Final Report - Mobile Human Robot Interaction Design

Trevor Morcott (trm75), Maria Teresa Parreira (mb2554), Pratul Tandon (pt347)

May 2023

1 Introduction

How do people carry out interactions with non-anthropomorphic, mobile objects? When do these objects cross the line into social entities? And what factors – including anthropomorphic elements – play a bigger role in changing the social framing of humans that are put in contact with these robots?

To answer these questions, we started by considering practical use cases in which an object – when turned mobile – could bring advantages in fulfilling certain stakeholders' goals, whilst being useful for humans. We were inspired by the *free sample* business model, which builds product awareness (a specific item, service, or event, for instance) by offering information, or samples of that product in public spaces, where a lot of bypassers are likely to engage, or, at least, take note of their presence. A mobile "Free Sample Bot" would offer the chance to move around the space, unobtrusively, increasing the chance for customer engagement.

Literature is sparse when it comes to this concept specifically, with perhaps the closest link being found in the hospitality business with helper bots [1]. As such, we decided to carry out an exploratory study with a free sample distributor robot, deployed in a in-the-wild setting (see Fig. **??** for sketched proposed interaction). We run a qualitative analysis of the interaction elicited. To add to our contributions, we further explore how to optimize this robot, by adding an anthropomorphic element to our robot and comparing measures of engagement with the agent. Since gaze is a very important component of non-verbal communication [2], we added eyes to our "Free Sample Bot".

In this work, we explored a novel experimental setting with a free sample distributor robot. We designed and built a table-like robot. We analyzed the interactions under ethnomethodological principles, with sociobehavioral focus. Further, we compared participant engagement in two conditions – no-gaze and gaze robots, to provide insights into how anthropomorphic design elements play a role in people's interactions with a mobile "Free Sample Bot".

Below, we describe the design process and specifications for the "Free Sample Bot" and lay out the setting used in our user study. We discuss our results and provide suggestions for future work.

Figure 1: A sketched interaction with the "Free Sample Bot".

2 Robot Design

Our design was motivated by a set of principles, which we describe below:

2.1 Hardware Design

1. **Easily iterated, accessed, and repaired** - no part of the robot should be difficult to replace; electronic sub-assemblies should be easily accessible;
2. **Clean, purposeful design** - robot look and design should not distract the user from the intended purpose, and the purpose should be very intuitive from the look;
3. **Stable and robust** - the robot should be well-balanced while moving and robust to bumps, falls and rough surfaces.

2.2 Software Design

4. **Consistent** - control of the robot should be easily replicable and consistent.

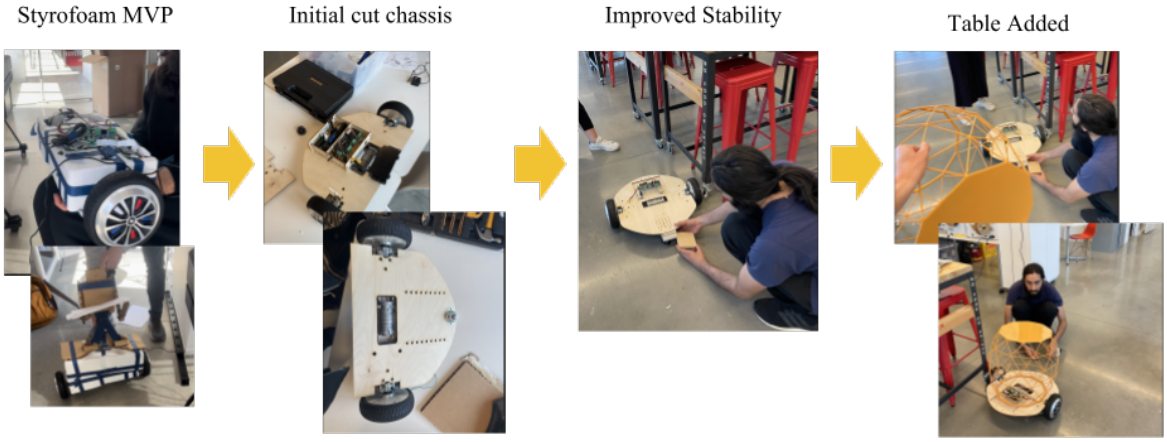

Figure 2: Different design stages for "Free Sample Bot".

With these in mind, we proceeded to brainstorm on robot designs (Fig. 2). Our final design has the following specifications:

Hardware: motion is made possible through a hoverboard base, which is connected to a Rasberry Pi for control and powered by battery. The chassis is custom-built from plywood (design files are provided as supplementary material). The table is made out of metal, with a net-like design that allows for quick access to the hardware components, whilst still being stable to sudden motion. The tablecloth is made out of linen fabric. The eyes are cardboard. After piloting the study (more details in Section 3), we added a cardboard sign with the words "Take One!", to easily clarify the purpose of the robot.

Software: all of the code will be provided as supplementary material. The robot was controlled through a remote control, connected via Bluetooth. A "wiggle" motion was programmed on the robot and could be activated through the press of the L2 button on the controller.

The final design can be seen in Fig. 3.

Figure 3: Final design for the "Free Sample Bot". The two conditions (*NoGaze, Gaze*) are described in Section 3.

