The Impacts of the Relation between Users and Software Agents in Delegated Negotiation: A Control Perspective

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ABSTRACT

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Bo Yu

Software agents are being increasingly applied to e-commerce activities, including commerce negotiations. Agents can be used to conduct negotiation tasks on behalf of users. When users delegate negotiation tasks to agents, information technology plays a role in determining social affairs. The locus of control over social affairs partially shifts from human participants to technology. When this negotiation approach is adopted, an important question arises: how will users treat and assess their agents when they delegate negotiations to agents? It is challenging to develop agents that are able to connect with users in meaningful ways. This thesis argues that users will not treat their negotiating agents in the same manner as they treat classical computer-enabled tools or aids, because of the autonomy of the agents. When assessing agents, users will be heavily oriented towards their relationships with the agents. Drawing on several streams of literature, this thesis proposes that the notion of control helps to characterize the relationships between users and agents. Users' experienced control will influence their assessments and adoption of their negotiating agents. Users' experienced control can connect to instrumental control, which is a set of means that empowers the interaction between users and agents. An experiment was conducted in order to test these propositions. The experiment results provide support for the propositions.

DEDICATION

To

my mother Guilan Gu

in my heart forever

Sincere thanks to

my wife Weizheng Gao and my daughter Emma

for their love

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LIST OF ABBREVIATIONS

A2A	Agent to agent
AI	Artificial intelligence
EC	Experienced control
HAI	Human-agent interaction
HCI	Human-computer interaction
HRI	Human-robot interaction
H2H	Human to human
H2A	Human to agent
IU	Intention to use
PCE	Perceived cognitive effort
PR	Perceived restrictiveness
PU	Perceived usefulness
TAM	Technology acceptance model
TPB	Theory of planned behavior
TR	Trust in agent

CHAPER 1 INTRODUCTION

Negotiation is a ubiquitous practice wherein dependencies exist and they cannot be resolved unilaterally. Negotiations often involve various types of social entities, such as individuals, groups, and organizations. They result in the transitions of social affairs, if agreements are implemented. Negotiation is a flexible mechanism of solving conflicts. The practices of negotiation appear in a broad variety of problem domains. Due to the importance and popularity of negotiations, they have been studied within multiple disciplines, including anthropology, social psychology, political sciences, economics, management, law and others (Bichler *et al*. 2003). Each discipline is usually concerned with different aspects of negotiations. A common feature shared in the classical research of negotiations is related to participants, i.e., human negotiators are assumed to conduct their negotiations.

One of the most recent thrusts in negotiation research is the fast growing domain of agent-based negotiation (Lin and Kraus 2010). This domain is mainly concerned with the engineering of software agents (or agents for short) that are able to conduct negotiations, which may or may not involve human participants. This new research domain was initially developed from computer science and engineering, particularly in the field of artificial intelligence (AI). It relies on the findings, models, and techniques offered by the aforementioned disciplines as its basis for building systems and modeling the behaviors of agents (Kraus 2001).

Agents that are able to conduct negotiations have been applied in operations management (e.g., Lopes *et al*. 2008) and e-commerce (e.g., He *et al*. 2003; Palopoli *et al*. 2006). They are becoming increasingly popular in contemporary commerce in the last two decades (Yu *et al*. 2015b), including commerce negotiations. Commerce negotiations require buyers and sellers to make decisions that determine social affairs, such as the allocation of social welfare, the delivery of goods, and after-sale services. In many situations, prompt decisions are needed. When using agents in negotiations, buyers and sellers can save time and other costly resources (e.g., human resources). These benefits help to explain why negotiations gain strong interests in the agent research community. The impacts of software agent applications are not limited to automation. Agents have the potential to enhance the interactivity between buyers and sellers, change business relationships,

and shift market structures. The large-scale deployment of agents in enterprise systems can help businesses build highly responsive and smart e-commerce systems (Yu *et al*. 2015b). Their potential impacts have caught the attention of scientists in other fields, such as economics (e.g., Kauffman and Walden 2001) and marketing (e.g., Redmond 2002).

Agents differ from classical computer-enabled tools and aids. A generic behavioral trait of agents is that they are autonomous and often proactive. They do not need continuous instructions from their users (Wooldridge 2002). Consequently, when users delegate their negotiation tasks to agents who make decisions about social affairs, the function of information technology (i.e., the agents) changes from a traditional supporting role into a determining role. The locus of control to both the negotiation processes and outcomes is partially shifted from human negotiators to agents. When the control is decentralized to more than one entity representing the same party, a team emerges. The members of the team will jointly influence the decisions and outcomes.

Despite the increasing importance of agent-based negotiation and the distinctive behavioral traits of agents, there is yet no clear research agenda to identify how to relate agents to human users in negotiations for business use. When agents negotiate on behalf of human users, the following questions need to be investigated:

1) Will users assess negotiating agents in the same way as they use classical computer-enabled tools or aids? Or, will users treat them differently?

2) What design choices will affect users' perceived relationships with agents?

3) What design strategy incorporating various guiding principles will be effective?

Drawing on several streams of literature, the current thesis argues that users will treat their agents differently than classical computer-enabled tools or aids. Their assessments of agents will rely more on relational factors than others, when they delegate negotiation tasks to agents. Moreover, the implemented means of empowering interaction (e.g., providing different system features or information) will influence users' perceived relationships with agents. The current thesis adopts the notion of control in order to develop theoretical insights about how users will assess their use of negotiating agents. It also explores the possibility that the constructs of control

are able to connect design choices and users' assessments. An online experiment was conducted. The results support the proposed propositions.

1.1 Research objectives and questions

The utilization of agents in negotiations can be beneficial in many aspects. In comparison with human negotiators, agents have computational advantages. They can operate faster and potentially optimize the outcome given the available information. They do not get distracted, which is very different from humans whose decisions are influenced by their selective attention. In addition, agents can be programmed to be immune to inconsistency problems that human negotiators may have (Greenwald *et al*. 2003). These traits of agents are particularly useful when they are applied in a decentralized, partially observable, stochastic, and continuously changing environment (Wooldridge 2002). They can influence not only negotiation outcomes, but also their users, when negotiation tasks are delegated to them. The development of agents that are able to connect with humans in meaningful ways is not a straightforward task (Edmonds 2002). The intelligence of agents is derived from not only their capabilities of conducting assigned tasks, but also their meaningful interaction with humans. The behaviors of agents need to be appropriate, acceptable, and comfortable for humans (Dautenhahn *et al*. 2002). Connecting agents to users in negotiation tasks and building sound relationships between them are challenging, despite the promising benefits of using agents.

Users and agents work in teams when users use agents in their negotiation tasks. The control mechanisms within a team are important. For instance, the classical principal and agency theory indicates that some control mechanisms (e.g., incentive, contract, and governance structure) are required in order to make a principal-agency relationship operable (Eisenhardt 1989). Similarly, the control mechanism between users and agents in delegated negotiations is a valid and important concern.

The current study argues that *control* is a useful notion that can be used to characterize the relationships between users and agents when the users delegate their negotiations to agents. Due to the agents' behavioral trait of being autonomous, the users' assessments of the agents will be more oriented to their perceived relationships with agents than to performance and efforts.

Therefore, focusing on classical criteria (e.g., efforts and performance) may not be sufficient to capture users' assessments. The notion of control is selected to be the focus of the current study for two reasons. First, this notion has been adopted in studies of both agent design and user assessment of technology. Second, it has the potential to connect design factors to users' experiences. The implemented means allowing users to interact with agents can be represented in the notion of *instrumental control* (i.e., the actual control users have). Users' subjective evaluation of their influence on agents can be captured in the notion of *experienced control* (i.e., the control experienced by users). This study proposes that instrumental control may influence users experienced control, which in turn leads to further impacts. More specifically, the underlying premise of this study is that users' experienced control is an important factor that will influence their assessments of agents and possibly connect back to its antecedents, i.e., specific design choices.

According to the Merriam-Webster dictionary (merriam-webster.com), the terms 'relationship' and 'relation' are often exchangeable when denoting "the way in which two or more people, groups, countries, etc., talk to, behave toward, and deal with each other". Sometimes they convey a slightly different sense. In the current study, the term 'relation' refers to the ways in which users and agents are connected together, i.e., the instrumental means in which users and agents can interact to each other. For instance, a user can instruct an agent and the agent can give feedback. The term 'relationship' is used to denote the state of being connected. This use will be more appropriate when capturing users' perceptions concerning their states of being connected with their agents. Users will feel that they are connected to agents when they perceive their control to them. If they perceive little control over the agents, they will not feel connected. Users' perceived relationships with agents are built on top of relations (interaction means) and beyond interaction.

In order to lay out a theoretical foundation, the current study first reviews the development of agent-based negotiations. The purpose is to highlight some generic characteristics of agents and the general implementation issues of agent-based negotiations. Second, the study discusses the possible ways of building relations between users and agents by reviewing literature of human-agent interaction (HAI), human-computer interaction (HCI). It will also review the aspects of human-robot interaction (HRI) that are relevant to this study. Third, it examines the concept and the constructs of control and then reviews the applications of this construct. Following this, a

general model characterizing the relation between users and agents in delegated negotiations is presented. The literature review also discusses techniques that can be used to implement control and factors that may influence users' perceptions of control. Based on the general model, a research model is proposed in order to carry out an empirical test. Essentially, the research model hypothesizes that users' experienced control over agents will have significant impacts on user assessments. Meanwhile, users' experienced control may vary when instrumental control is implemented differently.

The research of HAI, HRI, and HCI shows that the possibilities of implementing the means of interaction between users and agents are very broad. Specific design choices can not only shape the interaction between users and agents, but also affect users' subjective responses. Although the contributions of this research stream are growing, it currently posits a challenge in that the inventory of selectable design choices becomes very large. The combination of multiple design choices often causes less predictable effects, e.g., the constructive nature of decision making. It is difficult for designers to justify and verify their decisions for design without the guidance of an over-arching design principle. Sometimes, competing theoretical bases undying alternative choices make the situation more difficult. Given these challenges, it has been argued that understanding how users will respond to and assess technology would help in the design. Users' experiences of using technology and their subjective assessments have become an importance focus in HCI research (Grudin 2005). The involved psychological mechanisms underlying users' responses and assessments are often relative stable. For instance, the technology acceptance model (TAM) has been shown to be robust when predicting and explaining why users would like to use a technology (Davis 1989). If factors that influence users' perceived ease of use and usefulness are identifiable, they can be used to guide the selection of design choices or applied to the diagnosis of potential problems. Besides the TAM, enhancing decision accuracy (or performance) and reducing efforts have been shown to be useful strategies that can be used to guide the design of decision aids (Todd and Benbasat 1991).

Agent is a type of autonomous computing artifact. The usage of autonomous artifacts in businesses is common. For instance, robots are often used to automate manufacturing processes. Computer programs can automate batch tasks. Although most agents are still used to automate well-defined tasks, the situation has begun to change. Some agents are now applied to make

decisions on behalf of users (e.g., automated quote-review agents and automated trading systems). Some of them have started to participate in more complex social activities (e.g., virtual librarians or tour guides). These movements necessitate deeper insights into the potential impacts of these autonomous artifacts on users, businesses and our society. Therefore, the benefits of this study will be considerable. First, the research results will provide prescriptive suggestions for system designers when they need to conceive what type of control mechanisms should or could be utilized in a particular situation. Second, practitioners can also benefit from these suggestions as they need to be aware of the merits and pitfalls when agents determines social affairs. Useful findings may also be available to the scientists of decision making research and scholars who are interested in socially intelligent agents.

In summary, the current study applies the notion of control to characterize the relationship between users and agents in delegated negotiations and explores the potential individual impacts. Its research objective can be decomposed into more concreate research questions, including:

- How will users assess their use of agents in delegated negotiation? Will they focus more on relational factors than other competing factors?
- Will the specifics of the implementation of control influence users' perceptions and assessments of their use of agents?
- If the implementation of control has influences, how will the influences take place and what are the issues or challenges?

1.2 Research method and main findings

In order to test the theoretical propositions, a research model is developed based on the general model. An online experiment was conducted, in which users were asked to use software agents to shop for a travel insurance from multiple insurance dealers. Questionnaires were administered to participants in order to capture their subjective perceptions and assessments. The main findings can be summarized in the following.

First, three constructs, (1) trust in agent, (2) satisfaction with outcome, and (3) perceived usefulness, all significantly influence the construct of intention to use agent. The construct of

intention to use agent is adopted as a surrogate representing users' acceptance of the technology. Each of the three constructs represents a potential orientation, with which users may assess their agents. The construct of trust in agent represents the users' assessments derived from their relationships with their agents. The construct of satisfaction with outcome represents the users' focus on negotiation outcomes. The construct of perceived usefulness represents their assessments of the contribution made by agents to the achieved outcomes. The construct of trust in agent has the highest path coefficient compared to the other two constructs. These results suggest that users had multiple orientations when assessing their use of agents. They focused more on the relationship factors than negotiation outcomes and efforts.

Second, the construct of experienced control significantly influences the three constructs of trust in agent, satisfaction with outcome, and, perceived usefulness. The construct of experienced control has higher path coefficients to the three constructs representing users' assessments than negotiation outcome and the construct of perceived cognitive effort. These results suggest that users' experienced control has profound impacts on users' assessments. They also suggest that enhancing users' experienced control will be an effective strategy guiding the selection of design choices.

Third, a chain of significant effects connects the implementation of instrumental control, users' perceived restrictiveness, perceived cognitive effort, and experienced control. This result suggests that the specific design choices will influence users' perceptions. However, the relationship between instrumental and experienced control is not straight-forward. A discrepancy effect was found. The actual achievable effects need to be carefully examined. A diagnosis based on the data of users' system usage was conducted. The data indicate that the users did not actually need or use all the means provided to them, which explains the discrepancy effect.

1.3 The structure of the thesis

This thesis is organized into seven chapters. Chapter 1 is the introduction. It highlights the research questions that the thesis attempts to address. It also briefly describes the results, implications, and contributions of the study. Chapter 2 will discuss the theoretical foundations about user and agent relation in negotiations. The reviewed literature stems from multiple research

fields, including agent-based negotiations, HAI, HCI, HRI, and behavioral research of control. Drawing on studies and findings from these research fields, a general model of control is developed to characterize the relationships between users and agents in delegated negotiations. Chapter 3 will discuss a testable research model which is based on the general model. Related hypotheses will be proposed as well. Chapter 4 will describe the methodological details of testing the research model. It will discuss how the constructs of control can be operationalized. The design and conduction of the experiment will be described as well. Chapter 5 will present the analyses and test results of the research model. Chapter 6 will discuss the results and implications of the current study. Chapter 7 will conclude with a discussion of the potential contributions and the expectations for future research.

CHAPTER 2 LITERATURE REVIEW

This chapter attempts to establish the theoretical foundation for the research inquiries. First, it briefly reviews the research field of agent-based negotiation. Second, it presents several ways in which agents can participate in negotiations. Third, it discusses why the concept of control is important and helpful. Lastly, it proposes a general model, in which the notion of control is used to connect users and agents in delegated negotiations. Essentially, the thesis argues that the implementation of instrumental control (i.e., means empowering user agent interaction) will influence users' experienced control over agents, which will have impacts on users' assessments and their perceived relationships with the agents.

2.1 Agent-based negotiations

Early artificial intelligence (AI) attempted to generate intelligent capabilities and behaviors in machines. Its more recent interests have diversified due to different conceptualizations of behavior and rationality. For instance, Russell and Norvig (2010) distinguished between thinking humanly vs. rationally and acting humanly vs. rationally. Based on the distinctions, a quadrant schema can be used to classify the types of intelligence and behaviors. Basically, classical AI tends to build individual intelligent artifacts (e.g., robots and agents) that can function like humans or other intelligent beings. Although human-agent interaction may be set up in some tasks (e.g., testing the linguistic capability of a robot), the relation between humans and these intelligent artifacts may not be an explicit design objective in classical AI.

Multi-agent technology is a natural extension of classical AI in distributive environments. It is mainly concerned with agents and distributive control. This particular field is interested not only in individually agents, but also in groups. Agents may constitute a society and display some intelligence in swarms (Huhns and Stephens 1999). Distributive intelligence is useful in an open and dynamic environment where there is no overall control and each party has partial knowledge of the environment (Wooldridge 2002). Multi-agents systems often rely on traditional HAI techniques and adopt regular user interface designs in order to empower the interaction between

users and agents. Consequently, users may be unaware of the existence of agents and thus treat them as regular computer-enabled tools or aides that are able to automate some tasks or processes.

Agent-based negotiation can be deemed as a particular domain within the field of multi-agent systems and distributive artificial intelligence. This domain has experienced a fast growth in the last two decades. It adopts an interdisciplinary approach when building systems. It also attempts to model the behaviors of agents that negotiate with each other in order to resolve conflictive and mutually-dependent issues either for themselves or on behalf of human principals (Jennings *et al*. 2001). Agent-based negotiation has entered into our lives in many ways including automated trading agents, shopping agents, and recommendation agents (e.g., He *et al*. 2003; Palopoli *et al*. 2006). Some agents are used to control operations and facilitate supply chains across multiple partners (Lopes *et al*. 2008). Their applications are expected to have significant impacts on larger scale social and business environments (e.g., Kauffman and Walden 2001; Redmond 2002).

Interdisciplinary approaches are beneficial to the research of agent-based negotiation, as they provide rich and comprehensive knowledge about negotiations and negotiators. However, they also posit considerable challenges to this stream of studies, because interdisciplinary approaches often involve a larger and more dispersed knowledge base than the approaches supported by a single discipline. Meanwhile, interdisciplinary approaches may also need to integrate the distinctive perspectives rooted in each discipline. Integration becomes challenging when competing theories or solutions are available. For instance, traditional studies of negotiation often make various assumptions, develop or rely on distinct theoretical foundations, and are interested in very different aspects, e.g., the distinct rationality assumptions in game theory and in behavioral decision making theory. The available approaches, methods, and techniques related to negotiation are not always compatible to each other because of these diversities.

Software agents need to be designed and constructed, i.e., engineered. The engineering characteristics of agent-based negotiation force designers to make concrete choices in order to obtain the computability that is very essential to both the systems and agents. Lopes *et al*. (2008) demonstrated a broad scope of the choices that were made by designers of agent-based negotiation. The choices include preliminaries (the nature of negotiation), pre-negotiation (preparing and planning for negotiation), actual negotiation (moving toward agreement), and post-negotiation

(analyzing and improving the final agreement). Given the engineering requirements, the design choices are often eclectic and based on the designers' preferences and beliefs about negotiation. System designers need to balance between different views when making use of the available knowledge. The choices made by these scientists reflect not only the essential requirements of their projects, but also their views about negotiation. In many cases, the competing views adopted by the designers result in very different system features, in both the interaction among agents and their reasoning capabilities. A focal interest of this stream of research is to explore the approaches of constructing negotiation problems and to seek bases on which agents are able to make decisions. Several groups of agent-based negotiation systems are described and summarized in Table 1.

