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# **A Proposed Theoretical Model of Discontinuous Usage of Voice-Activated Intelligent Personal Assistants (IPAs)**

*Research-in-Progress*

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## **Abstract**

*Based on the contradictory phenomenon of rapid development of Voice-Activated Intelligent Personal Assistants (Voice-Activated IPAs) and discontinuous usage of it, this paper investigates the antecedents of discontinuous usage of Voice-Activated IPAs. We first analyze the topic of Siri usage discussion from Zhihu's Q&A website, and then propose a theoretical model which hypothesized that discontinuous usage of Voice-Activated IPAs are affected by perceived ambiguity, cognitive overload, privacy concern, social embarrassment and lack of integration. It is hypothesized that perceived ambiguity will exert nonlinear impacts on discontinuous usage. Meanwhile, perceived ambiguity is also affected by level of personification in a nonlinear way. Scale development and data collection would be conducted for the future work. It is expected that the results our research could provide theoretical and practical implications for the design of Voice-Activated IPAs.*

**Keywords:** Voice-Activated Intelligent Personal Assistants, Siri, discontinuous usage, perceived ambiguity, social embarrassment, privacy concern

## **Introduction**

Recent years have witnessed an explosive growth in the usage of gesture and voice controlled devices. Voice interface is becoming a standard feature for many mobile electronic devices. Applications of native Voice-Activated Intelligent Personal Assistants (Voice-Activated IPAs) have been embedded in many devices or platforms, e.g., Apple – Siri, Google – Google Now, Microsoft – Cortana and so on. Besides, Voice-Activated IPAs electronic devices such as Amazon's Echo, Alibaba's TmallGenie are also launched and get great attention. Take Siri as an example, which is debuted with iPhone 4S in 2011, in which “voice recognition, information management, artificial intelligence, task fulfillment, and user interface cooperate in a way the general public finds usable and productive enough to adopt on a global scale of tens of millions devices” (Apple Inc. 2017).

Relying on speech recognition technology, these Voice-Activated IPAs could perform simple tasks such as calling contacts, setting reminder or calendar through voice command input instead of manual operation. With the development of Artificial Intelligence, voice-activated IPAs could also perform more complex tasks, such as providing personalized recommendation based on users' preferences and habits. In the future, those voice-activated IPAs are expected to maintain natural-language

conversations, and provide health support, or even emotional support for their users. There are two characteristics of Voice-Activated IPAs. The first one is that most Voice-Activated IPAs are designed with humanlike features, such as conversational function, anthropomorphic design (e.g., names and personalities). The second one is the personalization of learning due to its capability of self-learning through repeat interactions to improve performance over time. This characteristic means that users and Voice-Activated IPAs learn from each other and also train each other at the same time. The extent of intelligence a Voice-Activated IPAs show to its user greatly depends on how much effort the user invests to train or interact with it.

Recent market research has forecasted that the worldwide Voice-Activated IPAs market will grow 32.8% a year from 2016 to 2024, and reach a value of US\$7.9 billion (Transparency Market Research 2016). Strategy Analytics also estimates that in 2022, the market for Intelligent Speaker (e.g., Echo) will reach US\$5.5 billion, and 3.3% of global households will have equipped with virtual personal assistant-enabled wireless speakers by 2020, due to their ease of use and their natural, intuitive interaction model (Gartner, 2016). However, according to the consumer behavior report from the Verto Analytics, 70% of users will not continue to use the Voice-Activated IPAs after the first attempt. Take Siri as an example, which ranked 1st in the Voice-Activated IPAs, its monthly subscriber base fell by 7.3 million between May 2016 and May 2017. At the same time, Siri's User Sticky Index, a ratio of daily users to monthly users, is a measure of user engagement, drops nearly a half, from 21% to 11% (Connie Hwang 2017).

