Will Anthropomorphic Intelligent Agents Be Perceived More Intelligent?

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ABSTRACT

As the usage of intelligent agents increase, understanding end-user perceptions becomes necessary to enhance human-computer interactions. The goal of this research will be to create congruency between an intelligent agent and the human category schema through the addition of gender and anthropomorphic features (personality, voice, and a virtual face) and to see how the user's perception of the intelligent agent's intelligence is affected as a result. Assuming the hypotheses are supported, designers can choose to include or exclude certain features in order to increase the perceived intelligence of intelligent agents.

KEYWORDS

Anthropomorphism, Perceived Intelligence, Intelligent Agents, Schema Theory

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1 INTRODUCTION

Intelligent agents (IA) like Siri, Amazon Alexa, and Google Assistant are becoming integrated into everyday life. Siri, the agent accessible on any iPhone, can give directions, find music, and can search for just about any question you may have. Alexa can tell you how your morning commute will be, brief you on current events, and tell you the weather forecast, just by saying "Good morning." Google Assistant can map out your commute to work, send it to your mobile device, and reroute you according to live traffic alerts.

As the usage of intelligent agents increases, understanding end-user perceptions becomes necessary to enhance human-computer interactions. In this paper, we will be looking into how perceptions of anthropomorphism impact users' perceptions of intelligence of intelligent agents (IA). Understanding what features may affect users' perceived intelligence of agents can help designers of intelligent agents make decisions on which features to include or exclude. It has been found that higher human-likeness of embodied agents increases perceptions of the agent's knowledge, which in turn increases the effectiveness of the agent [12]. We would like to extend these findings to intelligent agents through schema-based anthropomorphism. Specifically, we aim to explore the effect of varying levels of anthropomorphism of an IA – manipulated through the addition of physical features – on users' perceived intelligence of the agent.

Current research has looked into the effect perceived intelligence has on perceived anthropomorphism and the derivation of the respective measurement scales [14], along with the correlation between animacy and perceived intelligence [3], but there is little to be said on the effect anthropomorphism has on perceived intelligence of intelligent agents. To help understand the reasoning behind the effect of anthropomorphism on perceived intelligence, schema theory is used to explain how users anthropomorphize agents.

In this paper, we propose an experiment and use three anthropomorphic features (voice, personality, animated face) to vary the levels of anthropomorphism of IA's as follows: little to no anthropomorphism, low level of anthropomorphism, medium level of

anthropomorphism, high level of anthropomorphism. Additionally, the agents will have both male and female versions. The goal of this research will be to explore the addition of features to IA's and the effect these features will have on users' perceptions of the IA's intelligence.

2 THEORETICAL BACKGROUND

2.1 Schema Theory as a Basis for Anthropomorphism

Animacy, as defined by the Oxford Dictionary, is "having life, lifely" [15]. It has been shown that there is a significant correlation between animacy and perceived intelligence of robots [3]. While animacy is broadly covering all forms of life, in this paper, we would like to focus on human animacy, as intelligence is closer associated with humans rather than animals. To perceive something as having human animacy implies having the perception of human life. Therefore, human animacy can be directly linked to anthropomorphism.

Anthropomorphism is generally defined as the human tendency to attribute human-like characteristics to objects. In this paper, we will be discussing anthropomorphism in the context of intelligent agents.

Schema theory has been used to provide a theoretical basis for anthropomorphizing objects [1]. Schema theory refers to the cognitive framework of prior knowledge stemming from experiences a user has with a network of topics. A specific category schema is a cognitive instance of that category, and acts as a guide for the processing of new information and retrieval of stored information [6]. Previous research has shown that congruity between an item and that item's category schema affects the evaluation of that item [16]. Specifically, congruity between an IA possessing human features (i.e. face, voice, personality) and the human category schema will result in the attribution of human category schema characteristics, both positive and negative. For example, packaging shaped like an ideal human body activates human schema, which in turn results in favorable product evaluation [4].

With schema theory and IA's in mind, we will define *schema-based anthropomorphism of intelligent agents* as the tendency of humans to activate the human category schema when interacting with an intelligent agent. Depending on the IA's level of congruency to human schema (manipulated by certain features), users may experience a different level of anthropomorphism.

2.2.1 Relevant Anthropomorphic Features. In order to vary anthropomorphism, there is a necessity to designate specific features to manipulate. There are conflicting discussions on methodologies used in distinguishing which features should be manipulated [11], as creating anthropomorphic objects entails an infinite number of possible features. Any combination or variation to specific features may result in different levels of anthropomorphism. To avoid this, we chose features that enhance interaction and are essential to human communication.

In this paper, we will use three anthropomorphic features: *voice*, *personality*, and a *virtual face*. These three features are specific to human interaction. With the addition of each feature, the agent becomes more congruent with the human schema, and therefore, users are better able to anthropomorphize the agent.

