

Trust in Cognitive Assistants: A Theoretical Framework

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ABSTRACT

The main purpose of this research is to develop a framework of trust determinants in the interactions between people and cognitive assistants (CAs). CAs are defined as new decision tools that can provide people with high quality recommendations and help them make data-driven decisions to understand the environment around them. Trust is defined as the belief of people that CAs will help them reach a desired decision. An extensive review on trust in psychology, sociology, economics and policy making, organizational science, automation, and robotics was conducted to determine the factors that influence people's trust in CAs. On the basis of this review, a framework of trust determinants in people's interactions with CAs was developed where reliability, attractiveness, and emotional attachments positively influence people's trust in CAs. The framework also shows that relative advantages of innovativeness positively affect the intention to use CAs. Future research directions are suggested for developing and validating more concrete scales in measuring trust determinants in the interactions between people and CAs.

KEYWORDS

Cognitive Assistants (CAs), People's Interaction With CAs, Trust Determinants, Trust in CAs

INTRODUCTION

Today, Apple's Siri, Google's Now, Amazon's Echo, IBM's Watson, and other cognitive tools are beginning to reach a level of utility that provides a foundation for a new generation of cognitive collaborators and cognitive assistants (CAs) (Siddike & Kohda, 2018a; 2018b; 2018c; Siddike, Spohrer, Demirkhan, and Kohda, Siddike, Spohrer, Demirkhan, & Kohda, 2018a; 2018b; Spohrer & Banavar, 2015). CAs are new decision tools that can augment human capabilities and expertise in understanding the environment around us with depth and clarity (Siddike, Iwano, Hidaka, Kohda, & Spohrer, 2017; Spohrer, 2016; Spohrer, Bassano, Piciocchi, & Siddike, 2017; Spohrer, Siddike, & Kohda, 2017). CAs can provide people with high-quality recommendations and help them make better data-driven decisions (Demirkan et al., 2015). Trust is an important and essential issue to consider for CAs to be adopted by society. The progression from cognitive tool to assistant to collaborator to coach to mediator is in fact a progression of trust (Siddike et al., 2018a; 2018b).

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In the 19th century, people did not trust steam engines and “boilers.” The problem was that they often exploded. Over time, design and engineering improved, trust went up, and economic growth resulted (Siddike & Kohda, 2018c). For example, consider this one application of the steam engine in America (Arthur, 2011); in 1850, a decade before the Civil War, the United States’ economy was small—it was not much bigger than Italy’s. Forty years later, it was the largest economy in the world. What happened in between was the railroads (Arthur, 2011). In the 21st century, people do not fully trust CAs. Knowledge, technology, and organizations are three ways people augment themselves to become smarter (Norman, 1993). However, knowledge, technology, and organizations must be trusted to spur economic growth. Advanced cognitive systems must become trusted social entities to be effective in our culture (Forbus, 2016). Only as trusted social entities can cognitive systems augment human intellect and interact with people to co-create new knowledge, technology, and organizations (Siddike et al., 2018a; 2018b).

