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Fictional Robots as a Data Source in HRI Research: Exploring the Link between Science Fiction and Interactional Expectations

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Abstract—**Because interacting with a robot is a novel experience for most adults, expectations about a robot's capabilities must come from sources other than past experiences. This paper explores the relationship between capabilities of robots portrayed in popular science fiction films and students' expectations about a real robot. A content analysis of 12 American science fiction films showed that fictional robots reliably display cognitive capabilities, but do not consistently exhibit many humanlike social behaviors. Survey data collected from students follow the same basic patterns: people expect robots to have humanlike cognitive capabilities, but not social capabilities. The results are discussed in terms of how an empirical evaluation of cultural artifacts can inform the study of human-robot interaction.**

I. Introduction

As technology in artificial intelligence and robotics continues to develop, people will begin encountering robots in a variety of naturalistic settings. Currently, most people have never interacted with a real robot, and therefore robots are an entirely new class of interactional partner for most American adults. Given that most people have not had prior interactions with robots, their expectations about a robot's capabilities must come from sources other than past experiences. In this study, we examine people's interactional expectations about robots as well as the sources that may contribute to these expectations.

A. Extending Audience Design to Robots

Theories of audience design, which are rooted in social psychology and communication, attempt to explain how humans tailor their communication and interaction to match the needs of their human partner. Audience design theories propose that when deciding how to communicate with an interactional partner, people activate beliefs about the partner's abilities, knowledge, and experiences. However, these theories assume that speakers have had previous interactions with a particular partner or at least with individuals similar in class or category. It has been reported that people rely on prior shared experiences [1], [2], their partner's community membership [1], and their own previous experiences and abilities [2]-[4] when deciding how to communicate with a particular interactional partner.

At this point, it is difficult to extend theories of audience design to human-robot interaction, considering that most American adults have never interacted with a robot and therefore have no previous experience on which to base expectations about a robot's capabilities, knowledge, and experience. The question, then, is how do people develop expectations of robots as interactional partners when they have never before interacted with a robot or other artificially intelligent agent?

Several informational sources for expectations have been identified in previous HRI research, including situational factors of the interaction and the physical design of the robot. For example, Lohse [5] found that the interactional situation can affect people's expectations about a robot. Furthermore, a number of studies on robot appearance have suggested that the physical design of a robot can greatly affect people's expectations about its capabilities [6]–[9].

While expectations about a robot's capabilities seem to be based on interactional situations and the physical form a robot takes, there is no doubt that cultural artifacts such as science fiction novels and films play a role in people's understanding of robots. Science fiction films, television, and literature commonly portray robots, and these fictional depictions have been found to contribute to people's expectations about real robots. For instance, researchers have found that people often refer to science fiction films and books when they are asked to discuss robots [10], [11]. In fact, when asked what comes to mind when they hear the word "robot," 15% of participants in one study responded with a reference to science fiction films or books [11]. While these studies lend support for science fiction as a source for expectations about robots, the exact relationship between fictional representations of robots and people's interactional expectations about robots remains unclear.

B. Previous Findings in Media Effects Research

Research across several disciplines has documented concrete ways that fictional media such as film and television can affect viewers' behaviors in the real world. For instance, fictional television shows have been found to contribute to children's learning of gender role stereotypes [12]. Similarly, a link between violent behavior and children's viewing of violent television shows, films, and video games has been established [13], [14]. Additionally, studies have documented a relationship between seeing tobacco use in film and willingness to try smoking [15], [16].

Fictional media can be an especially powerful tool when it treats a subject that is not readily accessible in everyday life. Many times, fictional representations of a theme or event

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provide access to people that otherwise have no experience with the topic. For instance, young viewers often build an understanding of historical events based on what they view in fictional films [17]. Similarly, inmates entering prison for the first time have been found to use events portrayed in television fiction to anticipate what will happen in an environment previously unknown to them [18]. Because most Americans have not ever interacted with a real robot, it is likely that their understanding of robots and their expectations about robots' capabilities are at least in part based on what they know about fictional robots. Thus, it is probable that robots such as The Terminator, R2D2, and Wall-E contribute in some way to Americans' understanding of robots and robotic technologies.

C. Extending Media Effects Research to Expectations about Robots

While much of the research conducted on human-robot interaction evaluates an individual interacting with a robot, we believe there are several other fruitful methods that can be employed to understand issues in human-robot interaction. Specifically, evaluating how robots are portrayed in cultural artifacts such as fictional films, books, and games may provide insight into the societal messages that are currently present in our culture. The evaluation of the societal understanding of robots can be extremely informative, especially when considering the expectations that people bring to their first interaction with a robot.

