The Duality of Autonomy on Continuous Usage of Intelligent Personal Assistants (IPAs): From Agency Perspective

Research-in-Progress

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Abstract

Based on the contradictory phenomenon of rapid development of Intelligent Personal Assistants (IPAs) embedded in smart IoT devices, this study examines the dual role of IPAs Autonomy (in terms of decision-making autonomy, scheduling autonomy and methods autonomy) in influencing users' IPAs usage through users' experience of agency. Drawing on agency theories, we identify two different types of experience of agency — perceived competence and perceived uncertainty. We hypothesize that these two contradictory aspects of experiences of agency would well explain the complex relationship between IPAs autonomy and IPAs usage. Scale development and data collection would be conducted for the future work. It is expected that the findings of this study could contribute to theoretical and practical implications for the design of IPAs.

Keywords: Intelligent Personal Assistant, Autonomy, Agency Theories, Perceived Competence, Perceived Uncertainty

Introduction

The rapid development of Artificial Intelligence provides explosive growth of the Internet of things (IoT), which make a new challenge for users to learn and manage emerging smart IoT devices in their daily life (Ponciano et al. 2015). For this purpose, intelligent personal assistants (IPAs) have been launched by many large global technology companies, and extend from mobile devices to embed in smart IoT devices or platforms to assist their users to operate smart IoT devices to complete various daily tasks (Santos et al. 2016). IPAs such as Google's Google Assistant, Apple's Siri, Amazon's Alexa

have reached great attention in recent years, when integrated into various smart IoT devices, such as smartphone, smart TV, smart car, smart speaker (Reis et al. 2017).

IPAs are intelligent agents that employ Artificial Intelligence techniques to provide human-like interface (e.g., voice, vision) for performing the daily tasks or services of their users, such as sending a message, making a phone call, searching for specific information, setting reminder or calendar and providing personalized recommendation (Saad et al. 2017). They are also expected to perform more complex tasks, such as making purchases and accessing or managing smart IoT devices (Han and Yang 2018). Natural language processing and AI technologies enable IPAs to self-learn users' schedule and taste through daily interactions and/or collecting awareness data (e.g., location and context) from the Internet of Things (IoT), and then autonomously perform tasks based on users' preferences and habits (Santos et al. 2016). Therefore, external humanoid interfaces - the anthropomorphic design (e.g., voice, appearance, embodiment) enabled by smart IoT devices, and intrinsic autonomy - the capability of acting with less human interventions enabled by self-learning from interacting with users through smart IoT devices, give IPAs as intelligent agents.

Recently, market consultants have optimistically predicted that the global IPA market will expand at an annual rate of 32.8% from 2016 to 2024, reaching a value of $7.9 billion (Gartner, 2016; Transparency Market Research 2016). However, according to the Voice Assistant Consumer Adoption Report 2018 (Voicebot et al. 2018), the usage rate of IPAs in smart speakers, Smartphones and Car that IPAs are currently the most widely used in separately is 24.3%, 45.5% and 43.3% at least daily, which are less than half. This usage of IPAs may be inconsistent with the expectations of market consultants. As we have known, IPAs aims to assist humans' everyday life in the future, it is important to understand this question from users' perceptions.

This phenomenon has attracted extensive academic attention, and many researchers have discussed from different perspectives, such as perceived value theory (Yang and Lee 2018) and theory of planned behavior (Yang et al. 2017). These perspectives equate IPAs with general information systems, ignoring the unique characteristics of IPAs that leading to IPAs usage. A few studies begin to attach importance to the external characteristic of IPAs - humanoid interfaces, which developing human-likeness and anthropomorphism in IPA (Han and Yang 2018). However, to our knowledge, scarce academic research has been done to examine the issue of continuance usage of IPAs from the perspective of autonomy as intelligent agents (Nickerson and Reilly 2004).