This might be because as an ambiguous technology, the technological frame of Voice-Activated IPAs, which carries a set of assumptions, expectations, and knowledge that shapes subsequent usage, could not be clearly defined (Pillet et al. 2017). Actually, there are usually no (or quite simple) instructions for most Voice-Activated IPAs, implying self-driven exploratory forms of learning, rather than traditional instruction-based learning might be more suitable for learning to use Voice-Activated IPAs (Pillet et al. 2017). From a practical aspect, given that Voice-Activated IPAs are going to considerably change humans' everyday life in future, it is important to understand the user's perceptions of them, the characteristics that inhibit consumers' continuous usage. From the theoretical perspective, more empirical research is needed considering that only limited amount of research has been conducted on its usage and user experience (Cowan et al. 2017; Lovato and Piper 2015; Moore et al. 2016; Tundra 2017), though research on technical infrastructures of voice-activated IPAs are quite extensive. Therefore, we proposed the research question of this study: what are the antecedents of discontinuous usage of Voice-Activated IPAs?

## **Literature Review**

### ***Voice-Activated Intelligent Personal Assistants***

The concept of *Intelligent Assistants (IA)* was first proposed in 2000, refers to “an integrated system of intelligent software agents that helps the user with communication, information and time management”(Azvine et al. 2000). With the development of technology, the concept of *Intelligent Assistant* gradually evolved into *Intelligent Personal Assistants (IPA)* with different definitions. For example, from the perspective of data processing technology, Myers et al. (2007) and Santos et al. (2016) consider IPA are software agents that can automate and ease many of the daily tasks for their users. Meanwhile, from the perspective of interaction, Hauswald et al. (2015) defined IPA as “an application that uses input such as the user's voice, vision(images), and contextual information to provide assistance by answering questions in natural language, making recommendations and performing actions”. Luger and Sellen (2016) used the concept of conversational agent to define these assistant, whose purpose is “both support for real time task completion and to develop sufficient knowledge about the user in order to exert agency on their behalf”.Based on these definitions, we defined Voice-Activated IPAs as “an intelligent application/device which can autonomous learn user habits and preferences, and meet the demands of users and build user trust through interaction by natural language approximatively”.

With the rapid development of AI, those Voice-Activated IPAs show great potential and are expected to deeply change our everyday life, especially for the elderly and disabled users due to its simplicity of

interaction (Wulf et al. 2014). There are also research revealing that Voice-Activated IPAs could play an important role in young children's learning by exploration, information seeking, functional usage (Lovato and Piper 2015). Meanwhile, it is also found that most users do not use Voice-Activated IPAs frequently after trying the fancy features. There are some exploratory studies try to investigate the reasons behind. For instance, Moore et al. (2016) compared how ordinary people and experts think about Siri, suggesting that though ordinary people are more optimistic than the experts about what such spoken language technology might have to offer, the majority of end users still prefer to typing revealing by the usage patterns. In an exploratory study, Tundrea (2017) highlighted that privacy concern might prevent users from continuing to use Voice-Activated IPAs. A recent study conducted by Cowan et al. (2017) focused on the infrequent users' experience of intelligent personal assistants, and summarized the reasons why Siri users not use it regularly. Through qualitative interviews, this study reveals that besides interruptability in full hands free interaction, cultural norms, social embarrassment, impeding effects of human-like features, trust and concerns about privacy are also the barriers for widely acceptance and effective use of Siri. In sum, the research on users' discontinuous usage of Voice-Activated IPAs still remain in its infancy. Most of the related research are exploratory and there is a lack of empirical research on this phenomenon.

### ***IS Discontinuous***

As post adoption behavior, research on individual level IS continuance is one main stream of IS usage research because continuance is a vital premise of effective usage of IS. Different theories are applied to explain such behavior by taking specific characteristics of the target IT artifacts into consideration. For example, Bhattacharjee (2001) proposed technology continuance model and argued that whether users continue to use a technology depends on the level of satisfaction, which resulted from the confirmation or disconfirmation of original expectation. Besides, other major theories, such as TAM, TRA, TPB, UTAUT, IS success model, status quo bias and so on, are also applied to investigate users' continuous usage of various IT artifacts, such as specific devices, applications or services (Nabavi et al. 2016).

