, medical diagnosis, playing games, online assistants, online marketing and advertisements, and image recognition (Russell and Norvig 1995).

The growing volume of data, and the importance of gathering precise and accurate information in a short time led to the advent of search engines, specifically, web search engines. Web search engine is a software application designed to search requested information on the World Wide Web. The first web search engine was debuted during the mid-1990s, and developed very fast during the past years. Regarding the ease of using web search engines, people began to use this technology all around the world to find the data and information they required. Despite all the benefits of using search engines, they are unlikely to sufficiently satisfy today's dynamic needs. Moreover, use of a search engine, even by searching the key phrases, gives you a bunch of related websites that probably covers your answers (Brin and Page 1998).

In regards to these limitations, search engine developers start to think about using AI to provide intelligent search techniques such that simplify the search process and save more time to do multitasking (Rousso and Schwartz 2004). The outcome of their efforts is voice assistant systems (VASs) which can be used as tools for online shopping, learning/improving new languages, answering questions, controlling/using other applications and devices, communications, companionships and even building friendships through their intelligent searching techniques. Since AI-based VAS applications are capable of monitoring environments and users, they can provide high quality services. They offer new types of

interactions which are more implicit and transparent type of exchanges with users. Because of this specific feature, they create new challenges in quality evaluation of Human-Computer Interaction (HCI) such that any assessment of interaction quality should take it into account. However, no prior study considered adoption of AI-based applications from HCI quality perspective.

To address this gap, we aim to propose an adoption model composed of specific measures of HCI quality in AI-based systems. The following questions will be answered by this study: (1) What are the potential quality factors affecting adoption of AI-based VASs?; (2) How can the quality factors help VASs to be adopted?

This paper applies social exchange theory (SET) from sociology to the study of HCIs. The social exchange-theoretic approach traditionally defines a group as two or more humans whose interactions affect their attitudes and behaviors (Emerson 1972). Posard and Rinderknecht (2015) broaden the definition of group to include both humans and computers with AI capabilities. Based on this definition, we propose interaction quality as an important parameter that creates trust in users of AI-based technologies.

This study is an explorative study to develop a new adoption model that better fits with emerging AI-based technologies. Findings of this research could help businesses to better understand which aspects of new AI-based technologies are more important for users. Hence, they can improve the design of their services and introduce services to the market in a more effective way.

Theoretical Background

Development of technology and its application to individuals' life, has kept technology adoption among the interesting research areas. Technology acceptance model (TAM), the conceptual framework for user's tendency to use the technology was first introduced by Davis Jr (1986) and through the past decades, this basic model has received several extensions and modifications based on the features of the technologies and the behavioral aspects of end-users (see Marangunić and Granić (2015)). There are several studies attempted to find and explain factors that have influences on acceptance/adoption of a new technology by users, both in organizational and individual level (Venkatesh (2003; 2012)). However, this does not mean we have done research on adoption model since new technologies are coming each year and their specific features create request for specific adoption models.

There are some researches aimed to use psychological science and behavioral theories to find new constructs that help to develop better adoption models for new technologies. In AI-based systems, HCI is an important concept that should be considered. HCI has turned out to be much more important in recent years as computers have become commonplace in almost all facets of our lives. HCI is becoming ever more important in interactive systems, and will become even more critical as everything around us becomes digital and unknowingly embedded with interactive computing services that make our everyday lives more exciting, efficient, and convenient. Aside from merely making the necessary computational functionalities available, the early focus of HCI has been in how to design interaction and implement interfaces for high usability. Interaction is one of the key features of VASs, and nowadays because of its applications, people give more weight into it. Indeed, the interaction in VASs is not a simple interaction of a human and a machine, but it is going beyond to become much more similar to the human's interactions. In this study, we use SET to better understand this new type of interaction. SET describes the dynamics of interpersonal relations and social interaction (Blau (1964); Emerson (1962; 1972)). The relationship entails unspecified, broad and open-ended obligations on the part of two parties toward one another. All social exchange relationships can be characterized as high or low quality, and they encompass three components; trust, commitment, and respect (Blau 1964). Based on this theory, quality of interaction or relationship between two parties has a strong relation with trust. Jarvenpaa and Leidner (1998) have studied the communication and trust in global virtual teams and the importance of trust on the relations of the team members. The media richness and social presence theories also question the possibility of relationship development, and subsequent trust development, in virtual teams. These theories suggest that computer-based communication media may eliminate the type of communication cues that individuals use to convey trust, warmth, attentiveness, and other interpersonal affections (Jarvenpaa and Leidner 1998). Sweeney and Wyber (2002) indicated that when individual needs to make a decision about something, a cognitive incongruence is experienced related to the missing information and risk perceptions., therefore, trust plays an important role to perceive the provided services.