IPAs autonomy refers that IPAs as an intelligent agent can independently complete various tasks that their users appoint (Maes 1994). In the field of information system, many topics about autonomy focus on human autonomy, such as job autonomy (Ahuja et al. 2007), human autonomy (Erickson et al. 2016) and community autonomy (Jung 2011), and indicated that autonomy is a crucial and double-edged sword factor for the development of individual, communities, and organizations (Ahuja et al. 2007; Tripp et al. 2016). Autonomy can increase benefits, may also exert certain risks (Paul E. Spector 1986; Robert and You 2018). However, the effect of machine autonomy on human behavior has received limit attention.

The over-emphasis on human autonomy is because machines are not smart enough in the past, they can be regarded as relatively automation, rather than autonomy. Recently, artificial intelligence enables IPAs to self-learn users' preference through daily interactions and personal data from the Internet of Things (IoT), which ensures intelligent agents autonomy. Autonomy makes IPAs act as an autonomous

agent on behalf of the user to perform the user's tasks without human intervention, leading to different users' experience of agency. Therefore, the characteristic of IPAs autonomy cannot be neglected, may be an important factor for addressing the complex mechanism of users' continuous use of IPAs. Thus, the following research questions are attempted to examine: How autonomy impact the IPAs usage through users' experience of agency?

To determine inconsistency in the IPAs market, this study examines the duality of IPAs autonomy by dividing it into three dimensions, namely decision-making autonomy, scheduling autonomy, and methods autonomy. Drawing on agency theories, we identify two opposite users' experience of agency caused by IPAs autonomy: perceived competence refers positive experience of agency that users perception of increase their competence to manage smart IoT devices to perform the daily tasks when IPAs acting on their behalf of them, and perceived uncertainty refers negative experience of agency that the agency cost of IPAs autonomy caused by the information asymmetry between principal (users) and agent (IPAs). We propose that these two contradictory aspects of experience of agency would well explain the complex relationship between autonomy and IPAs usage.

The structure of this paper is as follows. The Sections 2 and 3, respectively, review the theoretical background of the research model and research hypothesis. In the end, we introduce the follow-up study.

Theoretical background

Intelligent Personal Assistants (IPAs) Usage

Consistent with previous research, intelligent personal assistants (IPAs) are intelligent agents that can complete the daily tasks of their users by collaborating with their users (Han and Yang 2018; Santos et al. 2016). The intelligent agents are the general term for a class of software that can autonomously and ease complex tasks or collaborate with other software agents to solve complex problems (Czibula et al. 2009). Further, intelligent personal assistants not only endowed with an initial (built-in) knowledge and with the capability of learning, but also can interact with their users via spoken interaction (Czibula et al. 2009). Therefore, IPAs also are intelligent agents that can able to adapt to their user's needs and actions by the learning capability, which of intelligence is reflected in the autonomy and humanoid interfaces (Garrido et al. 2010). Thus, in the field of Artificial Intelligence, intelligent personal assistants are called autonomous agents (Garrido et al. 2010; Maes 1994). In addition, intelligent personal assistants belong to the application of autonomous agents in the field of human-computer interaction (Czibula et al. 2009). At present, the research on the IPA characteristics of autonomy as intelligent agents is not rich.

Yang and Lee (2018) believed that it is a problem of IPAs diffusion, and from the perspective of perceived value theory investigated the adoption of IPAs devices. Yang et al. (2017) considered the usage of IPAs in smart home scenarios, and attempted to examine the intentions to adopt and use smart home services based on the theory of planned behavior. These perspectives equated the use of IPAs with the use of smart IoT devices, ignoring the characteristics of IPAs different from traditional human-computer interaction systems. Certainly, a few studies have noted the characteristics of IPAs anthropomorphism, and held that it can help IPAs build social relationships with users. For example, Han and Yang (2018), from the parasocial relationship perspective, explained users' intentions to adopt and use intelligent personal assistants.