Researchers in the fields of sociology and psychology, organizational science, economics, automation, and robotics have focused on trust (Costa, Heras, Palanca, Novais, & Julián, 2016; Friemel, Morana, Pfeiffer, & Maedche, 2017; Garcia, 2016; Hancock et al., 2011; Hoff & Bashir, 2015; Mayer, Davis, & Schoorman, 1995; McGuinness, Glass, Wolverton, & da Silva, 2007; Muir, 1994; Muir & Moray, 1996; Lankton, McKnight, & Thatcher, 2014; Ostrom, 2003; Ostrom & Walker, 2003; Rempel, Holmes, & Zanna, 1985; Schoorman, Mayer, & Davis, 2007; Yuksel, Collison, & Czerwinski, 2017). In psychology and sociology, researchers focused on interpersonal trust in close relationships (Rempel, Holmes, & Zanna, 1985). Researchers from organizational science focused on organizational trust (Mayer, Davis, & Schoorman, 1995; Schoorman, Mayer, & Davis, 2007). In addition, researchers from economics focused on trust in information and trust in action for governing common resources (Henry & Dietz, 2011; Ostrom, 2003; Ostrom & Walker, 2003). Furthermore, researchers from automation discussed the trust of people in reliance on automation (Mayer, Davis, & Schoorman, 1995; McGuinness, Glass, Wolverton, & da Silva, 2007; Muir, 1994; Muir & Moray, 1996). Researchers from IS showed that technology trusting expectations influence trusting intention through performance, disconfirmation, and satisfaction (Lankton, McKnight, & Thatcher, 2014). In robotics, trust is described in terms of the attractiveness of robots and the emotional feelings people have toward them (Hancock et al., 2011; Yuksel, Collison, & Czerwinski, 2017). Furthermore, Alaiერი and Vellino (2016) described ethical robots that can make ethical decisions in a way that gives them some degree of responsibility.

In the case of personal assistants or CAs, Nunes, Barbosa, and de Lucena (2010) theoretically described a domain-neutral user meta-model that enables high-level user models to be used with configurations and preferences that increase users’ trust in personal assistant software. In the same way, McGuinness, Wolverton, and da Silva (2007) explained that transparency (verification) and provenance (source of information) are the main factors in trusting CAs. But, no researcher has yet discussed how much people trust their CAs in daily life. Therefore, the above research background clearly demands research in the area of trust in CAs.

RESEARCH PURPOSE AND DESIGN

The main purpose of this paper is to conceptually develop a framework of trust determinants in people’s interactions with CAs. More specifically, the objective is to review literature on trust from psychology and sociology, organizational science, economics, automation, and robotics to conceptualize trust in CAs. The second objective is to conceptualize the trust determinants in people’s interactions with CAs. The third objective is to propose a framework of trust determinants in the interactions between people and CAs. The final objective is to suggest future research directions to develop scales for the proposed framework of trust determinants in people’s interactions with CAs.

In this paper, we reviewed trust-related literature in the fields of psychology, sociology, economics and policy making, organizational science, automation, and robotics. Because doing so provides a broad view of trust in different fields. We searched different databases subscribed to by the Japan Advanced Institute of Science and Technology¹, Japan. We used several keywords. In addition, we also searched in Google Scholar. We selected pieces of literature that were related to the current research purpose. Then, we conceptualized trust in CAs and developed a theoretical framework of trust determinants in the interactions between people and CAs.

COGNITIVE ASSISTANTS (CAS)

Cognitive Assistants (CAs) are new decision tools (Spohrer & Banavar, 2015; Demirkan et al., 2015). They are capable of providing high quality recommendations (Spohrer, 2016; Spohrer et al., 2017; Siddike et al., 2018a; 2018b; Siddike & Kohda, 2018a; 2018b; 2018c). They help people to make better data-driven decisions to understand the environment around them (Spohrer, Siddike, & Kohda, 2017; Demirkan et al., 2015). In this research, CAs are defined as new decision tools that can provide people with high-quality recommendations and help them make better data-driven decisions to understand the environment around them (Siddike & Kohda, 2018c; Siddike et al., 2017). CAs could be in different formats such as speech (conversational agents), typing, and gestures (real robots). Apple's Siri, Google's Now, Amazon's Echo, IBM's Watson and many other smart machines and cognitive tools are beginning to reach a level of utility that provides a foundation for a new generation of cognitive collaborators and CAs (Spohrer & Banavar, 2015). Cognitive systems can potentially progress from tools to assistants to collaborators and to coaches and be perceived differently depending on the role they play in a service system (Siddike et al., 2018a; Siddike & Kohda, 2018c).