Group	Description	Examples
Game-theory-based	This group draws on game theory. By default, game theory assumes a full rationality and computability of the negotiators. Agents in this group attempt to obtain what is the best, or the most rational, thing that they can achieve given the strategic moves of other agents. Negotiation problems in this group are often constructed as a game having complete information, in which the strategic actions of participating agents are jointly determined by their pay-offs. Some new systems have been developed so that incomplete information scenarios can be handled. Agents in this group tend to make *independent* interactive decisions, in which joint gain may not be interested or persuasion will not be attempted. A limitation of this group is that agents may not reach an agreement if they cannot obtain an optimal outcome or reach an equilibrium.	Fatima *et al.* (2005) Fatima *et al.* (2006) Zhong *et al.* (2002) Zlotkin & Rosenschein (1989) Jennings *et al.* (2001)
Heuristic-based	This group draws heavily on the behavioral theory of decision making. Systems in this group have the possibility of overcoming the limitations of game-theory-based systems. Basically, these systems acknowledge that there is a cost associated with computation and decision making. Instead of exhaustively searching the negotiation space, agents look for a solution in a non-exhaustive fashion and need to decide when to stop. Agents may adopt different searching approaches or strategies. Since these systems focus more on resolving the problem and less on maximization or optimization, agents in this group may produce good, rather than optimal solutions or equilibrium agreement. However, the performance of agents can be evaluated in the notion of ecological rationality (e.g., accuracy-effort trade-off). Thereby, the design objective for obtaining the best solution can be relaxed. Agents may be more likely to obtain an agreement than those in game-theory-based group.	Faratin *et al.* (1998) Faratin *et al.* (1999) Kraus & Lehmann (1995) Lai *et al.* (2008) Jennings *et al.* (2001)
Case-based	Systems in this group resolve negotiation problems by simulating a cognitive approach of case-based reasoning which suggests that our reasoning may rely on not only computing and knowledge, but also our own or others' experiences. Essentially, case-based reasoning proposes a way to solve a new problem by using the information, cues, and knowledge of a similar situation. Although case-based reasoning is a close kin of knowledge based problem solving, the former differs from the later in many aspects. Instead of solely relying on general knowledge and association techniques, case-based reasoning utilizes the specific knowledge obtained from prior concrete problem situations to produce new solutions. Case-based systems may adopt an incremental and continuous learning approach that is frequently used in knowledge based systems to update the cases.	Kwon & Sadeh (2004) Sycara (1988) Sycara (1991)

Constraint-based	Systems in this group adopts constraint-based reasoning as its core foundation. Constraint-based reasoning originated from artificial intelligence. The essential idea of this approach is that a solution to a negotiation problem must satisfy all the constraints possessed distributively by participants. Constraint satisfaction is the formal term that depicts a process of searching for solutions. Systems in this group often adopt a distributed constraint satisfaction model which is an analogue to classical constraint satisfaction and targets to resolve a joint problem wherein the related constraints are distributed among multiple entities or domains. Dynamic exchange of constraints (e.g., loosening or tightening the conditions) is permissible in order to enable interactive negotiations.	Kowalczyk & Bui (2001) Lin *et al.* (2005) Sathi & Fox (1989) Sathi *et al* (1986)
Argumentation-based	Systems in this group simulate the social interaction of human agents who persuade each other in negotiations. The basic idea behind this approach is to allow meta-information to be exchanged over and above proposals. The meta-information is expected to be able to explain the opinion of the agent who makes the argument. With argumentation, a broader range of permissible actions is provided. Agents of these systems may have the capability of persuasion, which is beyond that of generating and evaluating proposals. They would also be able to indicate their negotiation stances to their opponents. Therefore, agents of these systems are likely to solve flexible negotiation problems. For instance, their individual preferences may change due to the argumentation.	Rahwan *et al.* (2003) Ramchurn *et al.* (2007) Sierra *et al.* (1998) Jennings *et al.* (2001)
General specification	Systems in this group were developed in order to examine the possibility of specifying negotiations and agents' specific traits in a general manner. Negotiation instances and agents can be instantiated according to meta-data and adjusted at runtime, e.g., giving different parameters and rules. This approach enhances the flexibility of the systems. Research interests include the development of negotiation standards, rule based systems, and ontology based systems. New terminologies and languages are developed in order to formalize protocols, mechanisms, and agents strategies.	Wurman *et al* (1998) Bartolini *et al.* (2005) Bădică *et al.* (2005) Tamma *et al*. (2005)
Agenda-based	By default, systems in this group need to deal with multi-issue negotiations. The main purpose of these systems is to develop the capability of agents to make decisions on the negotiating order of issues in addition to the decision regarding the agreement. Although these systems may draw on game theory, their focus is not limited in obtaining an optimal agreement. Agents may have different preferences over the order of issues they need to negotiate, which are private, asymmetric, or exogenous to the negotiations.	Fatima *et al.* (2004) Fatima *et al.* (2006)

Table 1: The examples of agent-based negotiation systems

2.2 User and agent relation in automated negotiations

Various types of relations between a user and an agent may form when the agent plays different roles in a negotiation (Braun *et al*. 2006). Figure 1 shows several possibilities that an agent is able to participate in a bilateral negotiation. Classically, a negotiation takes place between at least two parties represented by human participants. This kind of negotiation is human to human negotiation (H2H). An H2H negotiation may involve agents when they are used as supporting agents in at least two modes. In the first mode, agents provide support to their users, but have little intervention in the negotiation process. For example, agents may help users to collect information

and prepare possible solutions prior to the negotiation. In the second mode, agents may provide support to their users during the negotiation (e.g., Chen *et al*. 2005). In this mode, however, agents do not actively participate in negotiation. For instance, agents may act as assistants by providing support to their users or supervising them by invigilating the negotiation. In this mode, agents need to observe the negotiation, but do not make any direct choice or decision. Other types or hybrid modes of supporting agents may exist. A distinct feature of *supporting agents* is that they do not directly interact with any other party.

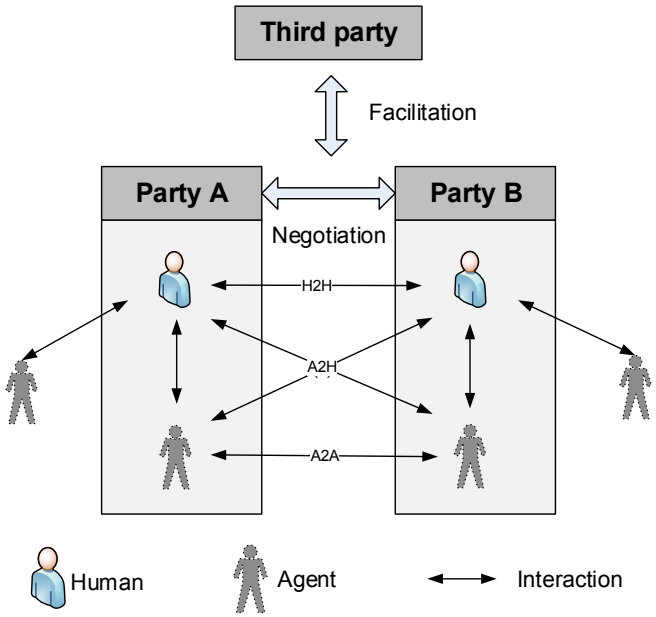

Figure 1: The roles and relationships of users and agents in bilateral negotiation

In another case, agents can act fully or partially as a negotiator (i.e., *negotiating agents*). If agents interact with someone representing the counterpart, two more types of negotiation may appear. They are agent-to-human (A2H) and agent-to-agent (A2A). Vahidov *et al*. (2014) conducted a study by comparing H2H negotiations with a set of A2A and A2H negotiations in which agents adopted five different negotiation tactics. They found that most agent types performed better than humans on a utility scale. Particularly, the performance of individualistic and tit-for-tat agents was significantly better than human negotiators. They also found that most agent types have outperformed human–human dyads in terms of agreement rates.

In A2H or A2A negotiations, users have a chance of being absent from the negotiating phase, which can be depicted as a delegation mode. Hybrid modes are also possible. For instance, a human user may supervise a group of negotiating agents. Or, a user can be paired with an agent working as a team that both members can propose offers or evaluate proposals. Agents may also participate in a negotiation by taking a role of the third party, such as a mediator. Similarly, agents can either provide support to a third-party user or take an acting role. They may play multiple roles at the same time, which makes their relationships with users and other agents more complex.

The composition of a negotiation instance sets up the relational basis for the participating users and agents (i.e., who can 'talk' to whom and in which way). Within the introduced possibilities, the notion of user and agent relationship concerns those instances that involve at least one user. Users may perceive their relationships with agents differently given the same negotiation composition when the implemented means enabling the interaction between users and agents vary. HAI is the field attempting to address related issues. HAI has many connections to two other fields, i.e., HCI and HRI. Agents are software empowered by computers. Thus, the design of interaction between users and agents may draw on theories, metaphors, and techniques developed in HCI. The recent development of embodied (or anthropomorphic) agents blurred the boundary between agents and robots. Similarly, HAI frequently borrows the knowledge developed for robotic control and interaction (Krämer *et al*. 2012).

An effective interaction design needs to consider both the functions on the physical system side and human factors on the user side (Norman 1986). *Functional design* focuses more on feasibility from the engineering perspective. Computer programs, agents, and robots are designed or adopted for different purposes. In order to fulfill the purposes, they need to have some functions. Functional design is often the main direction. Without functions, there is no need to involve users. When system functions require interaction with users, interaction design becomes another focus. *Interaction design* emphasizes the aspects of enhancing users' engagement, experiences, and performance when using systems (Kim 2012).

If the fulfillment of the functions of agents, robots, and programs involves users, users' capabilities, traits and possible responses need to be considered in the design. It has been argued that effectively including users in a design loop or even putting them at the center of design is the

best design practice (Norman and Draper 1986). Since users have constrained capabilities and behave psychologically, it may become problematic if they are simply treated like machines that are usually precise, consistent, and not bored with assigned tasks. Enhancing users' experiences is a main focus of HAI, HCI, and HRI. High usability is an objective usually pursued by designers who attempt to make users feel more comfortable, understandable, and realistic when the users use a system. Better usability can leads to broader acceptance and more usage.

Interaction between users and the artifacts of computers, agents and robots is the main focus of HCI, HAI, and HRI. Historically, three main research threads have been developed at different time. They rely on different approaches and pursue distinct objectives or interests. The first thread originates from the human factors and ergonomics field and focuses heavily on nondiscretionary use. The second thread is HCI in information systems, whose focal interest is managerial use of technology. The last thread is computer and human interaction and its antecedents. This thread focuses predominantly on individual discretionary use. Despite the fact that interaction between users and the artifacts is a common focus, the connection among the three threads has been very limited, because of the different perspectives, priorities, and difficulties of bridging and exploring each other literatures (Grudin 2005).

Deriving from HCI, HAI has generated new knowledge and demonstrates both opportunities and challenges of building relation between users and agents. Users' perceptions of their relationships with agents may vary according to the selected design choices (e.g., Dautenhahn *et al*. 2002; Krämer *et al*. 2012). Interaction with agents or robots adds new factors that are not by default actively studied in HCI. For instance, users and agents may need to conduct joint activities that require users and agents to have some common ground and solve conflicts (Krämer *et al*. 2012). The methods used to interact with robots need to consider the proximity between users and robots. In a long distance scenario or when there is few physical connections, remote communication becomes the only choice to convey information between them. When highly autonomous behaviors are desired, designers may have to reduce the level of user control in order to increase the level of autonomy of agents, robots, or automation programs (Goodrich and Schultz 2007).

Recent studies have extended the HAI and HRI research focus from interaction to relationships (e.g., Krämer *et al*. 2012; Takayama 2012). Building socially intelligent agents or robots is a trend in both HAI and HRI that pushes user related design to a higher level (Dautenhahn 2002). Essentially, this stream of research goes beyond the classical concerns of HAI and HRI and introduces broader questions, such as how users feel about their relationships with agents and robots, what are their roles in the tasks conducted by agents and robots, and whether their interaction is meaningful and natural (Edmonds 2002). The research of robot behaviors initially focused heavily on mobility. Later on, scientists sought to generate some life-like behaviors in them (Bradshaw *et al*. 2011). In term of interaction, HRI considers more emotional or social cognitive aspects in the design (Krämer *et al*. 2012). These advances successfully activate the issues of user and agent (or robot) relationships by investigating why and how users may treat agents differently, such as tools, peers, or subordinates. By applying various techniques, users may feel agents more bondable and then attribute more social and emotional engagement with them. It also broadens the scope of applications, such as accompany therapies, assistants, and education robots (Goodrich and Schultz 2007). Similarly, a group of scientists in the HAI field calls for the importance of building socially intelligent agents. When users and agents are involved together, it becomes important that these agents are able to not only conduct their assigned tasks, but also behave in a way that users perceive to be appropriate, understandable, and reasonable (Edmonds 2002). Researchers in this field argue that new forms of interactions and functionalities may emerge by exploiting the cognitive and social capabilities of humans. They also believe that the co-evolution of interaction between users and agents is possible (Dautenhahn 1998).

Functional design and interaction design are not orthogonal and nor always compatible. When users are deemed to be either an integral extension of the functions or the core of the design, designers need to consider the roles of users and how they may apply appropriate control to agents or robots (Bradshaw *et al*. 2011). For example, tele-operation with motion sensing capability (e.g., Wii controller) is able to better synchronize users' actions with controlling a target actor in a game. A similar design may be preferred for remotely controlled unmanned aircrafts. However, if the controlled targets are required to act very fast in order to perform their tasks (e.g., for a supersonic air missile), then this type of control may not be a good design choice, as humans may not be able to respond quickly enough. Designers may have to balance between the dual concerns of usability

and functionality by carefully considering the users, tasks, functions, and the applied environments. In some situations, the intervention of users to the autonomy of the controlled targets may have to be reduced.

In both functional and interaction design, designers are able to shape the relation between users and the controlled agents or robots. Agents or robots by default are autonomous. In order to shape a relationship between users and these artifacts, designers can apply different levels of control in order to change the autonomy of the artifacts. Goodrich and Schultz (2007) illustrate two scales that are presented in Figure 2. The first example is Tom Sheridan's scale, which has two extremes: (1) the artifacts being completely controlled by a human, and (2) the artifacts being completely autonomous and not requiring input or approval of their actions from a human. The second scale is used to position mixed-initiative interactions. This scale can be employed to conceive the degree of control and autonomy. These two scales suggest that the relation of users and controlled targets subscribe to design choices based on the functional requirements.

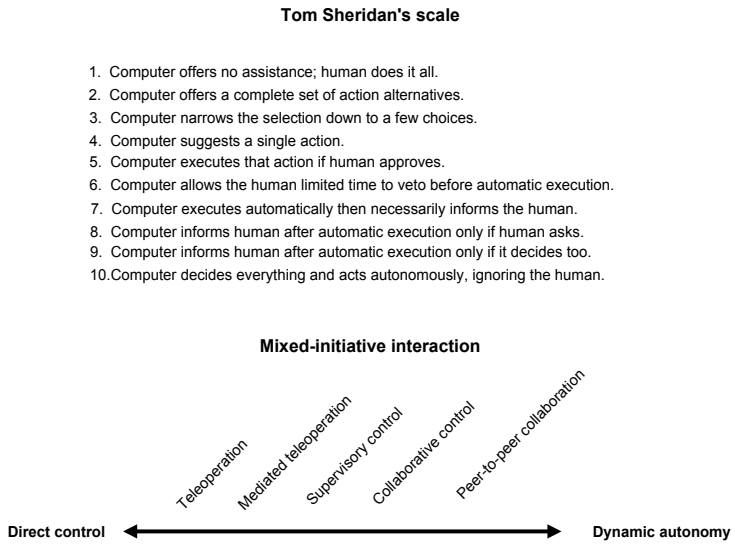

Figure 2: Users' control and the autonomy of artifacts

Human users' social psychological and cognitive mechanisms can be activated when they interact with agents or robots. They may treat agents or robots in a manner as they treat other

people or animals. For instance, it is reported that some owners of Roomba (robotic vacuum cleaner) formed social relationships or orientations to their robotic devices. They gave names to their Roombas. They even developed emotional or moral bonds with their Roombas. An owner was reluctant to return his or her device for maintenance because the owner did not want to get a replacement Roomba. Other owners worried that their devices could get choked on or stuck on when their Roombas were cleaning (Takayama 2012).

Agents can be animated as figures or life-like entities (e.g., embodied or anthropomorphic agents). Users may feel better when they interact with life-like entities than abstract objects. When an agent is given an artificial face that is able to mimic human face movements, it is possible to convey richer information to users. Users may find the agent more attractive and intelligent. Socially intelligent features may enhance users' acceptance of agents or robots as peers, instead of a machine or program (Bradshaw *et al*. 2011). However, socially intelligent features are not always better. For example, the uncanny valley effect shows that users may find robots to be scary when the likeness of the robots to humans falls into a particular zone (Seyama and Nagayama 2007). A well-known blooper of animation applications was the Windows Office assistant. The feature drew strongly negative responses from many users. They reported that the assistant was annoying, particularly when they concentrated on their work (Bickmore and Picard 2005).

Human users' opinions, preferences, and judgments can be shaped at certain levels through interaction design. The early research of judgment and decision making assumed that a person would have preferences that were independent of elicitation processes, e.g., one's preferences could be revealed by asking questions regardless of the form and sequence of questions. However, the finding of preference reversal effect suggests that this assumption can be invalid. The finding also successfully shifted the field and opened up a constructive perspective of judgment and decision making. Increasingly, studies show that human's judgment and choices are often contingent on the ways in which questions are asked, e.g., positive or negative framing (Payne *et al*. 1992). Constructive perspective of judgment and decision making has an important implication to HAI, HRI and HCI, as users' interactions with computers, agents or robots involve a sequence of information exchange. The content, form, pace, and sequence of the exchanged information will affect not only users' understanding of their problem domains, but also their opinions, preferences,

and judgments. There is a possibility to implement user and agent interactions in a constructivist fashion.

A constructivist approach of designing interaction may be achievable by leveraging users' folk psychology (Persson *et al*. 2002). Folk psychology studies have shown the importance of "folk theory of mind", which can be depicted as a sophisticated conceptual framework that relates different mental states to each other and connects them to behaviors. The process of reasoning about mental states is similar to scientific theory testing. One can postulate non-observables, predict them from observables, and use them to explain other observables. The environment differing on multiple aspects, such as institutions, education, and culture, will shape the theoretical framework of each individual (Malle 2005). Users' folk theories plus other psychological mechanisms, such as mental simulation, intention, desire, empathy, and sympathy, are useful for building human agent relationships. Designers do not need a precise and accurate model for human minds and behaviors. By mimicking social contexts and providing appropriate social cues, it is possible to activate users' folk theories. However, a fully-fledged approach of leveraging users' folk psychology is still not ready (Persson *et al*. 2002).