Though most research treat IS continuance and discontinuance as a bipolar construct, some researchers point out that they should be treated independently due to the different preceding influencing factors. Some scholars have revealed that perceived cognitive based inertia, perceived sunk costs, positive social influence, perceived usefulness have the positive effect on the continuance usage of self-tracking device in the consumer device, while the antecedents of discontinuance usage are negative social influence, system unreliability, system capability shortcomings, perceived routine constrains and perceived trustworthiness (Buchwald et al. 2015). From the individual level, discontinuous usage of IS including reducing the frequency of use, short-term interruption or permanent stop by users. From the opposite aspect, some researchers investigate why users discontinue to use a specific IT artifact by revealing the factors that lead to dissatisfaction or unpleasant experience after adoption stage. With the development of ubiquitous technology, technostress is also highlighted as an important perspective to explain continuous usage of IS (Pillet et al., 2017). Research on SNS usage indicated that strain from SNS usage, such as emotional exhaustion, social network fatigue are major antecedents of discontinuous intention of SNS (Gao et al. 2018; Maier et al. 2012, 2015; Zhang et al. 2016).

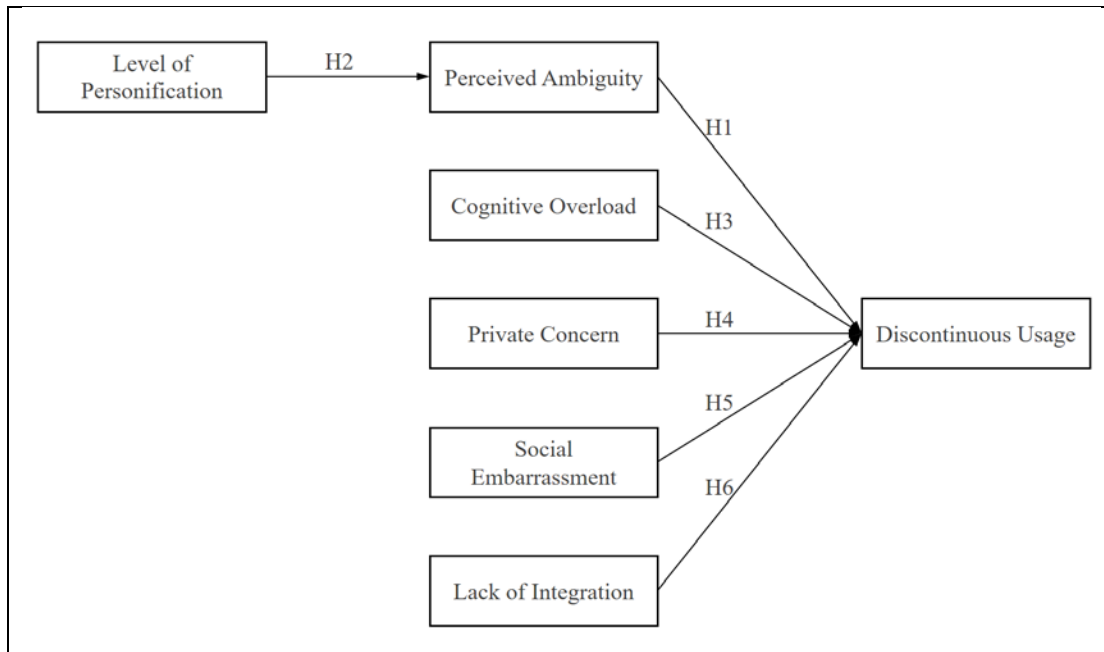
In sum, although extensive literatures have analyzed the influencing factors of discontinuous usage of various IT artifacts, there is a lack of research on Voice-Activated IPAs. As an innovative technology which still remain great potential to explore, there is a lack of clear technological frame to define this type of technology and there is also a lack of shared mental frame by developers and users. Users' mental model toward Voice-Activated IPAs would be adjusted continuously with the technological innovation on it. Thus, the current theories applying to previous IT artefacts might not be suitable for Voice-Activated IPAs, especially the knowledge about this type of technology updates rapidly (Aggarwal et al. 2015).

