

Title	コグニティブアシスタントとの信頼醸成について 人間とのインタラクションにおける信頼決定要因
Author(s)	Siddike, Md. Abul Kalam
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Description	Supervisor:神田 陽治, 知識科学研究科, 博士

氏名	SIDDIKE, Md. Abul Kalam		
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論文審査委員	主査	神田陽治	北陸先端科学技術大学院大学 教授
		西本一志	同 教授
		金井秀明	同 准教授
		白肌邦生	同 准教授
		Jim Spohrer	IBM Research – Almaden Director

論文の内容の要旨

Cognitive Assistants (CAs) are a new type of decision-making support tool. CAs are capable of providing high quality recommendations to people making a wide range of decision contexts, such as shopping, navigating, and researching. CAs help people to make better data-driven decision as well as to better understand the environment around them. However, in spite of the rapidly advancing capabilities of CAs, service-dominant (S-D) logic considers technology as a type of resource used by generic actors in service systems. S-D logic defines actors as the parties involved in resource integration, service-for-service exchange and value co-creation. But the S-D logic and service science literature does not currently explain how technology will someday soon be evolved as actors in service systems. Nor does the literature describe what are the factors that can positively and negatively influence the way people perceive technology as it becomes a responsible actor in service systems.

The main objective of this research is to develop a deeper understanding of service system in which CAs will evolve as actors, not simply resources, in service systems. More specifically, the objectives of this research are: to assess the current state-of-the-art of using CAs by people; to explore the factors influencing the way people perceive CAs will become responsible actors in service systems; and finally, to investigate the role of trust for evolving CAs as actors in service systems.

The literature review shows that CAs are appearing on the market, as tools that provide decision-making recommendations or information to users. In addition, the review shows that there is a lack of research about how users' trust their CAs. Therefore, in the second phase, I reviewed the literature of trust in sociology and psychology, organizational science, economics, automation, robotics, and CAs. Then a conceptualization of service system and the role of technology in service system is presented. As CAs, which are based on Artificial Intelligence (AI) technologies, are playing an increasingly important role in service systems, advances in AI technologies will impact all service industries. Finally, CAs, which will

someday be conceptualized as actors in service system, adds to the evolving paradigm of S-D logic and service science. Finally, I summarized the review of literature.

To achieve the objectives of this research, we adopted a qualitative and quantitative research approach. The qualitative part included open-ended questions and was conducted in three phases. In the first phase, a total of 10 online interviews was conducted with the fellows of first *HICSS (Hawaii International Conference on System Sciences) Doctoral Consortium*. In the second phase, a total of 12 (10 face-to-face and 2 online) interviews was conducted with the participants from *5th International Conference on The Human Side of Service Engineering (HSSE), July 17-21, 2017, The Westin Bonaventure Hotel, Los Angeles, California, USA*. For the final phase, a total of 10 (9 face-to-face and 1 online) interviews was conducted at *IBM Almaden Research Center, San Jose, CA, USA*. The data from these three phases were analyzed using qualitative data analysis software MAXQDA 12. In the case of quantitative research, which consisted of multiple choice questions, a larger-scale online survey was conducted. These data were analyzed using SPSS 24 and IBM SPSS AMOS 25.

The results show that most of the users use Apple Siri as their preferred CAs followed by Amazon Echo, Google Home, and Facebook M. In addition, users also use Google Now, IBM Watson, and Samsung Viv. Furthermore, users also use home security devices for controlling lights, temperature, air condition and alarming. Results also show that expert users may use high level CAs, namely Tesla driverless car. However, some users do not use any CAs. They want to have direct contact with nature. Results also show a wide range of usage contexts, such as placing calls, showing routes, things done quickly, searching information and learning. These usages contexts are the current capabilities of CAs. Furthermore, the results indicate a rapidly growing sophistication of models of the world, understanding contextual information, language learning, human-computer interface with augmented reality, learning emotions, security and privacy of personal data, providing personalized services, as well as other future capabilities of CAs.

Results also show that CAs are learning. CAs learn from interactions, context and recording and they will continue to learn. As with people, learning helps CAs become capable of doing more complicated and complex tasks. Results also indicate that CAs could learn among themselves, and this could be accelerated through more open collaboration among vendors of CAs. CAs could be interconnected together to form an open platform for CAs. Such platforms could be considered a “*society of CAs*.”

