To Shake or Not to Shake: Intuitive Reactions of Senior Adults to a Robot Handshake in a Western Culture

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Abstract— **Robots have the potential to provide everyday life care and support for senior adults, but acceptance is essential for successful implementation in the domestic environment. Nonverbal social behavior can enhance acceptance. These behavioral cues should be easy and intuitive to understand. However, which factors contribute to senior adults' intuitive understanding of social cues, such as handshakes? Our research aims to address this question using video observations and semi-structured interviews. Based on a thematic analysis and video observations, our findings indicate that some participants intuitively understood to shake hands. Still, the majority did not due to not understanding the behavior or fear. Other themes included contributing features for intuitive handshakes, design improvements, and experiences with the robot's end effector. Lastly, no effect was found between the initial response of the participants to the handshake and either the reaction time or the handshake duration. By designing the gripper and the robot itself in a more familiar, less fear-eliciting way, senior adults might understand the gesture of shaking hands more intuitively.**

Nonverbal Communication; Intuition; Handshakes; Senior adults

I. INTRODUCTION

Due to the worldwide aging society, there is an increased demand for aid in providing care for older adults [1]. Socially Assistive Robots (SAR), considered welfare technology [2], can be a solution to supporting this population and their caregivers [3]. By providing efficiency, quality care, and increased independence for this population, SAR are already successfully contributing to their care [3]. Still, acceptance is essential to successfully implementing this technology in the home environment [4], [5]. Equipping the robot with social skills contributes not only to the long-term acceptance of robots [6] but also increases the robot's likability [5], and the naturalness and efficiency of the interaction [7], [8].

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A robot can express social cues using verbal and nonverbal communication features such as voice, gesture, body language, and facial expression [9], [10]. The nonverbal cues allow the robot to communicate emotional intent [11] and depend on the social context, providing information about the aim of the robot's behavior [12]. Establishing an interaction that should be intuitively understood by humans [13].

Handshakes are a nonverbal cue considered intuitively understandable in human-to-human interaction [14]. It has been a social cue to establish trust and build relationships between individuals across different social contexts in Western culture [15]. Beyond merely being a gesture, a handshake shows the sensation of touch, an essential requirement in the physical interaction between humans and robots [16], [17], which is vital to establishing emotional connections [18].

Research on handshakes with robots has focused on evaluating human handshakes for modeling robotic handshakes, designing different phases, and evaluating handshakes between humans and robots as categorized by Prasad et al. [14] in their review. An example of a study in this latter-mentioned research area is the work by Jindai et al. [19]. They focused on analyzing various motions generated by their model and researching users' preferences regarding handshaking motion, velocity, relief, easiness, politeness, and security. Furthermore, they explored participants' responses to voice [20] and gaze [19]. Their results show a preference for shifting the gaze from the hand to the face after manifesting the connection. Work by Yamato et al. [21] showed that users preferred the robot to lead while shaking hands.

Even though much work is put into developing robot handshakes, more work is needed to know how users intuitively understand the experience of shaking hands with a robot and the interaction features contributing to this intuitive understanding. Therefore, our research explores the role of human intuition in understanding nonverbal social cues in a social context by addressing the question: *"How do senior adults intuitively understand the nonverbal social cue of handshaking with an assistant robot in a social context?"*. To answer this question, we conducted a qualitative field study using video observations and semi-structured interviews to measure the senior adults' intuitive reaction, understanding, and experience after being approached to shake hands with a robot. This study is a pilot and is part of a larger experiment.

II. THEORETICAL BACKGROUND

Intuition is a form of knowledge often described as a gut feeling, or a sense of knowing without conscious reasoning [22], [23]. It is an intuitive and spontaneous understanding of something that can be difficult to explain or articulate. Intuition is often considered a powerful and valuable tool for decision-making [24]. It draws on our past experiences and subconscious mind to guide us towards a particular action [24], [25]. It can be crucial in many aspects of our personal and professional lives. Cultivating and trusting our intuition can help us make more informed choices and navigate complex situations more quickly and confidently [25]. Intuition shares an essential link with familiarity; both are derived from experience and knowledge gained from previous experiences [23]. In human-robot interaction, this would mean that humans who interact with a robot rely on their experience with similar-looking entities to understand what it is trying to convey with its' body language.

