Experimental Assessment of Agent-supported Electronic Negotiations ♦

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Abstract

This paper presents the results of experimental evaluation of the effectiveness of agent support in e-negotiations. The agent-enhanced e-negotiation system e-Agora has been used in the experiments. The system features an agent that assists the user in generating candidate offers, evaluating and critiquing incoming offers, and critiquing counter-offers. The work investigates the effects of agent support and task complexity on negotiation performance and perceived measures of usefulness, satisfaction, ease of use and confidence. Overall, the results support the expectation that use of an agent leads to higher level of negotiation effectiveness, in particular for higher complexity tasks.

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1. Introduction

The development of electronic markets presents unprecedented opportunities for employing negotiations as one of the key market mechanisms (Bakos 1998; Kersten, Noronha et al. 1999; Chen, Kersten et al. 2005). Electronic negotiation systems (ENSs) are new technologies designed to facilitate the negotiation processes on the Internet among the negotiating parties. An ENS can incorporate analytical tools to help negotiators express their preferences, and construct a utility function. This, in turn, helps comparing offers and counter-offers, and assists in the post-settlement phase (Kersten and Noronha 1999).

Agent technologies have recently become one of the most popular areas of research. Software agents are autonomous proactive software components that promise to aid the users in performing difficult tasks or automate effort-consuming tasks (Jennings, Sycara et al. 1998). The applicability of software agents to automating negotiation processes has been investigated in the past [Beam, 1996 #34; Chavez, 1997 #37; Collins, 1998 #58; Dzeng, 2004 #81; Faratin, 2002 #82; Jennings, 2001 #39; Lee, 2004 #84; Maes, 1998 #32; Oliver, 1997 #44; Sandholm, 1999 #49]. However, while major effort has been made in attempt to fully automate negotiation processes, this approach is less adequate for business applications that require substantial judgmental input from the negotiators when preparing and conducting negotiations.

An alternative approach envisages the use of agents as assistants in the negotiation process, rather than automated negotiators (Kersten and Lo 2001; Chen, Kersten et al. 2005). In this approach, the agents proactively help the users by preparing candidate offers, critiquing potential offers, as well as the other party's offers, and providing other advisory functions. While agent-supported ENS promises to improve the negotiation experience and performance of the users; there is, however, little empirical evidence regarding the effectiveness of employing agents in this role.

The purpose of this work is to empirically investigate the effectiveness of agent-supported ENS solutions. To this end, we have employed an agent-enhanced ENS called eAgora in experimental settings. This paper presents our findings from the experiments. Overall, we have found that provision of agent support leads to substantial benefits, in particular when complex negotiation tasks are involved.

The remainder of the paper is organized as follows. The next section discusses the background including electronic negotiations, agent technologies, and past experimental studies involving human-agent interactions. Then a review of eAgora, an e-marketplace enabling the use of agents as advisors for the negotiators in terms of key capabilities and architecture, is provided. Furthermore, the research methodology, including research model, hypotheses, and experimental design are presented. Subsequently the results and are described and discussed. The paper finishes with conclusions summarizing the major findings, limitations, and directions for future research.

2. Background

2.1 Electronic negotiations

In the e-marketplace, transactions follow three basic stages: information, negotiation and exchange (Bloch, Pigneur et al. 1996). The information stage involves participants searching for trade partners. Buyers explore Internet to find suppliers that answer their product needs, and sellers advertise to attract potential buyer to purchase their products. The exchange stage includes the payment for the product, as well as possible after-sales services by the seller. The negotiation stage is much less developed commercially than the others, because of the complexity and intricacies that arise from back and forth discussions over the terms and conditions for transaction. Negotiation however, is essential to the specification of price and other attributes that would enrich both sides of the market (Rosenschein 1994; Raiffa 1998). The ability to negotiate electronically gives buyers more bargaining power, and sellers benefit from higher profits by collecting different prices from different buyers (Bakos 1998). Since e-negotiation removes the cost of face-to-face discussions, it shifts the emphasis on technology to support talks.

The technologies involved in e-negotiation systems are used to facilitate and support communication, provide decision aids for individuals and groups based on decision and negotiation analyses, and provide knowledge-based and other types of intelligent advice, recommendation and constructive critique. Electronic message exchange (e.g. through email) focuses purely on the communication aspect of e-negotiation (Croson 1999; Thompson and Nadler 2002). This simple form of Internet-based negotiation provides little support to negotiators beyond the management of messages and does not provide tools to alleviate the cognitive effort of the negotiators (Kersten, S. Strecker et al. 2004). Systems incorporating analytical techniques (e.g., Inspire (Kersten 1999)) provide users with on-line negotiation support that presents information in the form of utility values, graphs, as well as Pareto optimization features. Negotiators are able to structure their problem with such analytical tools and visualize different possibilities for improvement. Furthermore, offers and messages are separated to facilitate better communication and organization of information. The implementation of Inspire has proven successful in studying and teaching negotiation to business, educational and government organizations (Kersten and Noronha 1998).

