Importance of Interface Agent Characteristics from End-User Perspective

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ABSTRACT

This article reports on an empirical investigation of user perceptions of the importance of several characteristics of interface agents. Interface agents are software entities that are incorporated into various computer applications, including electronic mail systems. As evidenced by the growing body of empirical studies and the increasing number of interface agent-based applications on the software market, there is a strong need for the development of this technology. According to a meta-review of agent-related literature by Dehn and van Mulken (2000), there are several characteristics of interface agents that require special attention from agent developers. However, prior to this study, the importance of these characteristics from the end-user perspective remained unclear. In order to identify the significance of these characteristics, a group of actual users of an e-mail interface agent was surveyed. The results indicate that information accuracy and the degree of the usefulness of an agent are the most salient factors, followed by user comfortability with an agent, the extent of user enjoyment, and visual attractiveness of an agent. The implications of the findings for both theory and practice are discussed.

Keywords: human-agent interaction; interface agents, end-users, survey

INTRODUCTION

To create an artificial being has been a dream of men since the birth of science. Professor Hobby (William Hurt) in "Artificial Intelligence" (Spielberg, 2002)

For thousands of years, people have thought of someone doing basic tasks for them. That could be a robot, a cyborg, or a well-trained pet. Not until the beginning of the 21st century did it become possible.

Now, with the recent development of telecommunications networks and computer technologies, a new type of software application plays the role of virtual assistants that potentially may alleviate some of the problems associated with the employment of software systems. This class of applications often is referred to as intelligent agents, software agents, avatars, or interface agents. As demonstrated by the growing body of academic literature and by the increasing number of agent-based software applications on the market, there is increased interest in the creation of such software entities. In this article, these software systems are labeled as interface agents.

Interface agents emerged from the recent developments in the field of intelligent agents. The idea of software agents was first introduced by John McCarthy (1956, 1958) and later coined by the MIT Lincoln Laboratory computer scientist Oliver Selfridge. In the 1980s, this concept was explored by agent visionaries such as Marvin Minsky and Alan Kay and further utilized in the recent classic works of Pattie Maes, Nicolas Negroponte, Jeffrey Bradshaw, Hyacinth Nwana, and Divine Ndumu. The past few years have witnessed the rapid development of prototypes and working models of intelligent agents, many of which already are incorporated in end-user commercial applications. A number of recent studies demonstrate the fruitfulness and viability of using agent-based technologies in various areas; for example, in automatic negotiation (Castro-Schez et al., 2004; Fatima et al., 2005), natural-language customer support services (Lester et al., 2004), education (Takacs, 2005), and user notification systems (Horvitz et al., 2003). Some academics have shifted their research from human-agent interaction to human-agent cooperation (Rickel & Johnson, 2000; Rickel et al., 2002) and man-machine symbiosis (Klein et al., 2004; Lesh et al., 2004; Lesh et al., 1999), when the human user and the software agent collaborate toward achieving shared goals.

In terms of this article, an interface agent is defined as an autonomous (i.e., independent), continuous (i.e., long-lived), reactive (i.e., it monitors an external environment and reacts to any changes), and collaborative (i.e., it cooperates with other software processes or agents) software entity that exhibits strong visual or audio presence in the computer interface and that communicates with a user directly (i.e., by bypassing intermediaries) (Detlor, 2004; Lieberman & Selker, 2003; Serenko & Detlor, 2004). "Interface agents draw their strength from the naturalness of the living-organism metaphor in terms of both cognitive accessibility and communication style" (Laurel, 1997, p. 68). Typically, interface agents are personalizable and implemented in the form of humanlike or cartoonlike animated characters, electronic figures, graphical user interfaces, textual boxes, or any other visual components (Godoy et al., 2004; Schiaffinoa & Amandi, 2004).

Having the available agent technology is insufficient; it also should be accepted and utilized appropriately by its target users. For the past 10 years, there have been various attempts to understand

what people like or dislike in interface agents and why they adopt or reject them. The goal of this stream of research is to develop a valid, complete list of characteristics that interface agents should possess that would warrant the end-user acceptance of this technology.

By performing a meta-analysis of the human-computer interaction literature, Dehn and van Mulken (2000) presented a comprehensive yet exhaustive list of characteristics of interface agents that potentially may influence the human-interface agent interaction process. Most of these characteristics are drawn from various independent investigations conducted in laboratory settings. At the same time, no study reports how real-life users value the characteristics of an interface agent-based technology. In order to bridge that void, the present investigation attempts to solicit and to analyze the opinions of interface agent users on several key characteristics of the technology. It is assumed that this information potentially may improve the quality of the technology and the way it is delivered to the customer. For example, if agent manufacturers could know what interface agent characteristics are more or less important for users, they would be able to concentrate their short-term efforts to improve positive user perceptions of these characteristics. This, in turn, might increase user satisfaction with agent-based technology and accelerate the rate of innovation diffusion.