2.3 The concept and construct of control

The notion of control is important in HAI and HRI, as it is one of the key variables that set up the relational basis between users and their controlled targets. It determines the level and form of autonomy as well. Basically, the concept of control used in HAI and HRI focuses on objective control, i.e., the implemented means by which users are able to apply control to their robots or agents. In some situations, users' control over agents needs to be restricted, e.g., users' control over highly autonomous and fast acting agents. However, users should not be isolated from their used agents by removing all (direct and indirect) control that the users have over the agents. Without control, there is no good reason for users to feel that they are connected to agents, except that they may have an illusion of control. Although objective control (i.e., means to control) is important, it cannot replace users' subjective control for psychological and behavioral reasons. The notion of control and related constructs in psychological, behavioral, and information systems research will be discussed in this section.

Skinner (1996) conducted a systematic review, which shows that control is a complex concept that has been intensively studied in psychology and social psychology. It has been applied in management, marketing and politics. She suggested to distinguish between objective control, subjective control, and experiences of control. *Objective control* refers to "actual control or objective control conditions present in the context and the person." *Subjective control* refers to "perceived control or an individual's beliefs about how much control is available." *Experiences of control* differs from both objective and subjective control. It refers to "a person's feeling as she is interacting with the environment while attempting to produce a desired or prevent an undesired outcome" (op cit., p.551).

The experiences of control are the results of a process in which an individual intentionally exercises her influence. It is a feeling or perception that her effort and energy are transmitted into the environment and produces the outcomes. In contrast, subjective control, as a belief, may appear before any actual action is taken (Ajzen 1991). Frese (1987) used a similar term, "experiencing of control" and suggested that it has "an impact on the conditions and on one's activities in correspondence with some higher order goal" (p.315). Essentially, both authors indicated that control can refer to the experiences resulted from the process when one engages in implementing one's objectives. For convenience, the term "*experienced control*" is used to represent both notions.

Intuitively, the more objective control is available, the more control can be perceived. However, some disjunctive effects between objective and subjective control have been reported. For instance, it was reported that subjects experienced some helpless feelings (i.e., cognitive, motivational, and emotional deficits) when they were exposed to a prolonged non-contingency environment. The subjects' feeling persisted even when they were transferred to a subsequent situation in which they indeed had objective control (Seligman 1975). Simple tasks with objective control conditions may not be associated with a strong feeling of control as the non-challenging work may lead to decreased interests and involvement (Frese 1987). In contrast, the illusion of control indicates that people may perceive a high level of control when they are in an objectively uncontrollable or highly dynamic environment (Langer and Brown 1992).

Perceived control plays an important role in psychological functions. Research has demonstrated that perceived control is positively connected to well-being (both physical and

mental) and even perhaps longevity. It also influences individual development in a variety of life domains, such as achievement, optimism, persistence, motivation, coping, self-esteem, personal adjustment, and success and failure (Skinner 1996). Perceived behavioral control (i.e., one's perception of the ease or difficulty of performing the behavior of interest) has been recognized as a key antecedence, along with attitude and social norms, that determines one's planned intention and behaviors (Ajzen 1991). It can also be deemed as an assessment of the situation before one exercises efforts or takes an action in order to bring about the outcome of interest. (Skinner 1996).

Two distinctive views about the need for control have been established. The first is the *stimulus-response* view, which states that human need for control is an externally triggered motive to cope or manipulate the environment in order to obtain desirable effects. Increased need for control is frequently observed in an environment where one needs to deal with an aversive situation, such as stress (Skinner and Schwarzer 1992). The stimulus-response view highlights the role of the environment in shaping the individual's confidence, motivation, and perception of control.

The second is the *feedback-control* view, according to which the need for control can be deemed as an intrinsic motive with an internal eagerness to be in charge of given situations (Burger and Cooper 1979). This view argues that the control perceived by individuals involves an interaction between the ideal environment possessed by individuals and the actual environment that individuals are confronted with (Robertson and Powers 1990). The feedback-control view points out the determining role of individual characteristics in the formation of the feeling of control. The need for control is reflected in the concept of competence and effectance motivation i.e., humans have a need to feel effective and to succeed in their environment (Skinner and Schwarzer 1992).

Various studies of information systems research have adopted the concept of control. The theory of control and complexity proposed by Frese (1987) is a pioneering work that brings this notion into the field of information systems and software engineering. In the theory, he refined the

notions of control, complexity, and complicatedness[1] and discussed their relationships and implications on software design and information system use within work places. He indicated that users' experienced control would have a long term positive consequence on both stress-effect and performance. From this theory, a prescriptive postulate can be derived that users' experienced control needs to be enhanced, while the complexity needs to be optimized, and complicatedness should be reduced. The theory also points out that users' experienced control is shaped by two constructs, i.e., the internal and external decision prerequisites. These constructs are influenced by users' experiences of the functionality, predictability, and transparency of software and systems. *External prerequisites* include decision possibilities related to the work and the use of the system. *Internal prerequisites* refer to individual conditions, such as appropriate mental modes and adequate skills to use the system.

Morris & Marshall (2004) built their work on Frese's theory (1987). Their work is an exploratory work that aimed to further develop and investigate the concept of perceived control within the information systems field. They developed a survey instrument that initially contained 55 items measuring 16 factors by referring to the concepts of both internal and external prerequisites proposed by Frese (1987). They tested the instrument by surveying 241 subjects. Their final instrument had 16 items that were allocated to five factors representing a user's perceptions of control when working with an interactive information system. These five factors include 1) timeframe, 2) feedback signal, 3) feedback duration, 4) strategy, and 5) metaphor knowledge.

Taylor & Todd (1995) conducted a study in order to compare the explanative power of three theoretical models, i.e., the TAM and two variations of the theory of planned behavior (TPB). Their results showed that the TPB model, which includes perceived control, did not significantly explain more variation compared to the TAM. The decomposed TPB model provided a moderate increase in the explanation of behavioral intention. The study done by Venkatesh (2000) can be deemed as an extension of Taylor's work (1995) with an attempt to integrate the notion of control

[1] The author deems control as the decision possibilities and efficient action that users may take. Complexity refers to the decision necessities and complicatedness to those decision necessities that are difficult to control and are socially and technologically unnecessary.

with the TAM. Their results suggest that control has a positive relationship with the perceived ease of use of the system.

Sengupta & Te'eni (1993) used both individual and collective perceived control as dependent variables and examined whether cognitive feedback could help to enhance the perceptions of decision makers who were supported by a system in a group context. Their experimental results suggested that cognitive feedback helped users to maintain a high level of control over the process. Perceived control has been also examined in negotiation support systems. Wang *et al*. (2010) attempted to explain users' satisfaction when using negotiation support systems. Their research model considered multiple aspects of negotiations, including outcomes, negotiators' perception of the system, and the negotiation process. Their results showed that objective confirmation, perceived fairness, perceived control, and perceived collaborative atmosphere had a positive relation to negotiators' satisfaction.

2.4 Users' control to agents in delegated negotiations

The prior sections discussed the theories and findings from multiple fields that are closely related to the current study. This section will draw on these theories and findings in order to establish a theoretical foundation to address the question of how users and agents can be related together in delegated negotiation tasks and how users will assess their use of agents. It will first discuss the relevance of the notion of control for characterizing the relation between users and agents. Second, it will present a general model that depicts how the implemented means of control will influence users' perceptions about control, which will jointly cause further individual impacts.

Human negotiators participate in negotiations with the aim of reaching a potential agreement. During the negotiations, multiple aspects of negotiators' experienced control (e.g., decisions, behaviors, and cognition) are expected to be naturally aligned with each other. Alignment is expected because human negotiators may know themselves the best (e.g., their preferences and their interests). Negotiators, as intelligent beings, need capabilities to synthesize and balance their cognition, behaviors and decisions, although the level of alignment may vary according to individual characteristics and a broad scope of other contingencies. For instance, negotiators' knowledge about the negotiation problem and their skills to negotiate may vary. Other factors may

include individual characteristics, negotiators' relationships with others, connections with the environment, and the nature of the goal that one wants to achieve (Robertson and Powers 1990).

People and organizations may employ others to act on their behalf for many reasons. For example, others may have the desirable expertise, the access to resources, or the power to influence the outcomes. When one employs others as agents to achieve one's goal, the issue of control becomes complex as one needs to deal with the connections between self, agents, means, and ends (Skinner 1996). In a delegation mode, the locus of control towards the targeted objective is partially shifted from self to others. A team structure between self and others will unavoidably emerge. Consequently, the implementation of control among multiple entities becomes a valid concern.

Studies about teamwork and performance can be found in multiple disciplines. Some of them adopt the concept of control. For instance, the autonomy scales (see Figure 2) that have been discussed in the prior sub-section are good examples illustrating how users may have different levels of control on robots or agents. Negotiation within a team can also be a way of applying distributive control, as negotiation can be adopted as an underlying mechanism for coordination and cooperation of a team when none of the members has overall control. The principal and agency theory offered by management science indicates that some control mechanisms are necessary in order to make the teams of principals and agents effectively operable. The alignment of objectives, motivations and incentives is often the key to achieve control (Eisenhardt 1989).

The composition of each party, the configuration of negotiations, and the connections of negotiators to their environment are important contingencies that will influence the negotiation processes and outcomes. They need to be considered when examining control. Based on these structural arrangements, human participants' psychological responses are also important. Users may think and behave differently when they are coupled with agents that have different levels of autonomy and distinctive features in terms of their communication skills, appearance, and social intelligence. The prior discussion of HCI, HAI and HRI demonstrated that the relation between users and controlled targets can be shaped from multiple aspects.

In contrast to humans, agents do not need to be motivated by an incentive. However, agents alone cannot directly take social responsibilities or assume liabilities to compensate for any possible negative consequence. They may interact with some social entities, but they do not have social lives like humans. Currently, the use of intelligent agents and their resulted consequences still need to associate with social entities, who are under the regulation of laws or norms. In addition to liability issue, the use of agent may involve other issues, such as privacy and security (Stuurman and Wijnands 2001). Users or other social entities need to remain in control of the social outcomes, as all responsibilities related to the outcomes produced by agents will connect back to users. Considering this, users' perceived control can be an important indicator of users' perception of their roles in such situations. Users will be more likely to reject undesirable results or reluctant to adopt agents when they feel insufficient control over their used agents. In contrast, they may be more likely to accept the results and willing to use the agents when they perceive more control over the agents.

Despite the requirement that users need to have control over agents, the agents have many possibilities to influence their users and even proactively manipulate the users' decisions. It is not desirable that agents' influence reduces users' experiences of control. Norman (1994) provided a general discussion of how users and agents should interact with each other. He pointed out that users must have a feeling of control over the technology before they will finally accept to use it. He also pointed out that the overblown expectations of using agents need to be avoided. The achievable performance of agents is determined by the users 'goals and also what the environment may offer as well, although agents may have superior capabilities in conducting various tasks. The illusion of agents' possible performance may negatively influence users' perception and assessment. This necessitates a dual-influence loop design strategy that may enhance users' experiences. On one hand, users need to know the agents' behaviors in order to plan their intended objectives and then instruct agents. On the other hand, agents need to provide appropriate explanations, feedback, and even suggestions to users in order to appropriately support the users' judgment. This strategy may help users and agents to develop more realistic objectives and better align their intentions.

In summary, the notion of control is useful to characterize the relationship between users and agents. Users need to have means to apply their influence on their used agents in order to achieve

intended effects. Otherwise, users will be isolated from their intended effects, i.e., having no control. The "means" usually refers to objective control or actual control. The objective control is instrumental to the objectives. Thus, the current study will use the term 'instrumental control' to represent the means by which users and agents are related. Thereby, the control issue can be decomposed into two parts on the dimension of internal-external control proposed by Skinner (1996). The instrumental control represents the design aspect on how the mutual influence of users and agents is implemented. The experienced control represents the psychological aspects of users about their perceptions and evaluation of their roles in determining the negotiations when they use the agents.

Figure 3 depicts a general model that adopts the notion of control to characterize the relationships of users and agents in delegated negotiations. Instrumental control can be dual, i.e., users have means to influence agents while agents are able to influence users as well. This reflects the dual-influence loop strategy for design. Users need to instruct the agents on how to conduct the negotiation by providing them with information such as preferences, constraints, and concession plans prior to the negotiation. Users may also want to observe the negotiation, possibly intervene in the negotiation process, and give agents new instructions during the negotiation. Agents may influence users by helping them construct their preferences, provide feedback, or even give suggestions from an expert stance. In summary, there will be a possible variation of the implementation of instrumental control. It is reasonable to question whether the variation of instrumental control may influence both the achieved outcomes in negotiations and the experienced control of users. In addition, the particular traits of agents may influence the achieved individual outcomes. Similarly, individual characteristics may influence users' experienced control in their negotiations. Users' use of agents in delegated negotiations can further result in psychological impacts when users experience different types and levels of control, such as users' trust in agents, their satisfaction with the negotiation, and their assessments and adoption to the technology (e.g., Taylor and Todd 1995; Wang 2005; Wang *et al*. 2010).

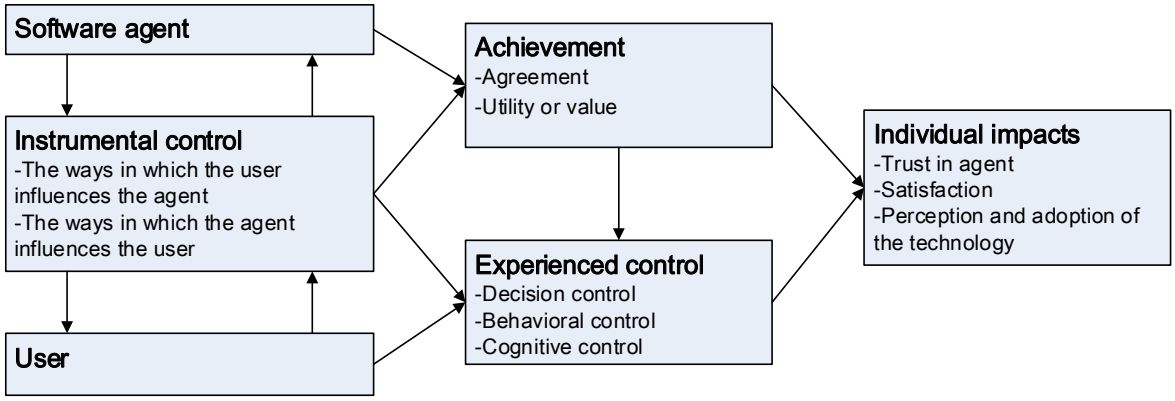

Figure 3: The individual impacts of control in delegated negotiation

The idea of using a dual-influence loop to characterize the relationships between users and controlled objects has been touched upon, but not explicitly included, in the field of HCI, HAI and HRI. It should not be difficult to agree that users' interaction with agents will influence users' perceived relationships with their agents. However, the issue of user and agent relationships cannot be reduced as being equivalent to interactions, because users' perceived relationships with agents have impacts that are beyond the scope of interactions. For instance, users may have emotional connections with their agents (e.g., like or dislike their agents) after their interactions with the agents ended. The HAI design needs to consider the effect of interface control (e.g., mouse and keyboard control, voice control, or touch screens), develop techniques that help the exchange of rich and effective information through the interface, and invent the metaphors and models that enhance users' understanding and engagement. Although these design techniques can help to build the relationships between users and agents, they are still insufficient. The recent development of socially intelligent robots or agents highlights a key point of relationship from the users' perspective, i.e., how users feel about the controlled objects through interaction. The idea of a dual-influence loop targets to the issue of how users and agents are able to influence their partners' behaviors or decisions when they interact through provided means, i.e., the instrumental control. It will be useful to know how instrumental control in delegated negotiation can be implemented by reviewing relevant studies. The review will start from potential techniques that allow users to apply influence on agents. Techniques about how agents may influence users will follow.

Available literature shows that the ways in which users instruct their agents in a negotiation often involve one or more of the three major components: 1) preference elicitation, 2) the specification of constraints, and 3) the selection of concession patterns[2]. Preferences and their formalization are within the very core of automated negotiation (Jennings *et al*. 2001). In order to represent users, agents need to capture their users' preferences. This process can be implemented using one of two major elicitation approaches (i.e., compensatory and non-compensatory) that were proposed respectively by analytical and behavioral decision making researchers (Einhorn and Hogarth 1981). There are debates about the efficacy and usefulness of these two approaches. Essentially, each approach adopts a distinct view about the rationality and the types of decisions that decision-makers make, i.e., either naturalistic or optimal (Klein 2008). These two approaches often demand the use of different cognition functions to process information. For instance, a compensatory approach by default involves trade-offs between alternatives, issues or options. Users may not like to deal with conflictive choices. In contrast, a non-compensatory strategy does not require users to confront conflictive choices.

Wang and Benbasat (2009) conducted a study to compare three types of agent-based decision aids that make recommendations for online shopping. Each of the aids adopted a different preference elicitation approach, i.e., additive-compensatory, elimination-by-aspects, and a hybrid of the two strategies. Their results showed that the additive-compensatory aid was perceived to be less restrictive, of higher quality, and less effortful than the elimination-by-aspects aid, whereas the hybrid aid was not perceived to be any different from the additive-compensatory aid. The elicitation process adopted in the study was implemented in a classical fashion. The additive-compensatory aid asked users to specify their relative weight of attributes. The elimination-by-aspects aid asked users to specify the order of the attributes and thresholds to eliminate alternatives. Other elicitation approaches are available. For instance, Dieckmann *et al.* (2009) compared two advanced compensatory and non-compensatory approaches, i.e., standard conjoint analysis and a greedoid algorithm which can generate a preference model with lexicographic order. They found

[2] This conceptualization is arbitrary and is geared towards a general case. Other conceptualizations may have advantages in particular scenarios.

that the lexicographic model derived from the greedoid algorithm did not outperform the compensatory model estimated by conjoint analysis.

Negotiation literature suggests negotiators to specify reservation levels (Raiffa *et al*. 2002b). Agents need to be able to handle related issues. Reservation levels are bounds that restrict the choices of agents. Constraints are another type of limitations; they are defined over the alternatives and/or selected issue options, e.g., the average value of options of two issues has to be greater than a certain threshold. On the agents' side, the representation of reservation levels or constraints needs to consider the traits of the adopted preference model and decision rules that are applicable to the model. Users' preferences can be represented with different computing models (e.g., rating vs. ranking). The coupling between the preference model and reservation levels/constraints needs to be appropriate (Svenson 1979). In constraint-based software agent negotiations, constraints can be specified as a type of users' preferences (e.g., Kowalczyk and Bui 2001).

Negotiators need to make concessions if they want to reach an agreement. In some automated negotiation frameworks, the determination of concessions is fully automated, such as in game-theory-based frameworks (Zlotkin and Rosenschein 1989). The best move that a party can make depends on the moves of other parties and the pay-offs. This type of framework gives few opportunities to users to specify the concession patterns that they may prefer. In contrast, some frameworks provide more opportunities to users. Faratin *et al.* (1998) provided a set of functions that allows users to specify concession patterns. A convex function represents 'boulware' or competitive types of concessions. A concave function represents 'conceder' or cooperative type of concession. In addition, several types of heuristics, such as time, resources, or the last offer of counterpart can be used to determine concessions.