This research identifies influential factors that play an important role in users’ perceptions of current CAs as actors in service systems. First of all, CAs have to gain rights by showing responsibilities for their actions. CAs could gain rights and responsibilities by legislation, and other actions of legal authorities. Secondly, the vendors of CAs should formulate proper open standards and policy for maintaining privacy and security of personal information. Thirdly, security and privacy are the most important factor impacting users’ perceptions of current CAs as actors in service systems. The vendors of CAs should maintain proper security and privacy of personal information, because users fear possible harmful or

malicious use of their private information. Fourthly, data ownership is another important factor. Furthermore, accuracy of information, worry about CAs taking away jobs from people, and accuracy of performance on tasks are also important factors for emergence of current CAs to responsible actors in service systems. Finally, the results show that trust is the most important factor for evolving CAs to responsible actors in service systems. In general, trust plays the most important role for adoption of CAs by people in business and society. Currently, compared to people, the capabilities of CAs are very limited, but increasing rapidly. In addition, CAs are relatively new in the market, from personal assistants on smartphones to home assistants to driverless cars. Users believe that over time, as design and engineering improve, the capabilities of CAs will be increased and so trust may go up, if vendor-adopted standards and government regulations ensure privacy. Eventually, CAs will be considered as a type of trusted social actor in service systems.

In this dissertation, a framework of trust building with CAs was developed based on the results of interview data analysis and validated by the analysis of survey data. The results from interview data analysis show that reliability, attractiveness, emotional attachments, trustworthiness of CAs by users, and relative advantages of using CAs are important factors. These factors play an influential role in the development of users' trust on CAs in a wide range of interactions and contexts. The results show that general users use CAs based on trustworthiness toward CAs and relative advantages of using CAs. However, expert users use CAs based on functionalities (relative advantages) of CAs.

In addition, the framework of trust building with CAs was validated by quantitative survey. Five hypotheses were generated. Four hypotheses were supported except perceived emotional attachments. The results show that perceived reliability and perceived attractiveness have statistically positive significant relationship with trustworthiness toward using CAs. Therefore, Hypothesis 1 and 2 were supported. But perceived emotional attachments have positive relationship with trustworthiness toward using CAs but that is not statistically significant. Therefore, hypothesis 3 was not supported. The results also showed that perceived trustworthiness toward using CAs has statistically positive significant relationship with users' propensity to use CAs. Thus, Hypothesis 4 was supported. The result also showed that relative advantages of using CAs have statistically positive significant relationship with users' propensity to use CAs. Therefore, Hypothesis 5 was supported.

Based on the results of this research, a framework of service system in users' interactions with CAs was developed. In the developed framework, CAs are considered as operant resources that provide precise recommendations or options for human actors in the framework. In this service system framework, users' interaction with CAs are influenced by the trustworthiness and relative advantages of using CAs. As users interact with CAs for certain types of requests and CAs provide precise recommendations or options—that are considered as value proposition. At the same time, users receive supports from CAs—that are considered as value determination by the users. Through the interactions with users, CAs are able to know the emotions, feelings and context of users. In addition, CAs are able to learn over the

internet. Through these ways, the existing capabilities or functionalities of CAs are improved over the period of time. These improved capabilities of CAs ultimately influence the trustworthiness and relative advantages and emerge new type of influencers in the service system.

Finally, an emerging service system in which CAs will evolve as actors was developed as a theoretical implication of this research. By considering the results of this research seriously, this research suggests that CAs will evolve as actors in service system. Because, the result of this research indicates that CAs will evolve. So in the future, people's attitudes toward CAs will also evolve. In this research, we have found two categories of users (general and expert) and their attitudes toward CAs. The findings of this research suggest that the evolution of technologies (CAs) will never stop. And people's attitudes toward CAs will also be changed. In addition, the results of this research suggest that technology development evolution is inevitable. Finally, CAs will be evolved as actors in service system through the people's partnership with CAs.

