

Speech Interface: An Enhancer to the Acceptance of M-commerce Applications

Yandong Fan
SNC, Faculty of IT
Monash University
fydl@yahoo.com

Anthony Saliba
Telstra Research Lab
Melbourne, Australia
Anthony.Saliba@jeam.telstra.com

Elizabeth A. Kendall
SNC, Faculty of IT
Monash University
kendall@infotech.monash.edu.au

Jan Newmarch
SNC, Faculty of IT
Monash University
jan.newmarch@infotech.monash.edu.au

Abstract

Speech interfaces have become increasingly popular to support mobile commerce. While interface frameworks and dialogue management have been well-studied, there is a lack of analytical research on the acceptance of speech-enabled m-commerce services. In this paper, we propose a framework to explain the acceptance of m-commerce from the consumers' perspective. The framework incorporates value propositions of m-service into a service acceptance model derived from a meta-analysis. The significance of a speech interface to m-commerce is evaluated and confirmed in line with the proposed framework. Strategies for developing speech-enabled applications are also suggested.

1. Introduction

Mobile commerce has attracted much interest among researchers, developers and service providers [1,2,3]. Supported by the sharply increasing penetration of mobile devices and the popularity of the Internet, many scholars and research firms optimistically predicted a substantial potential for m-business. Current market reality, however, seems that m-commerce has not lived up to the expectations and is moving relatively slowly [4, 5]. Among all the barriers to the acceptance of m-commerce, the restrictive visual interface that mobile devices currently provide is a key impediment [6,7,8]. Mobile users are generally reluctant to scroll up and down or enter large amounts of data due to the awkward input/output components.

Speech technology, as it improves, could become a naturalistic and powerful interface to support m-commerce. Domain-specific speech-enabled applications for information retrieval and online transactions through fixed line telephony networks have been introduced for many years and are now extended to mobile environments. Facilitated by industrial standards such as VoiceXML and SALT (Speech Application Language Tags), Voice recognition technology is starting to find its way into the

m-business arena. The technology has been utilised to support voice-activated directions on location-based systems and data-mining applications, and is potentially capable of supporting all classes of m-commerce applications identified in [1].

This paper seeks to analytically assess whether, and in what ways, a speech interface is likely to facilitate the acceptance of m-commerce from the consumer perspective. In order to achieve this objective, factors influencing user acceptance of technology-oriented services should be identified and examined first. The acceptance and diffusion of innovative services have been richly studied in the past three decades. Innovative diffusion theory [9] and intension-based models such as the Theory of Reasoned Action (TRA) [10], the Theory of Planned Behaviour (TPB) [11] and the Technology Acceptance Model (TAM) [12], provide significant help to understand adoption behaviour. Numerous studies based on these theories and models have been conducted to explore the effects of determinants on user acceptance, which have resulted in a long list of constructs that claim to significantly influence the adoption process. Confusion has been caused by the overlap among these constructs and contradictory results reported across studies. Thus, instead of selecting one model to explain m-commerce adoption, it would be more appropriate to conduct a review and synthesis, as was suggested by [13, 14].

Beliefs and perceptions about a technology-oriented service are the determinant of consumers' intention toward using the service [4]. In the context of m-business services, these beliefs and perceptions are, in turn, determined by consumers' perceived value of the mobile channel compared with existing alternatives [3,15,16]. M-commerce provides an opportunity to conduct business anywhere and at any time. Its nomadic nature offers unique value propositions for mobile users to perform transactions more conveniently and efficiently in comparison to the stationary machines. The technological limitations of visual interfaces provided by current mobile devices, however, degrade these value propositions. Research indicates that every extra input that a user needs to make in navigation with a mobile device reduces the

possibility of a transaction by 50% [15]. Speech interfaces, to a great extent, can compensate many of the limitations pertaining to the WAP-based visual interface.

If we synthesize the various studies of user acceptance and understand the added value created by m-business, we can propose an integrative framework that could help us better interpret the acceptance process of m-commerce services. Such a framework can then be utilized to evaluate the significance of speech interfaces to m-commerce.

