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Intelligent Agent Based Decision Making On The Internet: An Empirical Study

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Abstract

This exploratory experimental study was designed to explore whether the use of an intelligent agent for environmental scanning can assist a decision maker in international investment decisions. Subjects selected a country from a pair of countries, based on the analysis of the political, economic and financial dimensions. An experimental tool was developed and a laboratory experiment was conducted to examine how Information Delivery and Agent Facilitation may effect decision making processes and outcomes. Unrealistic high expectations promoted by computer trade magazines and software marketing literature may affect the implementation of Intranet/Internet systems and agent software. The results of this study demonstrate the potential lack of tangible performance improvement that may result even when expectations are high.

Keywords: Intelligent agents, decision quality, facilitation/level of technology support, experimental study, decision process/outcome.

Introduction

Currently, the Internet does not adequately address abstract activities such as information management, information representation, or other processing of information (Daig 1995; Lightner et. al. 1996). The volume of information has grown so much that it is almost impossible for a single human to keep up-to-date/make sense of it. The current, conventional search methods do not seem to be able to tackle these problems.

A solution for the problem is the use of intelligent software agents (Wooldridge and Jennings 1996). An agent can be defined as a software program that supports a user with the accomplishment of some task or activity. (Petrie, 1996). Agents can sort through a large volume of data and provide relevant information to the user. Agent technology offers an excellent means to release users of the Internet from lengthy and tedious tasks.

This research is an application of Internet agents in a business environment and is significant in several ways. First, it contributes to the body of research on Internet agents. Second, it is an innovative study of the use of an Internet agent for environmental scanning for international investment decisions. Third, it is an innovative use of the Internet for business purposes. Finally it provides insights in the use of Internet based decision aids. This research is a step in a new direction for decision aids for environmental scanning which is relevant for computer scientists and international business experts alike.

The primary research question of this study is to determine if the use of an intelligent agent for environmental scanning assists a decision maker in international investment decisions.

Scope of the Research

This research is exploratory in nature. No claim is made that this experiment is exhaustive. The specific agent used in this study is an Internet browsing agent system that aids in finding information for the decision making process. Since the agent used in the experiment is a prototype, the focus is on demonstrating potential rather than creating a definitive Internet agent.

Research Model And Hypotheses

Figure 1: Research Model
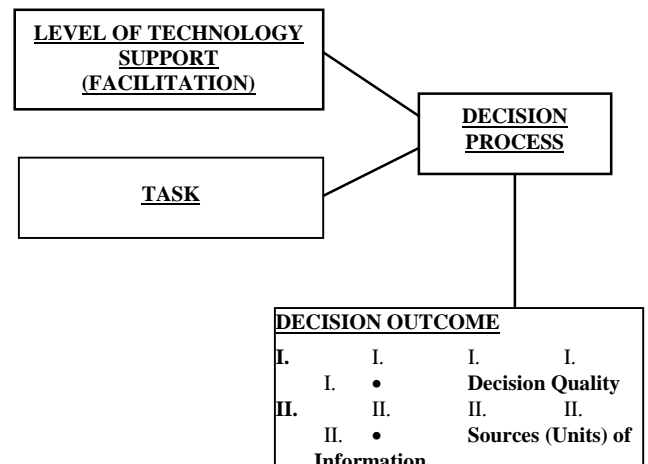
Control Variables

It is important to determine whether the causal relationship between independent variables and dependent variables is due to a causal relationship or it is a product of uncontrolled variables. In order to avoid conflicting results, this study tried to measure and/or control factors that are known from previous research to influence decision performance such as user characteristics and demographic data. In this research, control over concomitant variables is important for a better understanding of the effects of the use of an agent on decision outcomes.

Research Hypotheses

H1: Individuals with the Facilitation support of an Internet agent will produce a solution of higher Decision Quality than will individuals with no Facilitation support.

H2: Individuals with the Facilitation support of an Internet agent will find a higher Percentage of Information than will individuals *with no Facilitation support.*

H3: Individuals with the Facilitation support of an Internet agent will examine less reference sources than will individuals with no Facilitation support.

Research Methodology And Experimental Procedures

This laboratory simulation experiment was conducted making use of a post-test-only control group design. This design, used frequently in educational and psychological research (Campbell and Stanley 1963), compares the effects of a treatment on post-test measures given to an experimental and control group of subjects. To compensate for the absence of a pretest in this design, the most appropriate assurance of the lack of bias between groups is the random assignment of subjects to treatments. The choice of the post-test-only control group design helps to minimize the effects of factors, which may affect the internal validity of the experiment.

