ECSE 600 User Study Design
Group 2

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1. **Participants:** For this study, we will use within-participants design due to several reasons. Firstly, we have 5 different conditions in the experiment and using between-participant design requires more participants for each of these conditions while within-participants design requires fewer [1].

   Secondly, due to the aim of the study and the nature of the variables we will use, none of the order effects will not be a substantial confound that can affect our outcomes. Familiarity effect and learning will not substantially affect participants' experience since the experiment conducted does not include complex tasks which can be succeeded better with familiarity [1]. Fatigue effect will not substantially affect the participants' experience since the task (deictic gesture) is not using much cognitive effort and physical abilities [1]. Habituation effects and the novelty effects may affect participants when compared to the other effects but we will try to minimize them by conducting an experiment as short as it can be (for habituation effect) and interacting with the robot before the experiment (for novelty effect) [1].

   For this study, to find the sufficient sample size, we made power analysis by using a sample size calculator [2]. In order to make this analysis, we need to specify the desired statistical power, significance level and the expected effect size [1]. We set these parameters as in **Table 1.**

Test Family	t-test
Sample Groups	Same Subject
Number of Tails	Two Tails
Effect Size	0.4
Significance Level	0.05
Power	0.80

Table 1

Explanation of each parameters:

- **Test Family:** We will use the t-test family.
- **Sample Groups:** Since we are conducting within-participant study, we will take multiple measurements from the same person. This corresponds to the "Same Subject" option in this calculator.
- **Number of Tails:** The directionality of the hypothesis does not imply a direction because the different confirmation methods of Baxter robot to deictic gesture and self-adaptor gesture of the robot can affect the user experience in a positive or negative way.
- **Effect Size:** This parameter gives the strength of the relationship [2]. We give the effect size as 0.4 in this study.
- **Significance Level:** In this study, **Type 1** and **Type 2** errors indicate these:
    - **Type 1 error** will draw the conclusion that there is a significant difference in the user experience despite the fact that there is not.
    - **Type 2 error** will draw the conclusion that there is no significant difference in the user experience despite the fact there is.

  Considering these two errors, since it seems more crucial to be prudent when claiming non-existing effects, we prioritize avoiding **Type 1** error. Therefore, we chose a significance level as 0.05.
- **Statistical Power:** the statistical power shows the likelihood of being able to detect an effect in the sample assuming it exists in the general population [1]. We want this value as high as possible and give it 0.80 value.
  These parameters resulted in a total number of **52 participants.** Therefore, we will recruit 52 participants for this study.
- **Inclusion Criterias**
    - 18 to 65 years of age
    - Proficient level of English
- **Exclusion Criterias**
    - Have the physical ability to perform the deictic hand gesture
    - Have the ability perceive visual and hearing stimulants from robots for the confirmation methods
    - Refuses to give informed consent

2. **Location:** The study will take place in the SaPhHaRI lab at Case Western Reserve University, Glennan Building. This laboratory environment enables us to have more control over the variables and the experiment in general with higher possible internal validity compared to a field study [1].

3. **Duration**

In our HRI system, the experiment lasted about 45-50 minutes per participant. This period of time includes the time required for participants to receive instructions, interact with the Baxter Robot, perform assigned tasks and provide feedback.

The overall time allocated to the user study, including participant recruitment, setup and data collection for all participants. It will be approximately 2 to 3 weeks. This time frame allows for a sufficient number of participants to complete the questionnaire and ensures thorough data collection and analysis.

4. **Research Question/Hypothesis**

Q1: How the different confirmation methods (visual, verbal, body movement or no confirmation) of the robot affect the user experience during the retrieval of a pointed object by the Baxter robot (deictic hand gesture)?

H1:

- Null Hypothesis (H0): There is no significant difference in user experience when the Baxter robot employs different confirmation methods (visual, verbal, body movement, or no confirmation) during the retrieval of a pointed object using a deictic hand gesture.
- Alternative Hypothesis (H1): There is a significant difference in user experience when the Baxter robot employs different confirmation methods (visual, verbal, body movement, or no confirmation) during the retrieval of a pointed object using a deictic hand gesture.
- The alternative hypothesis (H1) suggests that at least one of the confirmation methods will have a notable impact on the user experience, while the null hypothesis (H0) posits that none of the confirmation methods will make a significant difference. We can conduct experiments to collect data and test these hypotheses to determine the influence of various confirmation methods on the user experience in this context.