If the duration of automated negotiations is long enough, users may have chances to intervene in the negotiation processes when sufficient and appropriate feedback is provided to them. Guttman *et al.*(1998) described a marketplace in which agents represented their users in order to buy or sell products. The marketplace was constructed particularly for agents. The users were provided with service kiosks, through which they could log into the system and review the trading status of their agents. The users could obtain the current market information, e.g., the price, to determine desirable concession patterns of their agents. Sometimes, agent-based negotiations can

be conducted very quickly, processing thousands of exchanged offers in a very short time. In such a situation, users may not be able to intervene in the processes.

The influence of agents on users may take place in more subtle ways than that of users on agents. Usually, a system provides control to its users, who will take actions to the system. Users are able to apply their influence by taking actions through the designed user interface. In contrast, applying influence to users is more restricted from the system perspective. The applied influence must be perceivable to users. The influence on users should cause little harm, if at all. It is also desirable that users will not feel the influence intrusive, but rather, easy to understand, user-friendly, and natural. Designers need also be aware that the applied influence may not produce the intended effect, or quite often it may miss the target, because human behaviors cannot be fully predicted. Designers can use at least three strategies when implementing agents' influence on users, i.e., passive, active, and promoting social intelligence.

The passive strategy covers the very classical techniques in HCI, HRI, and HAI that require users to take actions first. Feedback is a good example. When users interact with a system, the system will provide feedback to confirm with the users that their actions have been undertaken. The system can also inform users about their intended effects by providing more feedback. Without feedback, users may question about the interaction and lose their sense of control, as they may feel that their applied influence falls nowhere. The system can also provide explanatory information with feedback to users. Or, explanatory information can be provided as a stand-alone function, so that users can request it when needed. Explanatory information helps users to better understand the behaviors of agents (Wang and Benbasat 2009).

Feedback and explanatory functions help to maintain the cognitive connection between the intent of users and the behaviors of agents. However, both techniques are passive from the perspective of agents. In some situations agents may need to take initiatives to influence users. For instance, agents may signal the users or notify them in order to promote the awareness of certain situations. Agents can also proactively influence users' decisions by providing comments on their decisions or even persuading them to make certain choices. Sometimes, agents need to take strong roles when navigating towards the objectives. They may give users a very narrow control space,

such as providing only several options and then asking for some input from users. In these situations, agents undertake active strategies.

The passive and active strategies are not mutually exclusive to each other. It is quite common to integrate them together. They are helpful to designers when conceiving the behaviors of agents and considering what type of relations with users is needed. Appropriate use of both strategies from the system perspective may help to better set the dual-influence loop between users and agents. The combined use of both strategies can enhance users' experience (Dautenhahn *et al*. 2002). However, designers need to carefully balance them. The mixed initiative model offered from HRI is a good example (see Figure 2).

In addition to passive and active strategies, designers can introduce social intelligence in agents. A desirable outcome of applying this strategy is to enhance the effect of the prior two strategies by activating users' social psychological and cognitive mechanisms. Simple applications of passive and initiative strategies to agent design without considering social intelligence features may achieve functional and usability objectives. However, socially intelligent features may lead to more desirable effects. In some cases, socially intelligent features become necessary depending upon the requirements, such as in designing accompany therapy robots. It needs to be noted that promoting social intelligence is not a stand-alone strategy, as socially intelligent features involve both passive and active strategies as the underlying strategies.

The level of instrumental control offered to users may be justifiable from a design perspective, e.g., how many control conditions are considered and offered on the interface. In contrast, it is not so easy to predict the perceived level of control from the users' perspective. The level of instrumental control is not necessarily consistent with users' perceptions. Therefore, it is important to investigate users' actual responses to the applied means, e.g., perceived control. Users' perceptions are contingent on the characteristics of users, the nature of the decision problem, the implementations of instrumental control, and the traits of the agents. Wang and Benbasat (2009) developed an instrument to measure users' perceived restrictiveness in an agent-based recommendation system for online shopping. The instrument is appropriate when used to capture users' direct experiences with the implementation. However, the concept is weak in characterizing

relationships. It may represent an inverse direction of perceived control, i.e., the more users feel restricted, the less control they will feel.

2.5 The synthesis

Businesses can have benefits when applying agents to a broad variety of commerce activities. Agents have diffused from the technological sphere into the economic and social sphere. They have been increasingly taking active roles in determining social affairs. Agents used in commerce negotiations are good examples demonstrating these important movements. Thereby, the impacts of agent applications in commerce have important implications to both research and practices (Yu *et al*. 2015a).

Agents differ from classical computer-enabled tools or decision aids, because they have the generic trait of being autonomous. Users will and should not treat and assess agents as the same as the classical computer-enabled tools or decision aids. Users' assessments of agents are expected to be heavily oriented towards their relationships with agents. The issue of user and agent relationships become an important concern. Although this issue is a subject of an active research thread in the field of HAI and HRI, it is still rarely investigated in business contexts. Examining how users will respond to and assess their use of agents in delegated negotiations will help to fill in the gap between the increasing importance of agent applications in businesses and the limited knowledge about their potential impacts.

Users need to retain the sense of control over their agents when they delegate their negotiation tasks to them. Two aspects of control need to be examined: (1) instrumental control (i.e., objective control), and (2) experienced control (i.e., perceived control). The instrumental control refers to the means provided to users. The means empower the interaction between users and agents. Users' experienced control will develop from the interaction between users and agents and lead to further impacts. The more users experience their control over agents, the stronger they will feel being connected with agents. Thereby, the notion of control can be useful to characterize the relationships between users and agents in delegated negotiations.

Drawing on several streams of literature, this section presents two main theoretical propositions: 1) users' experienced control over agents will influence users' assessments and

adoption of the technology, and 2) it is possible to shape the relationships between users and agents by implementing instrumental control differently. A general model using the notion of control was proposed. It is desirable from the design perspective to have a concurring relation between instrumental and experienced control, e.g., increased instrumental control will lead to higher level experienced control. However, the literature has indicated a potential discrepant effect. Several challenges need to be handled in order to appropriately approach the research inquires of the thesis. First, agent-based negotiation systems can have various types of implementations. The reasoning approaches and the actual behaviors of agents will vary accordingly. Second, the design of interaction between agents and users can have multiple focuses, (e.g., function, usability and social intelligence) or adopt different strategies (e.g., enhancing performance, reducing efforts, or promoting engagement). It should be noted that these design practices result in a large inventory of design choices. Currently, there is no overarching design principle that can be used to guide the selection of concrete choices. Third, users' perceptions of control is not necessarily consistent with the actual control. The discrepancy effect between objective conditions and subjective perceptions is not unique for the issue of control.

In order to appropriately address these questions, the current study adopts a research strategy that is in line with the tradition of HCI in the information systems research (Grudin 2005). The current study will focus on users' subjective responses and assessments of their use of agents when they delegate their negotiation tasks to the agents. Users' experienced control will be the key construct, on which this thesis will focus. The potential impacts of experienced control need to reflect different orientations, in which users may assess their use of the technology. Meanwhile, the study also explores the possible connections from instrumental control to experienced control.

CHAPTER 3 RESEARCH MODEL FOR USER-AGENT CONTROL RELATIONSHIP

The development of computing technologies shows five continuing trends, including ubiquity, interconnection, intelligence, delegation, and human-orientation. Delegation means that users give control to computer systems. The combination of delegation and human-orientation drives the conceptualization and the use of computers away from the classical machine-oriented views. Agents or multi-agent systems are a promising solution to fulfill this growing requirement (Wooldridge 2002). Nowadays, business use of computing technologies has many examples showing the improvement of ubiquity (e.g., mobile and cloud computing), interconnection (e.g., the Internet), and intelligence (e.g., expert systems). However, commerce tasks delegated to agents are still frequently restricted in automations (Yu *et al*. 2015b). The retarded adoption of agents for delegated tasks suggests a need to explore the factors influencing users' acceptance of agents.

Drawing on the notions of control and technology acceptance, this chapter derives a testable research model from the general model discussed in the prior chapter. The research model adopts experienced control as its focal construct and integrates it with an adapted TAM. There are other competing factors that may influence users' acceptance of agents, besides the factors considered in the TAM. For instance, Komiak and Benbasat (2004; 2006) found that trust in agents influenced users' adoption of recommendation agents. Yu *et al*. (2014) found that negotiators' satisfaction with outcome influenced their assessments of the used electronic negotiation system. The research model integrates both of these two factors. The selection of these factors enables the comparisons of the effects of these factors on technology acceptance and the impacts of experienced control on these factors.

The first section will describe the research model. The adoption and definitions of the selected constructs will be discussed. The second section will develop the hypotheses, which posit the relationships between constructs.

3.1 The research model

Based on the notion of control, a general model characterizing the relationship between users and agents in delegated negotiation has been postulated in Chapter 2. The general model suggests that instrumental control involves a dual-influence loop connecting users and agents. The implementation of instrumental control may have an influence on the users' experienced control, which in turn will produce other individual impacts (e.g., users' trust in agents and acceptance of the technology). Both the users and the agents may influence each other in negotiations.

Three group constructs and variables are selected to build the research model: 1) the group on the dependent variable side, 2) the group of mediating variables and 3) the group on the independent variable side. The selection and definitions of the constructs are discussed in this section.

The group on the dependent variable side has four constructs, i.e., trust in agent, satisfaction with outcome, perceived usefulness and intention to use. *Intention to use* (IU) refers to users' behavioral intention to use their agents, if they have other chances (Wang and Benbasat 2009). It is the ultimate construct in the research model. It is a strong predictor of the behavioral adoption (Komiak and Benbasat 2006). The selection of the other three constructs in this group reflects three orientations, with which the users may assess their use of the agents. Each of these three orientations will be discussed.

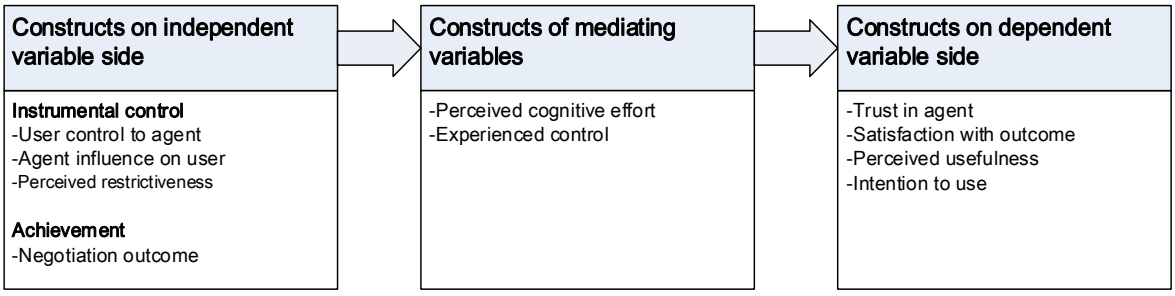

Figure 4: The selection of variables and constructs

First, the users may treat their agents as regular computer-enabled tools or aids, although the used agents are autonomous. The TAM is selected to capture the users' assessments of this aspect.

The TAM contains three main constructs: perceived ease of use, perceived usefulness, and behavioral intention to use. Perceived ease of use is believed to highly overlap with perceived cognitive effort, which has been studied in a closely related research of recommendation agents (Wang and Benbasat 2009). Thus, the TAM is adapted by replacing perceived ease of use with perceived cognitive effort. *Perceived usefulness* (PU) is defined as the degree to which the users believe that using their agents would enhance their performance in conducting the tasks (Davis 1989). It can also be deemed as the users' assessments of the contribution made by the technology. According to Wang and Benbasat (2009) and in line with the TAM, perceived cognitive effort should be an antecedence of PU and IU and will have a mediating effect between design choices and the users' assessments. Thereby, this construct is posited in the mediating variable group that will be defined and discussed latterly.

Second, the users may assess their agents based on their negotiation outcomes obtained by their used agents. *Satisfaction with outcome* (SO) refers to the users' integrative assessments of the negotiation outcomes. This construct represents the users' assessments oriented to this aspect. Empirical results have shown that negotiation outcome influences negotiators' assessments about their use of e-negotiation system (Yu *et al*. 2014).

Third, it is possible that the users may assess their agents on the basis of relationships. The constructs of PU and SO are not suitable to capture the users' perceptions that are oriented to relationships. *Trust in agent* (TR) is adopted to capture the users' assessments about their relationships with the agents. It can be defined as the users' rational expectation that the software agents will have the necessary traits that the users rely upon and feel secure and comfortable about using the agents (Komiak and Benbasat 2006). The constructs of TR, PU and SO will jointly influence IU.

The group of mediating variables contains two constructs: perceived cognitive effort and experienced control, which capture users' perceptions of the execution of their negotiation task. *Perceived cognitive effort* (PCE) refers to the users' psychological costs of conducting the task and processing information when they use negotiating agents (Pereira 2000; Wang and Benbasat 2009). *Experienced control* (EC) refers to the users' experiences of control that results from their use of the agents, when the users attempt to produce a desired outcome or prevent an undesired

one (Skinner 1996). It is adopted as the focal construct that is expected to capture the perceived control that the users will experience to have over their agents.

The group on the independent variable side contains four constructs. Two of them, i.e., user control to agent and agent influence on user, represent, from the design perspective, the potential implementation of instrumental control that involves a dual-influence loop between users and agents. The construct of *perceived restrictiveness* (PR) refers to the users' perceptions of the extent to which their decision processes are constrained by the functionalities of systems or agents. This construct is adopted for the following reasons. First, restrictiveness is an inherent feature in any system (Silver 2008). Second, PR is used as a subjective measure to capture the users' close perceptions about the implementation of instrumental control. Please note that the relation between EC and the implemented instrumental control may have a disjunctive effect. Thus, PR can help to probe the potential discrepancies if any appears. Third, PR was adopted in a closely related study that examines the role of recommendation agents applied to support online shoppers (Wang and Benbasat 2009). The last construct is *negotiation outcome*, which refers to the value achieved by each negotiation party. Obtaining the best individual outcome is an achievement goal for negotiators. Thereby, negotiation outcome is an influential factor for individual negotiators. Empirical results showed that negotiators referred to their achieved outcomes when they assess their negotiations (Yu *et al*. 2015a).

The current study focuses on the mode in which the users have the dominating role in specifying how the agents will negotiate. The agents will be designed to adhere to users' instructions, although the agents may be proactive when conducting the tasks. This research setting helps to remove the requirement of examining the impacts of the agents' behavioral feature of being proactive. In addition, the users are required to specify their own preferences to negotiation issues and options. This setting combined with the prior one helps to control the effect of instrumental control on negotiation outcome. Thereby, the potential relationship between instrumental control and negotiation outcome is removed from the research model. The details of the applied settings will be introduced in Chapter 4 Methodology. Their effects will be discussed in Chapter 5 Model Testing and Results. Lastly, individual traits and characteristics of the users are not included in the model. These variables will be considered as control variables because they may influence the proposed relations between constructs.

3.2 Hypotheses development

The selection and definitions of the selected constructs were discussed in the prior section. The relationships connecting these constructs map to the proposed hypotheses. The research model consisting of the selected constructs and the proposed hypotheses is depicted in Figure 5. The model contains multiple chains of causal relationships. These relationships connect the constructs between instrumental control and intention to use.

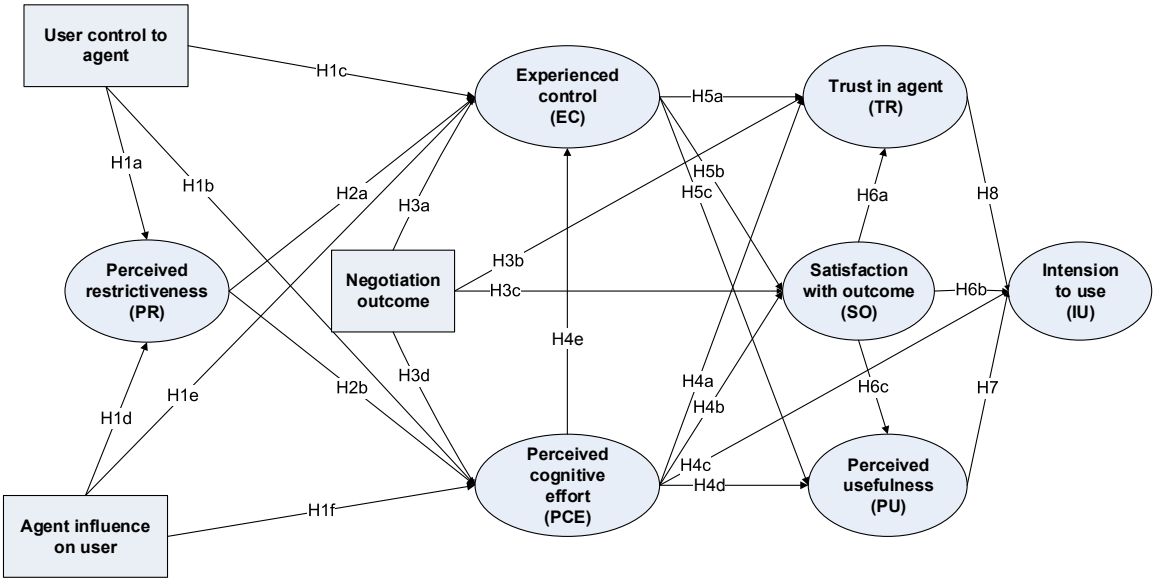

Figure 5: The research model

3.2.1 The effects of instrumental control

The instrumental control can be implemented in multiple ways and offered as set of system features, through which users are able to interact with agents. According to cognitive learning theories (e.g., Balzer *et al*. 1989; Dhaliwal and Benbasat 1996), the implementation will influence the users' understanding of how their agents work and their evaluation of the behaviors of the agents for the following reasons.

1. Alternative techniques and strategies adopted in the design may cause different levels of alignment between the behaviors of the agents and the users' observations and cognitive understanding. For instance, the agents may use different decision strategies when guiding the choices of the users and conducting the negotiations. The adopted decision strategies usually require that the users employ different cognitive functions to process information. The users need to know how the agents behave and make decisions and how to interact with the agents through the provided user interface. The more clearly the users understand the agents, the more they may align their cognition with the agents' behaviors and better instruct the agents through the use of the available instrumental controls. It is desirable, from the design perspective, to choose the right decision strategies and provide useful and meaningful information to the users in order to enhance their experiences. The users will then perceive the implemented instrumental control to be less restrictive, make more accurate assessments of the capability of the agents, and then perceive a higher level of control.

2. The agents are able to enhance the users' understanding of the agents' behaviors by providing to them relevant and rich information. For instance, the agents may employ different explanation strategies to help the users. They can also make comments on the users' choices and guide them in making informed choices. The better the users understand the agents' behaviors, the specifics of the situation, and the possible consequences, the better they may evaluate their agents, the instrumental control, and the negotiation outcomes.