Figure 2. Experimental Design

z	TREATMENT	OUTCOME
None	X_{1b}	Y
Yes (Agent)	X_{2b}	Y

FACILITATION		
	Yes	No
Internet/Standard Browser	Agent Treatment	Browser Treatment

Task Description

This study uses a multi-attribute decision problem where all of the available alternatives are pre-defined and relevant information for each factor has to be collected from either the Internet or secondary sources in the library. The task used in this experiment involves the selection of an alternative from a set of pre-defined alternatives valued along several factors. Specifically the decision maker must choose a prospective country for further consideration for international investment. Every effort was made to avoid researcher-bias and subject's hypothesis guessing.

Possible Covariates

The use of covariates is a means of increasing the measurement precision of treatment effects (independent variables) by removing other effects, which are not controlled by the experimental design. These effects should be correlated to the dependent variable are not affected by the treatments. Subjects completed a background questionnaire specifying their background and experience with the task and environment. Some other demographic variables that were gathered were: age, gender, work experience, academic background, business background, computer background, prior use of an agent, use of Internet, familiarity with the task, and so forth. The average age of subjects was calculated. These variables may provide some understanding of the subjects and may be useful for future research.

The responses to the questions regarding previous related experience were used to categorize subjects according to task experience. We also computed the number of students with previous international business experience and those with none. The level of previous related task experience may also be used as a covariate in the statistical analysis to determine if it impacts any of the dependent variables.

Data Collection and Characteristics of Subjects

At the initial stage of the experiment several data items were gathered. For those in the two computer treatments, a computer log of the session was used to collect data. The subjects were undergraduate business school students in a large public university. Students at this level are taking courses that provide an introductory knowledge of computer concepts and several courses that cover basic concepts of management, marketing, finance and economics from an international perspective. In order to minimize the noise introduced by the diversity of skills and experiences of the subjects, students were randomly assigned to each one of the four treatment in a

double-blind fashion. The task was to select a country for further consideration for international investment.

Experimental Setting

The Internet treatments took place in computer labs with over 24 identical personal computers with Internet access, and a Netscape browser. The intelligent agent software selected for this experiment was AgentSoft, which allowed the addition of JavaScript modules. Based on the feedback of the pilot test participants and the recommendations from the dissertation committee members, several changes were done to the agent to provide an easier and more efficient support to the participants and to improve the controls over the experiment.

Following each subject's training and the review of the task experimental materials and tutorials describing the use of the browser and/or agent (if applicable) and country rating concepts, s/he made a country selection using the resources available in the treatment. The subjects were told that they had 60 minutes to complete the task.. After computing the scores the subjects were asked to write a brief memo describing their selection to add some "realism" to the experiment, and to encourage students to take the task more seriously.

Results

Demographic Analysis

Table 1 presents a summary of the demographic characteristics of the subjects in this study.

Table 1. Selected Demographics by Treatment

	Agent	Browser
Number of participants	35	35
Age	23.6857	22.1714
GPA	2.995	2.9645
How computer literate are you? (1-7 scale)	5	5.0857
How comfortable are you with computers?(1-7 scale)	5.3714	5.4
How many computer related courses?	1.5882	2.0571
How many years of Windows experience?	3.7143	3.4857

The preliminary analysis of the data showed that the assumption of homogeneity of variance was valid for all variables but the assumption of normality was violated. Thus ANOVA was used for further analysis. Table 2 summarizes the results.

Table 2. Summary of Results

	** p-value significant at alpha = 0.05	p-value
H1	Under conditions of Internet Information Delivery, individuals with the Facilitation support of an Internet agent will produce a solution of higher Decision Quality than will individuals with no Facilitation support.	.0916
H2	Under conditions of Internet Information Delivery, individuals with the Facilitation support of an Internet agent will find a higher Percentage of Information than will individuals with no Facilitation support.	.08345
H3	Under conditions of Internet Information Delivery, individuals with the Facilitation support of an Internet agent will examine less reference sources than will individuals with no Facilitation support.	.0000**

Discussion And Conclusions

H1: Individuals *with the Facilitation support of an Internet agent will produce a solution of higher Decision Quality than will individuals with no Facilitation support.*

Although the sample means in this study indicate that given Internet Delivery, individuals with agent Facilitation had more accurate scores that those not using the agent, the statistical analysis did not provide sufficient evidence to conclude that Facilitation support of an Internet agent will produce a solution of higher Decision Quality. A possible explanation is that in addition to information availability, there are some other subjective factors involved in assigning a country risk score. It involves, not only finding relevant information, but analyzing this information, and assigning a score. The average score deviation for all treatments was 1.1. This level of accuracy is highly acceptable, given the fact that our subject pool was limited to university students. These scores are highly comparable, considering the fact that risk analysts are experts in political and economic information analysis, and they base their decision in current proprietary and privileged information from the countries they analyze. The comparable level of accuracy of the score suggests that the task was appropriate and had some level of realism.