Q2: What is the influence of the Baxter robot's self-adopter gestures on the overall user experience during human-robot interaction?

H2: The use of self-adaptor gestures by the Baxter robot during human-robot interaction significantly enhances the overall user experience. Users will report higher levels of engagement, comfort, and trust when interacting with the robot that employs self-adaptor gestures compared to a robot that does not use such gestures.

5. **Independent Variables**

    a. Confirmation Methods
        i. Verbal: The robot will classify the class of object and ask verbally to the user "Is the red one the object?" etc.
        ii. Visual: The Baxter Robot will show the picture of the detected object and ask for confirmation from the user.
        iii. Body Movement: It will ask the user by directing its hand towards the detected object, and waiting for confirmation
        iv. No Confirmation: The Baxter Robot will pick up objects without any confirmation from the user.
    b. Self-adaptor movements: such as stretching its arms, "uhmm" voice, scratching (minimal touch) to the other arm.

6. **Dependent Variables**

    a. User's Non-Verbal Behavior
        - User's Emotions in Response to Robot Gestures
        - User's Emotions sor self-adaptor movement
    b. User's Verbal Behavior
        - Sentiment Analysis during each interaction
    c. User's Satisfaction with Interaction
        - Overall User Satisfaction Ratings
        - User Feedback on What They Liked and Disliked about the interaction
        - User's Likability Ratings
        - Qualitative User Feedback on Likability and Anthropomorphism.

7. **Script（We should explain precisely what the experimenters or researchers are going to say to the participants during the entire procedure）just like stage script. Experimenters/Robot/Participants**

Stage 1: Introduction and Consent

Experimenter: Hello everyone! Welcome to our HRI research testing. Thank you for being here. Firstly, we will have all of you go over the informed consent document. Feel free to ask any questions.

Experimenter: (After clearly clarifying the informed consent document) You can review and sign the informed consent form if you are interested in taking part in our research study.

Participants: (Review and sign the form.)

Experimenter: Thank you for your time. The experimenter will lead the participant into the labotarory and the area of the robot's perception.

Stage 2: Experiment Overviews

Experimenter: In this experiment, you will be interacting with our robot, which we will introduce shortly. As participants, you will be asked to perform some tasks and have a conversation with the robot. The robot will use gestures to communicate with you.

Experimenter: We will be looking at your experience with the robot during this study. .

State 3: Robot Introduction

Experimenter: Let me give a brief introduction of the Baxter robot.(The Baxter Robot waves or performs a welcoming gesture.)

Robot: Hello! I'm (Robot's name), nice to see you!

Experimenter: The experimenter will teach the participant how to use a stop gesture to indicate starting and how to use a fist gesture to indicate ending.

State 4: Task Instructions

Experimenter: First, the experimenter will explain the tasks by reading the protocol to the participant, and teach the participant how to interact with the robot in different parts of the experiment.

Experimenter: Do you have any questions about the task or the instructions?

Participants: (The participant will ask some questions if needed)

State 5: Interaction Session

Experimenter: Now, we will begin the interaction session. Please start the interaction by making a start gesture and point one of the items on the table for 10 seconds.

Participants: making a start gesture.

Experimenter: After 10 seconds pointing towards the item, the participant will perform a stop gesture.

Participants: making a stop gesture

Participants: To act in different ways to different variables.(We considered giving every participant a copy of the protocol so that they could clearly understand the process and know what they need to do.)

State 6: Post-Interaction Survey

Experimenter: After the interaction, we will ask you to fill out a questionnaire to gather your feedback and impressions of the robot.

Participants:（Participants take surveys）

State 7: Ending

Experimenter: Thank you! Your participation in this study is appreciated. Good bye!