IPAs Autonomy

The concept of autonomy is complex and broad, and are defined across different fields (Hellström 2013). In the field of computer science, the hot topic of machine autonomy emerged early (Maes 1994). Broadly, autonomy is that machines can perform the tasks without human intervention for their operation (Noorman and Johnson 2014). Moreover, the level and degree of machines autonomy have improved from no assistance in deciding everything (Parasuraman et al. 2000). IPAs are also the product in this process, and can currently make some decisions based on the high level of autonomy. Therefore, IPA is a metaphor for user's assistants (Noorman and Johnson 2014), helping users perform certain tasks. In essence, it is just an application based on artificial intelligence technologies (Bhatia 2016). Based on these technologies, it has the ability to decide how to perform the jobs, schedule the work and make decisions to carry out the outcomes (Czibula et al. 2009). According to the definitions of autonomy in the work environment (Hackman and Oldham 1980), the process of IPAs' performing tasks can be regarded as the machines' job autonomy (Bhatia 2016). The biggest difference is that there is not a real person who is completing the set goal.

There are abundant researches on autonomy, which can be divided into a single-dimensional construct (Yuan and Liu 2017) or a multi-dimensional construct (Jain et al. 1998; Sandström and Van den Besselaar 2018). Based on the impact of IPAs autonomy on users, the concept of autonomy comprises three dimensions that are similar to the dimension of job autonomy (Ye and Kankanhalli 2018), namely decision-making autonomy, scheduling autonomy and methods autonomy according to the task instruction structure of IPAs. Moreover, in this paper, the division of IPAs autonomy dimension is consistent with the research of Humphrey and Morgeson (Humphrey and Morgeson 2006). Because IPAs are increasingly able to work like normal people, perhaps even more efficiently than a few. Specifically, decision-making autonomy refers to the extent to which choose to control the content or details of the tasks performed. For example, you may say "Alexa, play music.", Alexa is then free to choose the name and type of song to play. However, the schedule of this task has been specified by its user. In contrast to, you can say "Alexa, set the alarm clock." before going to bed at night, which is no specific time for the alarm clock. Thus, IPAs will set the alarm clock to wake up according to the user's habits, which reflects the IPAs scheduling autonomy that defined as "the degree to which can choose to control the timing and scheduling of tasks performed. At the same time, the complexity of IPAs executing both instructions is hidden, which will result in the user losing control over the specific execution process compared to the previous user's own execution. Thus, IPAs has the ability to select specific execution methods to achieve the goals set by users. Based on this, we mentioned IPAs methods autonomy.

Research model and hypotheses

Fig 1 shows the research model developed based on the above discussion. Drawing on agency theories, we examine how three dimensions of IPAs Autonomy, in terms of decision-making autonomy, scheduling autonomy and methods autonomy would have double-sword effects on IPAs usage through the positive and negative experience of agency (i.e., perceived competence and perceived uncertainty). We hypothesize that IPAs autonomy will be positively related to IPAs continuous usage through perceived competence, and negatively related to IPAs continuous usage through perceived uncertainty.