3 User Study

In order to explore how people interact with a "Free Sample Bot", we deployed the robot in a public space and collected data through two high-quality video cameras and in-the-spot annotations. The robot was controlled through Wizard-of-Oz. It could approach bypassers by coming close to them. The "free samples" were provided in the form of stickers, placed on a small metal platter that was stuck to the table top. We tested two conditions:

- **NoGaze**: the robot was designed as described in Section 2.
- **Gaze**: an anthropomorphic element (eyes) was added to the robot design.

3.1 Research Questions

We designed this exploratory study with the aim of answering the following research questions:

RQ1: What type of interactions are elicited by the "Free Sample Bot"?

RQ2: Do people engage more with an anthropomorphic robot (**Gaze**) than a non-anthropomorphic one (**NoGaze**)?

3.2 Study Setting

We piloted the study on the lobby of the Tata building, on the Cornell Tech campus (Roosevelt Island, NY, USA). Our observations were very informative and helped design the final deployment and data collection. Namely:

- we realized that the robot should be in motion before participants approach the area, so as to not surprise individuals;

- the robot should approach, or at least get close to bypassers; engagement was higher if the robot did a wiggle motion when participants first acknowledge its presence;
- a sign saying "Take One!" was added to the robot, was its purpose – or, at least, the awareness that participants were allowed to take a sample – was sometimes unclear.

Following this, we made the necessary changes and deployed the robot on the lobby of the Bloomberg building on the same campus. The robot was deployed for around 60 min (30 min per condition). A total of 61 interactions/participants were recorded and taken note of. Participants' were mostly members of the Cornell Tech community (students, faculty, staff), with ages likely between 20-50 years old.

4 Results

4.1 Engagement with the robot

To measure how people were engaging with the robot across the two conditions, we measured how many participants did not engage with the robot, how many approached it and how many got approached by it.

NoGaze: in this condition, 36 participants were annotated. 16 participants (44%) did not take a picture. 10 participants (28%) got approached by the robot and took a sticker, while 14 (38%) participants approached the robot and took one sticker.

Gaze: in this condition, 25 participants were annotated. 16 participants (64%) did not take a picture. 6 participants (24%) got approached by the robot and took a sticker, while 3 (12%) participants approached the robot and took one sticker.

While we did not annotate this fact, it is of note that most participants, even if not engaging with the robot's free samples, did *interact* with it, by acknowledging its presence (gazing in its direction, smiling, commenting out loud or to the robot).

4.2 Sociobehavioral observations

Interesting phenomena were observed through the data collected via video and audio streams. We leave some observations below:

- Some bypassers did not engage with the robot, but most acknowledge its presence. Some showed intent to engage, but had their hands full - so they could not stop and pick up a sticker.
- The "wiggle" motion was successful at signaling attention and incentivizing engagement.
- When participants interacted in a group, the reactions were heterogeneous. Smiles, laughs and verbal comments were exchanged between individuals, but usually only one or two would stop and engage with the robot.
- Some participants would acknowledge but not engage with the robot at first contact, and then come back again and engage. This was observed usually in groups of 2 or more people.
- While some participants verbally engaged with the robot, most participants either interacted non-verbally, commented something with another participant in the same group, or looked for the researchers controlling the robot and verbally engaged with them (e.g., saying "Thank you!" after taking one sticker).

These observations can be seen in a video provided as supplementary material.

5 Discussion

In this study, we explored the potential of a "Free Sample Bot" for product awareness. We built and deployed a product distribution mobile robot and observed the interactions elicited. We observe that the robot was acknowledged by participants, and its purpose was clear, thus complying with the design principles laid out in Section 2.

To answer **RQ1**, we compiled a set of behavioral observations that illustrate the types of interactions that may be observed when bypassers interact with a sample-distributing robot. Further, we explored the answer to **RQ2** and verify that the addition of an anthropomorphic element to the robot design does not improve participant engagement with the robot, instead decreasing the percentage of participants that took a sticker from the platter. These insightful results may provide guidance for researchers considering deploying service robots in similar scenarios.

We further provide some reflections about this project, namely limitations to the study design. First, we note that the population used in our study is composed of participants with technological literacy, which might be why the robot did not cause more reactions of surprise or confusion. This might also explain why some participants' instinct was to look for the "human controller" of the robot, rather than assuming its autonomy.

Further, we recognize that the novelty effect [3] has very likely played a role in how much people were interacting with the robot. While this might temporarily provide the sense of high effectiveness by the use of a mobile robot for distributing free samples, one should consider the effect of long-term exposure to these technologies as a detrimental element of the quantity of engagement;

Finally, while it falls outside the scope of this project, it would be interesting to compare the amount of engagement with a static "Free Sample Bot" (i.e., just a table with stickers) or, even, a human distributor.

References

[1] A.-H. Chiang, S. Trimi, and Y.-J. Lo. Emotion and service quality of anthropomorphic robots. *Technological Forecasting and Social Change*, 177:121550, 2022.

[2] B. Mutlu, F. Yamaoka, T. Kanda, H. Ishiguro, and N. Hagita. Nonverbal leakage in robots: Communication of intentions through seemingly unintentional behavior. In *Proceedings of the 4th ACM/IEEE International Conference on Human Robot Interaction*, HRI '09, page 69–76, New York, NY, USA, 2009. Association for Computing Machinery.

[3] C. V. Smedegaard. Novelty knows no boundaries: Why a proper investigation of novelty effects within shri should begin by addressing the scientific plurality of the field. *Frontiers in Robotics and AI*, 9, 2022.