The increasing interest in e-negotiations has revealed problems of information overload and a need for adequate support to engender effective and efficient negotiations (Maes, Guttman et al. 1998; Mudgal and Vassileva 2000; Weber, Kersten et al. 2006). Even if ENS imparts an analytical approach to e-negotiation, some participants may have difficulty finding and utilizing information relevant to their offer exchanges, due to the lack of experience, training in decision-making, or willingness to engage in bargaining tactics. In order to assist negotiators and provide them with context-dependent advice agent technology could be integrated into ENS.

Aspire, an agent integrated with Inspire, proved even more helpful and practical in a field test than Inspire (analytical support) alone (Kersten and Lo 2001). However, this agent was governed by very restricted rules that did not consider the opponents' counter-offers and concessions, and it functioned only in a specific problem set of Inspire. Therefore, there is a

need for an agent integrated ENS that effectively supports various aspects of negotiation tasks, while leaving flexibility for human decisions.

2.2 Agent technologies and experimental assessments of the utility of agents

As more people and businesses join the web community, more information becomes available, and users face the exacerbating problem of information overload. Not only does this medium provide an enormous volume of data, but the data also exists in a broad range of formats (text, image, audio, video, etc). Furthermore, information posted on websites changes at a rapid rate. One possible solution to overcoming these problems rests in the advent of agent technology. Rooted in artificial intelligence research, agents are used to conduct routine tasks, search and retrieve information, support decision-making, and act as domain experts. They respond to users' needs by acting autonomously and proactively, thus resulting in significant time savings (Maes, Guttman et al. 1998).

Maes, Guttman and Moukas (1998) postulate that in electronic commerce agents could play the role of matchmakers and intermediaries. In these roles they support users in one or more stages of business transactions. In the information stage, agents match buyers with sellers by: (1) filtering product information to recommend consumers with goods that fulfill their specific needs, or (2) anticipating consumer needs based on previous purchases (e.g., Amazon.com's "Eyes" software). In the negotiation stage, the task of the agent is to assist interactions between buyers and sellers. During the exchange stage, agents help buyers and sellers to manage the purchasing logistics, such as tracking and processing payments and deliveries, as well as after-sales services. As technology matures, investigators also anticipate that agents would grow to better adapt to the changes in the marketplace and to the uncertainty in modeling users' preferences (e.g., Karacapilidis and Moraitis 2001).

One way in which agents could be employed in negotiations is through assuming the role of a negotiator, (Beam, Segev et al. 1996; Chavez, Dreilinger et al. 1997; Oliver 1997). For example, early agent application in C2C e-commerce included Kasbah marketplace, where agents negotiated solely on price while buying and selling items for their human principals (Chavez, Dreilinger et al. 1997). In such applications, the objectives of the human user and the preferred negotiation strategies must be specified beforehand, or in other words the task of negotiation is relatively well-structured. Because, most real-life situations require at least some judgmental input from the human user, agents could be used as intelligent assistants that help inform the users' decision-making and negotiation activities. The Aspire and eAgora systems exemplify this approach by employing agents in an advisory mode (Kersten and Lo 2001; Chen, Kersten et al. 2005). In the related area of decision support systems, similar architectures that employ agents as components, have been proposed (Hess, Rees et al. 2000; Vahidov and Kersten 2004).

In light of the above developments in human-agent interactions in electronic negotiation systems, the question of empirical evidence on the value of such proactive support is of crucial importance. Past studies in human-computer interactions have focused on experiments featuring human-agent dialogues. One such meta-study reviews the findings reported in the literature on the utility of animated interface agents. Here, some important independent variables included kind of animated interface component and type of task (e.g. automated tutoring, game-playing, etc.) (Dehn and Mulken 2000). The dependent variables included intelligence, believability, activity, utility, engagingness, and others. Similar criteria were used

in another study focusing on e-retail applications of synthetic human-like agents [McBreen, 2000 #91]. Overall, the utility of synthetic agents seems to be questionable in cases other than gaming applications, where they provide an entertaining type of value (Dehn and Mulken 2000). Another experimental study had evaluated the impact of agent's competence on satisfaction, perceived utility and performance (Xiao, Stasko et al. 2004).

There have also been studies investigating the effectiveness of agents supporting information search and filtering. One such study investigated the effects of user profiling and "relevance feedback" on agent performance in retrieving financial news articles (Yang and Chung 2004). In another experimental work, an agent was utilized to provide customized browsing facilities for the users searching for books (Lai and Yang 2000). The agent support had led to improvement in terms of effectiveness, efficiency, and satisfaction.