8. **Surveys**

We will measure user experience by self-reporting questionnaires. There are several questionnaires that measure the social acceptability factors for the social robots such as Robot Acceptance Survey (RAS), Godspeed Questionnaire Series (GQS) and Multidimensional Scale for the Assessment of Social Robotics (MDSASR) [4]. However, the best fit for our project is the Godspeed Questionnaire Series (GQS). While RAS mostly measure the acceptance, trust and willingness to use robots, GQS focuses on user experience by measuring subscales such as anthropomorphism, animacy, likeability, etc [4]. On the other hand, MDSASR also includes these subscales like GQS, however MDSASR has some subscales that measure attitudes towards specific types of robots such as service etc [4]. However, we only seek subscales that measure general social robots. Therefore, we will use the Godspeed Questionnaire for this study. The GQS has 5 scale Likert assessing as seen in **Appendix A.** It is assessing anthropomorphism, animacy,likability, perceived intelligence and perceived safety of the robot.

9. **Analysis**

To effectively analyze data collected in gesture-based human-robot interaction (HRI) systems involving indicative gestures and adaptive gestures, we will employ statistical and mathematical models tailored to specific research objectives. In addition, the choice of mathematical model will be relevant to the aforementioned questionnaire, which may include Likert scale ratings and other quantitative measures. Here is a brief description of the method:

- Data analysis method:

a. Descriptive statistics: We will first use descriptive statistics to summarize the collected data. This includes calculating measures such as mean values, standard deviations and frequency distributions of other relevant variables.

b. Hypothesis testing: Appropriate statistical tests will be applied based on the research questions and hypotheses presented in the questionnaire. For instance:
   - T test: Compares the mean between different groups or conditions
   - Analysis of Variance (ANOVA): Used to compare the average of multiple groups or conditions.
   - Correlation analysis: examines the relationship between variables.

c. Regression analysis: When investigating complex relationships, we could use regression analysis to model the effect of independent variables (e.g. type of gesture, frequency) on dependent variables. It helps identify predictors of user response.

d. Structural Equation Modeling (SEM): For more comprehensive models involving multiple variables and relationships, SEM could be used to test and verify the theoretical model and evaluate the fit of the data to the model.

- Mathematical model:

a. Ordered Logistic Regression: This model is used when the dependent variable has a set of ordered categories, such as the Likert scale.
b. Proportional Odds Model: This is a variant of ordinal logistic regression that is used when the odds ratio is assumed to be proportional between different classes of dependent variables.

10. Protocol

1. The participant will fill the informed consent.
2. The participant will enter the labotarory and the area of the robot's perception.
3. The participant will complete the prior task which indicates starting (stop gesture) and ending gestures (fist gesture).
   (The visual, verbal, body movement and the no confirmation part will have changing order for each participants)
   Visual:
4. The participant will make a start gesture and after that point to one of the items in the table.
5. After 10 seconds pointing towards the item, the participant will perform a stop gesture.
6. The participant will look at the screen of the Baxter robot to see the pointed item that Baxter perceived.
7. The participant will say "Yes" if the object in Baxter's screen is the object that he/she pointed to before.
8. The participant will say "No" if the object in Baxter's screen is not the object that he/she pointed to before.
9. If the participant will say "Yes", the participant will take the object the Baxter gives to him/her.
10. The participant will wait 20 seconds before starting the next task.
    Verbal:
11. The participant will make a start gesture and after that point to one of the items in the table.
12. After 10 seconds pointing towards the item, the participant will perform a stop gesture.
13. The participant will listen to the Baxter robot to hear the color of the pointed item that Baxter perceived.
14. The participant will say "Yes" if the color that Baxter said is the same color of the object that he/she pointed to before.

15. The participant will say “No” if the color that Baxter said is not the same color of the object that he/she pointed to before.
16. If the participant will say “Yes”, the participant will take the object the Baxter gives to him/her.
17. The participant will wait 20 seconds before starting the next task.