2.2 Perceived Intelligence of Intelligent Agents

The definition of intelligence, given by Merriam Webster is "the ability to apply knowledge to manipulate one's environment or to think abstractly as measured by objective criteria," as well as "the ability to learn or understand or to deal with new or trying situations" [13]. Intelligence in the context of IA implies an agent that possesses autonomy, adaption to change, natural language processing, awareness of environment, knowledge representation, machine learning, and pro-activeness [14; 17]. Perception of the intelligence of IA will vary depending on the specific user's perception of the ability of the agent to meet a combination of these definitions. As such, in the context of this paper, we will be adopting Moussawi and Koufaris' (2019) definition of *perceived intelligence* as the formed perceptions about the extent to which an intelligent agent's behavior is efficient, useful, goal-directed, and autonomous with an

effectual output and an ability to produce and process natural language [14].

2.3 Hypotheses Development

Similar to the correlation between animacy and perceived intelligence, we expect an intelligent agent's level of anthropomorphism, or congruency to the human category schema, to affect the user's perception of intelligence. When users anthropomorphize agents, they imbue features or characteristics to that agent that are drawn from their human category schema. In doing so, users may assume the agent possesses qualities that are not present. For example, an IA that communicates through a voice and a virtual face may be perceived more intelligent than the same IA that only communicates through text.

Using the knowledge of schema-based anthropomorphism of intelligent agents, and our definition of perceived intelligence we theorize that congruency with human category schema will cause users to associate anthropomorphic IA's with higher levels of perceived intelligence, as compared to non-anthropomorphic IA's. Hence, we propose the following hypotheses:

H1: Users that perceive higher levels of anthropomorphism in an intelligent agent will perceive that agent to have higher levels of intelligence.

H2: Users that perceive lower levels of anthropomorphism in an intelligent agent will perceive that agent to have lower levels of intelligence.

3 RESEARCH DESIGN

3.1 Overview

The study will consist of eight intelligent agents. Each IA will have the same intelligence capabilities, i.e. autonomy, adaption to change, natural language processing, awareness of environment, knowledge representation, machine learning, and pro-activeness. Each IA will have their own level of anthropomorphism, varied by usage of the following features: voice, personality, and virtual face. Additionally, to make the results more generalizable, the agents will have a male and female version. Both the male and female agents will replicate the following design: IA-1 (Little to No Anthropomorphism) will interact with the user through *text*. IA-2 (Low Level of Anthropomorphism) will interact with the user through *text* with the addition of a *personality*. IA-3 (Medium Level of Anthropomorphism) will interact with the user through *text*, and *voice*, with the addition of a *personality*. Lastly, IA-4 (High Level of Anthropomorphism) will interact with the user through *text*, and *voice* with the addition of a *personality* and a *virtual face*.

This study will be a 2 x 4 between participant study (Male/Female x Level of Anthropomorphism). The participants will be randomly assigned to eight groups and will be asked to individually interact with an IA for 15 minutes. After their interactions, participants will complete a survey that will measure the perceived anthropomorphism of the agents as a manipulation check, as well as the perceived intelligence of the IA.

3.2 Participants

Postings will be made for undergraduate students, graduate students, and staff members at local universities in the US. The study will be conducted in English, and participants are expected be fluent in English.

3.3 Materials

3.3.1 Intelligent Agent (IA- 1, 2, 3, and 4). To ensure consistency, the IA used throughout the study will possess the same base features, and intelligence capabilities, i.e. autonomy, adaption to change, natural language processing, awareness of environment, knowledge representation, machine learning, and pro-activeness. The base IA, or IA-1, will be communicating with the user via text only and will intentionally lack personality, and thus represents the lowest level of anthropomorphism. A sample script highlighting the difference between IA-1 and IA- 2, 3, and 4 can be seen in Table 1.

3.3.2 Personality (IA- 2, 3, and 4). Extraverted personalities, one of the Big Five Personality Traits, can be associated with outgoing, sociable and

enthusiastic behavior [9]. Extraverted individual's word choice tends to be positive, informal, with short phrasing and more pronouns, and self-references [8].

Previous research has shown that the extraversion of agents positively influences social presence [10]. Therefore, by giving the IA an extraverted personality, the social presence of the agent increases, and the agent is more aligned with the human schema. As a result, the addition of a personality will increase the user's level of anthropomorphism. IA-2, IA-3 and IA-4 will all have a personality in order to increase the level of anthropomorphism. See Table 1 for a comparison of text with and without personality.

Table 1. Sample Script of IA-1 versus IA- 2,3,4

IA-1 – Text Only:

User: Can you give me the weather forecast for today?
IA-1: Pittsburgh will have a high of 55 °F and a low of 33 °F with a chance of rain.
User: Thank you.
IA-1: You are welcome.

IA-2,3,4 – Text with Extraverted Personality:

User: Can you give me the weather forecast for today?
IA-2,3,4: Of course I can! The weather in Pittsburgh will be have a high of 55 °F and a low of 33 °F with a chance of rain. Don't forget your umbrella!
User: Thank you.
IA-2,3,4: I am glad to help!