Application of agent technology in e-commerce is best exemplified by recommender systems. Research into the effectiveness of such aids has analyzed their impact on the amount of information search; consideration sets; and decision quality; the latter including non-dominance, reduced probability of switching to another alternative, and confidence (Haubl and Trifts 2000). The findings provide empirical support for the effectiveness of employing agents in e-commerce applications.

One approach to agent-enhanced decision support envisaged agents organized by phases of decision making (e.g., according to Simon's model), including intelligence, design, and choice (Vahidov and Fazlollahi 2004). The modes of employment and the roles played by the agents in this framework are to a large extent similar to the agent-assisted negotiation approach investigated in this paper. Among other capabilities and functions, agents in this DSS provided various recommendations and critiquing of decision alternatives. The experiments that had been carried out estimated the impact of agent involvement on such variables as performance, perceived usefulness, satisfaction, confidence, learning effect, and the number of alternatives considered. Overall, the findings provided support for the value of incorporating agents as aids in decision making contexts.

The above sample of experimental studies in agent-enhanced human-system interactions inform our subsequent decisions with regard to empirical investigation of agent-supported negotiations. Most importantly, while synthetic characters do not seem to contribute towards more effective computer-assisted work, the more substantial agent types, including recommender and critiquing agents, have been found to promote better performance, as well as improvement in perceptive, process, and outcome variables.

3. eAgora: A Marketplace for People and software agents

eAgora is an e-marketplace with an integrated agent aimed at the enhancement of customer-oriented e-commerce activities in the information and especially the negotiation stage of the transaction lifecycle (Chen, Kersten et al. 2005). It allows buyers and sellers to meet and negotiate over multiple issues with the possibility of appending additional issues during talks.

3.1 eAgora activities

The activities sustained by EAgora can be grouped in five distinct negotiation phases (Figure 1). The activities are undertaken by the user and they can be supported or guided by tasks performed by the agents.