As such, Dehn and van Mulken (2000) classified the various characteristics of interface agents (e.g., the user's subjective experience of the system, the user's behavior while interacting with the system, and the outcome of the interaction). Each category includes several factors. However, it is not viable to investigate the importance of these characteristics applied to all types of interface agents in a single project. Since interface agents may be incorporated in the form of personal secretaries, Internet guides, electronic commerce assistants, or educators, a separate study is required for each kind of interface agents. It is believed that interface agents embedded in different types of software environments may require certain system-specific features and facets. For example, users who work with an interface agent that facilitates online shopping may look for effectiveness and efficiency. In contrast, people who employ an interface agent as entertainers may emphasize the aspect of enjoyment over that of effectiveness or efficiency.

With respect to the present study, interface agents for electronic mail were chosen for two reasons. First, e-mail is an important telecommunications medium that is utilized heavily by both individuals and organizations. However, today's e-mail systems provide inadequate support for constantly changing user needs, fail to convey ambiguous content and human emotions, overload people with continually growing flows of unstructured information, and exhibit an inefficient direct manipulation interface. As a result, many individuals feel frustrated utilizing e-mail. The use of interface agents is a potential solution to the currently challenging task of e-mail management. Second, the software market presents several versions of interface

agents that have been delivered to end users. Currently, most other types of interface agents have been realized in the form of pilot studies, working prototypes, or beta versions. This identifies the opportunity to reach the actual users of this technology and to poll them directly. It is for these reasons that interface agents for e-mail were selected.

A review of the general characteristics of interface agents presented by Dehn and van Mulken (2000) allowed the identification of several factors that were believed to be applicable to the e-mail environment. Table 1 offers a list of these characteristics. However, little is known about how important these characteristics are for the actual users of e-mail interface agents. As noted by Dehn and van Mulken (2000), the results of the empirical studies that identified these characteristics appear to be mixed and inconsistent.

To bridge this void and to rank the importance of the previous characteristics, this study polled the actual users of e-mail interface agents. It was believed that the end users who have utilized this technology for a long period of time may present valid and reliable information that will be of interest to agent researchers and developers. The following research question was proposed:

How important are the characteristics of e-mail interface agents identified in Table 1 from the end-user perspective?

METHODOLOGY AND RESULTS

In order to answer the study's research question, a survey of current and past users of an interface agent-based application for e-mail was conducted. Despite the extensive work underway in the incorporation of interface agents in e-mail applications, most previous studies and projects have been realized in forms of conceptual discussions, preliminary empirical investigations, and pilot systems (Bergman et al., 2002; Dabbish et al., 2005; Florea & Moldovanu, 1996; Griss

Table 1. Characteristics of interface agents

N	Characteristics
	With respect to interface agents for e-mail, it is important for users:
1	to believe that an interface agent's appearance should correspond to its level of intelligence.
2	to believe that the information provided by an interface agent is accurate.
3	to like the appearance of an interface agent.
4	to feel comfortable with an interface agent.
5	to perceive an interface agent useful.
6	to perceive an interface agent enjoyable.
7	to perceive all interactions with an interface agent as natural.
8	to avoid being distracted by an interface agent while engaged in important tasks.

Table 1. Characteristics of interface agents

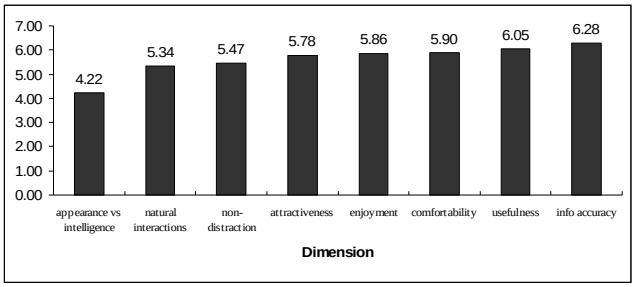
et al., 2002; Gruen et al., 1999; Lashkari et al., 1994; Maes, 1994; Voss, 2004) rather than in end-user products. E-mail notification applications are one of the first commercial systems that utilize interface agent technologies in the electronic mail environment. This type of interface agents was chosen to conduct a user survey. Out of all commercially available interface agent systems for e-mail, Blind Bat Software was chosen randomly by the researcher, the executives of the company were approached, and agreement was reached. The list of customers who potentially might serve as the study's participants was sent to the researcher. Figure 1 presents a screenshot of the software product.