H2: Individuals with the Facilitation support of an Internet agent will find a higher Percentage of Information than will individuals with no Facilitation support.

Individuals with agent Facilitation found on average more information than those without the agent. However, there was not enough statistical evidence to conclude that under conditions of Internet Information Delivery, individuals with the Facilitation support of an Internet agent will find a higher Percentage of Information than will individuals with no Facilitation support.

H3: Individuals with the Facilitation support of an Internet agent will examine *less reference sources than will individuals with no Facilitation support.*

Individuals with Agent Facilitation referenced a lower average number of web pages than individuals without agent Facilitation. There is a significant difference in the number of sources referenced. The only variable that had a dramatic difference was the number of sources visited. Agent-facilitated individuals consulted significantly more references that those without Facilitation. Agent-aided subjects visited, on average, less web pages (30.4) than those with no Facilitation (59). Sources of information are counted as unique web pages, that is, a web page is counted once, regardless of the number of times the same page was visited. This criteria was used to avoid that frequently visited web pages inflate the total count. For instance, a subject may go back to a search engine home page several times to conduct a new search, or subjects in the treatment may go back to the agent's home page. This result was expected and after analyzing the Netscape history files it was noted that subjects without agent Facilitation had to navigate through the results provided by search engines to discriminate which information was relevant. They also performed repeated searches from the same search engine home page. It was expected that the use of an agent would allow the decision maker to examine more pieces of information, and rapidly scan through those relevant to the problem at hand, and thus reducing the number of times the same piece of information is re-examined. With respect to the total number of units, if the number of items referenced is lower, it may be explained by the fact that the use of an intelligent browser directs the subject straight onward to the most relevant information, instead of wandering around examining irrelevant information.

This finding is important because, even though the subjects using the agent visited fewer web sites, their performance results did not reflect this saved effort. The agent provided relevant information at their fingertips and just visited the web sites provided by the agent while subjects with no agent Facilitation had to visit double the number of web sites to find equivalent information. Our assumption was that if subjects had to spend less time searching for information, they would have more time to analyze the available information; therefore, the quality of the solution would be better. However, it is surprising that, although those using the agent did not spend as much time looking for the information as the time spent reading and analyzing the information, this was not reflected in the performance variables. Both treatment groups completed about the same percentage of the task and the accuracy of the scores was comparable. Further research is necessary to determine why the effects on performance were not demonstrated.

Those individuals in the agent treatment tended to visit only those web sites suggested by the agent and did not browse beyond although they were told several times that the agent links were only a starting point, and they were encouraged to follow these links and go beyond the listed web sites. Subjects were satisfied after obtaining the results from the agent and were not willing to put any additional effort. The agent helps people find and focus on the most relevant information. People need some kind of filter, and if subjects did not browse beyond, it is because the agent is providing relevant results.

This finding is important because even though the subjects using the agent visited fewer web sites, their performance levels were not significantly better. The agent effect can be seen in terms of efficiency: individuals found the same amount of information (percentage of items) consulting fewer sources (less effort).

Another possible explanation for the fact that subjects did not browse beyond the hyperlinks provided by the agent provided may be the artificiality of the setting. Subjects reasoned "the agent is conducting the information search, if the agent is 'intelligent', and the agent report contains relevant links, why should I browse beyond? Simon's (1969) satisficing theory may be a plausible explanation for this attitude. He asserted that due to the limited information processing capacity of the individual it is impossible to make truly rational (i.e., utility maximizing) decisions in all but the most simplistic environments. Simon suggests that when an acceptable solution to a problem is found, the search for alternative solutions is stopped, and the solution is adopted although it may not be the optimal solution. Thus, subjects obtained the results from the agent and were "satisfied" with the information provided and did not consider it necessary to spend more effort in searching for more information. Additional research is required to more fully investigate how browsing behavior is influenced by Internet agents. Future research needs to focus on the goal of helping companies understand the design, development and implementation of agent technologies in the new millennium.

Implications of This Study

Greater understanding of the use of agents and the Internet for information gathering and decision making can provide valuable information to software developers and implementers. From a research perspective, there are two arguments for the study's justification. First, research on Internet agents in the Information Systems literature is almost nonexistent. Additionally, the research that has been conducted in Computer Science is more technical in nature.

It has been proposed that Internet Delivery is a proven way to improve information deployment and knowledge

sharing in organizations. However, more understanding is needed of the effects of Information Delivery in decision making and how Information Delivery is influenced by other variables. Many companies have implemented Intranet sites after high economic investments expecting improved information deployment and ultimately better decision making. However, developers and implementers should take into account other issues in addition to the technical ones. It is important to train and educate employees and managers to take full advantage of Agent technologies. Managers read articles that promise increases in revenue and productivity by implementing agent technology and they want to implement the same technologies in their companies. However, they may have no clear vision of how agents can enhance existing processes or improve information deployment.