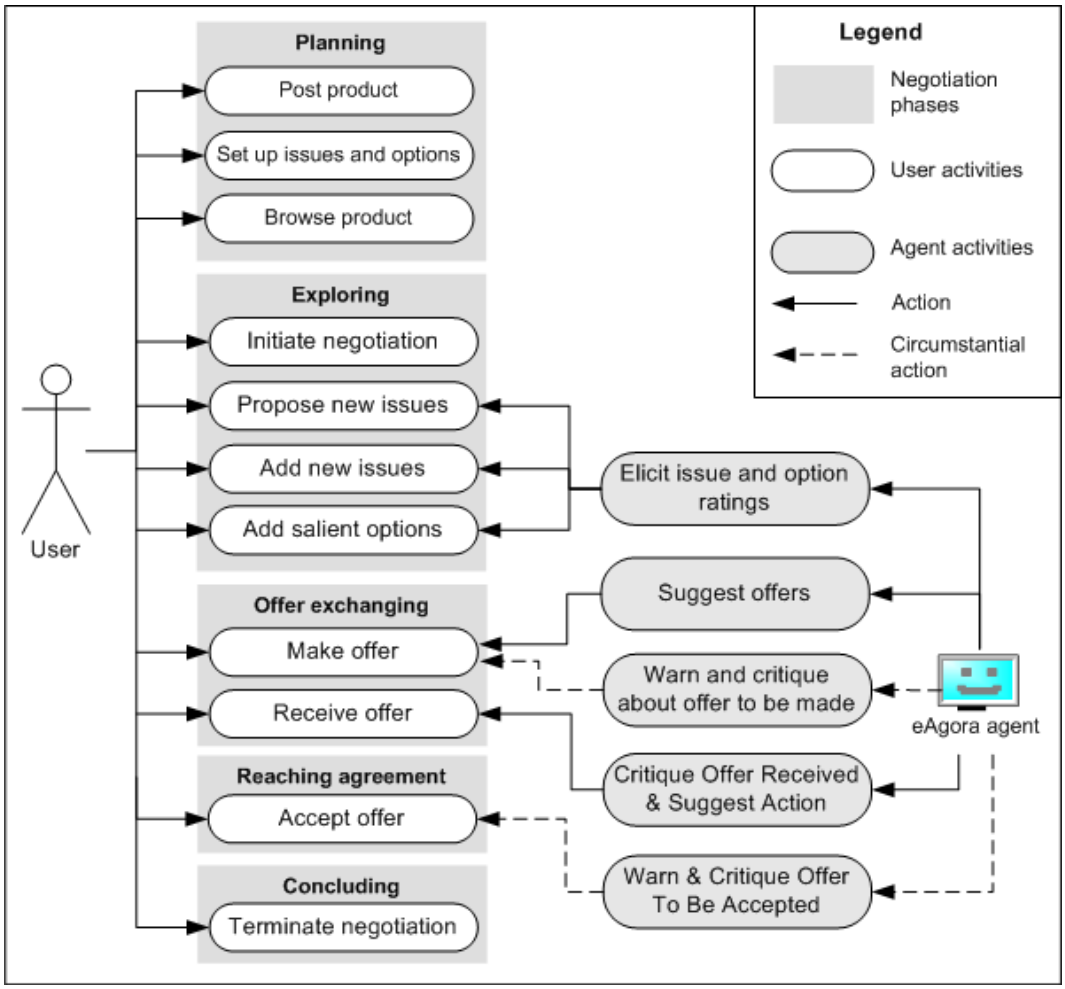

Figure 1: eAgora Architecture

In the *planning phase*, market participants may announce the goods or services that they intend to buy or sell (post product), and the terms and conditions for transaction (set up issues and options). Other users can peruse these postings (browse products) in hopes of finding a product that meets their needs.

Once transactional interests are set, buyer and seller enter the *exploration phase* that involves initiating negotiations and adding or modifying issues and options. If any party requests the assistance of the negotiation agent, then the agent elicits the negotiator's preferences and constructs a value function. Throughout negotiation, either party may suggest additional issues and options to be included as part of the offer package (propose new issues and options), and the other party is given the choice to accept or refuse this enlargement of the

negotiation pie. If both sides agree to the newly added terms (add new issues and options), the agent will need to elicit the users' preferences again to generate a new value function.

In the *offer exchange phase* the negotiators narrow their differences by exchanging offers. The purpose of the activities of making and receiving offer is to explore possible agreements that would suffice their negotiation expectations. During these exchanges, the agent monitors actions of the negotiator and aids him or her by suggesting a short list of promising alternative offers to be considered. The agent also appraises the offers proposed by the negotiator's counterpart and recommends a course of action. These tasks performed by the agent involve offer critique and action suggestion.

The agent uses the knowledge base in order to oversee two critical negotiation activities: making an offer and accepting an offer. The purpose is to warn the user against mistakes that would result in unfavorable agreements. These warnings are only sent out when actions deviate from acceptable ranges and are accompanied by explanations as to why an offer should not be made (warn and critique offer to be made) or an offer should not be accepted (warn and critique offer to be accepted). The negotiators are also given the opportunity to walk away from talks and cease all discussions (terminate negotiation) at any time. Since the agent is built independently of the e-marketplace, participants can engage in negotiations without assistance or they may disregard the agent's advice at any step. The agent's actions are governed by a knowledge base, which accounts for the users' preferences, strategies, concessions, as well as the offers and concessions made by the opponent. This approach allows the agent to remain flexible and adaptive in assisting the negotiator.

3.2 eAgora architecture

eAgora is based on a 4-tier architecture design following web-based and agent-oriented methodologies (Fournier 1998; Jennings, Sycara et al. 1998; Buffam 2000). The different tiers are briefly described below and illustrated in Figure 2.