In order to poll e-mail agent users on their perceptions of the importance of the characteristics of interface agents, a survey instrument was designed. The questionnaire provided basic instructions, a definition of an interface agent for e-mail, and several screenshots of the agent developed by Blind Bat. Users were asked to indicate their opinion on perceptions of the importance of agent characteristics outlined in Table 1. Particularly, the question stated, "Based on your experience with interface agents for e-mail, how *important* is it for you?" After this, eight statements were provided, measured on a seven-point Likert-type scale ranging from *totally unimportant* to *very important*. In addition, demographic information was solicited. The data for this investigation were collected as part of a larger project conducted by Serenko (2005).

By utilizing the total design method (Dillman, 1999), the four-phase survey process was developed. As such, all respondents were e-mailed an initial request to participate in the study and then three follow-up reminders. Fifty-nine usable responses were obtained. An acceptable response rate was achieved. Note that the actual response rate may not be revealed as per the nondisclosure agreement with Blind Bat Software.

Eighty percent of the surveyed users were male, and 20% were female. Over 65% of all users were between 31 and 50 years old, and the 46-to-50-age category was the most frequent user group. Over one-half of the respondents were occupied in the information technology sector; most of them were well-educated and financially well-off and demonstrated a high degree of personal innovativeness in the domain of IT. According to Rogers (2003), this group of people corresponds to innovators, who constitute 2.5% of all people that adopt a particular product or service.

Figure 2. User perceptions of the importance of interface agent characteristics



Recall that respondents were asked to rate their perceptions of the importance of eight characteristics of interface agents on a seven-point Likert-type scale. The purpose was to understand what characteristics were more or less imperative from the end user's point of view. Figure 2 visualizes the results, and Table 2 presents the list of questions sorted by the mean.

To analyze whether there were differences in these eight means, the ANOVA test was conducted. The goal of this statistical method is to determine the existence of differences among several population means (Aczel, 1996). This technique is an extension of the two-sample *t* test. The results demonstrated that there was a high degree of confidence that at least some of the means differed from one another ($F = 12.846$, d.f. between = 7, d.f., within = 456, significance level = 0.000). To measure the practical value of the detected differences, the effect size was calculated as the ratio of sum of squares between the sum of squares total. The effect size was very strong ($\eta^2 = 0.16$).

After it was determined that differences existed among the means, the Tukey Honestly Significant Difference test was done by using SPSS. The Tukey post hoc test is a statistical method of pairwise com-

Table 2. User perceptions of the importance of interface agent characteristics

Based on your experience with interface agents for e-mail, how important is it for you:	**Mean**	**Std dev**
to believe that the information provided by an interface agent is accurate?	6.28	1.04
to perceive an interface agent as useful?	6.05	1.13
to feel comfortable with an interface agent?	5.90	1.10
to perceive an interface agent as enjoyable?	5.86	1.13
to like the appearance of an interface agent?	5.78	1.17
to avoid being distracted by an interface agent while engaged in important tasks?	5.47	1.74
to perceive all interactions with an interface agent as natural?	5.34	1.36
to believe that an interface agent's appearance should correspond to its level of intelligence?	4.22	1.86

parisons of the population means. It allows the comparison of every possible pair of means using a selected single level of significance. With respect to this study, the 0.1 significance level was chosen. The test yielded a matrix where asterisks (*) indicated significantly different group means at an alpha level of 0.1. Table 3 presents the results of mean comparisons.

Based on these results, several statistically significant differences in item means were observed. Overall, the means of the questions positioned on the left-hand side and right-hand side of Figure 2 strongly differed from one another. This demonstrated a strong degree of confidence that respondents were able to distinguish among the questions and that the results presented in Figure 2 were statistically sound.

DISCUSSION AND CONCLUSION

Recall that the purpose of this study was to obtain strong empirical evidence on the importance of interface agent characteristics to bridge the gap in the human-agent interaction literature. The results of the survey showed that trust in an agent (i.e., information accuracy) as well as an agent's utility (i.e., the persona effect) were the most important factors from the end user's point of view. They were followed by the degree of conformability and enjoyment with an agent.

First, agent users believed that the accuracy of any information provided by an agent was the most critical factor. This finding is consistent with prior research that points out the importance of trustworthiness in human-agent interaction (Bickmore & Cassell, 2005; Bickmore & Picard, 2005; Hertzum et al., 2002). Indeed, in order to delegate tasks to an agent, a person must believe that the agent will perform them accurately and report back the true rather than the desirable state.