The *Dual Processing Theory*, by Kahneman [25], explains the role of intuitive and rational thinking processes. It divides cognitive function into two systems. System 1 operates automatically, is responsible for intuitive thinking, and relies on emotions, impressions, and reflexes. System 2 is considered rational thinking and requires focus and attention. Furthermore, System 2 suppresses impulses from System 1. Also, Kahneman [25] mentions that cognitive ease, and thus, intuitive understanding, is influenced by factors such as a clear representation, priming, mood, feelings, experience, and familiarity, which can be interchangeable depending on the context. Familiarity is generated by System 1 and used by System 2 to assess a situation. According to Lobato et al. [26], this theory can also be applied to analyze the human perception of a robot in interaction. They suggest looking at the appearance and behavioral patterns of the robot to use as variables to study System 1 and System 2 thinking, hypothesizing that the features of a robot should be perceived at the same level in human-robot interaction as in human-human interaction, yet it needs to be tested.

III. METHOD

A. Participants

Four male and six senior female adults were recruited and participated in this pilot study. The inclusion criteria for the study were: a) they should be older than 65 years. b) The participants should be able to communicate in Norwegian; c) they should be independent and able to make their own decisions; and d) they should have no prior experience interacting with robots. Participants were excluded from the study if they had signs of neurological disorders such as dementia. Therefore, they were recruited from an activity center for senior adults with a mean age of 85 (*SD* = 7.27). Table I shows an overview of the individual characteristics of the participants and their initial responses to the robot handshake.

B. Setting

This study was conducted at an elderly activity center in southeast Norway. The activity space was the location of the experiments inside the facility. We selected this location as it resembled a senior adult's home environment. Furthermore, it was a quiet area, so the participant could focus on the robot. The layout of the experiment is depicted in Fig. 1. Finally, the participants were seated facing the robot and a screen that would show information about the experiment and the robot.

Part nr.	*Gender*	*Age*	*Initial response to handshake*
01	Female	80	Encouraged
02	Female	75	Encouraged
03	Male	85	Self-Initiated
04	Female	96	Encouraged
05	Man	89	Rejection
06	Man	86	Self-Initiated
07	Female	96	Rejection
08	Female	86	Encouraged
09	Female	73	Self-Initiated
10	Man	87	Encouraged

TABLE I

OVERVIEW OF CHARACTERISTICS OF PARTICIPANTS AND THEIR INITIAL RESPONSES TO THE HANDSHAKE OFFER OF THE ROBOT

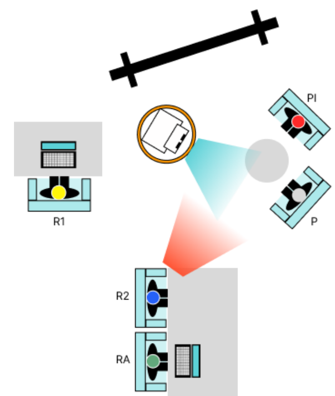

Fig. 1. Experiment with the layout of the chairs and the robot's starting position. The person with PI (red head) represents the Principal Investigator, and the person with R1 (yellow head) and RA (green head) is Researcher 1 and Research Assistant. They were in charge of controlling the robot. R1 would control the movement, and RA would control the speech. The person with R2 (blue head) represents Researcher 2, who would observe the interaction between the human and robot, and the person with the P (grey head) represents the participant. The orange and blue areas represent the location and view of the camera.

C. Procedure

The participants for this pilot study were recruited through the staff at the living facility using the selection criteria mentioned earlier. The participants were personally approached publicly and given information about the study with a poster. If senior adults were interested, they would receive more in-depth information on the study's aim, duration, and procedure. Furthermore, they were asked to sign an informed consent form when willing to participate in the study.