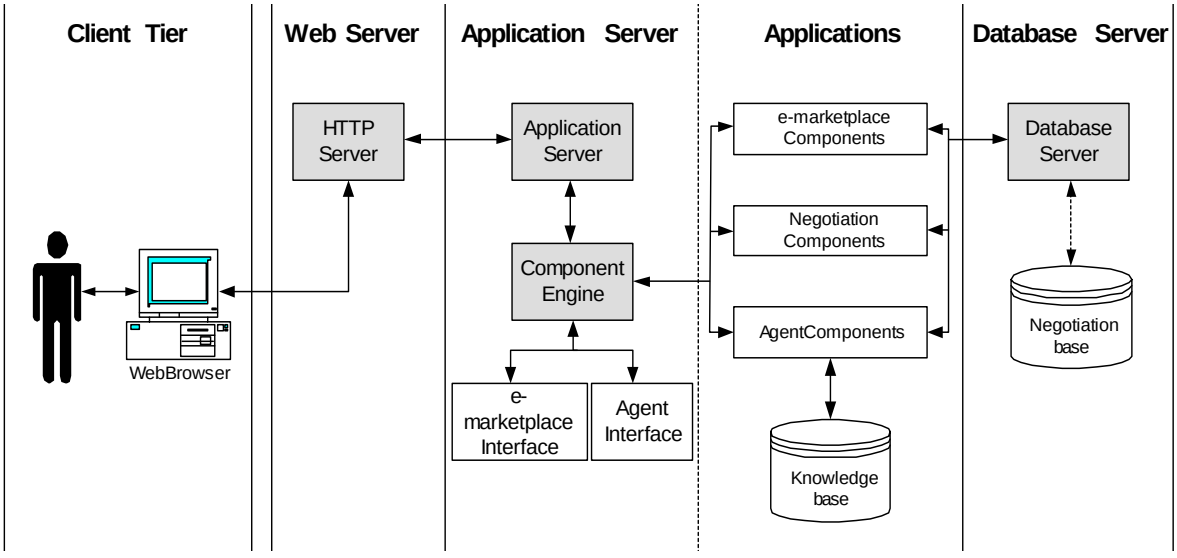

Figure 2: Research model

The client tier consists of web browsers used by market participants to connect to the system. The web server tier is an HTTP server that sends the web pages to the browsers. The application server tier is composed of an application server (ColdFusion) to generate dynamic pages. The component engine, adapted from the Fusebox engine (Peters and Papovich 2002), runs the system activities, which are encapsulated and modularized into e-marketplace, negotiation and agent components. The database tier relies on a database server to manage information on different users and negotiations. These four tiers enable eAgora to function as an e-marketplace for buyers and sellers to meet and negotiate over any product with or without the assistance of an intelligent agent.

4. Methodology

4.1 Research model

The purpose of this work is to empirically investigate the effectiveness of agent-supported negotiations. Thus, the research model should include at least the type of negotiation support (i.e. with or without agent involvement) on the independent side and the measures of effectiveness on the dependent side. In order to determine the most relevant variables on the independent side, we have relied on the task-technology fit model, which is applicable to information systems in general, as well as models for evaluating decision support systems, an area closely related to negotiation support.

The task-technology fit model posits that individual performance is influenced by the degree of fit between the type of technology support, the characteristics of the task, as well as the characteristics of an individual (Goodhue and Thompson 1995). This provides us with the initial list of independent factors to be studied in this research. In the context of studying DSS impact, Todd and Benbasat (1999) considered "DSS capabilities" and "Task" as independent variables. Within the context of group decision support the task characteristics (in particular, task complexity) and technology support are considered crucial variables influencing the outcomes (Fjermestad and Hiltz 1997; Tung and Turban 1998).

Based on the above, we have decided to include three independent factors in our study: (1) type of support; (2) task complexity; and (3) role that an individual plays in respect to the system use.

Type of support is the key variable of interest and includes use of the e-negotiation system with or without agent support. The task complexity was operationalized using the number of issues included in negotiations. We have also included the role of the negotiator (i.e., buyer or seller) in our model to represent the different users of the system.

Since the effectiveness of negotiation support is a complex, multi-dimensional variable, we have sought to include related outcome factors as dependent variables. The technology acceptance model is one of the most widely employed models in behavioral studies of IS. It posits that technology adoption is influenced by the perceived usefulness and ease of use of the system (Davis 1989; Davis 1993). Therefore, these two factors were included in our study on the dependent side. Other variables were derived from the relevant literature on negotiation and decision support. According to Bui (1994) the evaluation criteria for negotiation support

should include decision quality and satisfaction with the outcome, among others. Spector (1997) used the negotiation results and perceived positive impact to evaluate negotiation outcomes. It was found that provision of analytical support had strong influence on perception of effective solution, as well as number of agreements. Another conclusion was that analytical support is useful in bolstering complex negotiations.

The outcome factors for group decision support include various variables, in particular decision quality, decision confidence, ease of use, process satisfaction, and decision satisfaction (Tung and Turban 1998). The field of DSS has long been using a mix of variables to measure the effectiveness of system support, including: decision performance, system satisfaction, decision confidence, and others (Aldag and Power 1986; Sharda, Barr et al. 1988; O'Keefe 1989; Vahidov and Kersten 2004).

Based on the above review, we have decided to include the following variables on the dependent side of our model: negotiation performance (based on the indicated preference structure); perceived usefulness; perceived ease of use; satisfaction with the negotiation outcome; satisfaction with the process; and confidence in the outcomes. The resulting research model is shown in Figure 3.