Information systems success model (ISSM), another main theory employed in our study, argues that system quality and information quality affect usage intention and user satisfaction at both individual and organizational levels (DeLone and McLean 1992). Delone and Mclean (2004) later added service quality into the model. This model receives lots of attention and many researchers examined the effects of system quality and information quality on trust (Kim et al. (2004); Zahedi and Song (2008); Chen and Cheng (2009); Teo et al. (2008)). We also used diffusion of innovation model (Rogers 1962) in which innovators and early adopters are two types of users who pick up a technology earlier than others. They are curious to experience new technologies whereas there would be many uncertainties and risks. We employed this theory to test the impact of personal innovativeness on user's trust and intention to use AI-based technologies.

As our contribution, we combined the ISSM, SET, and HCI, and brought them in technology adoption literature to develop a new model which can better describe adoption of new emerging technologies. We also considered personal innovativeness as a moderator which can intensifies individuals' trust on using VASs. In the following section, we explain our constructs, and build our hypotheses upon the abovementioned theories and other researches.

Research Model and Hypotheses

Figure 1 shows our research model.
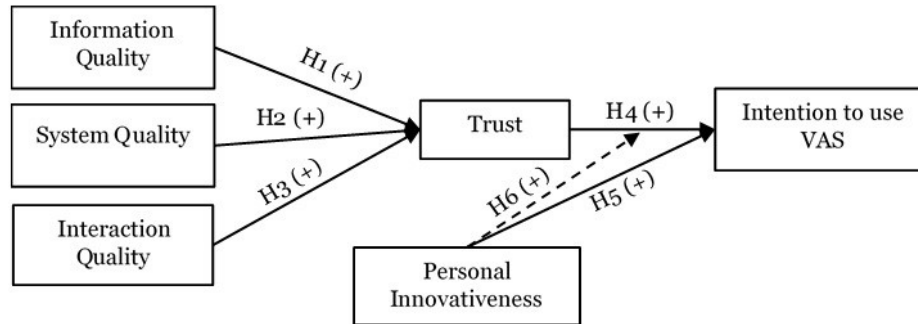
Figure 1. Research Model

Based on ISSM, information quality, system quality and service quality are the most important factors affecting users' satisfaction and usage intention. Zhou (2013) drawing on ISSM, identifies the factors affecting continuance of using mobile payment system. Results of this study indicate that service quality is the main factor affecting trust, whereas system quality is the main factor affecting satisfaction. Service quality, which refers to the service team and/or after sale services in the literature (Parasuraman et al. (1985); Kettinger and Lee (1994)), is the extent to which a service met the expectations of customers (Grönroos 1982). When the focus of the model is on the use of an application, they treated only the system and information characteristics, rather than the broader set of factors that might be used to evaluate satisfaction with overall IT services (Seddon 1997). Regarding this statement, the proposed model of technology adoption by (Wixom and Todd 2005) also addressed only the system and information quality and disregarded service quality. To have consistency with the previous researches, for the intention to use VAS as an application, we add system and information quality to the model. The following hypotheses regarding the relationships between information and system quality and trust are proposed.

Hypothesis 1: Information quality of a VAS positively affects user's trust on the VAS.

Hypothesis 2: System quality of a VAS positively affects user's trust on the VAS.