3. The agents may also possess information that is unknown to the users. Or, the agents may be able to direct the users' attention to certain important points. Assisting the users to make informed decisions can be a useful feature of the agents that helps to enhance the decision quality in a decentralized decision making scenario (Wooldridge 2002).When better informed, the users may feel a lower level of cognitive effort and experience enhanced control when the agents provide proper assistance.

A discrepancy between actual control and perceived control is possible, although it may not be desirable from the design perspective. For instance, it may not be possible to determine that the

users will necessarily perceive less cognitive effort and more experienced control when more actual control is offered to them. A particular attention is paid to this issue by adopting the construct of PR. This construct helps to captures the users' direct perception to the control conditions provided to them. If the users cannot effectively apply their influence on the agents by using the provided means, they will feel the means more restrictive; otherwise, they may feel better. Being more specific, it is desirable that the users will perceive more control over the agents and less restrictiveness of the means, when the actual control is increased. When a discrepancy effect appears, the users will not perceive more control or less restrictiveness of the means.

The implementation of systems or interaction means will unavoidably restrict users' behaviors and choices. Although it is often desirable, it is challenging to appropriately restrict the users' behaviors or choices and guide them in the process of achieving their objectives (Silver 2008). The agents' influence on the users will increase when the agents offer more information and ask the users to scrutinize their choices and potential consequence. When the agents increase their influence, the users will feel increased restrictiveness of the control means and experience less control over the agents.

Despite the potential discrepancy between actual control and experienced control, PR and PCE are expected to have a positive relationship. This relationship has been empirically investigated by Wang and Benbasat (2009). When the users feel their control over the agents is restrictive, they need to make increased cognitive efforts when instructing their agents. Based on the theoretical discussions and the results of Wang and Benbasat (2009), two sets of hypotheses related to instrumental control are proposed. The proposed effects of two instrumental control constructs (i.e., user control to agent and agent influence on user) on PR and EC are tentative, because of the potential discrepancy effect.

H1a: Increased user control to agent will lead to decreased perceived restrictiveness.
H1c: Increased user control to agents will lead to decreased perceived cognitive effort.
H1c: Increased user control to agents will lead to increased experienced control.
H1d: Increased agent influence on user will lead to increased perceived restrictiveness.
H1e: Increased agent influence on user will lead to increased perceived cognitive effort.
H1f: Increased agent influence on user will lead to decreased experienced control.

H2a: Perceived restrictiveness will positively affect perceived cognitive effort.
H2b: Perceived restrictiveness will negatively affect experienced control.

3.2.2 The effects of negotiation outcome

The purpose of conducting negotiations is to achieve potential agreements. The agreements can be assessed based on different criteria (e.g., utilities or monetary measures). Studies of negotiation (e.g., Raiffa *et al*. 2002b) and market exchange (e.g., Smith 2003) assume that negotiators will be motivated to obtain a deal as good as possible. Negotiations may not necessarily produce agreements. The achievable outcomes are not fully predicable. If negotiators are adherent to this goal, the achievement goal theory (Pintrich 2000) suggests that the achieved outcome at the end of a negotiation will become a key factor influencing the users' perceptions and assessments. The users' use of the agents in negotiations is not for the sake of just using them. Their use of agents is to assist them to achieve their negotiation goals. Thereby, the negotiation outcomes may impact the users' assessments on multiple aspects (Yu *et al*. 2015a). In addition, empirical results show that the impact of negotiation outcome on perceived usefulness is influenced by SO (Yu *et al*. 2014). In line with these theories and empirical findings, the current study proposes that negotiation outcome may influence SO, PEC, EC, and TR. In total, four hypotheses are proposed to explore the potential impacts of negotiation outcome.

H3a: Better negotiation outcome will enhance experienced control.
H3b: Better negotiation outcome will enhance trust in agent.
H3c: Better negotiation outcome will enhance satisfaction with outcome.
H3d: Better negotiation outcome will reduce perceived cognitive effort.

3.2.3 The effects of users' perceived cognitive effort

The users need to make concrete decisions when instructing the agents. Behavioral research of decision making and judgment has established the importance of cognitive factors in decision making. For instance, the cost-benefit framework of cognition suggests that decision makers trade off accuracy and effort (Payne 1982). The cost-benefit framework is also a referred theoretical foundation of the TAM. Effort is an expense and a finite resource for human users. They need to smartly allocate their efforts to various activities that often simultaneously require the users'

attention (Davis 1989). In line with this stream of thought, Todd and Benbasat (1991) suggested that, in addition to decision quality enhancement, effort reduction may be an effective design strategy for decision support.

Cognitive effort may be assessed from both subjective and objective perspectives. Recently, Wang and Benbasat (2009) use PCE to capture users' subjective assessments of their cognitive involvement when using recommendation agents that support online shopping. They found that PCE had a negative impact on intention to use agents as decision aids. The current study also considers PCE as an indicator of their assessments of the actual cognitive involvement in the negotiation task. The current study also argues that PCE may influence not only the users' adoption of technology, but also their assessments of the negotiation outcome, their relationships with agents, and their roles in the negotiation task. According to the cost-benefit principle, the users' assessments of the same results may increase when they feel that they put less effort to processing information and making decisions. Thus, the following hypotheses are proposed.

H4a: Perceived cognitive effort will negatively affect trust in agent.
H4b: Perceived cognitive effort will negatively affect satisfaction with outcome.
H4c: Perceived cognitive effort will negatively affect perceived usefulness.
H4d: Perceived cognitive effort will negatively affect intention to use.
H4e: Perceived cognitive effort will negatively affect experienced control.

3.2.4 The effects of users' experienced control

EC is the perception construct which corresponds to the implemented instrumental control. In general, people want have a certain level of control over the environment. In order to obtain the sense of control, they need to have means to influence the environment. In the current study, users' perception of control will partially result from their interaction with agents and partially from the achieved negotiation outcomes. EC can be deemed as the users' evaluation of the degree, at which they experience in the achievement of the outcomes they intended to obtain when using their agents. It encompasses the users' assessments of their roles in achieving objectives and/or applying

influences. Thus, the users' assessments on multiple aspects will become more positive when they experience a higher level of control. Accordingly, the following three hypotheses are proposed:

H5a: Experienced control will positively affect trust in agent.
H5b: Experienced control will positively affect satisfaction with outcome.
H5c: Experienced control will positively affect perceived usefulness.

3.2.5 Users' acceptance of agents

Four constructs representing the orientations that influence individual acceptance of agents are considered in the research model. IU captures users' behavioral intention to use agents, which is frequently adopted as an indicator of the users' acceptance of technology. As previously mentioned for the three constructs of PU, SO, and TR, they represent three assessment orientations that may lead to the users' acceptance of agents. PU was widely used to assess regular computer-enabled technologies (Lee *et al*. 2003). Therefore, it should capture the users' perceptions of employing agents, if the users treat the agents as classical computer-enabled tools or aids. SO is adopted to capture the users' assessments of their agents, if the users are outcome-oriented. TR is expected to capture the users' assessments oriented to their relationship with agents. This construct reflects the users' beliefs about what their agents are capable of. It also reflects the users' emotional response to their agents (Komiak and Benbasat 2006).

It has been discussed that negotiators often possess an achievement goal of obtaining their individual outcomes at the best possible levels. Thus, SO will influence TR and PU. Together with all these, the following hypotheses are proposed:

H6a: Satisfaction with outcome will positively affect trust in agent.
H6b: Satisfaction with outcome will positively affect intention to use agent.
H6c: Satisfaction with outcome will positively affect perceived usefulness.

H7: Perceived usefulness will positively affect intention to use.
H8: Trust in agent will positively affect intention to use.

CHAPTER 4 METHODOLOGY

This chapter is composed of three sections, each discussing an important aspect of the methodology. The first section will present the operationalization of the constructs of control. The second section will discuss the experimental design. The third section will present the results of the development of the instrument measuring experienced control.

4.1 The operationalization of the constructs of control

The concept of control has been intensively studied in multiple disciplines and fields. Several potential problems threatening the operationalization of this concept should be noted. First, heterogeneous definitions can be easily found. Second, quite a large group of other concepts closely surrounds this notion. Third, the operationalization of this concept often involves multiple constructs, rather than a single one. Fourth, it is difficult to determine the central components of the constructs of control. Last, the inclusion or exclusion of the peripheral notions and constructs often depends on the researchers' interests. Consequently, inconsistencies, lack of clarity, and redundant concepts may easily become obstacles when operationalizing the concept of control in research. In order to overcome these difficulties, the guide for the constructs of control provided by Skinner (1996) is adopted in the current study.

Skinner's guide (1996) helps to locate the related concepts and clarify their relationships. It also provides a pool of potential variables that need to be considered when operationalizing the constructs. A summary of the operationalization of the control constructs is provided in Table 2. The application of this guide is discussed in the following. The details of the operationalization of key constructs will be further introduced in several sub-sections.

The constructs of control in the current study include both instrumental control (i.e., a type of objective control) and EC (i.e., a type of perceived control). The instrumental control is concerned with the means that enable the interaction between users and agents. The instrumental control refers the objective control that relates the users and the agents together through user interfaces. EC is perceived control experienced by the users after they use the agents. EC is retrospective in

the current study, as the users need to assess their initial use of the agents based on their interactions. EC is specific control as the investigated phenomenon concerns the users' feeling of a specific type of technology use.

The type of control	
Objective control, subjective control or experiences of control	This study is interested in both instrumental control (i.e., objective control) relating the agents and the users and experienced control perceived by the users after they used the agents.
Retrospective vs. prospective	The perceived control is retrospective. The users of the agents need to assess their use of the technology basing on their experiences with it.
Specific vs. general	The perceived control is specific.
Central components	
Actors	User-agent dyads
Means	Users specify preferences, reservation levels, and concession plans and then delegate their negotiation tasks to their agents. The agents represent their users, negotiate with other agents. The agents generate or review offers according to the conditions specified by their users.
Ends	A user-agent dyad will try to obtain a potential best agreement based on a set of conditions specified by the user.
Objective control conditions	
Actor-means relation	The actor-means relation is through the instrumental control. The instrumental control can be implemented in different ways and allows users and their agents influence each other. The implemented bi-directional control reflects the dual influence loop design. Perceived restrictiveness is used to capture the subjective characteristics of the instrumental control perceived by the users. It is deemed as the users' direct assessments of the means.
Means-ends relation	Two set of contingencies are provided: 1) The decision contingencies offered to the users when instructing the agents. 2) The market contingencies generated by multiple competing agents on the seller side when they generate, evaluate, and accept offers in a given time span.
Antecedences or impacts	
Source of motivation for control	Negotiation outcome will influence experienced control. Demographic variables are adopted as control variables
Potential consequences	Intention to use is used as an indicator of technology acceptance. Three assessment orientations are considered: • Trust in agent • Satisfaction with outcome • Perceived usefulness.

Table 2: The operationalization of the constructs of control

Skinner's guide (1996) identified three groups of central components in the constructs of control. They are actors[3], means, and ends. The characteristics of these three components in the

[3] The author originally used the term of 'agent'. We change the term to 'actor' in order to reduce possible confusion with software agents.

current study need clarification. In this study, an "actor" was a dyad consisting of a user and an agent representing a party. The basic task for a user-agent dyad was to obtain a potential agreement from a negotiation. The user delegated a negotiation task to the agent. Upon delegation the agent represented the user and negotiated on the behalf of the user.

The user could exert control over the agent through the means empowered by the user interface and its related devices. The agent could apply influence back on the user in the ways that are perceivable to the user. The user can decide whether to respond to the agent by taking actions or giving different instructions. The essential objective of the user-agent dyad was to achieve the best possible agreement within a certain time span.

According to Skinner's guide (1996), the objective control conditions also need to address two set issues, including actor-means relations and means-ends relations. *Actor-means relations* (whether perceived or objective) refer to "the extent to which a potential means is available to a particular *actor*" (p.553, the original term of agent is replaced with actor). *Means-ends relations* (whether perceived or objective) refer to "the connection between particular classes of potential causes and desired and undesired outcomes" (p.552). The current study operationalized the actor-means relation by introducing a variation of instrumental control that was expected to cause different levels of EC for the user. The details of the implementation of the instrumental control will be discussed in the sub-section of 4.1.1. PR is the user's direct perceptions regarding to instrumental control. It was obtained from the user's initial assessments of the means that they used to instruct their agents.

Contingencies are critical to means-ends relations. The current study operationalized means-ends relations with two sets of contingencies that are relevant to the potential negotiation outcomes. The first set of contingencies was the decision contingencies offered to the user when she instructed her agent on how to negotiate. The users needs to determine her preferences, provide reservation levels, and specify a concession plan. The second set of contingencies was the market contingencies when the agents negotiated or competed with other agents in a time span. A market is a typical distributive control environment, in which each participant has partial control on the final outcome, but none of them is able to determine it independently.

The antecedences of EC include two sets of variables. Demographic variables are included in the first set. The second set includes the negotiation outcome, which will influence EC. These variables touch upon the motivation for goal achievement: negotiators are assumed to pursue the best individual outcomes. Achieved negotiation outcomes have been found as having an influence on negotiators' satisfaction (Oliver *et al*. 1994).

The potential impacts of the constructs of control are captured with four variables: TR, SO, PU, and IU. The operationalization of each of these four variables will be discussed in a separate sub-section. All the items of the subjective instruments measuring these constructs are summarized in Table 7.

4.1.1 Instrumental control

An agent-based system was developed for this experiment. The system architecture and features were described in (Yu and Vahidov 2014). The instrumental control was offered in several negotiation phases, which are illustrated in Figure 6. Users were able to interact with the system and their agents through a well-designed Web interface. They could instruct their agents using three main functions: 1) specify preferences for negotiation issues and options, 2) decide on reservation levels, and 3) specify parameters for their concession plans.

Negotiation planning			Negotiation execution	Negotiation conclusion
Preference elicitation	**Reservation levels**	**Concession plan**		
Users' preferences are elicited by using an additive-compensatory method	Users are provided with explanatory information. Commentary information given users' choices may or may not be provided depending on the treatments			According to the treatments, users may or may not have an control option to veto agreements if reached by agents

Figure 6: The phases in which manipulation of instrumental control was applied

Preferences are the central components of the negotiations conducted by agents. On one hand, it is necessary that the agents capture the users' preferences when the agents represented their users. On the other hand, preferences provide to the agents a basis, which allows them to determine their concessions and evaluate proposals when negotiating with their counterparts (Jennings *et al*. 2001).

In most situations, human users do not have well-defined preferences prior their interaction with the system. Therefore, preference elicitation methods are required.

Wang and Benbasat (2009) compared three types of agent-based decision aids; each adopting a different preference elicitation strategy, i.e., additive-compensatory, elimination by aspects (non-compensatory) and a hybrid. More complex elicitation methods are available, e.g., conjoint analysis and greedoid approach (Dieckmann *et al*. 2009). The current study adopted the additive-compensatory methods. By assigning a rating value to each issue and option, the users indicated the relative importance of each issue and option. A rating generator using an interpolation function was provided to the users, if the number of options associated with an issue was more than five. The users needed to provide ratings for three salient options when they used the generator. The generator then determined ratings for other options. The users were allowed to modify the rating value of each individual option after they used the rating generator.

The system adapted a heuristic model developed by Faratin *et al*. (1998). The model allowed the users to provide to their agents a concession plan prepared prior to their negotiations. The users specified a value to represent the initial level at which they wanted their agents to generate offers or consider offers to be acceptable. The users were also asked to select one out of three available concession profiles (including straight forward, boulware, and conceder). The selected profile was visualized with a function (linear, concave and convex). The users could refine the function's curvature by using sliders.

The instrumental control can be conceived in a dual-influence loop, in which the users can instruct their agents and the agents may apply influence on their users. The implementation of the means in current study is consistent with the experimental treatments. More details will be provided in the next section. From the design perspective, there are at least two scenarios to be considered.

In the first scenario, the level of objective control varies according to the number of points at which the objective control is applied in a negotiation process. The more points at which the objective control is provided, the more the objective control can be perceived. However, it is also possible that users may perceive having less control when too many control points are involved

due to, for example, their limited cognitive capacity. In the second scenario, objective control is applied at a single point. The objective control applied at a single point can be implemented in different ways. For instance, user interface containing same control components may adopt different styles and layouts.

The construct of user control to agent was operationalized at two levels. The first level involved a basic procedure in which the users could specify their preferences and concession plans. The users were able to set ratings, choose a profile (each represents a convex, concave, and linear function), set a coefficient for the initial level of concession, and refine their concession plans. Once the users provided instructions to their agents, the agents could begin to negotiate. The second level added to the first level by introducing a veto option to the users when their negotiations concluded.

The construct of agent influence on user was also operationalized at two levels. The first level provided necessary feedback and explanatory information to the users, which helped them to cognitively understand the way in which their agents worked. The second level was implemented on top of the first level and added commentary information when guiding the users to set reservation levels and select a concession plan. The users' choices would have both pros and cons for their negotiations. Comments provided by the agents were expected to inform the users about the potential consequences when the users set reservation levels and selected a concession plan. At the same time, the comments might restrict the users' choices.

4.1.2 Experienced control

Perceived control has been empirically investigated in information systems (e.g., Morris and Marshall 2004; Taylor and Todd 1995) and agent-based negotiations (e.g., Yang *et al*. 2007). The available instruments were examined. Taylor and Todd (1995) used the perceived behavioral control in two models built on the TPB. Thus, their instrument seems narrow in that it focused only on the beliefs of behavioral control (or subjective control). Morris & Marshall (2004) developed a 55-item instrument to measure users' perceived control when using information systems. The theoretical basis of this instrument is the concept of internal and external requisites that were conceptualized by Frese (1987). Skinner (1996) argued that the internal and external

requisites are conditions for control, rather than perceived control. Referring to Morris & Marshall (2004), Yang *et al.* (2007) adapted another set of instruments to measure perceived control for agent-based negotiation. Unfortunately, the information about the reliability and validation of this instrument was not reported. In summary, the development and validation of an instrument measuring EC needs to be conducted for the current study.

There is a convergent view that control is a multi-dimension, multi-component, or multi-aspect construct, regardless of the fact that the conceptualizations of control may differ in many ways (Skinner 1996). Although the prior discussion about the operationalization of the constructs of control has pointed out that EC is a focal construct of the current study, what elements need to be considered inside EC is still an unclear issue. Among available frameworks, the one noted by Averill (1973) is deemed as particularly relevant and helpful. He suggested three aspects of personal control, including behavioral, decision, and cognitive. It is one of the most intensively used frameworks in psychology and social psychology (Thompson 1981). The instrument used by Yang *et al.* (2007) also fits this framework.

It should be noted that the original purpose of the framework of Averill (1973) was not to study EC. Some concepts and variables (e.g., information control and actual behavioral control) identified in the work were not considered in perceived control by Skinner (1996). Perceived control focuses on the perceptions, beliefs and feelings of individuals, rather than the means (e.g., actual behavior control) or conditions (e.g., information control). Skinner (1996) provided a nomological guide for the construct of control, while Averill (1973) highlighted at least three aspects from which users can assess their experiences of control. Therefore, both the work of Averill (1973) and Skinner (1996) are adopted in the current study to guide the operationalization of EC. The work of Skinner (1996) is used to clarify the nomological structure of the constructs and identify EC as a focal construct. The work of Averill (1973) is used to determine what elements may be included inside EC or from what aspects we can ask users about their experiences.