Body Movement:

18. The participant will make a start gesture and after that point to one of the items in the table.
19. After 10 seconds pointing towards the item, the participant will perform a stop gesture.
20. The participant will observe which item that Baxter robot’s arm points.
21. The participant will say “Yes” if the pointed item that Baxter points is the same object that he/she pointed to before.
22. The participant will say “No” if the pointed item that Baxter points is not the same object that he/she pointed to before.
23. If the participant will say “Yes”, the participant will take the object the Baxter gives to him/her.
24. The participant will wait 20 seconds before starting the next task.

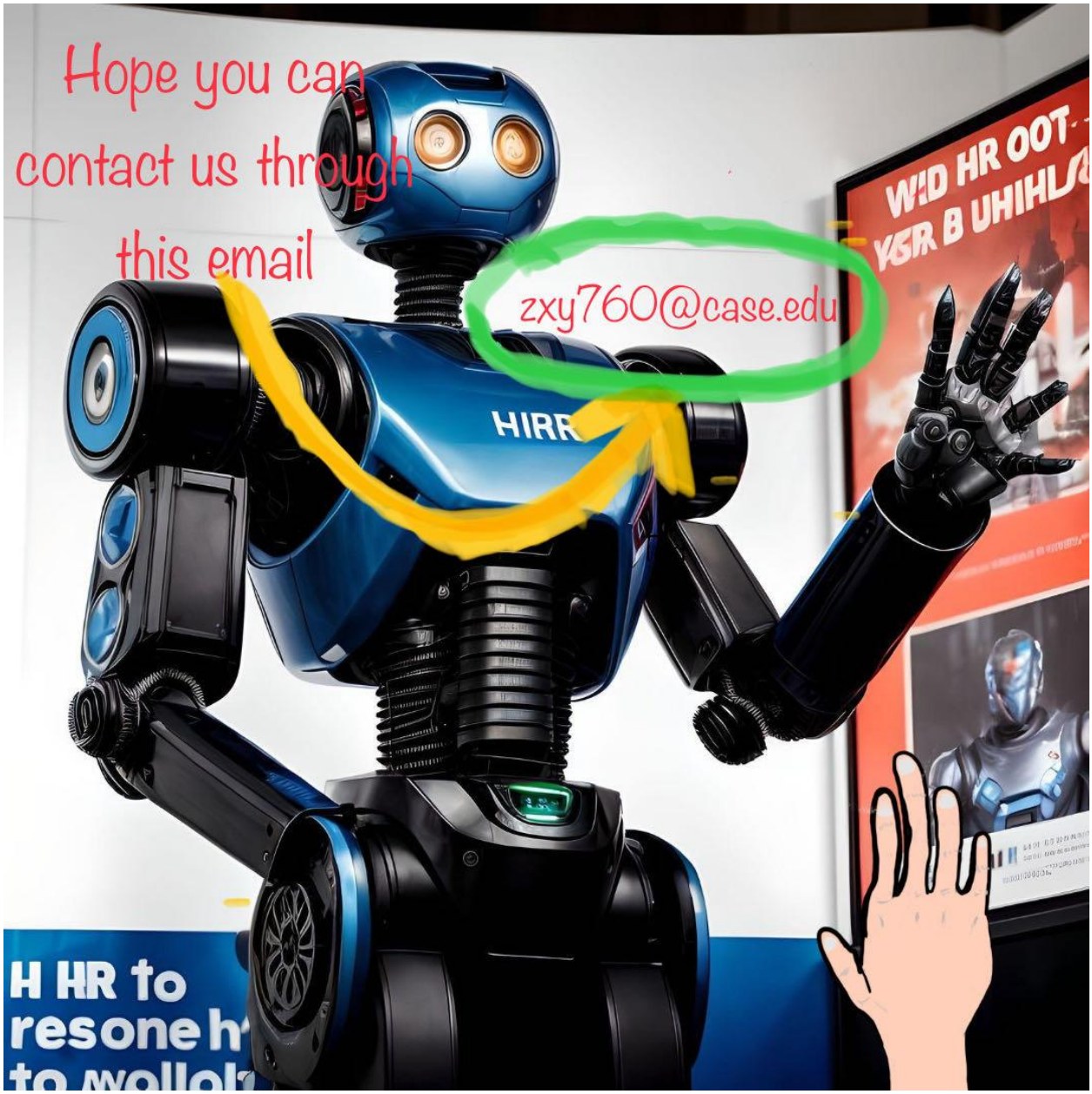
No Confirmation:

25. The participant will make a start gesture and after that point to one of the items in the table.
26. After 10 seconds pointing towards the item, the participant will perform a stop gesture.
27. The participant will take the object the Baxter gives to him/her.
28. The participant will wait 20 seconds before starting the next task.