Second, respondents indicated the significance of an agent's usefulness. This, again, is consistent with prior empirical research and speculations on the importance of the persona effect in agents. The persona effect emerges when an interface agent adds the positive perceptions of usefulness, ease of use, or enjoyment with an existing system. The key outcome of the persona effect is the improvement of existing software applications by embedding interface agents. By emphasizing the importance of an agent's usefulness, subjects demonstrated that value-added services were the key factors influencing their adoption decisions.

Third, perceptions of the importance of comfortability and enjoyment with an agent were also high. The extent to which a user feels comfortable employing an agent partially corresponds to the ease of use of the agent.

Fourth, items pertaining to non-distraction and the naturalness of interactions received lower scores. Prior work suggests that a user should perceive all interactions with an agent to be natural, and the agent is not supposed to disrupt current user activities. However, this item received a lower score compared with information accuracy, usefulness, comfortability, and enjoyment.

Table 3. The Tukey test

(I) CHARACTERISTIC	(J) CHARACTERISTIC	Mean Difference (I-J)	Sig.
1 appearance corresponds to the level of intelligence	2	-2.05(*)	.000
	3	-1.55(*)	.000
	4	-1.67(*)	.000
	5	-1.83(*)	.000
	6	-1.64(*)	.000
	7	-1.12(*)	.000
	8	-1.24(*)	.000
2 information accuracy	1	2.05(*)	.000
	3	.50	.486
	4	.38	.800
	5	.22	.986
	6	.41	.719
	7	.93(*)	.006
	8	.81(*)	.028
3 attractiveness	1	1.55(*)	.000
	2	-.50	.486
	4	-.12	1.000
	5	-.28	.956
	6	-.09	1.000
	7	.43	.674
	8	.31	.920
4 comfortability	1	1.67(*)	.000
	2	-.38	.800
	3	.12	1.000
	5	-.16	.999
	6	.03	1.000
	7	.55	.353
	8	.43	.674
5 usefulness	1	1.83(*)	.000
	2	-.22	.986
	3	.28	.956
	4	.16	.999
	6	.19	.995
	7	.71(*)	.092
	8	.59	.275
6 enjoyment	1	1.64(*)	.000
	2	-.41	.719
	3	.09	1.000
	4	-.03	1.000
	5	-.19	.995
	7	.52	.440
	8	.40	.761
7 natural interactions	1	1.12(*)	.000
	2	-.93(*)	.006
	3	-.43	.674
	4	-.55	.353
	5	-.71(*)	.092
	6	-.52	.440
	8	-.12	1.000
8 little distraction	1	1.24(*)	.000
	2	-.81(*)	.028
	3	-.31	.920
	4	-.43	.674
	5	-.59	.275
	6	-.40	.761
	7	.12	1.000

Finally, in contrast to prior research, respondents stated that the appearance of an agent should not necessarily correspond to its level of intelligence. Two assumptions may explain this contradiction. First, highly innovative individuals might wish to utilize an agent that looks maximally intelligent, regardless of its actual degree of intelligence. Second, if users were not satisfied with the agent's appearance, they easily might install another one, given that there is a variety of cartoon or humanlike agent characters available on the Web. Thus, end users had control over the interface of an agent that reduced their perception of the importance of the agent's appearance.

These findings are important for both theory and practice. With respect to theory, the investigation discovered some discrepancies between the view of agent researchers and the opinion of real-life users. With regard to practice, it is suggested that agent designers begin emphasizing the more important characteristics of e-mail interface agents in their products. In the short term, they need to concentrate their efforts on the development of interface agents that provide accurate and reliable information and are perceived to be really useful by the end users. After the issues of information accuracy and usefulness are addressed, agent developers may attempt to improve several other characteristics of interface agents. They may improve the degree of user comfortability with the software, increase user enjoyment, and advance the visual appeal of an agent. In the long term, agent manufacturers may want to decrease the degree of an agent's intrusiveness and facilitate the naturalness of human-agent interactions. However, it is unlikely that they will need to create an interface agent whose appearance would correspond to its level of intelligence. Instead, they should offer a variety of agent interfaces and leave it up to the end users to decide which one to utilize.

Overall, this investigation is one of the first documented attempts to explore the importance of interface agent characteristics by polling the actual users of this technology. The author hopes that other researchers will continue to explore this field that will lead to the creation of really useful interface agents.

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