The inclusion of fictional media as a data source in HRI research does not come without challenges. In order to explore the effect of science fiction on people's expectations, it is essential to conduct a quantitative study that can empirically test whether there is a relationship between how robots are portrayed in film and people's expectations about robots. While many analyses of film are qualitative in nature, we adopted a method of analysis—content analysis—that allows for quantitative measurements. Content analysis is an accepted methodology in media studies, and when performed correctly, provides objective, reliable, and quantitative results [19]. By comparing data obtained from the content analysis to people's expectations, we can directly test the hypothesis that there is a relationship between fictional media and people's expectations of robots.

This paper presents the results of a two-part quantitative study that explores the relationship between the depiction of robots in fictional media and people's expectations about robots' cognitive and social capabilities. First, we conducted a content analysis of 12 popular American science fiction films to inventory the cognitive and social capabilities commonly depicted by the fictional robot characters. Second, we collected survey data from students about their expectations of the cognitive and social capabilities of a robot. The findings of the content analysis were correlated with the results of the survey data to explore the overlap between people's expectations about robots and how robots are portrayed in fictional media.

II. Step 1: Science Fiction Film Analysis

The purpose of this step of the study was to inventory the cognitive and social capabilities commonly portrayed by fictional robots in American films. Given that the effect of fictional media on people's expectations and behavior has been widely documented, we were interested in first understanding the way fictional robots are generally portrayed in American popular films.

A. Method

The content analysis was limited to live-action (non-animated), feature length American films. To objectively identify the most relevant and most popular movies, the authors first searched the Internet Movie Database (www.imdb.com) for all films tagged with the keyword 'robot.' This yielded a list of 302 films. After eliminating foreign films, animated movies, shorts, and films made before 1950, the list consisted of 167 films. All of the films were researched and eliminated if they did not have at least one robot character central to the plot. This yielded a list of 68 films. These 68 films were reduced to 50 by eliminating 18 movies with the lowest IMDb user rating scores.

Second, a survey was administered to determine which of the 50 films were most often watched and remembered. An online questionnaire listed the films and their release dates in chronological order, and respondents were asked to indicate their familiarity with each movie by choosing one of the following five responses: (1) I have seen this movie many times and I remember it well, (2) I have seen this movie and I remember it well, (3) I have seen this movie but I don't remember it very well, (4) I have heard about or seen a bit of this movie, (5) I have never seen or heard about this movie. At the end of the survey there was space to write in additional live-action, feature length American films not on the list. The authors distributed the anonymous survey electronically, with approval from the University of Washington's Human Subjects Division.

Two hundred and forty-six people responded to the survey. The results were analyzed to determine the films that received the highest number of 'remember very well' and 'remember well' responses. Of the 15 most highly rated films, many were part of the same series. Therefore, in all cases in which a sequel film appeared on the top 15 list, it was replaced by the original film in the series, even if the original was not one of the top 15. For instance, six of the Star Wars films were rated among the 15 most watched and remembered. Because all these films share the same main characters, only the first film in the series (*Star Wars*, 1977) was analyzed. An exception to this was *Star Trek: First Contact* (1996). Although it is part of the Star Trek series, the characters were substantially different from those in the first movie of the series, *Star Trek: The Motion Picture* (1979), which did not rank in the top 15. Therefore, we chose to analyze *Star Trek: First Contact* (1996) rather than the original film in the series.

Table I shows the final list of 12 films analyzed in the

study. *Blade Runner* was included in the final list of films, although it was not tagged with the keyword 'robot' in IMDb. However, 11% of respondents suggested *Blade Runner* should have been included in the survey, and this far surpassed the frequency in which any other films were suggested.

