Should Assistive Feeding with the Stretch Robot Use Expressive Motion?

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***Abstract*— General-purpose mobile manipulators like the Hello Robot Stretch Robot are seeing increased use in assistive technology research, including work on assistive feeding. While this line of research presents important potential gains for enabling technologies, user perception of the inherent nonverbal expression of these manipulators is not well understood. Specifically, we posit that perceptions of robot-mediated assistive feeding can vary greatly based on the design of the robot motion. We generated two video stimuli of assistive feeding via the Stretch robot, each of which used a different motion approach. The pilot work presented in this paper shares the responses of $N = 10$ participants to these video stimuli. Our preliminary results suggest that the presence of expressive motion in the active gaze condition may improve viewer ratings of robot warmth, robot competence, and their own comfort.**

I. Introduction

Modern and lightweight mobile manipulators like the Hello Robot Stretch Robot are gaining traction for assistive applications due to their compactness and versatility for a range of tasks. At the same time, the social perception of these robots' motion (for example, their overground trajectories or arm motion in assistive tasks such as feeding) is not well understood. This knowledge gap is important since the transfer of food in assistive feeding inherently happens in personal day-to-day spaces and in close proximity to end users. Past robotic feeding solutions do exist, but they are typically single-purpose and take the form of stationary tabletop arms (e.g., [1]–[4]), compared to mobile manipulators which include both a mobile base and an arm. Thus, it is doubly important to understand the appropriate design of motion for mobile manipulators like the Stretch RE2 robot [5] when applied in assistive feeding. This paper focuses on early steps to understand human perceptions of different levels of motion expressiveness—specifically gaze coherence with end-effector motion—by the Stretch RE2.

We selected this motion type as an early expressive motion of interest in part because gaze in the analogous research area of manipulation tasks is known to benefit human-robot handovers. Joint attention demonstration by a robot can influence human planning and understanding of robot intentions during handover tasks [6]. Generally, gaze is also effective at helping users determine a robot's goal and behave proactively based on the inferred robot intention [7]. Active gaze behaviors can also promote better timing in handovers [8]. Further, active gazing back and forth between a user's face and hand during handovers leads to better ratings of robot intent and likeability of the system. In this short paper, we seek to leverage known advantages of active robot gaze in a mock assistive feeding scenario.

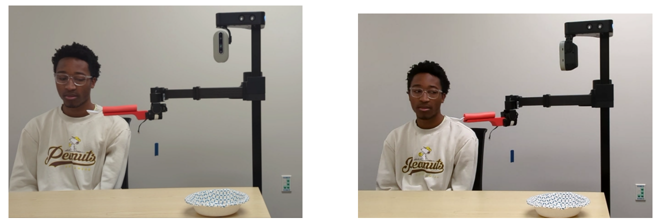

Fig. 1: Example frames from the study's video stimuli: the control condition (left) and the active gaze condition (right). The depth camera is the gray element near the top of the robot. Images include the Stretch robot, custom end-effector, and mock human user.

The aim of the presented work is to investigate the influence of robot gaze in assistive feeding, a sensitive type of handover task. We conducted an online self-report based empirical study toward this end goal. The study's findings highlight the potential benefits of intentional robot gaze design in assistive robot tasks (and beyond).

II. Methods

We used an online survey to conduct a brief within-subjects study on robot motion stimuli with and without expressive gaze. This effort was approved under Oregon State Institutional Review Board protocol #IRB-2019-0172.

Study Design: The video stimuli for the study utilized the Hello Robot Stretch RE2 with a dexterous wrist attachment. In both prepared video stimuli, the robot carried out a pre-programmed assistive feeding motion. A human mock user sat next to the Stretch robot in both videos. To complete the mock feeding scenario, we used a custom utensil holder (i.e., a 3D-printed mounting plate with a foam tube attached) as the Stretch's end-effector. Figure 1 shows a representative frame from each stimulus video.

The central independent variable in the study was level of expressive motion by the pan/tilt depth camera located near the top of the robot, which varied as follows:

1) *Control Condition:* Stretch's depth camera did not move during the feeding action.
2) *Active Gaze Condition:* Stretch's depth camera followed the end-effector's movement at the start of the feeding action, and then alternated between looking at the user's mouth and the end-effector near the end of the food delivery (in a similar style to [9]).