Self-Adaptor:

29. The participant will make a start gesture.
30. The participant will say one sentence.
31. The participant will observe the robot’s movement (10 seconds).
32. The participant will say one sentence.
33. The participant will observe the robot’s movement (10 seconds).
34. After 10 seconds pointing towards the item, the participant will perform a stop gesture.
35. The participant will complete the survey.
36. The participant will leave the laboratory.

11. Recruitment




YOU &
BAXTER
JOIN OUR
EXPERIMENT
ixk23@case.edu

12. Consent Form

Informed Consent Document

Title of Project: “Impact of Robot Confirmation for Deictic Gestures and Self-Adaptors on User Experience”

Principal Investigator: Alexis E. Block

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This informed consent form is required for you to take part in a human-subject experiment that is part of the project named above. This project aims to investigate the effect of self-adaptor gestures of robots and the different confirmation methods (visual, verbal, body movement, or no confirmation method) as a response to the deictic gestures on user experience. Personal data will be collected during the study; however, this information will be stored under a random subject number such as S1 or S2, and it will be kept in a way that makes identification very unlikely (see the description below). By signing this form, you allow us to process your stored data by law.

Your participation is voluntary, which means you can choose whether to participate or not to participate after reading the information provided in this document. This informed consent form describes the study purpose, the possible risks of participation, the financial reward (if any), the tasks that you will undertake if you decide to participate, and the data we will collect. If you are not sure about this experiment, you should ask the principal investigator or an investigator for additional information. You can withdraw from the experiment and revoke your consent at any time without any consequences, even after the end of the experiment. To do so, please contact Alexis E. Block whose contact information is listed on the first page of this document.

If any part of this document is unclear to you, please ask the investigator to explain what you do not understand before signing this form. If you do decide to participate in this project, please sign this form at the indicated location on the last page. You should keep a copy for future reference.

What is the purpose of this study?

The purpose of this study is to find the effect of four different confirmation methods (visual, verbal, body movement, or no confirmation method) which are performed by the robot as a

response to users' deictic gestures. Besides that, this study aims to find the effect of self-adaptor gestures in human-robot interaction.

What are the requirements to participate in this study?

- 18 to 65 years of age
- Proficient level of English

How long does it take to complete this study?

This study will take 45-50 mins to complete.

How many other people will be in this study?
There will be up to 52 participants in the study, depending on the outcome of the experimental sessions.
Where will the study take place?
The study will be conducted at SaPhHaRI lab at Case Western Reserve University, Glennan Building. The time and date of your participation will be determined through communication with the investigator.
What is my task?

1. The participant will fill the informed consent.
2. The participant will enter the labotarory and the area of the robot's perception.
3. The participant will complete the prior task which indicates starting (stop gesture) and ending gestures (fist gesture).

(The visual, verbal, body movement and the no confirmation part will have changing order for each participants)

Visual:

4. The participant will make a start gesture and after that point to one of the items on the table.
5. After 10 seconds pointing towards the item, the participant will perform a stop gesture.
6. The participant will look at the screen of the Baxter robot to see the pointed item that Baxter perceived.
7. The participant will say "Yes" if the object in Baxter's screen is the object that he/she pointed to before.
8. The participant will say "No" if the object in Baxter's screen is not the object that he/she pointed to before.
9. If the participant will say "Yes", the participant will take the object the Baxter gives to him/her.
10. The participant will wait 20 seconds before starting the next task.