During the experiment, the TIAGo robot [27] (shown in Fig. 2) would welcome the participant and introduce itself to the user, paired with an invitation to a handshake. The interaction would start with the robot saying: *"Welcome to the activity. What is your name? (Answer participants.) Nice to meet you, [name participant]"*. After this verbal interaction, the robot would reach out its arm to the user and navigate closer to them at a slow movement speed so they could shake the robot's end effector. Waiting for the participant to react to the behavior of the robot. In the continuation of the session, the user would receive more information about the robot and its capabilities. We will not incorporate this into this section of the study. Instead, the robot's speech and approaching behavior were controlled using a Wizard of Oz approach. The robot's approaching behavior was being controlled by Researcher 1 (AB), and the speech by the Research Assistant. The reaching out and handshake were pre-programmed. This choice was made to ensure proper proximity to the user so they could easily reach out and touch the robot's end effector.

During this robot interaction, the researchers gave no initial verbal instructions to the participant to shake the robot's hand because this study focuses on the user's natural response to the robot's nonverbal communication. While interacting with the robot, we recorded the participant's behavior with video and audio. After the interaction, the participant was asked about the robot's experience and behavior during the interaction. The greeting element of the study, including questioning, lasted about 10–15 minutes, and the total study lasted about 45–60 minutes for each participant.

Fig. 2. The TIAGo robot was used in the current study.

D. Measurement

A combination of video observations and interviews were used as measurements in this study. Using video observations, we analyzed the participant's initial response to the handshake, reaction time, and duration. The recordings were made from two angles. One angle was from the robot's perspective, using the cameras in its eyes, and the other was from the perspective of Researcher 2 (MO). These two angles provide a holistic view of the participant's behavior, as recommended by Luff & Heath [28]. Using these videos as a basis, we developed a coding scheme for analyzing the videos based on work by Peruglia et al. [29] and McGlynn et al. [30]. Both of these works assess the engagement behavior of senior adults with robots. However, we modified the schemes to fit better our interaction scenario, which we did in two steps. In the first step, open notes were made of the participants' behaviors by watching three videos from both perspectives. These notes were compared with those mentioned in [29], [30] and evaluated with two other authors (DS and AB) to reach the final scheme shown in Table II. The participants' gaze behavior was excluded from the study due to missing data caused by the movement of the robot's head. The observation in the video starts when the robot reaches out its end effector to the participant and starts approaching them for the handshake. It ends when the participant lets go of the robot's end effector.

A short interview was also conducted after the interaction to understand the motivation for the user's behavior, how they experienced the interaction, and any concerns they might have about shaking hands with the TIAGo robot. This interview was semi-structured.

E. Data Analysis

The video material was analyzed using the ELAN 5.9 software and scored using the scheme presented in Table II. To analyze the statistical data, SPSS was used. The software would export the duration of both the reaction time variable and the handshake duration variable in milliseconds. To analyze the reaction time, we computed a one-way ANOVA to see whether the participants' reaction time and handshake duration significantly differed between the different types of initial reactions. Furthermore, the initial response to the handshake was exported as an event.

For the analysis of the transcripts of the interviews, thematic analysis and the analysis software NVivo 12.0 were used. The analysis used an inductive approach, allowing the data to determine the findings' themes and ensuring we would get all the details. Based on the transcript analysis, we identified the following themes that relate to the experience and impressions of the participants in their interaction with the robot. The identified themes are *'Features that influence the understanding of the robot's behavior'*, *'The Gripper of the robot'*, *'Impressions the robot makes on the users'*, and *'Verbal interactions of the user during interactions with the robot'*.