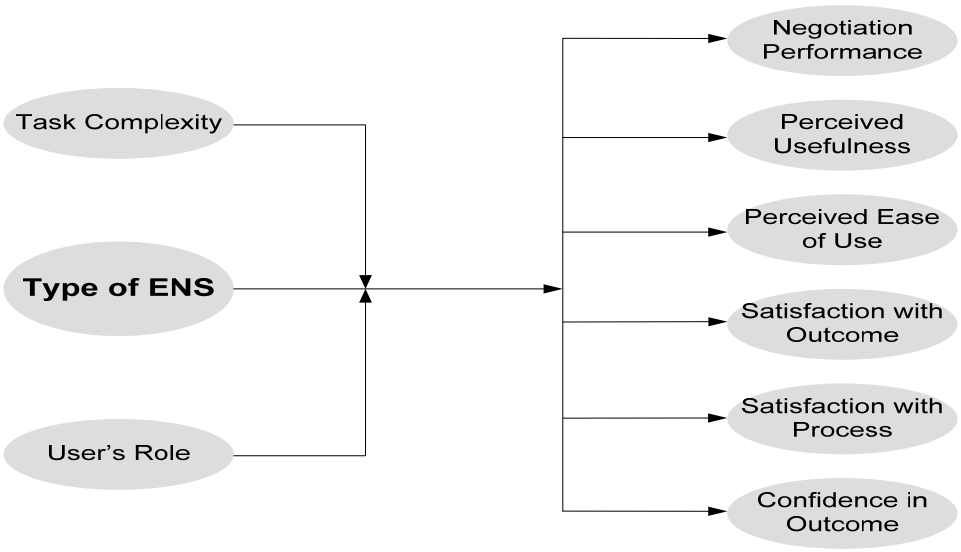

Figure 2: Research model

4.2 Hypotheses

Our research model shows the anticipated influences of independent factors on various measures of effectiveness of e-negotiation support. More specifically, we hypothesize that the agent-supported ENS will yield higher effectiveness than the ENS without such support. Use of analytical tools, in particular those of qualitative nature (information organization, comparison, creativity, etc.) has been shown with some quantitative support to foster improved negotiations (Spector 1997). Moreover, we anticipate that this effect will be stronger when dealing with complex negotiation tasks as opposed to relatively simple ones. This expectation is based partly on the idea of task-technology fit, as well as previous studies in

group and negotiation decision support (Fjermestad and Hiltz 1997; Spector 1997). In other words, we expect that the support provided by the agent will be more effective when dealing with complex negotiation tasks.

The six hypotheses given below posit the added value of the agent-supported ENS versus the same ENS but with disabled software agents; this value primarily exhibits itself in terms of the effectiveness variables. From now on we will use the acronym ANS to denote agent-supported ENS, and TNS to denote "traditional" ENS (i.e., the one without agent).

H1a: ANS users will reach better outcomes than TNS users in terms of indicated user preferences.

H2a: ANS users will find the system more useful than TNS users.

H3a: ANS users will find the system no more difficult to use than TNS users.

H4a: Using ANS will lead to more satisfying outcome than using TNS.

H5a: Using ANS will lead to higher user satisfaction with process than using TNS.

H6a: ANS users will have higher confidence level in negotiation outcome than TNS users.

As one can see these six hypotheses are straightforward as they set forth an anticipation of improvement for the users of agent support. Note that the hypothesis 3a dealing with ease of use is the "weak" one as it states that the users of agent supported system will not find it more difficult to use. The rationale is that since the agent-based system is the more complex one, its benefits will not come at the expense of ease of use. In other words, we expect that the system will be at least as easy to use as the one without agent, while we also anticipate significant improvements on other criteria.

The next set of related hypotheses basically adapts the above expectations when comparing complex negotiation tasks with simple ones.

H1b: ANS users will reach better outcomes than TNS users in terms of indicated user preferences when dealing with complex negotiation tasks vs. simple ones.

H2b: ANS users will find the system more useful than TNS users when dealing with complex negotiation tasks vs. simple ones.

H3b: ANS users will find the system no more difficult to use than TNS users when dealing with complex negotiation tasks vs. simple ones.

H4b: Using ANS will lead to more satisfying outcome than using TNS when dealing with complex negotiation tasks vs. simple ones.

H5b: Using ANS will lead to higher user satisfaction with process than using TNS when dealing with complex negotiation tasks vs. simple ones.

H6b: ANS users will have higher confidence level in negotiation outcome than TNS users when

dealing with complex negotiation tasks vs. simple ones.

4.3 Experimental Design

4.3.1 Subjects

The subjects were recruited from the population of graduate and upper-level undergraduate students at two major Canadian universities. Overall, 104 subjects attended the experiments. The age of subjects ranged from 21 to 30 years. The vast majority (98%) of them were business students, with the rest enrolled in science and arts programs. The analysis revealed that forty-five percent of the participants spent more than 20 hours a week on Internet. Fifty-six percent had online purchasing experience and thirty-eight percent had online auction system experience.

4.3.2 Systems

In order to assess the effectiveness of agent-supported negotiations an on-line agent-enhanced negotiation system eAgora was employed. Agent support was used as a treatment (if included, the negotiator received assistance from agent during the course of negotiations). The agent helps negotiators to compose offers in accordance with chosen strategy, preferences, and counter-party's offers, and provides verbal critique of offers and counter-offers. In our experiments each dyad comprised of person using the ENS with agent-based support and one person who used the same ENS but without agent support.

4.3.3 Tasks

We have prepared a case for conducting our negotiation experiments. Since our target group composed of students, the case needed to match their level of knowledge and experience. Our case consisted of a rental negotiation of a one bedroom condominium located in downtown Montreal, Canada. Since most of the student population chooses to live close to the university campuses, which are located in the city, we believe that the case had been chosen adequately.