2. Factors influencing user acceptance

A comprehensive review has been conducted in this study to identify determinants of user acceptance of technology-oriented services. The review eliminates the confusion surrounding the meanings of independent variables of user acceptance. Following an intensive search of existing acceptance studies in IT/IS, e-commerce and m-commerce domains, sufficient quantitative research findings have been retrieved, and a meta-analysis has been performed to measure the extent to which the relationships between user acceptance and its determinants are supported. Potential moderators of these relationships have also been investigated.

2.1 Determinants

Perceived Usefulness

Perceived usefulness is defined as how well consumers believe a service can help them perform their daily activities [12,4]. There are other constructs that have identical meaning, including relative advantage, extrinsic motivation, and job fit of perceived consequences. The similarity between these constructs has been verified in [14, 17, 18]. Previous studies suggest a positive relationship between perceived usefulness and user acceptance. When this belief increases, consumers' intention to use a service will increase correspondingly.

Perceived Ease of use

Perceived ease of use refers to the extent to which a user believes that using the service will be free of effort [12]. Complexity was also introduced in the literature to measure the degree to which a service is perceived as relatively difficult to understand and use. The complexity construct is just the opposite of the perceived ease of use construct [19]. A service perceived to be less difficult to use can attract more users to adopt it. Consequently a positive relationship is expected between perceived ease of use and user acceptance.

Social Influence

Social influence is defined as the degree to which an individual user perceives that important others believe he/she should use the service [14]. There has been a long history to support social influence as a determinant to

predict behavioural intention, beginning from the introduction of subjective norm in TRA [10]. The perceived critical mass construct in [20] has an identical meaning with social influence as group members' influence was observed instead of measuring the actual critical mass.

Confidence Belief

As it is difficult to find a construct in the literature that has an identical meaning to confidence belief, we define the term as the extent to which a user believes that a service is trustworthy, and that using the service will be free of risk. The construct has become increasingly important in the context of m-commerce as security and privacy concerns have a significant impact on consumers' confidence. [14, p.453] uses facilitating conditions to represent such beliefs, which is defined as "the degree to which a user believes that an organizational and technical infrastructure exists to support use of the service". It seems likely that it is the degree of trust and perceived control that has a direct influence on usage intention [21], although facilitating conditions can significantly enhance a user's confidence in using a service.

Affective Attitude

Many studies adopt attitude as a construct that measures to what extent a user has a favourable or unfavourable evaluation or appraisal of the behaviour in question. [19] argues that attitude is not a precise term when conducting research on the relationship between attitude and behaviour. Instead, a separation of the affective and cognitive components of attitude is recommended. The affective attitude is the perception of joy, elation or pleasure; while the cognitive component refers to the evaluation, judgement and perception of the service based on value. It seems that the influence of cognitive attitude has been measured by other constructs like perceived usefulness and confidence belief [22]. Therefore, affective attitude is a more accurate construct. A user who believes pleasure and enjoyment can be derived from using a service is likely to use it extensively.

2.2 Meta-Analysis

The selection of studies for meta-analysis was initiated through intensive search of publications since 1989 that were related to user acceptance of technology-oriented services. Studies were included if they met four criteria:

- Reporting of the sample size
- Reporting of either Pearson correlation coefficients or statistics that could be used to calculate correlations
- Measuring one or more of determinants mentioned in Section 2.1
- The service being studied falls into domains of IT/IS, e-commerce or m-commerce.

Additional considerations were also made:

- To lessen the severity of the “bias problem” [23], papers from refereed conference proceedings were included.
- In line with the assumption that the selected samples should be independent in meta-analysis, only one report is included if several results have been reported based on the same data.
- Studies with a sample size of more than 600 were excluded according to [23]’s warning that a very large sample size may distort analysis result.