In the literature, HCI is described as the communication and interaction between human users and a computer. The important point about VASs is that they are not only a computer, and sometimes, based on the usage, they are like a friend for users. Indeed, some people communicate with these systems as a human. In this case, the quality of interaction should be extended and contains some aspects of human interactions. Interaction quality is an important issue for various kinds of application and relationships. For examples, Wang et al. (2005) have studied quality of interaction between the information system

project team and the users, and its effect on performance and success of the project. Ekinci and Dawes (2009) have studied how frontline service employee and their personality traits affect interaction quality and consumer satisfaction from the consumers' point of view. They have found that the three personality traits – extroversion, conscientiousness, and agreeableness – have a strong effect on interaction quality. Interaction quality is also related to customer's perception of the interactions with service providers during service delivery (Grönroos 1982). In some other researches, the impact of interpersonal interactions on customers' perception of service quality has been reported. Moreover, other studies mention the design aesthetics of information systems as an important parameter of system performance and technology usage. Considering these researches, we define interaction quality as the extent to which the influence of intelligent application has on human in the AI-based technology context. We believe since AI-based VAS is designed to interact with users like a virtual human, interaction quality can positively create trust between intelligent VAS and its users.

Hypothesis 3: Interaction quality of a AVS positively affects user's trust on the VAS.

In literature, uncertainty and perceived risk of a new technology are two important inhibitors of its adoption. Trust, in general, is an important factor that could reduce uncertainties and perceived risks in social or economic interactions especially when making important decisions or adopting new technology (Gefen 2002). In mobile systems, trust is one of the most important factors affecting adoption (Zhou 2013). Trust is defined as "a psychological state comprising the intention to accept vulnerability based upon positive expectations of the intentions or behavior of another" (Rousseau et al. 1998). Trust is more complex and crucial in M-commerce environment than traditional commerce because of its uncertain environment (Lu et al. 2005). Kim et al. (2004) developed a model which posits that initial trust in the electronic channel as a banking medium and trust in bank are the major determinants of adoption of Internet banking. Their findings indicate that a significant relationship exists between initial trust in the electronic channel and the adoption of Internet banking. Yu et al. (2015) based on trust theory, empirically examines the role of trustworthiness and trust on users' intentions to continue using internet banking. Regarding the theory of reasoned action (TRA), initial trust and perceived usefulness as beliefs will affect behavioral intention. Gefen (2002) argues that perceived risk and trust affect behavior. Trust and risk are important in consumers' electronic commerce purchasing decisions (Kim et al. 2008). Kim et al. (2008) find the antecedents of trust and risk, and they developed a theoretical framework describing the trust-based decision-making process. Dastan (2016) also come up that perceived trust, perceived mobility and attitudes positively affect adoption of mobile payment systems. Trust is playing an important role not only on intention to use but also on continuance of using a technology. Drawing on ISSM and flow theory, Zhou (2013) has identified the factors affecting continuance intention of using mobile payment system. He has addressed information, system, and service quality as three antecedents of quality influencing post-adoption of mobile payment system along with trust, flow, and satisfaction. Regarding to these studies, we proposed our hypothesis on trust as follow.

Hypothesis 4: Trust on a VAS positively affects user's intention to use the VAS.

Personal innovativeness was introduced at the first time by Agarwal and Prasad (1998) which is the willingness of an individual to try out any new information system. They have studied the effects of personal innovativeness on the relationship between knowledge about a new technology and the perception of it, and the relationship between this perception and intention to use. Innovative person is more likely to adopt a new technology since avidly looking for new information. Personal innovativeness has a strong influence on adoption of innovations. Lu et al. (2005) have studied the relationship between intention to adopt wireless mobile technology, social influences, and personal innovativeness. They found a strong causal relationship between the social influences, personal innovativeness and adoption intentions. In another study, Rouibah et al. (2016) have found that personal innovativeness has a significant relationship with trust in adoption of online payment systems. Following these findings, we believe personal innovativeness can affect individual's intention to use AI-based technology.

Hypothesis 5: Personal innovativeness positively affects user's intention to use a VAS.

Apart from the main effect of personal innovativeness on intention to use VASs, we also propose its moderating effect on the relationship between trust and intention to use VASs. AI-based technologies are new technologies which are in the early stage of their life cycle and similar to any other new technologies, they are associated with higher risk and uncertainty (Agarwal and Prasad 1998). Diffusion of innovation

model explains that innovators and early adopters are the ones using a new technology earlier than others and deal with higher level of uncertainty. Indeed, highly innovative individuals are active information seekers taking higher levels of risk toward acceptance of a technology (Rogers 1962). Accordingly, we believe personal innovativeness affects people's perception of trust on using new technologies.