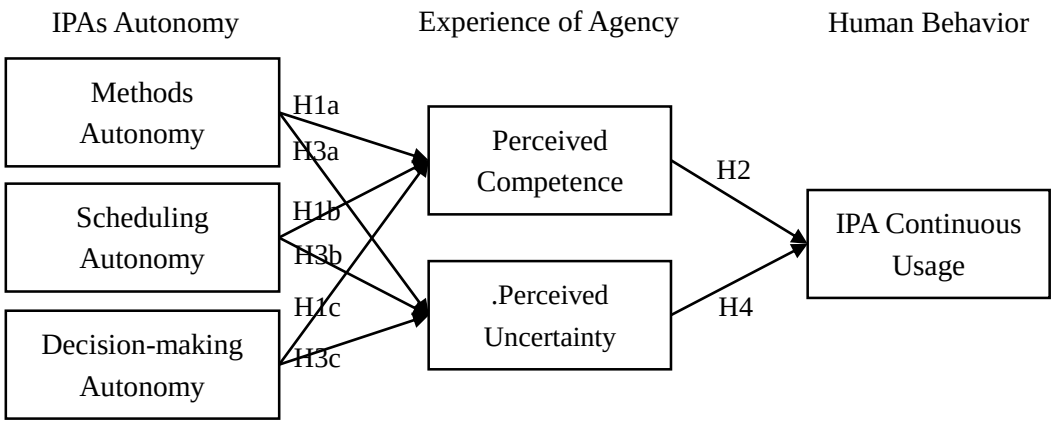

Figure 1. Research Model and Hypotheses

The positive experience of agency

Perceived competence refers to the degree to which IPAs users have the feel that IPAs increase their abilities to perform tasks and can reach his/her goal (White 1959). According to agentic theory, when people do not have direct control over tasks that affect their everyday lives, they rely on the proxy agency who have the resources, knowledge, and means to act on their behalf to achieve the outcomes they desire (Bandura 1989).

Applied to IPAs context, IPAs act as a proxy agent on behalf of the users to directly manage smart IoT devices to perform daily tasks. Autonomy will increase the resources, knowledge, and ability for IPAs used to autonomously perform the daily tasks without user's operating smart IoT devices, which make IPAs users have the perception of increase their competence to handling their daily tasks. In line with the existing literature, competent experience will attract users to use IPAs continuously. Therefore, we propose hypotheses:

H1a: Methods autonomy will have a positive influence on perceived competence.

H1b: Scheduling autonomy will have a positive influence on perceived competence.

H1c: Decision-making autonomy will have a positive influence on perceived competence.

H2: Perceived competence will have a positive influence on the intention to IPAs continuous usage.

The negative experience of agency

Perceived uncertainty is defined as the degree to which the consequence of IPAs performing tasks cannot be the accurate prediction by their users (Pavlou et al. 2007). Based on the principle-agent theory, perceived uncertainty is a significant problem in an agency relationship, when goal inconsistency and information asymmetry between principle and agent (Kathleen 1989).

In the context of IPA, IPAs might be designed on the basis of benefiting companies, rather than benefiting users. Autonomy will decrease the transparency in the process of IPAs act as agents on behalf of users to operate smart IoT devices to handle the tasks, then inducing two types of perceived uncertainty of users, namely perceived fit uncertainty and perceived privacy uncertainty (Hertzum et al. 2002). Perceived fit uncertainty refers that IPAs users are not sure whether these hidden processes will lead to inaccurate results to fit their needs, causing the uncertainty perception for the outcome of the

agency. Perceived privacy uncertainty refers that IPAs users may not understand how IPAs works, which can lead to suspicion and anxiety of privacy concerns about the process of agency. For example, some IPAs users feel that IPAs may be monitoring their daily routine without they know.

Previous studies have shown that perceived uncertainty is a negative experience that has a significant negative impact users' behavior (Hertzum et al. 2002). In the context of IPA, uses' perception of uncertainty about the outcome and process of using IPAs may reduce IPA usage during their daily life. Therefore, IPAs autonomy may cause the perceived uncertainty of IPAs users, which may have a negative impact on IPAs usage. Therefore, we propose hypotheses:

H3a: Methods autonomy will have a positive influence on perceived uncertainty.

H3b: Scheduling autonomy will have a positive influence on perceived uncertainty.

H3c: Decision-making autonomy will have a positive influence on perceived uncertainty.

H4: Perceived uncertainty will have a negative influence on the intention to IPAs continuous usage.

Following Work and Expected Results

We will conduct an online survey to test the research model and hypotheses. Only those who had used IPAs were targeted as respondents for this study. We plan to recruit 300 participants and they will be given monetary rewards for participation.

Next, we are going to develop a scale for each construct and plan to conduct an online survey from typical IPAs users, such as Google Assistant, Siri, Alexa, to test the research model and hypotheses. 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 autonomy, agency theories in the context of IPA. From the practical perspective, our study could also beneficial for the developers to improve the design of IPAs.

Acknowledgements

This work is partially supported by grants from the National Science Foundation of China (71602063, 71810107003).

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