Thirty-five primary studies from 25 reports were chosen for meta-analysis. We follow the meta-analytical procedures introduced in [23] to examine the relationships between the five determinants and user acceptance. Table 1 represents the results of our meta-analysis. The 95% confidence interval results indicate that all mean correlations weighted by sample size significantly deviate from zero. The values of these mean correlations also suggest relatively strong positive correlations between each of the five determinants and user acceptance. The significant χ^2_{k-1} -statistics sharply imply that moderators should be introduced to explain all the correlated relationships.

We examine the effect of four moderators: type of applications, stage of adoption, environment of study and type of subject. Approximate t-tests were performed for the examination. Table 2 shows the results of the approximate t-tests on the difference of the mean correlations across sets of studies distinguished by moderators. The results suggest that stage of adoption and type of subject are more effective moderators than environment of study and type of application. This indicates that the direct effect of beliefs and perception on users’ intention of acceptance may vary over time with increased experience of a service. As well, the behaviour of an individual user may also be different from that of a group member when confronting the decision of service adoption.

3. Integrative framework

3.1 Value propositions of m-business

Value propositions specify the interdependence between the attributes of a service and the fulfilment of needs from the consumer perspective [15]. Unique value created by m-commerce has been acknowledged by many researchers [3,15,24,25]. [24] analyses the added value of m-commerce from time and space aspects and concludes that mobile technology can help a number of business activities gain flexibility, along both temporal and spatial dimensions. The value offered by mobile channel is distinctively separated into wireless value and mobile value in [3]. Wireless value includes convenience and cost-savings. Mobile value can be created in five identified settings: time-critical arrangements, spontaneous decisions and needs, entertainment needs, efficiency ambitions and mobile situations. [25] states that m-commerce can offer consumers six additional benefits in comparison to e-commerce: location-awareness, multi-engagement, ‘adaptivity’, ubiquity, personalization and broadcasting. To summarise, we demonstrate the extra value created by m-commerce through five propositions.

- **Ubiquity:** the ability to retrieve information and conduct transactions from virtually any location on a real-time basis.
- **Convenience:** the specific comfort created by the agility and accessibility of mobile devices, and the spontaneous engaging of multiple activities.
- **Adaptability:** the ability to receive relevant information pertaining to the specific context such as the current geographic position and environment.
- **Entertainment:** the opportunity of fast and easy access to entertainment to kill time or have fun.
- **Personalization:** the ability to personalise services and customise the user experience.

Table 1. Results of meta-analysis for determinants

Determinants	Number of Studies (K)	Total Sample (N)	Mean Correlation (r)	95 Percent Confidence Interval	Observe Variance	Sampling Error Variance	Percentage Explained	Homogeneity Test (χ^2_{k-1})
Perceived Usefulness	34	4364	0.481	(0.458, 0.504)	0.0298	0.0046	15%	220.44
Perceived Ease of Use	33	4734	0.416	(0.392, 0.44)	0.0199	0.0048	24%	137.88
Social Influence	6	1241	0.426	(0.38, 0.472)	0.0175	0.0032	18%	32.45
Confidence Belief	9	1764	0.399	(0.36, 0.438)	0.0344	0.0036	10%	85.85
Affective Attitude	13	2501	0.503	(0.474, 0.532)	0.0468	0.0029	6%	209.60

Table 2. Results of t-approximation tests

Determinants	Stage of Adoption	Type of Subject	Type of Technology	Environment of Study
	Initiation vs. Implementation	Organizational member vs. Individual	IT/IS vs. Web Applications	Academic vs. Commercial
Perceived Usefulness	11.18 **	3.46 **	1.57	1.60
Perceived Ease of Use	4.87 **	2.53 *	1.40	0.08
Social Influence	3.06 *	3.06 *	2.28	3.06 *
Confidence Belief	1.15	9.15 **	0.63	0.46
Affective Attitude	3.91 **	3.10 *	2.65 *	1.63