Unrealistic high expectations promoted by computer trade magazines and software marketing literature may affect the implementation of Intranet/Internet systems and agent software. The results of this study demonstrate the potential lack of tangible performance improvement that may result even when expectations are high.

Before implementing a new Internet technology, managers and users should be aware that a new technology does not guarantee improved productivity just by itself. In the present experiment, the implementation of an agent did not result in productivity improvements. If the agent effect did not exist in reality, then the implication is that implementing the most expensive or the more sophisticated Intranet system may not necessarily provide benefits reflected in improved productivity; in fact, a less costly system may provide the same productivity level. There are instances where systems may be implemented as easily, without using sophisticated agents. It is really important to carefully plan agents' implementation in order to truly increase productivity and reduce the risk of implementation failure.

Limitations of This Study

Every research involves inevitable tradeoffs resulting in certain limitations. As in all research of this nature, the findings from this experiment are based on the software (browser and agent) and the task used in the experiment. The agent is task specific, and the result can not be generalized without caution. The results have a specific agent bias. Caution should be exercised when applying the findings to other situations.

Future Research

The results from this study raise several issues that need to be addressed in future research. Although this study has not analyzed all aspects involved with Information Delivery and Facilitation, an attempt to study all of the aspects in one single study may only produce

unclear results. A program of research may be implemented after analyzing the results of this study. The review of avenues of future research identifies questions that have been prompted by this experiment and provides suggestions for future studies. Future research should examine these problems more carefully in a an effort to gain understanding on the effects of Information Delivery and Facilitation. Avenues for future research proceed in four directions. They include:

1. The replication of this experiment with other categories of agents.
2. The replication of this study implementing a different task type.
3. The replication of this experiment without a time limit restriction.
4. The replication of this study in a field setting.

Further research should also be undertaken that tests other agent categories. The agent used in this experiment was an information retrieval agent, and it was not "intelligent" since it was not based on Artificial Intelligence techniques. Future experiments may use an agent that is truly intelligent, or may test other categories of agents such as mobile agents, electronic commerce agents, and so forth.

Another study that may further explain the relative usefulness of different agents could involve a within-subjects design. Each subject would use each one of the agents and rate the ease of use and usefulness of each system. The different characteristics of the agent systems could be determined and its effects evaluated.

Extensions of this research in the laboratory environment might involve the modification of the time limitations. A total of 60 minutes was given to subjects to search for information. It would be interesting to conduct an experiment with no time constraints for the search stage. The lack of significant differences in performance may be attributed to the fact that the time was artificially constrained to 60 minutes and this limitation did not allow for the effects to make a difference. For example, in medical research, studies look at only five years when considering survival rates; by limiting the time frame, studies overlook any effects after the time frame.

Given the length of time permitted, one may question if the observed differences would persist over time or if they are transitory reactions to the experimental setting. Further studies should consider the following question: In a real environment, would users of an agent develop more skills and perform even better than users of a standard browser? To investigate this question, future research may be used to evaluate the duration of the effects in a longitudinal study and observe if variables behave differently across time. It would be interesting to conduct a longitudinal study in order to analyze how Decision Time evolves. It can be assumed that initially, users would

spend more time to get to the solution because of lack of familiarity with the agent.

An additional avenue for future research mentioned earlier involves the replication of this study in a field setting. In a field setting, problems associated with time constraints and artificiality of the task may be reevaluated. Results from this experiment may be used to undertake a study in a more realistic setting. An appropriate setting for a field study might be company that has implemented an Intranet. Employees and decision makers would access the Intranet on a daily basis, and agents would facilitate information deployment and provide access to the most relevant information for the task at hand. Multiple agents would be customized to serve several functional areas.

References

Campbell, D. and Stanley, J. *Experimental and Quasi-Experimental Designs for Research*. Chicago: Rand McNally, 1963.

Daig L. Position Paper, ACM SigComm'95 - MiddleWare Workshop, April 1995.

Lightner, N.J., Bose, I. and Salvendy, G. "What is wrong with the World Wide Web? A Diagnosis of Some Problems and Prescription of Some Remedies," *Ergonomics* (14), 1996.

Petrie, C. "Agent-Based Engineering, the Web, and Intelligence," *IEEE Expert*, December 1996, pp. 24-29.

Simon, H.A. *The Sciences of The Artificial*, MIT Press, Cambridge, MA, 1969.

Wooldridge, M. and Jennings, N. "Intelligent Agents: Theory and Practice," *The Knowledge Engineering Review* (10:2), 1996, pp. 115-152.