Regarding practical applications, this research broadens the field of service science and S-D logic by developing an emergent service system in which CAs will evolve as actors. It provides a new way of thinking about service systems with responsible CAs. In addition, transition in diffusion, transition in interactions and transition in influencers play the most important role to evolve CAs as actors. Furthermore, this research develops and validates the framework of trust building with CAs. The framework of trust building with CAs is a new and unique contribution of this work to the world. Therefore, this research significantly contributes to trust literature in automation, robots and intelligent systems. In addition, this research contributes to design disciplines as well. Because, designers and developers could develop more attractive and emotional CAs in the future. Last, but not least, this research provides a potential opportunity for technology companies (vendors) to collaborate and develop new "*platforms of CAs*" that have the potential to create another revolution in the sharing economy.

The present research provides directions and suggestions for future research to undertake a study covering more experts from several companies in which they have their own CAs. Further research could be carried out covering more types of background information of users to observe whether nationality, gender, education and other experiences have any effect on the trust building framework. Another quantitative research should be carried out by including a moderating variable that reflects the degree to which a user views CAs as a human over a technology. Finally, future research should be carried out to justify and validate the service system in which CAs will evolve as actors covering more high level CAs namely IBM Watson Oncology for cancer treatment as well as Uber driverless taxis for transferring passengers from one place to another place. This will provide deeper insights to evaluate and validate the proposed service system in which CAs will evolve as actors.

Keywords: actors, agency, cognitive assistants (CAs), institutions, service-dominant (S-D) logic, service science, service system, smart service system, trust in CAs, wise service system

論文審査の結果の要旨

技術は社会に影響する。特に、昨今の AI（人工知能）技術の進歩（スマートスピーカーや自動運転車）が、我々の暮らしに大きな影響を与えつつある。本研究は、サービスに AI 技術がより深く広く組み込まれるだろう将来、利用者の受容行動にどのような質的变化をもたらさうかを、社会調査によって明らかにしようとする研究である。調査は、一般利用者や専門家へのインタビュー調査（3 回に分けて合計 32 名）と、質問紙調査（一般利用者 94 名、専門家 83 名）である。インタビュー調査には米 IBM の研究所で IBM Watson の開発や応用に関わっている専門家 10 名が含まれている。質問紙調査は、AI 技術に関心がある人々が誰でも自由に参加できるインターネットコミュニティ（異なる 2 グループ）で実施した。

スマートスピーカーや自動運転車は、「物」であるが、提供されているのは検索や移動に関わるサービスである。AI 技術は検索や移動を高度化するために「物」にサービスの形で埋め込まれて行く。普及理論に従えば、サービスが AI 技術によって便利になったとき、機能を理解し便利さを受け入れる人から使い始め、それを見て真似て使い始める人に広がる。人々はブラックボックスであっても信頼するようになり、最後には頼るようになって行く。AI 技術がさらに高度化したとき、人間のパートナーになって行くかどうかを研究の焦点に置いた。本論文は、利用者を一般利用者と専門家に分け、その差異を考察することで、AI 技術が組み込まれて行くサービスの発展過程についての理論モデルを構築した。

インタビュー調査では、AI 技術が組み込まれたサービスを利用する利用者に半構造化インタビューを実施し、（現状の）AI 技術に利用者が抱いている信頼(Trust)について質的分析した。その結果と、他分野における信頼（親近者への信頼、組織レベルでの信頼、経済分野での信頼、オートメーションやロボット分野での信頼）の文献調査結果と合わせ、信頼を作り出す因子(Trustworthiness)のサブ因子として、確実性(reliability)、魅力(attractiveness)、愛着性(emotional attachment)を導出した。質問紙調査では、これらの因子に、便利さの因子(relative advantage)を加えて調査した。インタビュー調査から導いた因子がどの程度、質問紙調査の標本データに当てはまるかを見る確認的因子分析(confirmatory factor analysis)と、因子間の関連をパス図によってモデル化する SEM(Structural Equation Model) 分析を実施した。確実性や便利さの因子については予想通り決定因子であったが、現時点においては、今後の普及に関わると想定していた、魅力や愛着性の因子については明確な結果を得るには至らなかった。

以上、本論文は、AI（人工知能）技術が我々の社会にもたらす影響を実証的に分析しようと試みたものであり AI 技術の急速な進歩を考え合わせると、時を得た研究と位置付けることができ、学術的に貢献するところが大きい。よって博士（知識科学）の学位論文として十分価値あるものと認めた。