* p < 0.05

** p < 0.01

3.2 Impact of value propositions on perception

With the help of mobile devices, users are likely to be benefited from time and location sensitive services such as wireless finance and mobile advertising. The effectiveness and efficiency of conducting business activities in a timely and space-independent manner can obviously enhance consumers' perception of usefulness of the service. The direct influence of technological characteristics of a service has been evaluated and confirmed in [26]. Furthermore, the ubiquitous nature of mobile technology represents a kind of fashion. The freedom of conducting transactions anywhere and at any time may be perceived as an advantage within a society. As mobile users are usually in social situations, using m-services is a sense of social image [27]. The relationship between social image and social influence has been supported by the popularity of i-mode phones in Japan and other cultures, and the high penetration rate of mobile phones among the executive class in China.

The convenient use and accessibility of m-commerce allows consumers' business activities to be performed regardless of time and place. In addition, consumers can spontaneously engage in multiple activities. For example, rather than passively waiting in a queue, users can now check stock prices or browse sports news simultaneously. Such convenience can increase consumers' perception of ease of use. Moreover, a special comfort may be recognized, and could further transform into an improved quality of life [15]. The improvement of life quality can positively influence a consumer's affective attitude toward m-services.

With the help of the global positioning system and sensor networks, location-awareness becomes a reality. Knowing where the user is located creates a great opportunity for location-based services such as geographically targeted advertising and logistics management. Traditionally, information quality has been measured by accuracy, relevance and timeliness [28]. The

supply of accurate and relevant information is a key enhancer to users' perceived usefulness, as the issue of information overloading has become a serious concern.

Intrinsic motivation has been associated with willingness to spend more time with the activity [29]. The affective attitude toward a service may simply be positively influenced by labelling the service as "entertainment". Personal perception of playfulness and enjoyment has a social function. According to personal experiences, a user is more likely to recommend a service to his/her friends and colleagues if he/she is amused by the service. The importance of individual affection on social influence has been substantially established in psychology and behavioural research [30]. Given the increasing effect of word of mouth, friends and colleagues might take a significant role in persuading consumers to use m-services.

A mobile device is typically used by a sole user and can be transported with the user anywhere and at any time. This characteristic of mobile devices makes them ideal for context-specific services personalized to each individual. Knowing who the customer is provides a business great opportunity to customise its services. This becomes even more important due to the limitations of the user interfaces of mobile devices. Compact and attractive forms and optimised interaction paths can help a consumer reach the desired services in the shortest time. Personalization can significantly improve the effectiveness of m-commerce strategy [15], and consequently enhance consumers' perception of usefulness of m-services [6]. Traditionally it is believed that personalization might cause consumers' concern on privacy and therefore negatively impact confidence beliefs. Studies, e.g. [6], however, imply that consumers are willing to allow service providers to retain user profile if they realise the benefits of personalized services.

Based on the above analysis, we proposed an integrative framework (Fig. 1) for m-service adoption, which identifies both factors influencing user acceptance of m-services and their antecedents.