To be people-centered, this progression requires that cognitive systems recursively acquire more advanced models of their users in order to develop expert-level cognitive and social capabilities (Siddike et al., 2017). Eventually, CAs will exist for all types of occupations and societal roles in service systems—and this will be the dawn of the era of smart, people-centered service systems. The ownership of cognitive systems and the personal data on which they will operate—as CAs build user models—will become an active area of legislation in the coming years, as companies that produce intelligent personal assistants seek to fully monetize the benefits they create for customers (Spohrer, Siddike, & Kohda, 2017).

Trust

In general, trust is considered to be a belief or attitude about others or a willingness to accept vulnerability or the behavioral state of vulnerability (Kee & Knox, 1970). In this section, we review the components of trust from psychology and sociology (trust in close relationships), organizational science, economics, automation, and robotics to conceptualize trust in the interactions between people and CAs. Table 1 summarizes the review of literature in different disciplines.

Components of Trust in Close Relationships

Researchers from psychology and sociology discussed interpersonal trust in close relationships (Deutsch, 1960; Rempel, Holmes, & Zanna, 1985; Rotter, 1980; Scanzoni, 1979). In close relationships, faith in partners helps to foster dependability and integrity (Rempel, Holmes, & Zanna, 1985). Our review shows that willingness, confidence, predictability, dependability, faith, and integrity are the main components of trust in close relationships (Deutsch, 1960; Rempel, Holmes, & Zanna, 1985; Rotter, 1980; Scanzoni, 1979).

Components of Trust in Organizations

In organizations, people have to work in different self-directed teams, and each team collaborates with different teams. Trusting in teams means trusting the individuals of an organization.

Table 1. Components of trust in different disciplines

Components of Trust	Discipline	Authors
Willingness, confidence, predictability, dependability, faith and integrity, group norms, altruism, shared values, good will	Trust in close relationships	Deutsch, 1960; Rempel, Holmes, & Zanna, 1985; Rotter, 1980; Scanzoni, 1979
Ability (competencies), benevolence (loyalty, openness, receptivity, availability of caring) and integrity (consistency, discreetness, fairness, promise, reliability, value congruence)	Organizational trust	Butler, 1991; Gabarro, 1978; Jones, James, & Bruni, 1975; Mayer, Davis, & Schoorman, 1995; Schoorman, Mayer, & Davis, 2007
Accuracy of information, trust in information, trust in action	Trust in economics	Henry & Dietz, 2011; Ostrom, 2003; Ostrom & Walker, 2003
Reduced workload, reduced uncertainty, reduced risk reliability, robustness, familiarity, accuracy, task complexity, ability, predictability, dependability, benevolence, openness	Trust in automation	Jian, Bisantz, & Drury, 2000; Lee & See, 2004; Muir, 1994; Muir & Moray, 1996; Parasuraman & Riley, 1997; Xu, Le, Deitermann, & Montague, 2014
Attractiveness, enjoyment, performance, attributes	Trust in robots	Yuksel, Collison, & Czerwinski, 2017
Reliability, attractiveness, emotional attachment, trustworthiness, innovativeness	Trust in CAs	Our framework (Figure 1)

Source: (Authors)

Mayer, Davis, and Schoorman (1995) defined trust as “...the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party...” (p. 712). Our review shows that ability (competencies), benevolence (loyalty, openness, receptivity, availability of caring), and integrity (consistency, discreetness, fairness, promise, reliability, and value congruence) are the important components of trust (Butler, 1991; Gabarro, 1978; Jones, James, & Bruni, 1975; Mayer, Davis, & Schoorman, 1995; Schoorman, Mayer, & Davis, 2007).

Components of Trust in Economics

In economics, trust is related to trust in information and in action (Henry & Dietz, 2011; Ostrom, 2003; Ostrom & Walker, 2003). Trust in information is related to actors (people, nations, agencies, and stakeholders) having to rely on information from different actors and sources in governing common resources in economics and policy making (Henry & Dietz, 2011; Ostrom, 2003; Ostrom & Walker, 2003). Information is an important motivator in decision making in common governance systems, and trust in information is at least as important as trust in actions in supporting successful governance (Henry & Dietz, 2011). Trust in action is related to actors taking action on the basis of information (Henry & Dietz, 2011; Ostrom, 2003; Ostrom & Walker, 2003).