## **Research Model and Hypotheses**

To discover the antecedents of discontinuous usage of Voice-Activated IPAs, we firstly conducted an exploratory study on Siri by analyzing the discussion on Siri from the website of Zhihu. Similarly to Quora, Zhihu is a social Question & Answer site based on community, user relationships and content operations. It launched on January 26, 2011, and the total number of registered users are over 100 million as of September 2017, with 26 million daily active users. Siri is chosen as the target IT artifact because it is the first Voice-Activated IPAs application, and as of June 2017, it had now been used on more than 500 million devices (Connie Hwong 2017). Actually, Siri gets far more discussion than other Voice-Activated IPAs on Zhihu, such as Contana and Google Now. In the topic square of Zhihu, using 'Siri' as the keyword, we collected 3614 answers under 772 questions in total. We analyzed the questions and answers related to use experience of Siri, and summarized the findings related to usage of Siri as follows.

- 1) Most users only use Siri to complete quit simple tasks, such as setting alarm or reminder, searching online when hands-free context is needed. Some users only use Siri to practice oral English. There is a consensus among the users that Siri is not suitable to deal complex tasks because of difficulty in interaction, uncertainty about the output. These phenomena reveal that Siri's intelligence is still in its infancy and will increase users' cognitive load.
- 2) Teasing Siri for fun is quite popular from these Q&A. There is a great amount of Q&As about how to raise interesting questions or get interesting responses from Siri. There is a tendency among the users to personify Siri with personalities, and even to make up "her" own stories.
- 3) A great portion of users don't know what they could use Siri do considering there are limited resources it integrates. They hold the opinion that it is inconvenient comparing to manual operation. As for Siri, there are few official guides given, and it is more necessary for users to explore which applications Siri can be integrated with and which functions they can develop.
- 4) Some users can't get used to voice activation. Some also worried that there is privacy threat using voice activation. Some feel embarrassment to use Siri in the public space and only use Siri privately.
- 5) A small portion of users try to explore new functions of Siri, such as setting and controlling intelligent household electrical appliances.

Based on the result of our exploratory study and literature review, we developed our research model as presented in Fig. 1.



**Figure 1. The Research Model**

Perceived ambiguity of Voice-Activated IPAs refers to “a categorization difficulty that disrupts the process of learning” about Voice-Activated IPAs, and includes three dimensions, which are purpose ambiguity, use ambiguity and relative ambiguity (Pillet et al. 2017). To be specific, purpose ambiguity refers to multiple or inconsistent interpretation of why to use Voice-Activated IPAs; use ambiguity refers to inconsistent interpretation of how to use Voice-Activated IPAs and relative ambiguity implies that Voice-Activated IPAs have attributes in common with unrelated ITs (Pillet et al. 2017). Appropriate level of ambiguity could facilitate users’ intrinsic motivation, such as curiosity or conquering challenge, but when it exceeds certain level, users are more likely to quit because of frustration or exhaustion. Thus, we hypothesize that:

*H1: There is a nonlinear relationship between perceived ambiguity of Voice-Activated IPAs and discontinuous usage.*

Level of personification refers to the extent to which Voice-Activated IPAs are personified by users. According to the Computers as Social Actors (CASA) paradigm, when computers show similar social attributes as humans, human mindlessly apply the same social heuristics used for human interactions to computers (Nass and Brave 2005; Nass and Moon 2000). When users have higher level of personification of Voice-Activated IPAs, they would have higher expectation of its intelligence. However, how level of personification affect perceived ambiguity might be complex. Some research revealed that more anthropomorphic cues will elicit more social responses, such as trustworthiness, likeability (Gong 2008). But other researchers also point out that anthropomorphism set unrealistic expectations and might lead to greater level of frustration when confronting failure, especially for those with lower level of technological knowledge (Luger and Sellen 2016). Thus, we proposed that there is a nonlinear relationship (U shape) between level of personification and perceived ambiguity. That is, perceived ambiguity decreases with level of personification increase until the level of personification reaches a point, and after that perceived ambiguity increase with level of personification continues to increase.