In order to manipulate the complexity of the task we have prepared two versions of the condominium case. The first, "simple" version included only two issues: rental price, and inclusion of the parking spot. The second, "complex" one involved five issues. These comprised, in addition to the above, the rental period (6 months, one year, and two years as options); deposit amount ($0, $500, and $1,000); and the possibility of cleaning the condo prior to the rental.

The cases were prepared both for buyers and sellers with varying preferences. For example, in the simple case the buyer's acceptable price ranged from $500 (best) to $800 (worst) and had an importance of seventy percent, with the remaining thirty percent allocated to the inclusion of the parking spot. For the seller (i.e., landlord) the price ranged from $700 to $1,000 and had a ninety percent importance weight, whereas the parking spot was only valued at ten percent.

4.3.4 Experimental Procedure

Prior to the experiments, the recruitment efforts were made though advertising using flyers and short in-class presentations. In order to attract the participants it was decided that each of them will be paid a $10 reward for completing the task. In addition, a $50 reward was promised to four best negotiators (i.e., those who achieved the best negotiation outcomes according to the indicated preferences among the issues) among buyers and sellers, to further motivate the subjects towards successful completion of the task .

The experiments were conducted in two computer-equipped laboratories in sessions with between 4 and 20 participants. One laboratory was used for subjects using agent support, and the other one for their counterparts without agent support. At the beginning of the sessions, the cases were explained to the subjects along with the instructions and a short demonstration of using eAgora. There were two monitors in each lab to provide the subjects with technical support.

The pre-negotiation settings, including descriptions of issues, options, and rankings were entered into the system beforehand to minimize error and reduce time needed for the experiment. The negotiations were initiated by one party making the initial offer, and then waiting for the other party to respond. The negotiations ended with parties reaching an agreement or one of the parties deciding to terminate negotiations. After completion of the task, which took on average about an hour, the subjects were asked to complete an online questionnaire that included demographic questions, and questions related to the constructs of the model. The latter part was derived from past literature (as cited in the previous section) and included sixteen questions, as we tried to minimize the length of the questionnaire so that that the whole session would not exceed two hours. In cases where agreement was reached, the system had automatically recorded the utility values of the agreements in accordance with the given preferences.

5. Results and Discussion

Out of the 104 participants, 82 usable responses were collected and used for data analysis. Out of these, 46 participants had reached an agreement, with the rest of negotiations being terminated without an agreement. Thus, only 46 usable data points for measuring negotiation performance directly were collected, while 82 observations for the perceptive measures were obtained.

We have used exploratory factor analysis in order to investigate the validity of our constructs. The initial list of measures did not yield clear pattern of loadings. After removing four items, the remaining twelve items yielded an acceptable pattern of loadings as shown in Table 1.

As one can see in Table 1, factor 1 relates to satisfaction with the outcome (SO), factor 2 pertains to ease of use (EA), factor 3 measures perceived usefulness (US), factor 4 relates to satisfaction with the process (SP), and factor 5 measures the confidence in the outcome (CN). Overall, the pattern of loadings suggests the adequate degree of convergent and divergent validities.

The research model (Figure 3) was formulated in terms of a general linear model (GLM) in order to explore the differences of influence, from three independent factors, on the system

effectiveness that is measured by five factors (perceived usefulness and ease of use, user satisfaction with process and negotiation outcome, and user confidence in the negotiation outcome). In this part of analysis we omitted the negotiation performance, as it was only measurable for the dyads that made an agreement. This was done to test if there are multi-variate effects on the dependent constructs of the role of negotiator. Based on Wilks' Lambda and Hotelling's trace, the significance of the influence of the role when taken (i) separately, (ii) in combination with task complexity, (iii) in combination with agent support, (iv) or with all three factors combined was found to have a p-value above 0.05, more specifically 0.795, 0.123, 0.950, and 0.638 respectively. Thus, it could be concluded that negotiator's role (buyer vs. seller) does not have a significant effect on the subjective dependent variables.

Table 1: Results of Factor Analysis

	Factors				
Items	1	2	3	4	5
SO1	.781	.022	.235	.376	.273
SO2	.839	.109	.182	.315	.272
SO3	.832	.362	.223	.003	.113
EA1	.135	.767	.286	.303	.032
EA2	.149	.853	.052	.224	.318
US1	.260	.110	.844	.207	.280
US2	.253	.311	.788	.278	.194
SP1	.254	.473	.313	.639	.092
SP2	.254	.559	.216	.615	.202
SP3	.261	.322	.258	.752	.246
CN1	.303	.179	.287	.202	.833
CN2	.390	.409	.341	.177	.608