Hypothesis 6: Personal innovativeness has a positive interaction with trust in determining the intention to use a VAS.

Research Methods

Our study is a cross sectional one and we used an offline survey to gather data for our model analysis. First, we developed pertinent and validated items for each construct based on the previous studies. By doing so, content validity of our survey items is met. Table 1 provides a summary of our measurements with their sources.

Construct	Measurement Description	Sources
Information Quality	The perceived quality of the information provided by VASs	Zhou (2013) and Kim et al. (2010)
System Quality	The perceived system quality of a VAS	Zhou (2013) and Kim et al. (2010)
Interaction Quality	The perceived quality of interacting with VASs	Ekinci and Dawes (2009)
Trust	Participants' trust in using VASs	Pham and Ho (2015) and Kim et al. (2010)
Intention	Participants' intention to use VASs	Pham and Ho (2015) and Kim et al. (2008)
Personal Innovativeness	Willingness to try out any new technology	Agarwal and Prasad (1998) and Lu et al. (2005)

Table 1. Measurements and resources

Second, we administered the voluntary survey to students at a university in North America and achieved a total of 104 samples. Considering the explorative purpose of this study, the sample size is deemed acceptable.

Results and Analyses

We used partial least squares (PLS) to analyze our structural equation model. We first check the validity of our measures and constructs, and then analyze our structural equation model with and without each moderator to see how well our proposed model can describe variance of intention to use VAS.

Measurement Model Validation

We used convergent and discriminant validity to evaluate the measurement model.[1] For convergent validity, the reliability of items, composite reliability of constructs, and AVE of constructs were examined. For reliability of reflective items, the reliability score (outer loadings while using PLS) should be over 0.707 (Hair et al. 1998). For evaluating composite reliability, 0.8 is suggested as an indicator (Nunnally 1967). In addition, we used Cronbach's alpha as another evidence of construct validity (Cronbach 1951). To count on the reliability of constructs, Cronbach's alpha should be greater than 0.7, although small degree lower than 0.7 might be acceptable for exploratory research (Hair et al. 1998). Taking 0.5 as the indicator for AVE (Fornell and Larcker 1981), verified constructs have adequate convergent validity.

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[1] For latent variables with reflective indicators, it is expected to see all the weights of the corresponding items have the positive sign. This criterion is met for all the indicators except the fourth indicator for "personal innovativeness" which had a negative relation with this construct. We believe it is because of the negative nature of the question that is not perceived properly by participants. For this reason, we considered the reverse scaling for this item and observed that the addressed problem is solved. However, the reliability score of this item is not acceptable (less than 0.3). To enhance convergence and discriminant validities, we eliminated PInn4 item from the personal innovativeness construct. For the similar reasons, we also removed InfQ2 and InfQ3 from the information quality construct; and Trust4 from the trust construct.

Results of these tests are reported in Table 2, which confirm the convergent validity of our measurement model.

Constructs	# of Items	Reliability of Item	Composite Reliability	Cronbach's Alpha	Variance Extracted
Information Quality	2 items	.903 -.927	.912	.808	.838
System Quality	3 items	.799 - .947	.924	.877	.805
Trust	3 items	.922 - .951	.956	.931	.879
Intention	4 items	.876 - .944	.955	.937	.843
Personal Innovativeness	3 items	.908 - .947	.947	.916	.857

Table 2. Convergent validity tests for reflective measures

Among the research constructs, we have one with formative measures, interaction quality. Even though interaction quality is addressed as a reflective construct by Ekinci and Dawes (2009), in our study, and by using Jarvis et al. (2003) rules, we identified it as formative one. To assess formative measurement model, we checked the significance and relevance of each items of the related construct. All the items have positive outer weights, and all items have significant relations to interaction quality at 0.01 level of significance except one, IntQ3. Since we added these items based on the previous theories, we choose to have IntQ3 for doing structural model analysis.

For discriminant validity, we used method proposed by Chin (1998) in which root of the AVE for a reflective construct is compared with its correlations with the other constructs. Results are shown in *Table 3,* and since the square roots of the AVE (diagonal numbers) are larger than the other numbers in the corresponding column and row, discriminant validity is verified.