TABLE I: FILMS AND MAIN CHARACTERS ANALYZED

Film	Main Robot Characters
Star Wars (1977)	C-3P0 R2D2 Darth Vader
Alien (1979)	Ash
Blade Runner (1982)	Rachel Roy
The Terminator (1984)	Terminator
Short Circuit (1986)	Number 5
RoboCop (1987)	RoboCop (Murphy)
Star Trek: First Contact (1996)	Data The Borg (incl. queen)
The Matrix (1999)	Neo Trinity Morpheus Cypher Agent Smith
AI (2001)	David Teddy Joe
I, Robot (2004)	Sonny
The Stepford Wives (2004)	Mike
Transformers (2007)	Bumblebee Frenzy Optimus Prime Megatron

Films were coded to determine whether the robot characters exhibited several core cognitive and social capabilities. A codebook was developed to provide instructions on how to code the presence or absence of each capability. The codebook cited example actions and behaviors that could be used as evidence to fulfill each of the categories to be coded. Definitions of relevant social and cognitive psychology concepts were also included in the codebook to aid coders. The codebook can be viewed at: http://depts.washington.edu/hrcl/projects_movies.html.

The cognitive capabilities coded in this study included: visual perception, spatial cognition, language production and comprehension, learning, problem solving, episodic memory, and categorization. The social capabilities were: attribution, prosocial behavior, group processes, close relationships, aggression, stereotyping and prejudice, conformity, and self-knowledge.

Content Analysis Procedure First, each movie's main robot characters were identified. The authors watched the films and documented the robot characters that appeared in a film for 20 minutes or more. These characters are listed in Table I. For the purpose of identifying main characters, the term "robot" was very loosely defined as a non-human, non-animal being.

The 12 films were divided up so that each film was coded independently by two authors. For each film, coders determined whether the main robot characters exhibited the social and cognitive capabilities listed in the codebook. The presence of a particular cognitive or social capability was coded if the robot exhibited one or more example behaviors that fulfilled the feature. Discrepancies between the coders were discussed by all authors until an agreement was reached.

To determine inter-rater reliability, percent agreement for each category was calculated. Because all films were coded by two researchers, inter-rater reliability was calculated per category, based on whether coders agreed that a character exhibited evidence of having the capability in question. Of the 25 characters coded, 75% agreement or better was achieved for all the categories except episodic memory (72% agreement), problem solving (68% agreement), and learning (60% agreement). Due to the exploratory nature of the study, these categories were included in the data analysis despite their low reliability. The statistical analysis was conducted both with and without the low reliability categories, and the inclusion of these categories did not affect the results.

B. Results

Table II shows the results of the content analysis. Each capability is listed along with the percentage of robot characters that exhibited the capability. Note that short-term memory was not coded because it was impossible to identify particular behaviors that specifically signaled the existence of short-term memory capabilities. To summarize the main findings shown in Table II, 100% of the robot characters exhibited the cognitive capabilities of vision, spatial cognition, and language. Conversely, the capabilities exhibited by the fewest robot characters were generally social capabilities (e.g., stereotyping/prejudice, conformity, close relationships).

C. Discussion

The results of the content analysis showed that the fictional robots in these 12 films were frequently depicted as having cognitive capabilities and less frequently depicted as having social capabilities. This finding led us to the next step in our study, to determine whether the same pattern is evident in people's expectations of a real robot.

III. STEP 2: EXPECTATIONS SURVEY

In order to explore the expectations people have about a real robot, we collected survey data from undergraduate engineering students. The survey data were then compared to the results of the content analysis to determine whether there is a relationship between how robots are portrayed in film and people's expectations about a real robot.

TABLE II: PERCENTAGE OF ROBOT CHARACTERS THAT EXHIBITED EACH CAPABILITY IN STEP 1 AND THE MEAN SURVEY SCORES FROM STEP 2.

Capability	% Robot Characters	Mean Survey Score (SD)
Short Term Memory	Not coded	1.87 (0.92)
Vision	100%	2.01 (0.96)
Spatial cognition	100%	2.12 (0.90)
Language	100%	2.88 (0.98)
Group processes	96%	2.85 (1.01)
Episodic memory	76%	2.89 (1.58)
Learning	40%	3.31 (1.37)
Attribution	76%	3.60 (1.52)
Self knowledge	76%	3.52 (1.43)
Problem solving	80%	3.75 (0.97)
Categories	84%	3.80 (1.34)
Prosocial behavior	76%	4.31 (1.46)
Conformity	52%	5.40 (1.28)
Aggression	88%	5.41 (1.43)
Stereotyping/Prejudice	44%	5.79 (1.43)
Close relationships	72%	5.58 (1.19)

A. Method

Participants Seventy-seven engineering students took the survey in exchange for course credit. Responses from international students, participants who had taken a robotics class, and participants who had previously interacted with a robot were excluded from the study. Data from the remaining 51 participants were analyzed.