Furthermore, existing literature about control talks mainly about personal control, i.e., when individuals adopt themselves as the actors. In contrast, the actors in the current study were user-agent dyads. Each dyad of user and agent acted as a negotiation party. It is necessary to clarify and distinguish the definitions used to operationalize EC. The users might develop their feelings about

their agents from at least three perspectives, i.e., the behavioral traits of the agents, the critical decisions made by the agents, and users' understanding about how to apply influence. *Behavioral control* refers to the extent to which the users feel their influence on the behaviors of their agents. *Decision control* refers to the extent to which the users feel their influence on the decisions made by their agents. *Cognitive control* refers to the extent to which the users cognitively understand their influence on their agents. The users' understanding may not be precise.

In comparison to the earlier studies, the current study took a survey approach when measuring EC. Fifteen items in total were compiled in the instrument. Theoretically, these three aspects will highly overlap to each other. For instance, decisions made by agents can be easily deemed as a type of behavior. While behavioral traits of agents can be a broader concept, decisions are often critical. Decision making is a behavior, while decisions are often key facts. At the same time, the users' interpretation of their observations of the agents also depends on their understanding. In summary, the current study does not expect that the responses of these questions are able to be nicely loaded on three dimensions, but they will fall into at least one category that is distinguishable from other instruments measuring other constructs.

4.1.3 Perceived restrictiveness

PR reflects users' perceptual evaluation of the instrumental control, in the sense of how freely they can instruct agents. Wang and Benbasat (2009) developed an instrument to measure PR when using a decision aid to do online shopping. This instrument is considered to be appropriate for capturing users' perceptions that are close to instrumental control. In total, six items were adapted from Wang and Benbasat (2009).

4.1.4 Perceived cognitive effort

Cognitive effort has been studied in multiple research fields, including psychology, decision theory, and economics (e.g., Garbarino and Edell 1997). It can be measured using objective instruments. For instance, Todd and Benbasat (1991) used elementary information process, which involves a low level cognitive operation to measure cognitive effort. Subjective instruments measuring PCE have been used in studies of decision aid in e-commerce. For instance, Pereira (2000) used PCE to capture users' assessments of agents that were used as decision aids. The

instrument was also adopted in the study of Wang and Benbasat (2009). The current study employed the same instrument and only slightly adapted it to fit the context of delegated negotiation. The instrument includes six items.

4.1.6 Negotiation outcome

Users in the current experiment were asked to shop for a travel insurance contract with multiple insurance dealers. The contract involves multiple issues. The number of issues is represented by M (non-zero). Those issues include both price and non-price issues. Let X_j denote the set of all possible values of issue $j \in \{1, \ldots, M\}$. An offer can be described as an M-dimensional vector $x=(x_1,\ldots,x_m)$, while $x_1 \in X_1, \ldots, x_m \in X_m$. Each negotiation instance involves one buyer b who negotiated with multiple S sellers ($S>0$; $s \in (1,\ldots,S)$). θ_b denotes the preferences of the buyer b, while θ_s denotes the preferences of a seller s. The preferences of the negotiators can be mapped to a specific value function (or scoring schema): $V(x,\theta)$, $\theta \in (\theta_1, \ldots, \theta_S, \text{and } \theta_b)$. Only one seller will be chosen to make an agreement. The achievable outcome of the sellers and the buyer can be presented in this formula:

$$u_i(x,\theta_i)=\begin{cases} v_i(x,\theta_i), & \text{if an agreement is reached;} \\ 0, & \text{if no agreement is reached.} \end{cases} \quad i \in \{1, \ldots, S, b\}$$

The users' preferences were elicited with a traditional additive-compensatory approach, with which the users were asked to assign ratings to issues and options. The users were only assigned to the buyer side. All sellers in each instance were represented by agents, whose preferences were pre-specified. Negotiation outcomes achieved by individual buyers were thus measured with the rating score within the individual preference space. If no agreement was reached, the score would be zero.

4.1.7 Trust in agent

Trust has been intensively investigated in many disciplines. There are several sources that may be applicable. Among those candidates, the instrument developed by Komiak & Benbasat (2006) is considered to be the most appropriate for the current study. This instrument is able to

measure three aspects of TR, i.e., cognitive trust in competence, cognitive trust in integrity, and emotional trust. The application of this instrument was an agent-based decision aid for online shopping, which closely resembles agent-based negotiation issues. In total, nine items were adapted for this construct.

4.1.8 Satisfaction with outcome

Instruments measuring negotiators' satisfaction have been developed by Wang *et al*. (2010) and Oliver *et al.* (1994). Oliver *et al.* (1994) used a single question to measures SO. The instrument of Wang *et al*. (2010) tends to measure negotiators' satisfaction with the negotiation support system, as their instrument is adapted from the measurement of end-users computing satisfaction initialized by Doll & Torkzadeh (1988). In contrast, Yu *et al*. (2014) adopted a multi-aspect concept of users' satisfaction in negotiation tasks. The instrument measuring SO in their study are adopted and adjusted for the current study. In total, four items were slightly adapted to measure SO.

4.1.9 Technology acceptance

The research model features an adapted TAM. The concept and instrument of PU and ease of use were developed by Davis (1989). An instrument measuring behavioral IU was separately developed by Davis & Kottemann (1994). Their empirical tests showed both validity and reliability of the instruments. In total, nine items were adapted to measure PU and IU.

4.2 Experimental design

4.2.1 Treatments

The treatments of the current study are consistent with the possible manipulation of the instrumental control discussed in the prior section. In the current study, the instrumental control was operationalized with two variables, i.e., user control to agent and agent influence on user. User control to agent was manipulated by either having or not having a veto option to agreement. Agent influence on user was manipulated with two settings, i.e., either providing or not providing commentary information to users. Accordingly, this study adopted a 2×2 factorial experimental

design, resulting in four treatments if a full test of all possibilities is required. The comparison between treatments allows us to examine whether the instrumental control has impacts on EC, negotiation outcomes, and users' other assessments.

		User control to agent	
		Without veto option	With veto option
Agent influence on user	With commentary information	TI02	TI01
	Without commentary information	TI03	TI04

Table 3: The experimental treatments

4.2.2 Procedure

An online experiment was conducted. Figure 7 depicts the basic procedures of the experiment. The negotiations were set up in a bilateral market that involved a buyer vs. multiple sellers. All participants were set up on the buyer side.

A business case was used to describe a negotiation scenario in which the participants were asked to purchase a travel insurance plan in order to protect themselves for a vacation trip to Alaska. Further details of the case can be found in Appendix. The participants needed to negotiate over several categories of benefits with multiple insurance providers. The participants employed agents to negotiate on their behalf. At any point during the negotiations, they were able to check the negotiation transcripts and the agreement if one was achieved. Without the aid of the agents, the participants might easily become stressed in this type of markets as they need to simultaneously make quick decisions when interacting with multiple sellers. The users can partially withdraw from their stressful tasks if they used the agents.

On the buyer side, users and agents were paired into dyads and worked together when participating in a negotiation task. On the seller side, multiple fully automated agents were used as counterparts in each negotiation instance. All the preferences, constraint conditions, and concession plans of these automated agents were pre-specified for each negotiation instance and fixed during negotiation. Theoretically, the outcomes possibly achieved by the participating users will depend mainly on the conditions that the users specified to their agents.

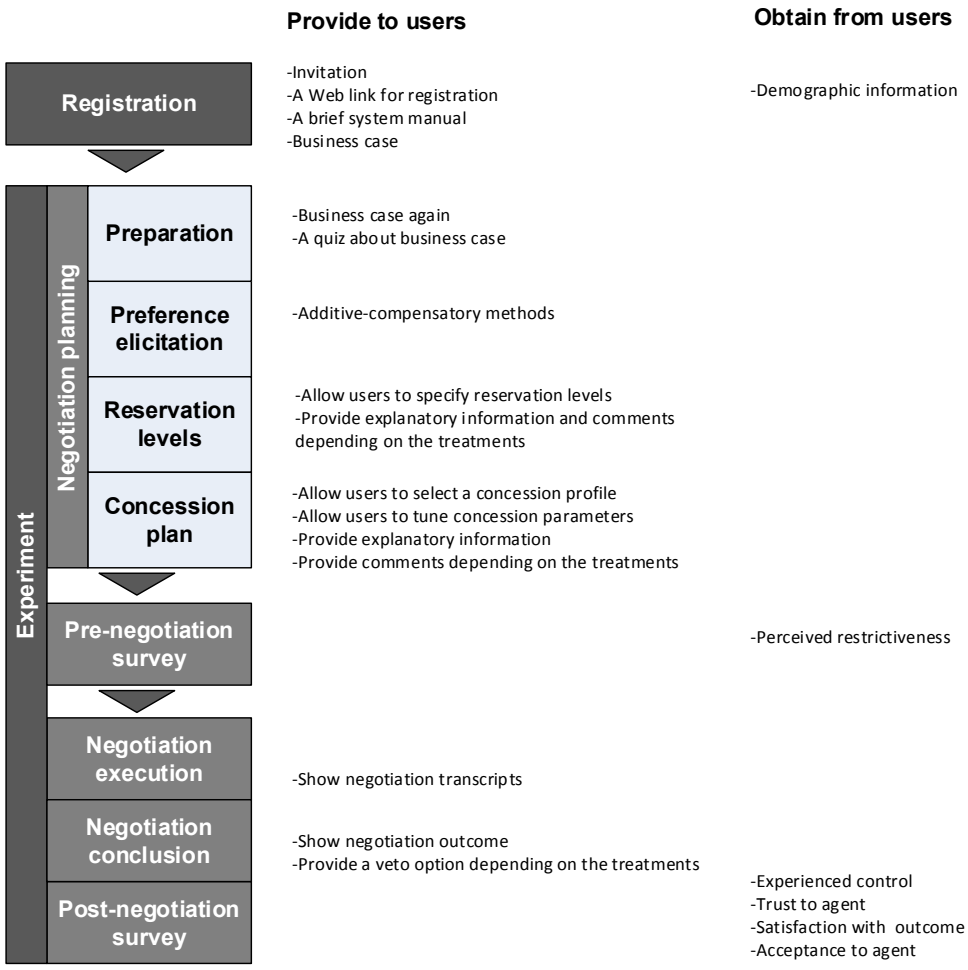

Figure 7: Experimental procedure

The negotiation case included information about the negotiation issues and the available options of each issue. No conjunctive or disjunctive relationship between issues and options was included in the case. The case was carefully designed to be easy for participants to read and understand. The case allowed the users to utilize their own knowledge, judgment, and experiences to build their preferences. With this kind of setup, the users were expected to utilize their own preferences to instruct the agents and thus enhance their psychological participation.

Experiment participants were asked to register online prior to the start of the experiment. During registration, they were asked to answer questions about their demographics and individual characteristics. After registration deadline, each participant was randomly assigned to a negotiation instance belonging to one of the four treatments. The participants were provided with a system

manual. An online experiment facilitator was available for assistance. The experiment negotiation process was divided into five phases: planning, pre-negotiation survey, execution, conclusion, and post-negotiation survey. In the planning phase, the participants were asked to read the business case and complete a short quiz which was designed to increase their comprehension of the case, before instructing their agents. Once the users instructed their agents, but prior to the start of the negotiation, the users were asked to complete a pre-negotiation questionnaire about PR. After completing this questionnaire, the users could send out their agents to negotiate with the other agents on the seller side. Once the negotiations were completed, another set of questionnaires (i.e., post-negotiation questionnaires) was administered to capture the users' other subjective responses.

The execution phase begun once the participants instructed their agents to carry out the negotiations. The users' agents automatically negotiate with sellers' agents for fifteen minutes. During this phase, the negotiation transcripts were displayed on the screen in order to maintain an interaction between the users and the system. The negotiation speed was controlled so that the participants are able to follow the negotiation progress. The users could choose to be absent during this phase by simply closing the browser. The transcripts and results could be viewed at a later time, if the users logged in the system again. The negotiation conclusion phase followed the termination of the negotiations, when either an agreement was made or the deadline was reached.

4.2.3 Participants, incentives, and negotiation task

The participants of the experiment were recruited from a large online class of the undergraduate level in a North American university. The course is designed to acquaint the students with the fundamental knowledge of information technology and develop their computer skills that they need. The information about the experiment and a hyper link for registration were posted on the course website. Part of the registration included the consent for participation. Students who opted to participate in the experiment earned a bonus mark. Once registered, participants were instructed how to complete their experiment tasks via email communications. They could choose another task for the same bonus. No student was forced to complete the task even after they registered.

4.3 The measurement development for experienced control

An instrument to measure EC was newly developed for this experiment. A formal procedure for the purpose of developing and purifying the instruments was adopted from Churchill (1979). An initial set of items was generated or collated from the literature review. The initial version of items was reviewed by two professors and a senior research project manager.

In accordance with the suggestions of Moore & Benbasat (1991) a card sorting practice was conducted electronically using a free web application. The web application allowed its users to allocate items into a group of categories representing the constructs. The system automatically shuffled the items prior to sorting. The application also allowed the researchers to provide a brief introduction on how to use the system. Extra information was included in the emails that were sent to the invited participants. The participants freely volunteered in this practice. In total, three rounds of card sorting were conducted. Information on the card sorting is presented in Table 4. The comments made by the participants and the statistical results in the prior round provided support for the refinement of the instruments for the next round. The statistics showed a clear improvement of the instrument. The Kappa index in the third round was deemed to be satisfactory according to the suggestion of Moore & Benbasat (1991).

	Round 1	**Round 2**	**Round 3**
Participants	4 Ph.D. candidates specialized in information systems	4 Ph.D. candidates specialized in management science	1 assistant professor and 3 Ph.D. candidates specialized in information systems
Fleiss Kappa	0.6540	0.8152	0.9169
Standard Error	0.0212	0.0222	0.0223
95% Confidence Interval	0.6124 ~ 0.6956	0.7717 ~ 0.8588	0.8733 ~ 0.9605

Table 4: The statistic indices of card sorting practice

CHAPTER 5 DATA ANALYSIS AND RESULTS

This chapter presents the analysis and results based on the data collected in the experiment. This chapter contains four sections. The first section will present the basic characteristics of the sample. The manipulation effects of the experiment will be checked in the second section. The procedures of refining subjective instruments will be introduced in the third section. The results of the confirmatory factory analyses will be reported. The reliability and discriminant validity of the subjective instruments will be examined. The last section will conclude this chapter with path analyses used to test the research model.

5.1 Descriptive analysis

In total, 386 participants registered for the experiment. After registration, each participant was assigned with a negotiation task. The number of negotiation instances were divided evenly among the four treatments. Among the 386 negotiation instances, 178 were completed. Students volunteered to participate in the experiment. Data screening showed that several participants registered and completed more than one task, although they were instructed not to do so. For these participants, only the first completed task were used. Some instances were unusually terminated due the request of the participants or particular technical issues encountered by some individuals. After cleaning the data, a data set containing 155 participants who fully completed their tasks was obtained. In addition, three more observations were removed because they have missing responses to the questionnaires. The final data set has 152 observations with complete responses to questionnaires. This data set is used in the analyses.

Among the ultimately selected participants, 93 (61%) were less than 20 year old and 39 (26%) are between 21 and 25 year old. Forty four (29%) participants indicated that English was their mother tongue. Twenty six (17%) reported that their mother tongue was French. Thirty eight (25%) participants did not reported. The left portion was distributed in 22 other languages. Other variables included in the descriptive analysis are reported in Table 5. The results show that TI02 has higher ratio of agreement and mean of agreement rating comparing to the other three treatments.

Treatment		TI01	TI02	TI03	TI04
Instance number		35	45	31	41
Gender	Female	14	25	11	23
	Male	21	19	17	18
	Not reported	0	1	3	0
Agreement	Yes	29	40	24	32
	No	6	4	7	9
Used veto option		4	N/A	3	N/A
Mean of agreement rating		34.3	42.34	31.76	36.01

Table 5: The descriptive statistics

5.2 Manipulation checks

Three manipulation checks were conducted. The first check was to compare the values of raw items measuring three constructs: PR, PCE, and EC. The applied treatments were supposed to have significant impacts on some items measuring at least one of the constructs. Three MANOVA (multivariate analysis of variance) tests using coded variables of user control to agent and agent influence to user as fixed factors were conducted. Significant difference were found among the items measuring PR between the treatments (Wilks' Lambda equals 0.008). No significant effect was found among items measuring PCE and EC. The results indicates the effects by manipulating instrumental control were obtained.

The second check was to examine the correlation between negotiation outcome and the raw items measuring SO. Users were assumed to achieve the best possible deal. Thus, the significant correlations indicate that the participants were adherent to the objective. A correlation analysis was conducted. It was found that negotiation outcome significantly correlates to all items used to measure SO.

The third check was to compare users' preferences, reservation levels, concession plans, and negotiation outcomes between treatments. No significant effect is expected, because the users were required to specify their own preferences, set reservation levels, and construct concession plans. Particularly, the preferences were the key factor that determines the possible outcome when all individual preferences on the sellers' side were pre-specified and fixed for each negotiation instance. In addition, allowing the users to specify their own preferences would help to reduce the direct effect between instrumental control and negotiation outcome. No difference of negotiation outcome was found among treatments.

5.3 Refining subjective instruments

A confirmatory factor analysis, by using EQS 6.1, was carried out with the maximum likelihood method and the robust option. As it is shown in Table 6, the initial factor model showed a poor goodness of fit. The normality of the measurement was also checked. The indices indicated the slight non-normality of the data. Concerning the relatively small sample size, this suggested that the statistic indices of robust option would be more appropriate to use. The items having low loadings and high standard residuals were repeatedly removed from the factor model. After several round modifications of the initial measurement model, a final confirmatory factory model was obtained by using the same method and option. All indices show that the final factor model has a reasonable goodness of fit. In comparison to the initial model, all indices of the final model are improved and meet the recommended cut-off points. Thus, this model was accepted as the final factor model.

Indices	Initial Model	Final Model	Cut-off Point
NFI (Bentler-Bonett Normed Fit Index)	0.618	0.841	NFI >0.90 good fit (Salisbury *et al*. 2002); NFI >0.8 reasonable fit (Hadjistavropoulos *et al*. 1999; Hair *et al*. 1998)
CFI (Comparative Fit Index)	0.774	0.949	CFI>0.90 (Bentler and Bonett 1980; Salisbury *et al*. 2002).
IFI (Bollen's Incremental Fit Index)	0.777	0.950	IFI >0.90 good fit (Bollen 1989; Salisbury *et al*. 2002)
RMSEA (Root Mean Square Error of Approximation)	0.076	0.051	RMSEA<0.01 excellent, <0.05 good, and <0.08 reasonable fit. (MacCallum *et al*. 1996)
90% confidence interval of RMSEA	0.070~0.080	0.040~0.061	

Table 6: The statistic indices of factor analysis

The measurement reliability was checked. The factor loadings, Cronbach's Alphas and Reliability Coefficient Rhos are reported in Table 7. All loadings of the factors were greater than 0.5. All Cronbach's Alphas and Reliability Coefficient Rhos are greater than 0.7. These results suggest that the scales measuring the factors have a good reliability. After removing the items, the content validity of the measures was also checked. The discriminant validity of the subjective measures was examined as well. All the values of AVE are above 0.5, which is the recommended cut-off value (MacKenzie *et al*. 2011).