Verbal:

11. The participant will make a start gesture and after that point to one of the items on the table.
12. After 10 seconds pointing towards the item, the participant will perform a stop gesture.
13. The participant will listen to the Baxter robot to hear the color of the pointed item that Baxter perceived.
14. The participant will say “Yes” if the color that Baxter said is the same color of the object that he/she pointed to before.
15. The participant will say “No” if the color that Baxter said is not the same color of the object that he/she pointed to before.
16. If the participant will say “Yes”, the participant will take the object the Baxter gives to him/her.
17. The participant will wait 20 seconds before starting the next task.

Body Movement:

18. The participant will make a start gesture and after that point to one of the items on the table.
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20. The participant will observe which item that Baxter robot’s arm points.
21. The participant will say “Yes” if the pointed item that Baxter points is the same object that he/she pointed to before.
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29. The participant will make a start gesture.
30. The participant will say one sentence.
31. The participant will observe the robot’s movement (10 seconds).
32. The participant will say one sentence.
33. The participant will observe the robot’s movement (10 seconds).

34. After 10 seconds pointing towards the item, the participant will perform a stop gesture.
35. The participant will complete the survey.
36. The participant will leave the laboratory.

What are the risks from this experiment?

The risks associated with participation in this study are not greater than those encountered in daily life. We try our best to avoid any problems that could arise for participants from this project.

After the confirmation of the item, the robot will give the confirmed item to the user. In this process there will be a minimal risk of accidental mishandling or dropping objects.However; since the objects will be small and light items, they will not cause any kind of damage even if this possibility occurs.

Participants should be prepared to spend the allotted time in the lab and be aware of the time commitment needed for the experiment.

You are also welcome to ask for a break at any time during the experiment.

Can I leave the study before it ends?

The study may be stopped without your consent for the following reasons:

- The investigator or principal investigator feels it is best for your safety and/or health.
- The experimental equipment is not functioning as expected.
- You have not followed the study instructions.

You have the right to drop out of the user study at any time; simply contact Alexis E. Block using the information provided on the front page of this document.

How will confidentiality be maintained and my privacy be protected?

The project team will make every effort to keep all the information we record during the study strictly confidential, as required by law. Any documents you sign, where you can be identified by name, will be kept in a locked archive in Dr. Block's department. These documents will be kept confidential. All signed documents will be destroyed when the study is over. The surveys you fill out and the electronic data we record will be marked with a unique subject identification number, but we will not keep any data that will connect this number with your name. The surveys and electronic data will be destroyed when the investigators decide that they are no longer needed for active projects.

The data recorded during the sessions (video data of the user (face and the hand), voice) will be stored on secure computers and servers. To protect your privacy, your name will be stored only on this paper consent form. The rest of the data will be stored by your unique subject identification number, and there will be no occurrence of your name in the digitally stored data. Unauthorized people will not have access to the stored data.

What will I receive after the experiment?

Participants will not be compensated for their participation.

Your rights

Within the scope of the legal possibilities, you have the right to obtain information regarding your stored data, the right to correct inaccurate data, and the right to demand the deletion of data in cases of inadmissible data storage and portability within the scope of the legal possibilities.

Signature

When you sign this document, you are agreeing to take part in this user study. If you have any questions, or if there is anything you do not understand, please ask the investigator. You will receive a copy of this informed consent form.

Printed Name

_____

Signature

_____

Place, Date

_____

13. Media Release

Media Release Form

Human-robot interaction research has become increasing popular. Research in this field has previously received media attention, including being featured on NowThis Future, IEEE Spectrum, The New York Times, NBC, SWR, and Late Night with Seth Meyers. Occasionally, media outlets ask us for video footage and images to appear alongside an article or presenter. We never share names or any other personal information about our participants outside the research team, but participants are recognizable in our videos because your face will not be blurred.

Would you allow us to share video and images of the main tasks of this study (hand gesture, emotion and gaze detection and recognition) with any media outlets that contact us requesting this? If yes, please read and sign the form below. Signing this form is completely voluntary; you may participate in the study without signing it. Please feel free to ask the experimenter if you have any questions.

I, _____, hereby give Ilke Kas, Zhengyu Yang, Jiayi Chen and Alexis E. Block, and other members of the project team at Case Western Reserve University the right and permission to copyright and/or publish, reproduce or otherwise use my face, voice, and likeness in video, photographs, written materials, and audio-visual recordings. I acknowledge and understand these materials about me will only be used for non-commercial purposes.