Materials Survey questions were designed to measure expectations about a robot's social and cognitive capabilities. The questions were written so that each of the categories included in the content analysis in Step 1 was represented by at least two questions. For instance, the cognitive category of learning was represented by the questions, "How likely is it that this robot could learn the meaning of a new word if you teach it?" and "How likely is it that this robot could learn how to do a new task if you teach it?" Table III provides some examples of questions used to measure expectations about selected capabilities.

Procedure After giving informed consent, participants were seated in a chair facing a PeopleBot robot. (See Fig. 1). The robot displayed a human avatar face on its touch screen, but did not exhibit any movement or sound.

Participants rated on a scale of one to seven the likelihood that the robot they saw in front of them could exhibit the behaviors specified in the survey questions. The scale was arranged so that a rating of 1 represented "very likely" and a rating of 7 signified "very unlikely." The same scale was used for all 51 questions. Participants were asked to complete the survey on a laptop computer at their own pace. They did not interact with the robot, nor were they given any information about the robot or its capabilities.

TABLE III: SAMPLE SURVEY QUESTIONS FOR SELECTED CAPABILITIES.

Capability	Survey Question
Self-knowledge	How likely is it that this robot could understand that it is a robot?
Group Processes	How likely is it that this robot could cooperate with a group of humans to complete a task?
Close relationships	How likely is it that this robot would befriend a human?
Prosocial Behavior	How likely is it that this robot would respond to help to someone calling for help?
Aggression	How likely is it that this robot would purposely hurt a human?
Stereotype	How likely is it that this robot could discriminate against someone because of their gender?
Episodic memory	How likely is it that this robot could remember something that happened a day ago?
Spatial cognition	How likely is it that this robot could understand the difference between left and right?
Language comprehension	How likely is it that this robot could understand English?
Categorization	How likely is it that this robot could tell the difference between a pen and a pencil?

After completing the survey, students provided information about their major, details about their prior experience with robots, and information about the science fiction movies they had seen.

Fig. 1: The PeopleBot robot on which participants based their ratings.

B. Results

The majority of the participants (69%, n = 35) reported that they had seen at least 6 of the 12 films analyzed in the content analysis, and 92% (n = 47) reported that they had seen at least 3 of the films.

Responses to the 51 survey questions were divided into two categories (cognitive and social), and each participant's mean cognitive and social capability ratings were calculated. A paired samples t-test was conducted and responses to social questions ($M = 4.65$, $SD = .87$) were found to be significantly higher (rated less likely) than responses to cognitive questions ($M = 2.81$, $SD = .75$) [$t\,(50) = 13.46$, $p < .01$]. This suggests that participants were fairly confident in the robot's cognitive capabilities, while they thought it was less likely that the robot had humanlike social capabilities.

In order to evaluate differences in ratings across the individual cognitive and social features, each participant's responses to the 51 questions were collapsed into the 16 feature categories, and the means for each feature category were analyzed. Table II shows the mean likelihood ratings for the 16 feature categories. The four capabilities rated as most likely—short-term memory, vision, spatial cognition, and language—were cognitive, whereas the five capabilities rated most unlikely—prosocial behavior, conformity, aggression, stereotyping, and close relationships—were social.

Data from the content analysis were correlated with the survey scores to determine whether there was a relationship between the likelihood ratings obtained from the survey and the number of robot characters that exhibited a given capability. A Spearman's rho was conducted and the variables were found to be strongly correlated [$\rho\,(13) = -.62$, $p = .01$]. Table II shows the mean ratings for each capability and the percentage of robot characters that exhibited that capability. Recall that a rating of 1 signified "very likely" and a 7 rating meant "not very likely." As is shown in Table II, most of the cognitive capabilities, which were rated as being likely, were exhibited by the overwhelming majority of robot characters. Furthermore, capabilities rated as unlikely, such as conformity and stereotyping were exhibited by few of the fictional robots.

C. Discussion

The survey results clearly show that participants expected the robot to have basic human cognitive capabilities, while they were less likely to expect the robot to exhibit humanlike social behavior. The findings suggest people do not assume that a robot will have humanlike capabilities, particularly with regard to its social behavior. These findings match previous research conducted in our lab using the PeopleBot [20].