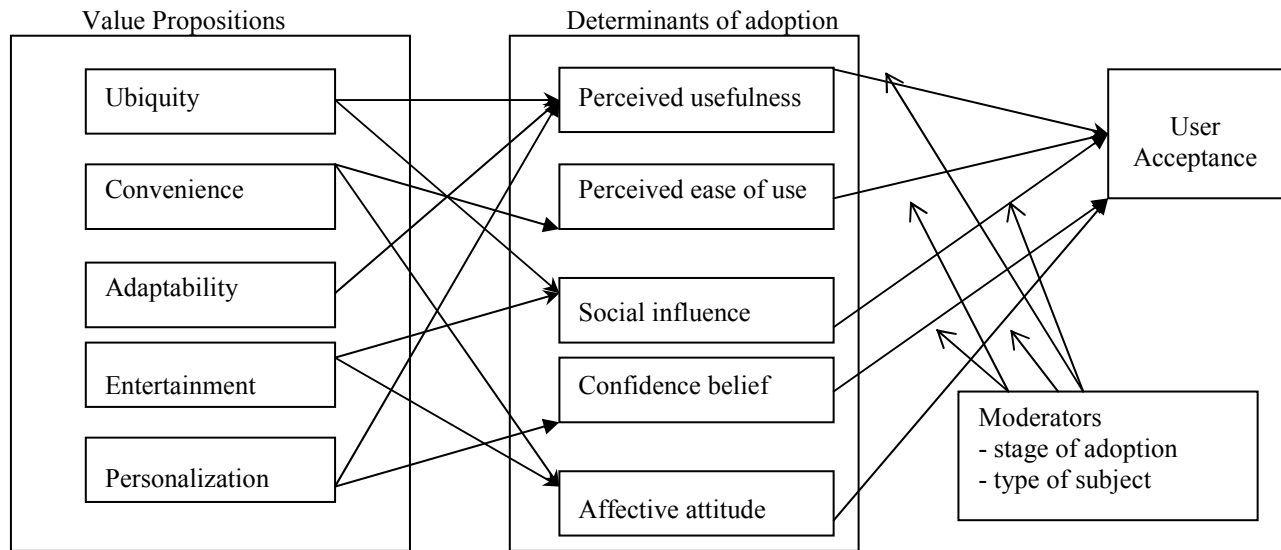


Figure 1. An integrated framework for m-service acceptance

4. Significance of speech interfaces

According to the independent research commissioned by *Speech Technology Magazine*, consumers generally are willing to accept speech technology, and perceive businesses with a speech interface to be providing more advanced technology and better customer service than those without a voice presentation [31]. According to [32], users show a supportive attitude and strong intention toward using speech interfaces, even though they know that voice recognition and synthesis technologies are far from perfect. The motivation behind such positive response from consumers again substantiates the perceived value of speech channels. Specifically, speech interfaces for m-business differs from conventional visual interfaces on the following value proposition attributes:

Naturalness

Voice is portrayed as the most naturalistic way to interact with a system. Even without generating true natural speech, the nature of voice input/output during the interaction is often sufficient for users to react enthusiastically to the computer system. Despite experiencing some frustration due to the inaccuracy of speech recognition, most users have greater concerns regarding ease of use of the interface rather than for any other interaction issues. The value of naturalness provides a direct perception of ease of use. Speech interfaces bring substantial advantages for consumers who lack proficiency with computers, but are familiar with mobile phones. This market is likely to be large, since there are many more mobile phones users than PC users throughout the world. When people realize that performing information browsing and transactions is just easy as making phone calls, the affective attitude to use and

consequently the intention to adopt m-services will increase.

Efficiency

As most people speak faster than any other common communication method, such as typing or writing, speech interfaces are appealing for improving efficiency. Research [33] has shown that people might be able to generate more than twice as much text in the same period of time by speaking compared to computer keyboard input. The efficiency of voice input is crucial to many applications, such as medical reporting for doctors, source data automation for sales, and stock checking for inventory staff. As time-critical settings are one of the key situations where m-commerce can create significant mobile value, speech interfaces are an enhancer to the perception of usefulness and social image.

Parallelism

Mobile technology provides users the freedom of independence of time and space. Such flexibility is not available without a condition. With a visual interface, it is difficult, if it is not impossible, to perform "hands-busy" or "eyes-busy" activities simultaneously. A range of m-services are operated in such multi-task situations, such as traffic guidance for vehicles, logistics management and medical reporting. An audio-interface facilitates multi-tasking, particularly where the secondary task is highly visual [34]. Given the fact that a large percentage of consumers use mobile devices inside a vehicle [34], hands-free and eyes-free voice interaction for services becomes a necessity to realize true ubiquity of m-commerce. The parallelism of multi-task processing can enhance consumers' perceived usefulness of mobile devices by providing a time-saving, where multiple tasks are completed within the timeframe that one task might

otherwise have taken. The affective attitude of usage might be positively influenced as well.