*H2: There is a nonlinear relationship between level of personification and perceived ambiguity of Voice-Activated IPAs.*

One difference between interaction with Voice-Activated IPAs and interactions with a human is that the former involves computerized speech recognition and generation, whereas the latter involves human speech. Though there are no differences between cognitive workload associated with comprehension of computerized speech and human, cognitive workload

associated with computerized speech generation is much greater than human speech generation (Strayer et al. 2014). This is because Voice-Activated IPAs users often have to learn to interact with Voice-Activated IPAs by making use of a particular economy of language, such as removing colloquial or complex words, using more specific terms, changing enunciation or accent, which will increase the cognitive load (Luger and Sellen 2016). According to Miller's Law (Miller 1956), the maximum number of chunks of information that the human brain can remember in a short time is seven. Thus, we believe that when the cognitive load exceeds the accepted level for the user, he is more likely to feel exhausted and quit the interaction. Therefore, we assume the following:

*H3: Cognitive overload toward the Voice-Activated IPAs is positively related to discontinuous usage*

While surrounded by others in a public space, users might not want to verbalize information of a private nature. For example, users might not want to disclose their credit card number while dictating an e-mail in a quiet restaurant, home address when looking up directions at a supermarket line, or social security number while sending text messages through voice commands in a crowded bus. Previous studies have shown that smartphone users are more protective of their private digital information compared to non-private information (Marques et al. 2012). Out of privacy concerns. Users may not use Voice-Activated IPAs when entering private information. Therefore, we assume the following:

*H4: Private concern toward the Voice-Activated IPAs is positively related to discontinuous usage.*

Talking to Voice-Activated IPAs was discussed as different to talking to someone on the phone, it was more like "talking to a wall" and it felt weird or inappropriate to use Voice-Activated IPAs in public spaces or in the presence of others, especially strangers. For example, interacting with the Voice-Activated IPAs by talking and issuing voice commands in public might make users believe that they are being watched or judged for their behavior. The potential risk for causing social embarrassment by using Voice-Activated IPAs in public seemed to be a major concern and an obstacle to user. Previous research also reveal that social acceptability exert great effects on usage of Voice-Activated IPAs in public space (Moorthy and Vu 2015). Therefore, we assume the following:

*H5: Social embarrassment toward the Voice-Activated IPAs is positively related to discontinuous usage.*

Users commented that they would be more likely to user Voice-Activated IPAs if there was the option to customize its use across other apps and platforms. The lack of integration and customization is a key barrier for users. A main source of frustration for many users was Voice-Activated IPAs's default use of Apple apps – its Apple exclusive- and lack of integration when it comes to third party apps. This inconvenience caused by incompatibility can also lead users not to use Voice-Activated IPAs. Therefore, we assume the following:

*H6: Lack of integration toward the Voice-Activated IPAs is positively related to discontinuous usage.*

### **Following Work and Expected Results**

Next, we are going to develop a scale for each construct and plan to collect data from typical Voice-Activated IPAs users, such as Siri, Contana, or Alibaba's TmallGenie, to validate the research model. We are going to use the internet-based questionnaire to collect the data, demographic characteristics, personalities or cultural factors (if possible) might be added to the research model as influencing factors or control variables for further analysis, the structural equation model will be applied to test the hypothesis.

It is expected that most the hypotheses would be supported and the results of our research could shed a light on the discontinuous usage of ambiguous IT, such as Voice-Activated IPAs. From

the practical perspective, our study could also be beneficial for the developers to improve the design of Voice-Activated IPAs.

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