The correlation between the survey participants' ratings of the PeopleBot robot and the capabilities commonly conveyed in fictional movies suggests a link between how robots are portrayed in film and people's expectations of actual robots. Fictional movies depict characters like David in *AI* and the Terminator, who can perceive visual information through humanlike eyes and process spatial information effortlessly and without error. Similarly, survey participants rated the Peoplebot robot's visual and spatial cognition capabilities highly likely. Of course, a significant correlation does not allow us to make assumptions about causality, but it does suggest a relationship between fictional robots and people's expectations of real robots.

One limitation of this study is that the data may not be generalizable to all robots. Participants' ratings were based on a specific robot, and some of the expectations may be related to the design of the PeopleBot. The decision to ask participants to base their ratings on a particular robot rather than robots in general was made because people's representations of a prototypical robot may vary drastically. Regardless of how the results extend to other robots, the results suggest that expectations about the PeopleBot robot's cognitive and social capabilities are highly correlated with how a wide variety of robots are depicted in fictional films.

IV. General Discussion

The purpose of this research was to explore the overlap between people's expectations about a robot and the way in which fictional robots are depicted in American science fiction films. The results suggest that people expect robots to have basic human cognitive capabilities, but they have much lower expectations about a robot's social capabilities. This research also provides strong correlational data that suggest a positive relationship between the capabilities of fictional robots and people's expectations about the capabilities of a real robot.

It is important to note that certain capabilities did not follow the same positive relationship found in the majority of the categories. That is, although some capabilities like aggression and close relationships were exhibited by many fictional robots, their likelihood ratings in the survey data were fairly low. This result is understandable when considering that suspension of disbelief is finite, and some behaviors depicted in fiction are outlandish enough that even an individual with little understanding of robotics can recognize them as the products of fiction. No matter how many films might depict robots with emotionally-based close relationships or tendencies towards aggression and violence, it is unlikely that viewers will extend these unrealistic behaviors to real-world robots. Therefore, while the overall results suggest a positive relationship between the capabilities of fictional robots and people's expectations of real robots, they also suggest a caveat that this relationship only holds for capabilities that do not exceed a certain threshold of implausibility. The exact point at which people determine a behavior or characteristic to be implausible is a topic for further research.

Although this study focused specifically on the relationship between fictional robots and people's expectations about a robot's capabilities, it is worth briefly

discussing how news media coverage of developments in robotic technologies may influence people's expectations of robots. Robots and their development have always garnered coverage from media outlets, but in recent years relatively little attention has been given to advancements in cognitive capabilities such as vision, navigation, and natural language processing. The recent boom in social robotics has been widely covered by the media, however. Many high-profile technology news outlets (e.g. Engadget.com and NewScientist.com) feature entire sections dedicated to robot-related news, most of which focus heavily on the social aspects of robot development. Very recently, the well-known magazine *Popular Mechanics* featured a cover story dedicated to a discussion of the development of social robots and its implications. It is possible that this strong focus on the social side of robot development has instilled in the public a false sense that the cognitive issues are already "figured out." The recent decline in reports of cognitive advances may be one reason why participants rated cognitive capabilities more likely than social capabilities.

Step 2 of this study explored expectations about robots' cognitive and social capabilities. The survey data captured information about people's *explicit* expectations about robots. However, what people *implicitly* expect when they are interacting with a robot for the first time may be quite different than what they report on a survey. Research previously conducted in our lab shows that, in fact, when speaking to a robot for the first time, people implicitly expect the robot will have a wide variety of cognitive capabilities, including visual perception, spatial cognition, and language comprehension and production [20]. Thus, the survey findings are corroborated by related work on implicit expectations, and both suggest that people expect a robot to have basic cognitive capabilities.

As stated earlier, current theories of audience design that are rooted in human-to-human interactions cannot account for the way people assess common ground between themselves and a novel class of non-human interactional partners. Because most American adults do not have prior experiences with robots, they must use information from a variety of sources to build expectations about a robot's capabilities. This work is the first step towards understanding exactly how cultural artifacts contribute to expectations about robots. The significant correlation between the survey data and the film data suggests that there is a consistent view of robots that exists at a societal level, and warrants further empirical investigation of these issues. Beyond fictional media, research on other cultural artifacts, such as the news media and other intelligent agents can also provide further information about expectations of real robots.

Our success in employing methodological tools, theories, and data sources from outside the boundaries of traditional HRI and robotics research serves as a reminder that a multidisciplinary approach can yield results and insights that cannot be obtained from traditional HRI methods alone. We envision a future in which HRI researchers utilize a wider variety of methodologies and will see value in collaborations with the arts, cultural studies, and humanities disciplines.

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