Components of Trust in Automation

Trust plays an influential role in reliance on automated systems (Jian, Bisantz, & Drury, 2000; Muir, 1994; Muir & Moray, 1996; Parasuraman & Riley, 1997). Trust can affect how much people accept and rely upon increasingly automated systems (Jian, Bisantz, & Drury, 2000). Our review shows that most of the researchers (Jian, Bisantz, & Drury, 2000; Kee & Knox, 1970; Muir, 1994; Muir & Moray, 1996; Parasuraman & Riley, 1997) used the components of trust from close relationships, organizations, as well as economics and applied them to measure users’ trust toward automation. The components of trust in automation are ability, predictability, dependability, benevolence, openness, and risk.

Components of Trust in Robots

Trust toward robots mainly depends on the physical appearance and capabilities of the robots (Hancock et al., 2011; Yuksel, Collison, & Czerwinski, 2017). Hancock et al. (2011) stated that the performance and attributes of robots are the largest contributors to the development of trust in people and robot interaction. Yuksel, Collison, and Czerwinski (2017) mentioned that reliability and attractiveness are the main components of trust. In addition, researchers also noticed that trust depends on enjoyment and feeling like people are making contact with people (physical appearances).

Components of Trust in CAs

Trust plays an important mediating role in reliance on automated systems (Jian, Bisantz, & Drury, 2000; Muir, 1994; Muir & Moray, 1996; Parasuraman, & Riley, 1997). In general, trust is considered to be a belief or attitude about others or the willingness to accept vulnerability or the behavioral state of vulnerability (Kee & Knox, 1970). In this research, trust is defined as the belief of people that CAs will help them reach a desired decision. On the basis of the review of literature and our understanding of trust, we find that reliability, attractiveness, and emotional attachments are the main components of trust in the interaction between people and CAs. In this case, innovativeness provides relative advantages to generate the trust of people.

Trust Determinants in People's Interaction With CAs

On the basis of the discussion in the previous section, we conceptualize the reliability, attractiveness, emotional attachments, trustworthiness, and relative advantages of using CAs as being the important factors that play an influential role in the intention to use CAs. In this section, we describe the determinants of trust in the interactions between people and CAs.

Perceived Reliability

System reliability is the most important element in trust in the interactions between people and CAs. A number of researchers have discussed similar constructs of reliability using several synonyms (Frost, Stimpson, & Maughan, 1978; Hovland, Janis, & Kelley, 1953; Kee & Knox, 1970; Lieberman, 1981; Muir, 1994; Muir & Moray, 1996; Rempel, Holmes, & Zanna, 1985; Rosen & Jerdee, 1977). Researchers used the term "reliability" to express the ability and competency of a system to provide accurate information (Deutsch, 1960; Good, 1988; Muir & Moray, 1996; Sitkin & Bies, 1994). In addition, some indicated that functional/specific competency as well as the capabilities of a system generate the reliability of the system (Deutsch, 1960; Pentland, 2008). Some researchers indicated that predictability, dependability, and faith in a system denote the reliability of the system (Muir, 1994; Muir & Moray, 1996; Parasuraman & Riley, 1997; Rempel, Holmes, & Zanna, 1985). If a system is reliable, it ensures dependency, predictability, and the faith of people, so people use the system.

In this research, the term "reliability" denotes the abilities, capabilities, or competencies of CAs for providing high quality recommendations. People from different professions use CAs for different purposes on the basis of the reliability of the recommendations provided by CAs. Therefore, we predict that reliability greatly influences people's trust in CAs. As a result, we propose:

Proposition 1: Perceived Reliability Positively Influences People's Trust in Cas.