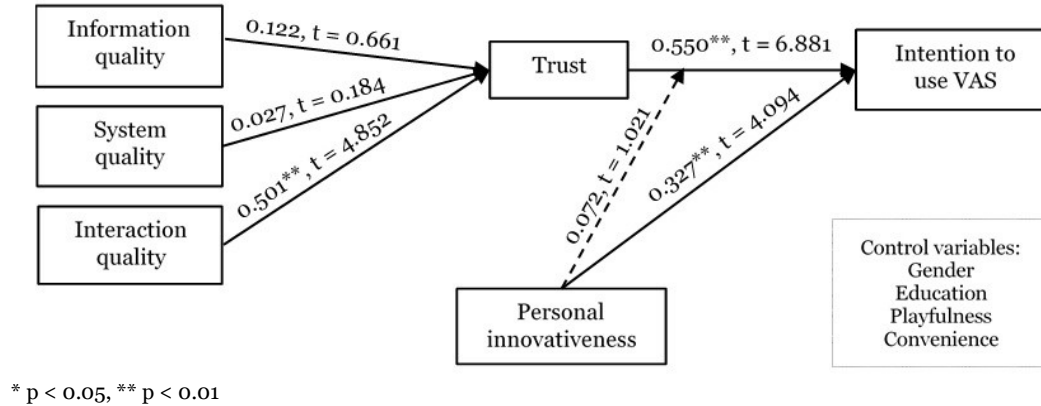|	Information Quality	Interaction Quality	System Quality	Trust	Intention	Personal Innovativeness
Information Quality	**.916**					
Interaction Quality	.676	**N/A**				
System Quality	.616	.593	**.897**			
Trust	.478	.601	.401	**.938**		
Intention	.567	.620	.447	.656	**.918**	
Personal Innovativeness	.595	.514	.312	.368	.507	**.926**

Table 3. Discriminant validity

However, the correlations among some of the constructs are relatively high. To address this issue, we further investigated any potential of multicollinearity problem. We conducted VIF test and found that all the VIF values were less than 2.6. The results confirm that no significant multicollinearity exists in our measurement model.

Structural Model Analysis

Using the final items and constructs after doing the measurement validity section, we analyze our model by using the bootstrapping mechanism of PLS 2.0 with 500 sub-sampling. Figure 2 illustrates the significance of relationships. As we expected, interaction quality has significant impact on building trust and trust strongly affects intention to use VAS.

Figure 2 indicates that hypotheses 4 and 5, the impacts of trust and personal innovativeness on intention to use a VAS, respectively, were supported (at the 0.01 level of significance). Hypothesis 3, the impact of interaction quality on trust, was also supported (at the 0.01 level of significance).

* p < 0.05, ** p < 0.01

Figure 2. Model Test Results

Discussion

The aim of this work is to better understand the quality preferences of users, which affect adoption of AI-based technologies. We found that interaction quality is an important factor for adoption of VAS, as an example of AI-based systems. As shown in Figure 2, the hypotheses regarding interaction quality is supported at the 0.05 significance level. Moreover, the positive relationship between both trust and personal innovativeness with intention to use is supported at the 0.05 significance level, and the explanatory power of our model is 54.9%. Also, it is interesting that the relationship between both information quality and system quality with trust is not supported whereas they were supported in previous researches (Kim et al. (2004); Zahedi and Song (2008); Chen and Cheng (2009); Teo et al. (2008); Zhou (2013)). This result for AI-based technologies could be described by Herzberg's motivation-hygiene theory (Herzberg 2005). Considering this theory and the role of satisfaction on trust studied by Garbarino and Johnson (1999), we believe in our study, both information and system quality are the factors that should be at a high level of quality to avoid loss of trust. Indeed, these two factors are hygiene factors which should be at an acceptable level that meets users' expectations. On the other hand, interaction quality in VAS technologies is the motivation factor that adds value, and creates trust.