In order to test the *H1a* and *H1b*, the computer-recorded utility values for the reached agreements were used. When the data were pooled across both simple and complex negotiation cases the average utility of agreements for agent-supported negotiators was determined to be 0.37, while for those using no agent support, it was 0.19. The t-test showed that the difference was significant with the p-value of 0.016. Thus our hypothesis (*H1a*) that

agent-supported negotiators will perform better is confirmed. With regards to *H1b*, we compared the average improvement induced by agent support in the complex case with the average improvement in the simple case. This hypothesis was not confirmed as we did not find an improvement in negotiation performance to be significantly greater in the complex negotiation case. This may be due to the fact that we had a relatively small sample of recorded values for parties that reached an agreement. Another difficulty lies in the fact that preferences were assigned to participants, which may not reflect their actual preferences, while some of them may have negotiated based on their own intuition with the choice to accept or reject the suggestion provided by the agent.

In order to test the hypotheses related to the perceived measures of effectiveness, we have employed factor scores obtained from the factor analysis. Table 2 shows the details of our findings.

Table 1: Results of Comparing Factor Scores

Hypothesis	Variable	With agent	Without agent	p-value	Confirmed (0.10 level)
All cases					
H2a	Usefulness	0.139	-0.139	0.10	Yes
H3a	Ease of use	0.069	-0.069	0.27	Yes*
H4a	Satisfaction with outcome	0.091	-0.091	0.20	No
H5a	Satisfaction with process	-0.058	0.058	0.30	No
H6a	Confidence	0.087	-0.087	0.22	No
Complex over simple cases					
H2b	Usefulness	0.41	-0.48	0.005	Yes
H3b	Ease of use	0.11	-0.37	0.11	Yes*
H4b	Satisfaction with outcome	0.22	-0.24	0.09	Yes
H5b	Satisfaction with process	0.027	-0.22	0.23	No
H6b	Confidence	0.17	-0.35	0.06	Yes

*Note: *H3a* and *H3b* stated "no more difficult to use". Thus finding no significant difference

supports these hypotheses.

The results suggest that most of our expectations were in the right direction, although when all cases were aggregated these differences were not statistically significant. However, when comparing the effectiveness of agent support in complex vs. simple negotiation tasks, we found that most of our hypotheses were confirmed. These findings are consistent with the results from the general linear model that suggested the only significant interaction to be task complexity and agent support.

In summary, our findings seem to support the view that agent assistant is perceived to be effective in negotiations that involve complex cases dealing with many issues as compared to cases with few issues (i.e., two in our case).

6. Conclusion

The objective of this study was to empirically investigate the effectiveness of agent support in conducting online negotiations. To this end, we used an agent-enhanced negotiation system eAgora in our experiments. Agent support in eAgora included most importantly analysis of offers and counter-offers, suggestion of candidate offers during the negotiation process, and critique of the negotiator's and the opponent's offers. We have employed a variety of variables, both objective and perceptive to assess the utility of agents. Our findings suggest that agent support leads to improved negotiation performance in terms of specified preferences for negotiated issues and options. Furthermore, it seems that the users perceive agent support to be more valuable when they are negotiating over complex cases that involve multiple issues. In such tasks agent's help in organizing information, keeping track of multiple issues, preparing offer packages, and critiquing offers appears to be more highly valued by the negotiators. One major limitation of our study was use of students as subjects. However, we chose our experimental task to match the expected level of knowledge and experience of our subjects.

Based on the findings of the study, we believe that the results provide empirical support in favor of agent-supported negotiations, in particular when complex negotiation tasks are involved. This conclusion provides justification for future efforts focusing on agent-assisted negotiations. Some possible directions to explore in this regard include, but are not limited to the following:

Handling uncertainties in user preferences and negotiation strategies. In a given negotiation task the user may not have a well-defined preference structure with regards to issues, opinions, and negotiation strategies. An appropriate enhancement to an agent model would thus be the ability to tolerate some level of vagueness in the specification of the above;

Automated profile tracking. The negotiator's preferences may change over time as the situation changes, due to new information, or as a result of better understanding of the market, the negotiated issues, or the opponent. It would thus be interesting to investigate the possibility of employing agents that dynamically and proactively track the dynamic preference structure of the user;

Opponent profiling. By default the preferences of the negotiators are part of the private information. Knowing these preferences, could enable reaching efficient agreements and faster speed of convergence towards the agreement. An agent that learns the opponent's profile through using offer exchange data could be a valuable addition; and

Information delivery. An agent that keeps the negotiator informed about the current relevant information on economic and market data could enable better decision making by the negotiator, and ultimately lead to better negotiation outcomes.

While these and other possible projects would lead to the enrichment of the negotiator's analytical arsenal, we'd like to stress that the experimental studies similar to this one are essential in safeguarding the claims to value of any new additional features and functions that agent technology has a potential to deliver.

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