Perceived Attractiveness

In social psychology, the physical attractiveness of people is considered to be a positive personality trait (Dion, Berscheid, & Walster, 1972). Dion (1972) described that adults view more attractive children's transgressions less negatively and view less attractive children's offenses as more of an enduring dispositional fault. Similarly, Efran (1974) discussed that physically attractive defendants are found to be guilty less often and are given shorter sentences. Stewart (1980, 1985) mentioned that

attractiveness is highly predictive of both minimum and maximum sentences in judicial decisions in real courtrooms. Downs and Lyons (1991) indicated that judges exhibited a strong attractiveness-bias in the bails and fines that they set.

In general, people are attracted to handsome or beautiful people. The same thing happens in robots, technologies, and CAs. However, it is expected that CAs will become increasingly embodied in the future, so it seems unlikely that unattractive intelligent personal assistants will become the norm (Yuksel, Collison, & Czerwinski, 2017). However, in the case of robots, they have attractive shapes and appearances, but in the case of attracting people to use CAs, attractiveness is considered to be in physical shapes as well as in the voice. In addition, attractiveness is also considered as how fashionable and attractive the use of CAs is. Furthermore, using CAs is a point of pride or personal style or identity statement—these points are also considered as attractiveness in using CAs. We predict that attractiveness positively influences people's trust in CAs. Therefore, we propose:

Proposition 2: Perceived Attractiveness Positively Influences People's Trust in Cas.

Perceived Emotional Attachments

In general, emotional attachments influence people to trust their partners, technologies, or pet robots. In the case of people, people interact with other people in a way in which they interact with their family members, friends, or people in their community, and they feel the emotions and values of others. In the same way, when people interact with pet robots, they feel a sense of emotion as if they were interacting with real pets. In this research, we consider emotional attachments as the feelings that people have when they are interacting with their CAs in a way similar to how they interact with their family members, friends, and people in their community. Therefore, we assume that emotional attachments positively influence people's trust in CAs.

Proposition 3: Perceived Emotional Attachments Positively Influence People's Trust in Cas.

Perceived Trustworthiness of People

In general, people have the attitude or willingness to believe their partners (Rempel, Holmes, & Zanna, 1985). This denotes people's faith in others (Deutsch, 1960). In the case of economics, actors (people, organizations, or agencies) have the willingness to believe in the information or actions provided by other actors in order to govern common resources through deeds, contacts, rules, or other kinds of mechanisms (Henry & Dietz, 2011; Ostrom, 2003; Ostrom & Walker, 2003). In the case of organizations, people work in different teams, so team members have the tendency to trust in other team members (Butler, 1991; Gabarro, 1978; Jones, James, & Bruni, 1975; Mayer, Davis, & Schoorman, 1995). In a similar way, people have the willingness to trust in automation (Jian, Bisantz, & Drury, 2000; Lee & See, 2004). In the same way, we believe that people will have the tendency to trust in their CAs. When CAs are reliable and attractive, people have more of an intention to use them for different purposes (Davis, 1989; Venkatesh, Morris, Davis, & Davis, 2003; Wang & Benbasat, 2005). In addition, when CAs produce more emotional feelings in people, people will have more of an intention to use them. As a result, people's trust in CAs positively influences their intention to use them. Therefore, we assume that people's trust in CAs positively affects their intention to use them.

Proposition 4: People's Trust in CAs Positively Influences Their Intention to Use Them.

Relative Advantages of Innovativeness

Innovativeness provides relative advantages to users of a particular technology. In the theory of the diffusion of innovation, Rogers (2003) indicated attributes of innovativeness, namely, relative

advantage, compatibility, trialability, and observability. In this research, we consider innovativeness to be the relative advantages gained by people while using CAs. Therefore, we assume that the greater the rate of the innovativeness of CAs, the more rapidly CAs will be adopted in society. Therefore, we predict that relative advantages of innovativeness positively influence people's intention to use CAs.

Proposition 5: Relative Advantages of Innovativeness Positively Influence People's Intention to use CAs.

