Effects of Speech On Perceived Capability

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1. INTRODUCTION

Domestic robots have an increasing presence in the home each year [10]. For these robots to be accepted, their capabilities must match our expectations [1, 5]. However, there is often a mismatch between a robot's true capability and its *perceived* capability (i.e. how capable users believe the robot to be) [2, 6].

Speech is a human behavior known to cause anthropomorphization – the process of attributing human-like characteristics and behaviors [3, 4, 7, 9]. Thus, we hypothesize that when a robot speaks, users are likely to attribute not only capabilities related to speech but other unrelated abilities that humans are adept at, such as physical manipulation.

We explored this hypothesis – that speech affects a robot's *perceived* capability – in a user study that manipulated a robot's use of speech and its success at completing a physical task (Fig.1). We found that when a robot speaks, perceived *social* capability increases. Surprisingly, we also found that perceived *physical* capability increases as well, despite the fact that speech does not add to the true physical capability. For example, just because the robot can engage in dialogue, users believe it will be better at doing their laundry.

Overall, our findings suggest that speech is an important tool in altering expectations during human-robot interactions, and that robot designers should be cautious about setting the wrong expectations when using speech.

Figure 1: We analyzed the effects of two different factors — success and speech — on the robot's perceived social and physical capability.

2. EXPERIMENTAL DESIGN

We conducted an online study to explore the effects of speech on perceived capability. Participants were shown videos of HERB, a bimanual mobile manipulator, retrieving a microwave meal and sometimes engaging in dialogue.

Manipulated Variables: We manipulated the *presence of speech* and the robot's *success* in completing the task (success vs. failure) for $2 \times 2 = 4$ videos.

In the *success* videos, the robot successfully retrieves the meal and leaves the kitchen with it. In the *failure* videos, the robot drops the microwave meal before leaving the kitchen and does not acknowledge its failure.

In the *speech* videos, the robot exchanges dialogue with a nearby actor washing dishes about an upcoming sports game. In the *no speech* videos, there is no dialogue and neither the robot nor the actor acknowledge one another.

Subject Allocation: We chose a 2×2 mixed study design, where participants rated 2 of the 4 scenarios. We recruited 48 participants (20 females and 28 males) through Amazon Mechanical Turk, aged 18 to 61 (M=32.13, SD=9.77) years. Participants rated their familiarity with robots as 2.54 (SD=1.55) on a 7-point Likert scale. All participants were located in the United States, primary English speakers and had over 95% approval ratings.

Procedure: We opted for a mixed study design, where participants watched 2 videos, in order to enable direct comparisons and stay away from absolute ratings (as suggested by our pilot study). We balanced the order that videos were shown to participants, to prevent ordering effects. Participants were shown 2 videos before answering 2 sets of questions: forced choice comparisons between the robots shown in each video and 7-point Likert ratings for each robot.

Dependent Measures: We split capability into two measures: perceived physical capability, the robot's ability to perform physical tasks in the home, and perceived social capability, the robot's awareness and ability to communicate effectively during interactions. We derived our physical capability questionnaire from domestic survey literature. Our social capability questionnaire is inspired by the Robot Anxiety Scale (RAS), developed by Nomura [8].

TABLE I: Perceived Capability Scales

Physical	Social
wiping down cleaning surfaces	giving information and news
cleaning up the dining table	understanding what I am talking about
taking out the trash	understanding my emotions
tidying up	informing me when something is wrong
organizing the pantry	following the direction of a conv.
doing laundry	understanding difficult conversations
preparing simple meals	informing me what it is about to do
doing lawn work	making me understand what it saying
bringing a drink	understanding what I am doing
helping me get ready	talking about irrelevant things*
acting as alarm system	-
watering/caring for plant	-
pet care	-
child care	-