Upon diffusion of innovation model (Rogers 1962), innovators and early adopters are two types of users who pick up a technology earlier than others. Indeed, they are curious to experience new technologies whereas there would be many uncertainties and risks. AI-based technologies are new branches of science based on several disciplines which are in the early stage of their life cycle. Accordingly, people who intend to use them can be considered as early adopters. In line with this model, we tested the impact of personal innovativeness on users' trust and intention. Although the results of our sample do not illustrate the moderating role of personal innovativeness on the relationship between trust and intention of using AI-based VAS, we believe by increasing our sample size, this hypothesis can be supported.

The results of this study provide valuable ideas to both researchers and practitioners. This research has extended the literature in three significant ways. First, we applied many different theoretical perspectives including ISSM, SET, and HCI, and brought them in adoption literature to develop a new adoption model that can better describe adoption of new emerging technologies. Multiple theoretical perspectives allow us to investigate phenomena in different aspects, and develop a more comprehensive model to better interpret them and the relationships between them. Second, by combining different theoretical perspectives, we found interaction quality as an important factor in adoption of new technologies. Interaction quality was identified between frontline service employees and customers in marketing literature, and in information systems literature, the quality of interaction was studied based on machinery characteristics of technologies/systems. In this study, based on some human characteristics of AI-based technologies, we combined two previous perspectives, and new concept of interaction quality has identified which could better describe some aspects of emerging technologies. Third, we illustrated the possibility of moderation of personal innovativeness between quality factors and trust. Although this moderation role is not significant, as we discussed before, some interesting issues have been found which could raise some new research questions to be investigated.

In perspective of practical implications, results of this study allow developers to design services or products much more attractive for users. Our findings show that interactive quality is an important parameter for AI-based technologies, so businesses should consider this parameter in design and development of their applications. For example, using human face and facial impressions for VASs could improve the interaction quality of them by mitigating sense of interacting with a machine. Moreover, the results could be helpful to design better marketing strategies and advertising plans. Findings of this study helps businesses and marketing managers to better understand perception of their customers, and which aspects of their products are more important in assessment of their customers. In this way, managers could increase their sales by focusing more on users' assessment criteria in their marketing plans and advertisements.

In this explorative study, we investigated the adoption of AI-based technologies based on effects of quality factors on building trust in users. The suggested factors were tested, and the results were interpreted from theoretical and practical perspectives. As common to other studies, this research also has some limitations. The first limitation is the sample we used in this study. Although the sample size in this study was large enough to count on the results, investigating more samples could be helpful in better understanding the relationships between constructs. In this study, respondents of our survey were students of a university in North America, and most of them were native English, so some aspects of quality in using VAS could not be covered completely. For instance, the importance of accent or different languages in quality of VAS to whether understand words clearly could not be investigated completely. Therefore, the selected sample might not be a good representative of the whole population, and it would be difficult to generalize our findings. Based on this limitation, future research could be done with more sample size, and respondents from a bigger population and different countries. Second, because of using the survey method, the variables can only be measured in terms of respondents' self-reported perceptions. For more explicit analysis in the future research, some variables, e.g. personal innovativeness, are better to be measured by some accurate methods. Third, although interaction quality has been studied, we did not study dimensions of interaction quality. Findings of this study shows that interaction quality is an important factor of quality in intention to use of AI-based technologies, so future research could be done to investigate its dimensions and antecedents. Understanding antecedents of interaction quality could be helpful to better understand this factor of quality which helps managers and designers to develop applications with higher quality and more attractive. Fourth, dependent variable in this study is intention to use of VAS, and we did not study actual adoption of this technology. As users' actual behavior could not be measured directly by their intention, and it is important to investigate actual usage instead of intention to use, future research could be done to study actual use of VAS. Finally, we have studied only VAS as a sample of AI-based technology: therefore, investigating adoption of other AI-based applications is desirable to investigate the current weaknesses of VAS and barriers of adopting this technology. Understanding these weaknesses and barriers could help service designers to develop better applications and services.

Conclusion

In this study, we studied adoption of AI-based technologies, and explored new phenomena which can better describe adoption of these technologies. From the research results, we found that interaction quality is the most important factor of quality which builds trust in users, and as a result they intend to use the VASs. In this study, we combined many different theoretical perspectives including ISSM, SET, and HCI, and found interaction quality as an important factor in adoption of new technologies. Findings of this study help managers to design more services and products with higher level of quality, and also attract more users by designing better marketing strategies and advertising plans.

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