Trustworthiness

As telephony networks have been running for more than a century, people generally perceive voice services as more trustworthy compared with the newly emerging Internet-based services, regardless of the technical reality. This is supported by the fact that the monetary transaction value performed by U.S. consumers over the telephone in 1999 was ten times more than that of global Web purchases [36]. People feel comfortable to provide their most confidential information over the public telephony network. Speech interfaces facilitate a seamless migration from cell phones to Web-enabled mobile devices.

In addition, speech interfaces create a unique opportunity to authenticate a user through speaker recognition without obstructively requiring password input. Various services, including mobile banking, wireless database access, mobile shopping and confidential information retrieval, could benefit from this technology. The robustness and accuracy of this biometric could obviously enhance consumers' confidence beliefs on the security and trust of transactions. In addition, personalization to each individual can be conducted more easily. Consequently, users are more likely to be positive in judgements of perceived usefulness.

5. Strategies for developing speech-enabled m-commerce services

Speech interfaces have their own limitations. People normally can only remember less than 7 choices when listening to a voice menu [36]. Voice recognition for large vocabulary continuous speech is far from perfect even in a quiet and stationary environment, not to mention the noisy and mobile scenarios. Synthesized speech still sounds like a robot. Furthermore, speaker recognition techniques are still in their infancy. In order to develop commercially acceptable speech-enabled applications, we have to combine understandings of both user acceptance factors and limitations of speech interfaces to develop suitable strategies.

● **Application-directed vs. Mixed-initiative dialogue**

There are two common approaches to complete a voice-enabled transaction. The first is application-directed, which forces consumers to use a limited vocabulary tailored for the application in response to system prompts. This approach significantly increases recognition accuracy and reduces maintenance effort, but does restrict the user from speaking naturally. The other is mixed-initiative powered by natural language understanding technology, in which consumers use conversational speech rather than a limited number of phrases. The approach enhances users' perception of naturalness, but is

prone to recognition errors. Considering the current state of the art of speech recognition technology, it is practical to combine the two approaches together. At the beginning of a conversation, mixed-initiative dialogue can be applied to allow users to specify their interest and preferences. If this approach fails to capture users' meaning, an application-directed dialogue could then be enforced to guide users in finding the desired products or services.

● **Detail-focus dialogue design**

It is important for the system to give necessary feedback or confirmation during the dialogue. [31] points out that users would not accept a speech-enabled service that could not give immediate and accurate feedback or confirmation on crucial information like mailing address, order completion, etc.. In addition, detail designs such as barge-in, combination of recorded prompts and synthesised speech, and universal navigation commands, should be considered carefully.

● **Personalization**

Mobile users demand packets of relevant information, not scaled-down versions of generic information. As users cannot remember many items simultaneously, personalization becomes extremely important for voice applications. In [37], we propose a decision-tree approach to voice-enable m-commerce applications. As a decision-tree has a perfect match with an application-directed dialogue, this approach significantly simplifies the procedure of dialogue design.

6. Conclusion

This paper proposes a framework to explain the acceptance of mobile commerce from the customers' perspective, and analytically assess whether, and in what ways, speech interfaces are likely to facilitate users' adoption process. The framework incorporates added value analysis of mobile services into a service acceptance model derived from a meta-analysis. Five factors: perceived usefulness, perceived ease of use, social influence, confidence belief and affective attitude, have been found to positively influence users' usage intention. The value propositions created by speech-enabled mobile services, such as ubiquity, convenience, naturalness, efficiency, parallelism and trustworthiness were analysed to explain how users' perception and beliefs about the five determinants of acceptance can be positively influenced by the added value.

The study suggests that compared with other determinants, perceived ease of use and social influence could play a more important role in explaining users' acceptance of technology-oriented services. It also results in some valuable implications on strategies of developing speech-enabled mobile commerce services. It presents a pioneering research to assess the suitability of speech

interfaces for mobile commerce, and highlights the significance of human factors when developing speech-enabled mobile services.

7. References

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