Items	Factor loading	Cronbach's Alpha	Rho	AVE
Perceived restrictiveness (PR): six questions with anchors varying from "Strongly disagree" to "Strongly agree"				
*#PR1. I was able to freely instruct the agent.		0.827	0.833	0.645
*#PR2. The agent allowed me to develop a preferred plan for this task.				
*PR3. I felt constrained when specifying the way in which the agent interacted with the others.				
PR4. The agent limited my choice of possible approaches for this task.	0.642			
PR5. In terms of my preferred way to negotiate, the approach used by this agent was rigid.	0.855			
PR6. In terms of my preferred way to negotiate, the agent's reasoning processes were restricted.	0.890			
Perceived cognitive effort (PCE): six questions with anchors varying from "Strongly disagree" to "Strongly agree"				
PC1. The trading task using this software agent was very difficult.	0.726	0.808	0.833	0.624
*# PC2. I could easily found helpful information about the trading task.				
* PC3. The trading task using this software agent took too much time.				
*# PC4. The trading task using this software agent was easy.				
PC5. The trading task using this software agent required too much effort.	0.666			
PC6. The trading task using this software agent was too complex.	0.949			
Experienced control (EC): fifteen questions with anchors varying from "Strongly disagree" to "Strongly agree"				
*EC1. I felt I had a strong influence on how the agent conducted this task.		0.894	0.894	0.538
*EC2. I felt I had a substantial influence on the behavior of the agent.				
EC3. I felt that I made the agent behave in favor of my interests.	0.714			
EC4. I felt that I was able to affect the way in which the software behaved.	0.731			
*# EC5. I felt a lack of control over the behavior of the agent.				
EC6. I understand how to control the agent.	0.712			
*EC7. I felt that my understanding of how I could influence the agent was good.				
*EC8. It was clear to me how the agent made its choices.				
*EC9. I had a clear picture of how the agent might work.				
*# EC10. I did NOT understand how the agent did its job.				
EC11. I felt control over the decisions made by the agent.	0.720			
EC12. I felt that I was able to apply strategies to guide the decisions of the agent.	0.733			
*# EC13. I felt UNABLE to affect the decisions made by the agent.				
EC14. I felt that I made the agent make good decisions for me.	0.753			
EC15. I felt my substantial influence on the decisions made by the agents.	0.771			
Trust in agent (TR): nine questions with anchors varying from "Strongly disagree" to "Strongly agree"				
*TR1. The agent was capable of conducting this task.		0.930	0.932	0.722
*TR2. The agent was qualified to conduct this task.				
*TR3. The agent had the skills required for this task.				
TR4. Based on my experience with the agent, I knew it was trustworthy.	0.767			
*TR5. This agent was honest.				

TR6. I considered this agent to be of integrity.	0.826			
TR7. I felt secure about relying on this agent to trade.	0.841			
TR8. I felt comfortable about relying on this agent to trade.	0.944			
TR9. I felt content about relying on this agent to trade.	0.861			
Satisfactions with outcome (SO): four questions with anchors varying from "Strongly disagree" to "Strongly agree"				
SO1. I was satisfied with the achieved outcome.	0.930	0.964	0.965	0.871
SO2. I was satisfied with the outcome in terms of meeting my expectations.	0.967			
SO3. I was satisfied with the outcome being favorable for me.	0.930			
SO4. I was satisfied with the outcome compared to what I wanted.	0.904			
Perceived usefulness (PU): six questions with anchors varying from "Extremely unlikely" to "Extremely likely"				
PU1. Using the agent would enable me to more quickly accomplish this task.	0.901	0.961	0.961	0.858
PU2. Using the agent would improve my performance in this task.	0.907			
PU3. Using the agent would increase my productivity in this task.	0.949			
PU4. Using the agent would enhance my effectiveness in this task.	0.947			
*PU5. Using the agent would make it easier to trade.				
*PU6. I would find the agent useful in conducting similar business trade.				
Intention to use (IU): three questions with anchors varying from "Strongly disagree" to "Strongly agree"				
IU1. Assuming I had access to the system, I intend to use the agent.	0.944	0.966	0.966	0.904
IU2. Assuming I had access to the system, I predict that I would use the agent.	0.959			
IU3. Assuming I had access to the system, I plan to use the agent.	0.950			

All questions are on 7-point Likert-scale.
* The items were removed from the initial factor model.
# Reverse questions.

Table 7: The factors, items, loadings and reliability of subjective measurements

5.4 Research model testing

In total, the research model contains ten variables. Two variables, i.e., user control to agent and agent influence on user, are coded variables according to the treatments. The variable of user control to agent was operationalized with the option of whether or not the participants had the veto option to agreements. This variable was coded 1 to represent having the veto option, and 0 to represent having no veto option. The variable of agent influence on user was operationalized with the option of whether or not commentary information was provided to the users. This variable was coded to be 1 when agents provided commentary information and 0 when they did not. Negotiation outcome was measured with the rating score of the achieved agreements. If no agreement was achieved, the score of 0 was assigned. The other seven variables are subjective constructs, each is measured with several items (see Table 7). The research model also contains many paths

connecting variables and constructs, since it attempts to explore the potential effects in line with different theories. Due to these conditions, a path analysis method was used to test the research model. Path analysis helps to reduce the number of paths connecting subjective constructs and their indicators. It is robust to test a model that contains categorical variables. The sum scores of the items measuring subjective constructs were used. In variance analysis, the use of sum score to represent factors is an appropriate or even preferred technique (DiStefano *et al*. 2009). The correlation of the aggregated factor scores of subjective measures are reported in Table 8.

	PR	PCE	EC	TR	SO	PU
PCE	.333**					
EC	-.132	-.414**				
TR	-.192*	-.325**	.600**			
SO	-.062	-.366**	.721**	.559**		
PU	-.245**	-.494**	.362**	.239**	.239**	
IU	-.251**	-.407**	.558**	.578**	.491**	.369**
** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).						

Table 8: The correlations of aggregated factor scores.

The software EQS 6.1 was used to conduct the path analysis of the research model. The results show a very good fit (Chi-square = 21.548 with 20 degree of freedom, probability value for chi-square = 0.3655, GFI=0.973, NFI = 0.948, CFI = 0.996, IFI = 0.996, RMSEA =0.023, and 90% confidence interval of RMSEA is between 0 and 0.075). These results are given in Table 9. The coefficients for the paths contained in the model are presented in Figure 8. The significant paths (at 5% significant level) are highlighted.

The results support the research model. Significant paths go from instrumental control to IU. The results show that all of the three constructs of TR, SO, and PU have a significant effect on IU. EC has a significant effect on each of these three constructs. In contrast, PCE has only a significant effect on PU. It needs to note that PCE has a significant effect on EC.

Indices	Research model	Restricted model
Chi-square	21.548	40.802
Degree of freedom	20	21
P-Value of Chi-square	0.3655	0.0059
GFI	0.973	0.952
NFI	0.948	0.902
CFI	0.996	0.947
IFI	0.996	0.950
RMSEA	0.023	0.079
90% confidence interval of RMSEA	0.000~0.075	0.041~0.115

Table 9: The statistic indices for research model testing

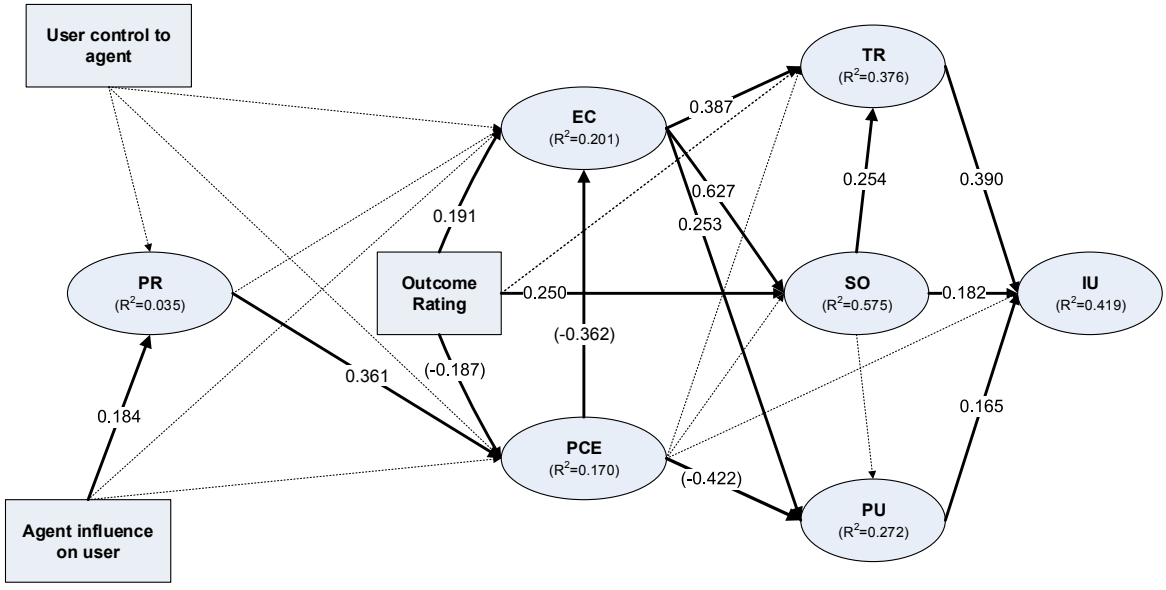

Figure 8: The testing results for the research model

In order to check whether the path between PCE and EC is necessary, a restricted model were tested. This model is depicted in Figure 9. The restricted model forces the path coefficient between PCE and EC to zero. The fit indices of the restricted model are shown in Table 9. The results show an acceptable fit (GFI=0.952, NFI = 0.902, CFI = 0.947, IFI = 0.950, RMSEA = 0.079, and 90% confidence interval of RMSEA is between 0.041 and 0.115), except that Chi-square = 40.802 with 21 degree of freedom is significant (probability value for chi-square = 0.006). The significant p-value of the chi-square suggests that the restricted model does not sufficiently capture the variation of the interested variables. Therefore, the model must be rejected, although other fit indices are acceptable.

The restricted model is a nested model of the research model. Comparing to the research model, the chi-square of the restricted model increases 19.254 with 1 extra degree of freedom. The result is also significant, which suggested that the effect of PCE on EC is necessary. In addition, the testing of restricted model shows that two path coefficients are significant after the effects of PCE on EC is forced to be zero. One is the path between PCE and IU. This result suggests that the relationships of the TAM are supported when the effects of PCE is blocked from going to EC. The other one is the path between PR and EC. This result indicates that users' perceptions of instrumental control may have direct effect on EC if the connection between PCE and EC is blocked. The other coefficients and their direction of effects have almost no difference.

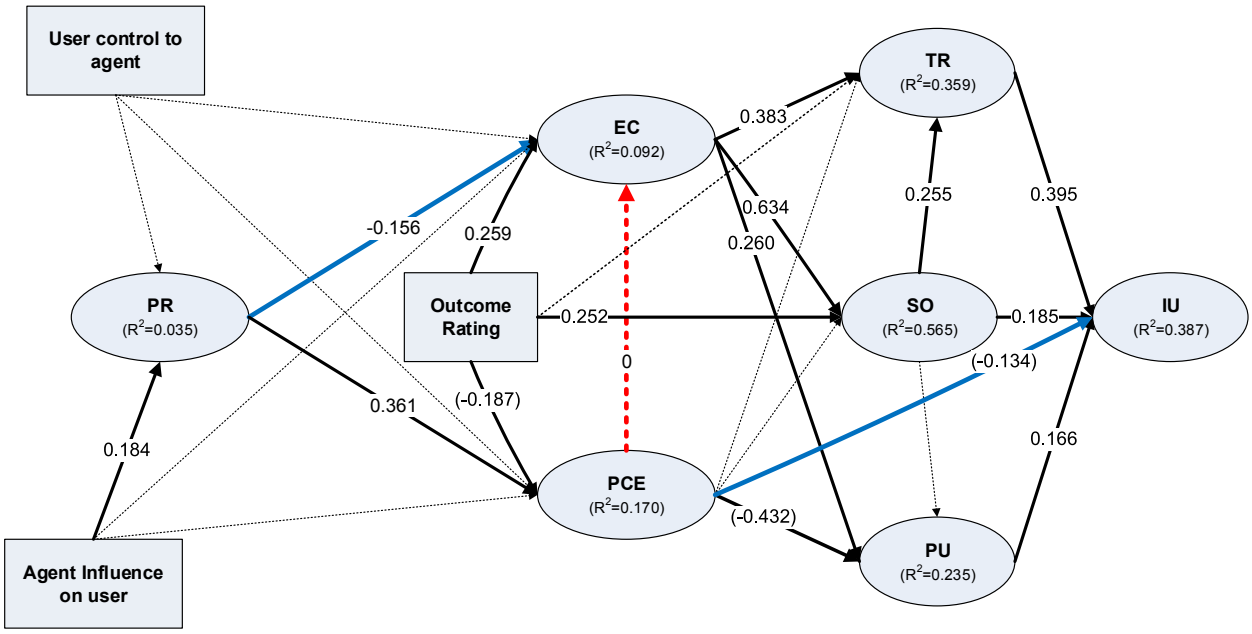

Figure 9: The testing results for a restricted research model

CHAPTER 6 DISCUSSION

This chapter will discuss the experimental results in four sections. The first sections will check the nomological validity of the research model. The results of testing the research model will be interpreted in the second section. The third section will conduct a brief diagnosis about the discrepancy effect between instrumental control and EC. The last section will discuss the implications of the research findings.

6.1 Nomological validity check

Overall, the results support the research model. Paths having significant coefficients show multiple chains of impacts coming from instrumental control and negotiation outcome to IU. The nomological validity is checked by examining three sets of relationships connecting variables and constructs. These relationships can be verified with the results of earlier theoretical and empirical studies. The confirmation of these relationships is an indicator of the validity of the current study.

The first set of relationships is related to the adapted TAM contained in the research model. The relationships are expected to be consistent with the TAM. The research model contains an adapted TAM, which replaces perceived ease of use with PCE. The TAM states that PU has a positive impact on IU and perceived ease of use has both a direct impact on IU and an indirect impact on IU mediated by PU (Davis *et al*. 1989). Empirical studies showed that the direct impact of perceived ease of use on IU was weaker than that of PU (Lee *et al*. 2003). The tested research model has two significant paths connecting PCE to PU and PU to IU. Thereby, the relationships of the adapted TAM are partially confirmed, because the relationship between PCE and IU is not significant. The testing results of the restricted model show that this path becomes significant after the effect of PCE on EC is forced to be zero. This result suggests that the direct effect of PCE on IU is partially captured by EC, which helps to explain why the path is not significant when testing the research model.

Besides the constructs of PCE and PU, TR and SO are the competing constructs that may have impacts on IU. Komiak and Benbasat (2006) found that TR had a significant effect on users'

intention to adopt agents as both decision aids and delegated agents when the users did online shopping. Wang *et al*. (2010) found that SO had an impact on users' adoption of a negotiation support system. The research model shows that both TR and SO have positive impacts on IU, which is consistent with existing empirical results.

The second set of relationships expected to be confirmed is related to negotiation outcome. The research of market exchange (e.g., Smith 2003) and negotiation (e.g., Raiffa *et al*. 2002b) assumes that negotiation or market participants will pursue the best individual outcomes. It was found that negotiation outcome had impacts on market participants' subjective assessments (Yu *et al*. 2015a). Similarly, the results of the current study show that negotiation outcome has significant and positive effects on three constructs, including EC, SO, and PCE. Particularly, the path coefficient between negotiation outcome and SO is 0.250, which is greater than those of the other two paths to EC and PCE. These results provide evidence showing that negotiators were adherent to the goal of obtaining an outcome as good as possible.

The third set includes only the relationship connecting PR to PCE. This expectation is consistent with the proposition empirically verified by Wang and Benbasat (2009), which states that PR will negatively influence PCE. The relationship between PR and PCE is confirmed.

6.2 Main findings

Following the nomological validity assessment, the experimental results can be interpreted with confidence. The results can be highlighted with several main findings. First, the results show that the users indeed had multiple orientations and weighted each differently when they assessed their use of agents. The current study argues that agents used in delegated negotiations are more than classical computer-enabled tools and aids, in that the agents are autonomous entities engaged in performing tasks and deciding on the negotiation outcomes. The current study considered three orientations with which users might assess their use of agents, including: 1) tool-orientation (i.e., the users deem their agents as a kind of tool), 2) outcome-orientation (i.e., the users prefer better negotiation outcomes), and 3) relationship-orientation (i.e., the users prefer better relationships with their agents). Each of the three orientations was represented with a respective construct. PU captures users' assessments of agents as a tool. SO represents users' assessments of negotiation

outcome. TR captures users' assessments of their relationships with agents. The results show that all of the three constructs positively and significantly influence IU. The coefficients of the three paths indicate the relative weight of the impacts of these three constructs on IU. TR has the strongest impact (i.e., path coefficient is 0.390). SO has the second strongest impact on IU (i.e., the sum coefficient of direct and indirect effect of SO on IU is 0.287). PU has the weakest impact on IU (i.e., the coefficient between PU and IU is 0.165). These results confirm that users indeed assess their agents with multiple orientations. At the same time, the results indicate that users' assessments are more orientated to relationship than to outcome or tool.

The second main finding is that EC has positive impacts on users' assessments. The results show that the direct effects of EC on the three assessment constructs are all significant, including a positive effect on TR (i.e., path coefficient is 0.387), SO (i.e., path coefficient is 0.627), and PU (i.e., path coefficient is 0.253). In contrast, PCE has only a significant direct effect on PU (i.e., path coefficient is -0.422). The comparison between the effects of EC and PCE suggests that EC plays a more important role of influencing users' assessments. Despite its importance, the effects of EC should not be over-interpreted. It is found that PCE has a significant effect on EC. This results suggests that PCE still provides an underlying ground to support EC. In other words, the users may experience the lack of control if their cognitive efforts are too high or they cannot effectively understand how they are related to the agents and connected to the negotiation outcomes. In order to test an extra proposition that PCE provides a necessary support to the formation of EC, a restricted research model was tested. The restricted model forces the effect of PCE on EC to be zero. The significance of Chi-square index basing on one extra degree of freedom shows that the restricted model needs to be rejected. This result confirms that the supporting effect of PCE on EC is necessary.