I understand that my image may be edited, copied, exhibited, published and/or distributed. I also understand this material may be used individually or in conjunction with other media in any

medium, including without limitation to print publications, digital publications, and/or public broadcast for any lawful purpose. There is no time limit on the validity of this release, nor are there any geographic limitations on where these materials may be distributed.

I understand that my participation is voluntary and that I may, at any time, discontinue my involvement before signing this document. If I choose to discontinue participation, I will notify the principal parties of Case Western Reserve University by providing written notice.

I hereby certify that I am over eighteen years of age and am competent to contract in my own name insofar as the above is concerned. By signing this form, I acknowledge that I have completely read and fully understand the above consent and release and agree to be bound thereby. I hereby release any and all claims against any person or organization utilizing this material for marketing, educational, promotional, and/or any other lawful purpose whatsoever.

Participant Name (please print):

_____

Participant Signature:

_____

Place, Date:

_____

14. References

[1]Hoffman, G. and X. Zhao (2021). ”A Primer for Conducting Experiments in Human–Robot Interaction.” ACM Transactions on Human-Robot Interaction 10(1): 1-31

[2] “Sample size calculator,” AI, https://www.ai-therapy.com/psychology-statistics/sample-size-calculator (accessed Oct. 5, 2023).

[3]C. Bartneck, “Godspeed questionnaire series: Translations and usage,” *International Handbook of Behavioral Health Assessment*, pp. 1–35, 2023. doi:10.1007/978-3-030-89738-3_24-1

[4]C. U. Krägeloh, J. Bharatharaj, S. K. Sasthan Kutty, P. R. Nirmala, and L. Huang, “Questionnaires to measure acceptability of Social Robots: A critical review,” *Robotics*, vol. 8, no. 4, p. 88, 2019. doi:10.3390/robotics8040088

15. Appendix [3]

Bartneck, C. (2023). Godspeed Questionnaire Series: Translations and Usage. In C. U. Krägeloh, O. N. Medvedev, & M. Alyami (Eds.), International Handbook of Behavioral Health Assessment (pp. 1-35). Springer. https://doi.org/10.1007/978-3-030-89738-3_24-1

English

Translated by: Christoph Bartneck
Publication: https://doi.org/10.1007/s12369-008-0001-3
Instructions: Please rate your impression of the robot on these scales:

Anthropomorphism						
Fake	1	2	3	4	5	Natural
Machinelike	1	2	3	4	5	Humanlike
Unconscious	1	2	3	4	5	Conscious
Artificial	1	2	3	4	5	Lifelike
Moving rigidly	1	2	3	4	5	Moving elegantly
Animacy						
Dead	1	2	3	4	5	Alive
Stagnant	1	2	3	4	5	Lively
Mechanical	1	2	3	4	5	Organic
Artificial	1	2	3	4	5	Lifelike
Inert	1	2	3	4	5	Interactive
Apathetic	1	2	3	4	5	Responsive
Likeability						
Dislike	1	2	3	4	5	Like
Unfriendly	1	2	3	4	5	Friendly
Unkind	1	2	3	4	5	Kind
Unpleasant	1	2	3	4	5	Pleasant
Awful	1	2	3	4	5	Nice
Perceived Intelligence						
Incompetent	1	2	3	4	5	Competent
Ignorant	1	2	3	4	5	Knowledgeable
Irresponsible	1	2	3	4	5	Responsible
Unintelligent	1	2	3	4	5	Intelligent
Foolish	1	2	3	4	5	Sensible
Perceived Safety						
Anxious	1	2	3	4	5	Relaxed
Calm	1	2	3	4	5	Agitated
Still	1	2	3	4	5	Surprised

Fig. 1 English (original)

Bartneck, C. (2023). Godspeed Questionnaire Series: Translations and Usage. In C. U. Krägeloh, O. N. Medvedev, & M. Alyami (Eds.), International Handbook of Behavioral Health Assessment (pp. 1-35). Springer. https://doi.org/10.1007/978-3-030-89738-3_24-1