Participants watched one video from each of these conditions during the study.

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Participants: 10 participants completed this study (5 men, 5 women). The group was aged 18 to 55 years ($M = 26.4$, $SD = 10.3$). 40% of participants had STEM training.

Procedure: In this online survey, participants watched each video stimulus and completed a set of questions after the video, as further described in the following subsection. The two videos were shown in a counterbalanced order to mitigate ordering effects. The study lasted approximately 7 minutes.

Measures: In the post-stimulus question sets, we gathered both scale-based and free-response self-reported data from participants. The Robotic Social Attributes Scale (RoSAS) was administered to assess *social aspects* of the video stimuli in terms of warmth, competence, and discomfort [10]. We used a 6-pt Likert scale from "Definitely Not Associated" to "Definitely Associated," omitting a neutral scale option to force decisions. The survey also included the Price Sensitivity Meter (PSM), a standard inventory from marketing research for assessing *perceived value* [11], which has been used in the past by robot sound research [12]. This inventory collects user purchasing interest on a 5-pt Likert scale from "Not at all interested" to "Extremely interested," in addition to four dollar-valued price points: Too Cheap, Cheap, Expensive, and Too Expensive. Lastly, the *free-response questions* queried participants for their preferred stimulus, the reasoning for their preference, perceived differences between the videos, and additional thoughts on the videos.

Hypotheses: We sought to assess the following two exploratory hypotheses in this pilot work:

- **H1:** The active gaze condition will be perceived as more warm and competent, but will inspire more discomfort, compared to the control condition.
- **H2:** The active gaze condition will be perceived as more expensive than the control condition.

The reasoning behind **H1** comes from similar increases in likeability for active gaze [9]. **H2** is an extension of the above; we expected higher value in the case of higher competence.

Analysis: We used descriptive statistics to assess trends in the data, in addition to tallying preferences for each condition. Free-response quotes help to contextualize our pilot findings.

III. Results and Discussion

Table I shows the descriptive statistics results for the RoSAS and PSM questions. Ratings for warmth and competence tended to be higher for the active gaze condition. Discomfort tended to be lowest for the active gaze condition as well. Purchasing interest was similar for both conditions. The pricing results were varied; the Too Cheap and Expensive price points tended to higher for the control condition, but the Cheap and Too Expensive conditions trended higher for this same condition.

TABLE I: RoSAS and PSM results for each condition, formatted as $M \pm SD$.

	Control	Active Gaze
Warmth	1.73 ± 1.24	1.93 ± 1.16
Competence	3.40 ± 0.695	3.48 ± 0.995
Discomfort	1.47 ± 0.684	1.17 ± 0.839
Purchasing Interest	1.10 ± 1.45	1.10 ± 1.00
Too Cheap ($)	1032 ± 1201	1073 ± 1521
Cheap ($)	1418 ± 2207	1325 ± 2004
Expensive ($)	2583 ± 3709	2748 ± 4199
Too Expensive ($)	8574 ± 15720	4914 ± 7239

40% of participants preferred the gaze condition, while 60% indicated no preference for either condition. 30% of participants explicitly labeled the difference between conditions correctly. Of that group, two-thirds preferred the gaze condition. All participants that preferred the gaze condition documented in their free response answers that the movement of the robot's camera was a key deciding factor. At the same time, another participant attributed their survey responses to arm movement, rather than camera movement. Some participants described the robot as more "like a person" or "more interactive and capable" during the active gaze condition. Most others, however, claimed that the two videos "seemed the same."

The trending of the results suggests that the active gaze condition may enhance warmth, competence, and comfort of interactions with an assistive-feeding Stretch robot. This result supports part of **H1**; we did expect gains in warmth and competence ratings, but the improvement in comfort was an unexpected outcome. Related to **H2**, it is not yet clear if the addition of expressive motion might enhance the purchasing interest for and value of an assistive feeding Stretch system. With the current sample size and small number of stimuli, it is difficult to make broad recommendations about robot motion in feeding contexts; however, the study could be strengthened by a larger sample size and broader stimulus design space. The pilot work presented in the paper can help to inform hypotheses for future explorations of expressive motion in assistive feeding applications.

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