A FRAMEWORK OF TRUST DETERMINANTS IN PEOPLE'S INTERACTIONS WITH CAs

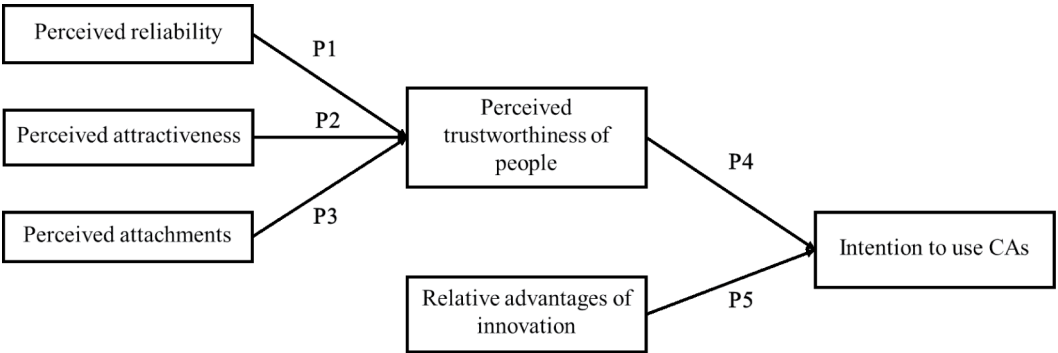
In this section, we propose our framework of trust determinants in people's interactions with CAs. Figure 1 shows our framework of trust determinants in which people interact with CAs. Our framework has not been completed yet; it is still under development. In the proposed framework, reliability, attractiveness, and emotional attachments are influential factors for generating trust in using CAs. First of all, reliability, in terms of the abilities, capabilities, or competences of CAs to provide high-quality recommendations, positively influences people's trust in using CAs (P1). Second, attractiveness in the form of physical shapes, attractive voices, or attractive sentences provided by CAs positively influences people's trust in using CAs (P2). Third, emotional attachments in terms of friendliness or feeling emotional support from CAs also positively influence people's trust in using CAs (P3). Fourth, people's trust in using CAs positively influences their intention to use them (P4). Finally, relative advantages of innovativeness positively influence people's intention to use CAs (P5).

DISCUSSIONS AND FUTURE RESEARCH DIRECTIONS

The main purpose of this research was to develop a framework of trust determinants in people's interactions with CAs. In this framework, reliability, attractiveness, and emotional attachments are influential factors for generating people's trust in using CAs. In this case, people's trust in using CAs positively influences their intention to use them. In addition, relative advantages of innovativeness also positively influence people's intention to use CAs. Our framework is still under development.

Our framework provides an opportunity for human-computer interaction, system science, and cognitive computing researchers as well as service science researchers to quantitatively measure trust determinants in the interaction between people and CAs through the development and validation of concrete scales. We believe that designers and engineers will greatly benefit from our framework of trust determinants in people's interaction with CAs. Last but not least,

Figure 1. A framework of trust determinants in people's interactions with CAs (Source: Authors)



system science, cognitive computing, as well as service science disciplines will also greatly benefit through the use of our framework.

This research is not free from limitations. First of all, our framework is based on a literature review and our understanding of trust and CAs. Second, the framework is conceptual and has not been validated yet. However, we provide several propositions for developing concrete measurement scales as part of a future research agenda. Initially, a series of workshops (discussions) could be arranged for getting feedback from engineers, designers, academics, and users from all over the world to gain a deeper understanding and further improvement of our trust-determinant framework in people's interaction with CAs. In the second phase, we could conduct interviews with engineers, designers, academics, as well as users of CAs globally. Next, we could concretely develop constructs or variables for our framework. Furthermore, we could survey engineers, designers, academics, and users to validate and justify our framework. Finally, we could develop our final version of the trust-determinant framework on the basis of the data obtained in the several phases as well as use simulations and mathematics.

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ENDNOTES

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