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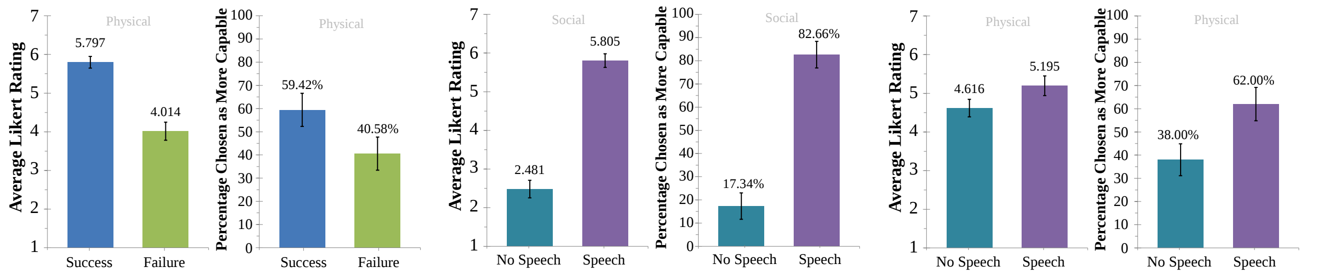

(a) Hypothesis 1 (b) Hypothesis 2 (c) Hypothesis 3

Figure 2: The average rating and percentage of time chosen for each of our hypotheses.

Hypotheses:
1: When the robot *fails* to perform a physical task, perceived physical capability decreases.
2: When the robot *uses speech*, perceived social capability increases.
3: When the robot *uses speech*, perceived physical capability increases.

3. RESULTS

Our hypotheses predicted the effects of a robot's success and its use of speech on perceived capability. To test each hypothesis, we performed a factorial repeated-measures ANOVA for each of our measures: perceived social capability and perceived physical capability.

Hypothesis 1: Participants rated robots that were successful, on average, 1.783 more than robots that failed to complete the meal retrieval task on the perceived physical capability scale ($F(1,73)=37.11$, $p<0.001$). They also chose robots that were successful 60% of the time. Fig.2(a), hypothesis 1 shows a comparison between robots that were successful and robots that failed at the meal retrieval task.

We did not find a significant difference in the perceived social capability ratings for robots that succeeded versus robots that failed: *failing at a physical task does not necessarily make participants believe the robot is less socially capable.*

Hypothesis 2: Participants rated robots that used speech, on average, 3.324 more than robots that did not speak on our perceived social capability scale ($F(1,73)=215.85$, $p<0.001$). Robots that used speech were also chosen as more socially capable 83% of the time. Fig.2(b) shows a comparison between the robots that spoke and those that did not.

Hypothesis 3: Participants rated robots that used speech, on average, 0.579 more than robots that did not speak on our perceived physical capability scale ($F(1,73)=4.61$, $p=0.035$). They also chose robots that spoke as more physically capable 65% of the time. Fig.2(c) shows a comparison between the robots that spoke and those that did not.

4. DISCUSSION

As predicted in Hypothesis 1, we found that physical failures negatively affect participants' ratings of *only* the robot's physical capability (Fig.2(a)). This is not surprising, as retrieving a meal is a physical task and does not rely on the robot's social abilities. We also found, as Hypothesis 2 predicted, that speech positively affects participants' perceptions of the robot's social capability (Fig.2(b)). This is expected since speech is a strong component of social interaction. Both results show that manipulating true capability can affect perceived capability.

Surprisingly, we also found that speech positively affects participants' perceptions of the robot's physical capability (Fig.2(c)). Although true physical capability was the same, participants rated robots that used speech significantly higher and chose them more often in the fixed choice measure. These results suggest that users may anthropomorphize the robot, attributing human-like strengths and weaknesses, despite the robot possessing very different capabilities.

These findings suggest that speech raises expectations of a robot's capability. However, when expectations do not match reality, users may be disappointed, hindering acceptance. Understanding how a robot's behavior or attributes alter expectations can help robot designers to appropriately balance user expectations against robot capability.

This work is a first step in exploring how robot behaviors, such as speech, affect users perceptions of a robot's capability. Our results show that a robot's use of speech alters users' expectations. However, speech has many levels and functions. We are excited to investigate in future work how different types of speech (e.g. conversational speech vs. functional) differ in their effects on the perceived capability of a robot.

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