3.3.3 Voice (IA- 3 and 4). The addition of voice to an intelligent agent will simulate an interaction between two humans. As a result, the addition of voice will further align the agent with the human category schema. Additionally, the voice added will mimic the personality of the IA.

Extraverted individuals speak at a faster pace, louder, and have a greater range of voice frequency than introverted individuals [2;18]. Because there will be both Male and Female versions of IA-3 and 4, the agents will incorporate the following voice features adopted from Hess et. al (2009) and modified for two genders: fast pace (165 words per minute); large range of frequency; higher pitch (100 hertz for male voice and 210 hertz for female voice) [19]; volume: (60 decibels) – max of 65 decibels [10].

3.3.4 Virtual Face (IA - 4). The last feature that will be added to the IA is a virtual face. By adding a virtual face to the agent, the user interacting with the IA will have the ability to speak "face to face" with the agent. This will increase the IA's congruency with human schema. IA-4 will be the highest level of anthropomorphism, as it will have all of the features previously listed.

The virtual face of the agent will be displayed through Haptek's PeoplePutty which is a software that displays faces through script and allows for expressions and gender. There will be two faces, one male and one female, for both IA gender types. The virtual faces will show facial expression that match the context of their interaction. Extraverted individuals are more expressive in their interactions [5], therefore the IA will be expressive.

3.4 Procedure

Participants will be asked to interact with a randomly selected IA type (gender and anthropomorphic level) for 15 minutes. During their interaction, the participant will be given a set of questions that they will need to ask the IA. These questions will be a set of simple, fact-based questions that will ensure the IA is successful in answering them. See Table 2 for sample questions.

Table 2. Sample Questions

1. "Can you give me the weather forecast for today?"
2. "What is the top song in the U.S. right now?"
3. "How many planets are in our solar system?"
4. "Who was the emperor of Rome in 55AD?"

Once the 15 minutes of interaction is over, the participant will be asked to complete a short survey measuring the perceived anthropomorphism the user experienced and the perceived intelligence of the IA.

3.5 Measures

In order to measure perceived intelligence and perceived anthropomorphism, we adapt Moussawi and Koufaris' (2019) measurement scales originally developed in the context of personal intelligent agents, as shown in Table 3 and Table 4 [14].

Table 3. Measurement Scale for Perceived Anthropomorphism	
PA1.	The intelligent agent is able to speak like a human.
PA2.	The intelligent agent can be happy.
PA3.	The intelligent agent can be friendly.
PA4.	The intelligent agent can be respectful.
PA5.	The intelligent agent can be funny.
PA6.	The intelligent agent can be caring.

Table 4. Measurement Scale for Perceived Intelligence	
PI1.	The intelligent agent can complete tasks quickly.
PI2.	The intelligent agent can understand my commands.
PI3.	The intelligent agent can communicate with me in an understandable manner
PI4.	The intelligent agent can find and process the necessary information for completing the tasks.
PI5.	The intelligent agent is able to provide me with a useful answer.

4 CONTRIBUTION

While perceived anthropomorphism and perceived intelligence have been studied previously, there has not been any direct research showing the effect perceived anthropomorphism has on the end-user's perception of intelligence. The focus of the paper was to measure how the perceived intelligence of an IA changes due to different levels of congruency between the agent and the human category schema.

Assuming the results support the hypotheses, simply by adding human-like features to an IA, designers of these agents can increase the perceived intelligence of that agent. From this, we can argue that the effectiveness and usability of the agent increases with the addition of certain anthropomorphic features. These findings would add to Moussawi and Koufaris' (2019) results by indicating that the relationship between perceived intelligence and perceived anthropomorphism is reciprocal. Additionally, the findings of this study would extend those of Powers and Kiesler (2006) to the field of intelligent agents.

5 LIMITATIONS AND FUTURE RESEARCH

Providing participants with a set of questions that the IA is successful at answering limits the generalizability of the results. In a real-world environment, users may ask questions that an IA will be unable to answer, which could negatively affect the perceived intelligence of that IA.

Additionally, the anthropomorphic features selected in this study may not be the most effective features at varying levels of anthropomorphism. To better understand this, future research can look at specific features and their effect on perceived intelligence; for example, a study can be done to test whether an IA with an introverted personality will have a higher perceived intelligence than an extraverted IA.

Another study can be done to show how perceived intelligence influences user experience. It is important to understand how users may respond to highly perceived intelligent agents, and what these perceptions may entail.

6 CONCLUSION

With the growing usage of intelligent agents like Siri, Google Assistant, and Alexa, it is important to understand the effect of certain features on end-user perceptions. We argue that more congruency of an IA with the human category schema will result in higher user perceptions of anthropomorphism of the agent, which in turn, will alter the user's perception of the IA's intelligence. Future research can look into the effect specific features have on perceived intelligence, as well as the effects that perceived intelligence has on user experience.

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