The third main finding is that negotiation outcome influences not only SO, but also other perceptions, including PCE and EC. The direct impact of negotiation outcome on TR is insignificant. The impact is mediated by EC and SO. The expectation of the effects of negotiation outcome is in line with the achievement goal theory. It has been discussed that negotiators are expected to obtain the best individual negotiation outcomes. According to goal achievement theory (Pintrich 2000), the better the outcome is, the better the users will perceive or assess their negotiations. From the psychological perspective, it is reasonable that the negotiation outcome

positively influences users' perceptions and evaluations. However, the issue may become debatable if we consider the effect of negotiation outcome from the perspective of negotiation analysis (Raiffa *et al*. 2002a) and experimental economics (Kagel and Roth 1995). Theoretically, the individual outcome of a market exchange instance can be predicted based on all individual preferences, if all negotiators are fully rational and patient given the environmental conditions and market institutions (Smith 2003). In the current experimental setting, agents were designed to be adherent to users' instruction and preferences. All individual preferences and parameters for the fully automated agents on the seller side were fixed and kept the same in each negotiation instance. According to the market exchange theory, the users and their used agents would have little influence on the achievable negotiation outcome after the users instructed their agents by specifying their preferences and selecting a concessions plan. Therefore, the experimental result suggest an important issue that users may bias their assessments. For instance, negotiation outcome should not have a direct impact on PCE.

The last main finding that needs to be highlighted is the result showing that a chain of impacts connecting implemented instrumental control to users' perceptions, assessments, and acceptance of technology. Increased agent influence on user leads to the increase of PR. In addition, significant paths connect agent influence on user, PR, PCE, and EC. These results confirm that design choices indeed have impacts on the users' experienced control, which leads to further impacts on the users' adoption of agents. The results, however, also show that the impacts do not take place in a straightforward fashion. Increased user control to agent has no significant effect. The reason of these results will be explored in a diagnosis in the next section.

6.3 Diagnosis of instrumental control

It is desirable from the design perspective that the implemented instrumental control and EC can be straightforwardly connected, because it will be easier to apply influence on users' perceptions and assessments by adopting different design choices. However, literature has pointed out the possible discrepancy between actual control and perceived control, i.e., increased or decreased objective control may leads to the opposite or no effect of perceived control. Discrepancy effects between objective conditions and users' perceptions are not rare. The

empirical findings of the discrepancy sometimes are more valuable, because they remind designers about the challenges.

The current study adopts the construct of PR in order to probe the potential discrepancy effect between instrumental and EC. This construct has been empirically tested in studies about system design. Some studies have shown the potential discrepancy effect between the implemented system restrictiveness and PR, i.e., objective restrictiveness has a U-shape relation with PR (Silver 2008). Instrumental control in certain sense can also be characterized with the notion of system restrictiveness. For instance, a system can be deemed as being less restrictive when adding more user control to agent, or as being more restrictive when increasing agent influence on user. However, PR may not necessarily be consistent with objective restrictiveness. For instance, the users may feel the means of instructing agents more restrictive when there is too much control provided to them or if they are unable to clearly understand how to use the control. The results of current study shows that increased user control to agent has no effect. In order to probe the possible reasons for this discrepancy effect, some diagnosis is conducted.

User control to agent was operationalized with the option of whether or not the users had a veto option to an agreement if any was achieved by their agents. Having the veto option should be a less restrictive system feature comparing to having no such option. Accordingly, having veto option is supposed to result in less PR or enhanced EC, if no discrepancy effect appears. The experimental results show no significant effect of having veto option on PR. System usage data were used in the diagnosis. There were just seven users who used the veto option. Please refer Table 5. There are several competing reasons that the other users would not choose to use the option. First, it is possible that the users did not need a veto option if they had a good agreement. Second, having an agreement was better than having no agreement for some of the users. Thus, having the option was not that important for these users. Third, the effect of this option may be in the shade of the effect of negotiation outcome. For instance, it was quite possible that the users who used the veto option were really unhappy with their agreements and then decided to decline their agreements that had been reached. Using the option will lead to a zero value of negotiation outcome, i.e., the use of the veto option resulted in a zero rating value for their negotiation outcomes.

The variable of agent influence on user was operationalized by whether or not providing commentary information to explain the potential consequences when the users added reservation conditions or decided the parameters for their concession plans. The operationalization was based on a principle of helping users to make informed decisions. The users' decisions on setting the conditions and parameters have both pros and cons on their negotiation outcomes before the outcomes are known. For instance, a reserved condition will reduce the overall number of considerable alternatives. Thus, the commentary information was attempted to assist users to clarify their objectives. For instance, a reservation condition is needed, if a user, for sure, will not consider some offer packages. Other than that, they need not to set reservation conditions. Although the informed decision-making principle may sound useful, the actual effect may not be that helpful. Users may feel it is more difficult to make decisions when they are better informed about conflictive choices. In turn, they perceive a higher level of PCE (Wang and Benbasat 2009). Other empirical results have shown that better knowledge may lead to worse performance in a preferential choice task. The interaction of knowledge and restrictiveness may amplify the effect, i.e., better knowledge in a less restrictive context leads to even worse performance (Davern and Kamis 2010).

The effects of instrumental control on EC shown in current study demonstrate the challenges of building relationship between users and agents in delegated negotiation through design. Research in HAI, HCI and HRI demonstrates other challenges from different angles. The current study did not explore more combinations of design choices. The reason is twofold. First, the emphasis of the current study is on users' experiences. Second, the inventory of design choices is very large, which is out of the scope of the current study. However, it will be definitely beneficial to further develop the concept of instrumental control. HAI, HCI, and HRI have shown many possibilities and promising directions. The current study suggests to consider the analysis of the roles between users and agents in the task environment. For humans, the meaning of our interaction and relationships with others are constructed in our social contexts. Human users and agents take different roles if they are teamed up. Human users will expect and assess their used agents through their roles. The relationship issue is built on top of interaction and beyond interaction. Focusing solely on interaction will not be effective for the design that attempts to related users and agents together.

6.4 Key insights and implications

The current study has several important implications. The first one is that the main proposition discussed in the current study is supported. The main proposition states that the control over agents experienced by users will play an important role of influencing users' assessments and acceptance of agents in delegated negotiation tasks. In order to empirically investigate the importance, the current experiment compares three orientations, with which the users may assess their use of agents. The experiment results show that EC has significant effects on TR, SO, and PU. This finding suggests that users indeed evaluated their influence on the agents with multiple orientations. EC has an impact on each of these three orientations. Thus, enhancing users EC will be an effective strategy that can be used to guide the design of interaction between users and agents and the practice of introducing agents to users. Enhanced EC will help to promote users' acceptance. The research results also imply that the classical design strategies of performance enhancement or effort reduction are not sufficient. The current study showed that the achievable individual outcomes were mainly determined by the preferences elicited from the users. Design choices adopted in the implementation of instrumental control played little influence on negotiation outcome. PCE has no significant impact on TR and SO. The impact of PCE on IU is very limited.

The second implication is that users indeed deem agents more than a regular computer-enabled tool or aid. They emphasize more relational factors in their assessments. The comparison of the effects of three constructs of TR, SO, and PU on IU shows that TR is a more important factor influencing users' acceptance of negotiating agents than the other two. This result indicates that the users are more oriented to relationships when they assess their use of agents. The coefficient of the path from TR to IU is higher than the coefficients of the other two paths from SO and PU. The coefficient of the path from PU to IU is the smallest. These results suggests the descending order of the orientations with which the users assessed their agents, i.e., relationship-oriented, outcome-oriented, and tool-oriented. This order implies that the users are less likely assess their agents as a regular computer-enabled tool or aid. Thereby, building sound relationships between users and agents will be helpful to promote the adoption of the agents in delegation tasks.

The third implication is that cognitive factors still play a fundamental role of supporting users' assessments, although their effects are limited. The research results show that PCE has weaker

impacts on users' assessments comparing to EC. However, it has a significant effect on EC, which in turn influences TR and SO. The paths connecting PCE, PU, and IU suggest that a cognitive chain of assessments is necessary. The results of testing the restricted model also show that the relationship between PCE to EC cannot be removed. A better suggestion can be offered to designers by combing the first and second implications. That is enhancing cognitive understanding of users will secure the effect of the endeavors of enhancing EC and building the relationships between users and agents.

The last implication is that design choices indeed have impacts on EC, but the effects may take place in a non-straightforward fashion. The effects of instrumental control on EC suggest that it is very challenging for designers to make decisions when they need to do concrete selection in a large inventory of design choices. The current experimental results show that the users perceived different levels of restrictiveness, although the manipulation of instrumental control in the current study was quite simple. It may become more challenging for designers to predict the desirable effects, when introducing advanced control means between user and agents (e.g., anthropomorphized agents), or connecting users and agents in more complex negotiation tasks (e.g., new negotiation issues can be added during the process). The diagnosis of the effects of instrumental control on EC shows the potential reasons that are able to explain the discrepancy effect. The diagnosis shows both challenges and opportunities. Further studies on developing the instrumental control concept will be definitely helpful.

CHAPTER 7 CONCLUDION

The scope of agent applications in commerce keeps growing. The dedicated efforts of agent research community make the related technologies more mature and propel the progress not only in research, but also in practice. The potential benefits of applying agents are attractive for businesses. It is foreseeable that more and more agents will be applied to business use (Yu *et al*. 2015b). The increasing importance of agent use for commerce necessitates research about user and agent relationships. There is a growing requirement that users and agents need to work in teams in order to achieve business objectives. Agents used in delegated negotiation is an example.

The current study highlights at least two important implications for both research and practice. First, the current study found that users treated their agents more than a regular computer-enabled tool or aid. The users' assessments were more oriented to their perceived relationships with agents. The users were more willing to accept agents if they perceived better relationships with agents (e.g., more trust in agents). It also found that users' experienced control had profound impacts on users' assessments. The results suggest that the established design principles of enhancing performance and reducing efforts will not be sufficient to guide the design of building relationships between agents and users. Enhancing users' experienced control to and their perceived relationships with agents would be a more effective design principle.

Second, the current study confirms that design choices of human-agent interaction can influence users' perceived relationships with their agents when the users delegate their tasks to the agents. The users' subjective perception of their control over agents (i.e., experienced control) influences the users' subjective assessments, which suggests that the users will more likely accept their used agents when they perceive stronger control over their agents. However, the effects of objective control (i.e., the instrumental control having different implementations) on users' experienced control may not take place in a straightforward fashion. The discrepancy between objective control and experienced control will make the impacts from design choices on users' assessments difficult to predict. Providing more objective control to users may not necessarily enhance their experienced control. Future research focusing on refining and conceptualizing instrumental control is promising.

The current study attempts to make contributions to the agent-based negotiation research community and the businesses that adopt agents in their commerce practices. First, it offers theoretical insights and empirical evidence showing that agents will not be treated the same way as regular computer-enabled tools or aids when they are introduced to users. Attention needs to be paid to the relationships between users and agents. Second, the current study demonstrates the challenges of building user-agent relationships through interaction. If building relationship will be an effective design strategy, designers would like to know not only whether design choices matter, but also how their impacts take place. A challenge for designers is that they confront with a large inventory of design choices. It is not easy to justify the appropriateness of their design. Designers often need to draw on competing theories when determine the concrete choices. This make the third contribution of the current study possible. The current study proposes that the notion of control can be used to bridge design and users' assessments. Its empirical results confirmed its main proposition. It also developed an instrument for measuring users' experienced control. This instrument can be adopted as an indicator of the quality of design and a predictor for the potential impacts on users, besides others including decision quality, negotiation outcome, and effort.

The theoretical foundation and empirical results of the current study also shed light on the research about human-agent relationship and human-agent teamwork. The current study argues that the concept of control is twofold. It consists of both instrumental control and experienced control. The instrumental control is dual-directional, in that users can instruct their agents, while the agents may influence the users as well. Instrumental control is built upon human-agent interaction, but goes beyond the interaction. It emphasizes the mutual manipulation of behaviors between users and agents. Experienced control can be deemed as assessments by the users of their roles in their decision scenarios. Instrumental and experienced control will jointly influence the users' other subjective responses. When the users experienced stronger control to agents, they would feel enhanced relationships with agents (e.g., more trust in agents). The current study provides a prescriptive support to both user-agent relationship design and the practice of using agents in commerce.

It needs to be noted that the potential variation of the means supporting the interaction between users and agents will be very broad. The experimental setup in the current study can only represent a very limited case. This is an obvious limitation of the study. However, the current study

demonstrates research opportunities, while it exposes some challenges. The prospect of applying agents to business use is promising. When agents with different levels of intelligence are increasingly deployed in enterprise systems, the relationship between artificial intelligence (i.e., the collective intelligence of autonomous artifacts) and natural intelligence (i.e., the collective intelligence of human employees) will have both practical and strategic implications for businesses. The increasing applications of agents to businesses necessitates both theoretical and empirical studies about agents, users, and organizations. Another limitation is that the current study has not identified the potential reasons why participants dropped their experimental activities after they registered. An online experiment approach was adopted in order to resemble a discretionary use scenario. However, it was challenging to communicate with the participants when they were not very active.

Agents may be applied in a variety of areas (Wooldridge 2002). They increasingly participate in a number of commercial activities (Yu *et al*. 2015b). Agent-based negotiation is a particular example. Given the increasing applications of software agents in terms of the depth and scope, information system and management research do not appear to pay sufficient attention to the issues arising from the agents' participation in socio-economic activities. When these autonomous artifacts participate in decision making for social affairs, their impacts should be carefully examined and the potential implications assessed. These artifacts need to connect with some social entities (e.g., users or organizations) that are eligible and able to take the related responsibilities. The outcomes that the agents produce are intertwined with the outcomes produced by people. Therefore, the control of users to these autonomous artifacts plays a critical role in the adoption and use of this type of technology.

The current study may be extended in several ways. The market dynamics can be manipulated, e.g., changing the market to be stochastically stable or unstable. Also, the teamwork between users and socially intelligent agents is an interesting research direction. It is also possible to investigate H2A negotiations. In H2A negotiations, socially intelligent features become more important. Another direction can involve the manipulation of the negotiation problems. This will allow to study users' response to differences in the issue types from the conflict perspective (e.g., aligned vs. conflicting preferences), and their formal representation (e.g., interval vs. ordinal). In addition, users may repeat their use of agents in negotiations if they accept the technology. Mutual learning

between users and agents will become important in repeated use. In order to better understand users, it will be useful to characterize the types of users, such as applying some techniques of profiling users. It will be also interesting to verify whether experienced control and perceived cognitive effort will have a mediating effect between instrumental control and users' assessments and acceptance of agents in other tasks, which could be potentially delegated to agents.

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APPENDICES

A.1 The public information of the business scenario for the experiment

With incredible wildlife, icebergs, forests, glaciers and jaw-dropping scenery, Alaska is a vacation dream land filled with adventures and some of the most breathtaking views in the world. From fresh coastal seafood to unforgettable flight seeing, Alaska! Millions of travelers visit Alaska each year and you are lucky enough to be going for a one week trip with an off-season vacation package.

Since much of Alaska is inaccessible by road, the best way to explore it is by cruise and/or, a small plane. At 60 % of the regular cost, your off-season package features a five-day cruise and a flight seeing trip to the Arctic Circle. The cruise ship will stop at famous ports and visit some of the world's most magnificent glaciers. The flight to the Arctic Circle will provide an aerial view of the vast Alaska wilderness.

An off-season vacation does not mean inferior services. Many Alaskan tour services operate year round. So, the quality of your vacation package should be guaranteed and your trip should be safe unless there are extreme weather conditions, e.g., a storm. To compensate for the low price, the tour service provider will charge you minimum 50% of the price of your package if you want to cancel it.

Purchasing an insurance package is especially important when traveling to remote areas of the U.S. Medical expenses can be unbelievably costly, especially if one is hospitalized and requires emergency transportation to medical facilities. It should also be noted that goods in Alaska cost much more than in other U.S. states. This may be a problem if your baggage delayed or lost requiring you to make purchases. If not properly insured, you risk not being reimbursed for flight costs should something happen to seriously interrupt your trip.

Now that you have booked your flight, your personal information (such as age, gender, and prior insurance history) and your trip information (such as destination, the travel period, and itinerary) are in the system. This information will be useful when you purchase travel insurance. Insurance providers usually price insurance packages differently and shopping with multiple insurance providers can be difficult. At your request, the booking system will provide you with a software agent that is able to simultaneously negotiate with multiple insurance providers on your behalf. The software agent will automatically exchange offers with a group of qualified insurance providers. In order to represent you, the software agent will need to obtain more information from you. It is important to provide the agent with information as accurate as possible.

A.2 The private information of the business scenario for the experiment

For a true sense of security, a primary and comprehensive travel insurance policy is paramount as it will cover all your qualified expenses or loss regardless of whether or not you are covered by other policies. For instance, your public health insurance plan may protect travel within the country, but not abroad. You are going to shop for a primary and comprehensive plan that consists of **five** categories of benefits. Details and options for the insurable benefits are provided below.

1. Medical expense

When you begin your trip, you will be covered up to a certain amount of eligible unexpected emergency medical expenses in case you are hospitalized. There are **five** options to choose from: $0, $500,000, $1,000,000, $1,500,000 and $2,000,000.

2. Emergency travel assistance service

Besides medical expenses for hospitalization, there may be other expenses in case of an emergency or an accident. Below are the insurable services and assistance covered by the insurance companies:

- Medical referrals, consultation, monitoring and transportation to another medical facility, or medical payment assistance.
- Legal referrals and bail bond assistance.
- Emergency cash transfers (up to your available credit limit).
- Assistance with replacement tickets and travel documents.
- Emergency return (airfare + nursing).

In this category, there are **six** options: $0, $10,000, $20,000, $30,000, $40,000 and $50,000.

3. Trip cancellation & interruption

In the case of an uncontrollable event that prevents travelers from completing their trip, they can be covered for eligible trip cancellation & interruption expenses. Travelers are able to choose one of the following **six** options: $0, $1000, $2000, $3000, $4000, and $5,000.

4. Baggage (delayed, damaged, and lost)

Travelers can be insured for the expenses that incur if their checked baggage is lost or delayed by more than eight hours. The allowable expenses include the cost to replace essential items and personal property. There are **five** options that travelers can choose from: $0, $500, $1,000, $1,500 and $2,000.

5. Common carrier travel accident insurance

In the case of an accident, travelers may incur expenses other than medical costs. When a traveler travels on a common carrier (train line, bus line, taxicab, and cruise ship) and an accident takes place, the following expenses will be covered: funeral or cremation at the place of death, return of the body and properties of the insured deceased, and cost of delayed return. An insured traveler can be covered with the following options: $0, $10,000, $20,000, $30,000, $40,000 and $50,000.

Price

The insurance package consists of all five categories of benefits. However, if in any category the value “0” is selected, then this category is not included (i.e., there is no insurance for the benefits). The price of the complete package varies from $0 to $500. The maximum cost of your insurance package, even if each category is insured at its highest level, will not exceed $500.

For the sake of simplicity, it is assumed here that there are no limitations and exclusions for the insurance. All insurance providers are equally trustworthy and their services are equitable.