F. Ethical considerations

Before participating in the experiments, the participants received information about the study and signed an informed consent form. Withdrawing from participation in the study could be done at any time by them without giving an explanation or negative consequences. After completing the experiment, the participant received a gift card of 100 NOK that could be spent in the canteen of the living facility. The total duration of the entire trial was 45 to 60 minutes. The handshake, on the other hand, lasted 10 to 15 minutes. The study was conducted according to the ethical guidelines from the Norwegian Center for Research Data (NSD) (Ref. No.: 863469). The data was collected on a dedicated computer and stored on the Service for Sensitive Data (TSD) (Ref. No.: p1582), owned by the University of Oslo, Norway.

IV. FINDINGS

A. Initial responses and impressions

For participants' initial responses to the reaching out of the robot's end effector for a handshake, the reactions varied across the participants, as shown in Fig 3. Three participants initiated a handshake response, and five needed encouragement to shake hands with the robots. The way they were encouraged is shown in Table II. Lastly, two participants refused to shake hands with the robot. However,

Behaviors of Participant	***Directions***	***Description***
Handshake	Self-initiated handshake	The participant shakes hands with the robot on their initiative.
	Encouraged handshake	The participant shakes hands with the robot because of encouragement from a researcher (inviting the participant to shake hands) or from the robot performing an example handshake.
	Rejecting handshake	The participant refuses to shake hands with the robot.
Time	Reaction time before shaking the hand	The time between the robot reaching out its gripper and the participant shaking it
	Duration of handshake	The time the user shakes hands and holds the robot's gripper.
Other	Open notes	

TABLE II

THE CODING SCHEME FOR MEASURING ENGAGEMENT AND REACTION TO THE HANDSHAKE OFFERING OF A ROBOT IN A GREETING SCENARIO BY SENIOR ADULTS.

the Principal Investigator (PI) (DS) invited one of the two to shake hands and, in the second instance, shook hands with the robot.

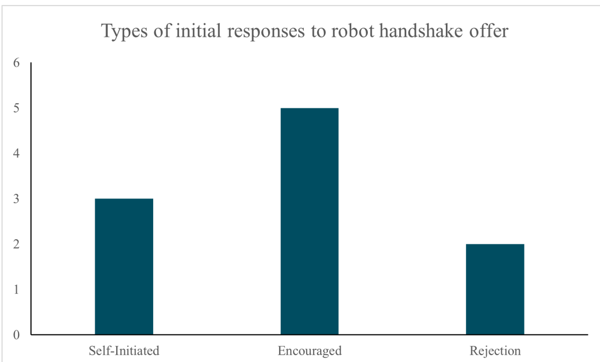

Fig. 3. Overview of initial responses to handshaking with a robot

Our qualitative findings indicate that the participants who self-initiated the handshake understood the robot's movement. *"I understood that it wanted something, taking my hand, and that is what I did."* (P3).

Participants who were encouraged to shake hands by the PI (DS) or robot indicated they were unafraid of it. Two participants indicated they did not understand that the robot was trying to shake hands with them. Another participant stated that they were unsure if the robot wanted to say "Hi" and whether they were physically able to touch the robot due to a physical disability in their hand. There was also one participant who was scared to break the robot. The last participant in this group was not motivated to react.

Additionally, our findings indicate that one participant who rejected the robot's handshake did not want anything to do with the robot and was afraid. *"I thought he wanted to hit me. It is a thing for me. It is a machine that I refuse to call a name."* (P7). The other participant thought that the robot looked dangerous. However, that person was not afraid of the robot and, in a second instance, did shake hands with the robot.

Furthermore, some participants (7) verbally reacted to the robot during the interaction. The reactions varied from greeting the robot back and thanking it (2), sharing their personal story with the robot (1), expressing curiosity about meeting the robot (1), and calling the robot out for being outlandish and rude for asking the participant how they were doing (2). *"You are an outlandish person."* (P7). Another one expressed gratitude for the robot's existence. The last person even reacted while shaking hands with the robot. *"Good boy, good boy."* (P1).

B. The Aspect of Time

1) Reaction Time: A one-way between-groups ANOVA was used to analyze whether the type of intuitive response to handshaking with the robot impacted the participants' reaction time. The conditions for performing this analysis were not violated. The ANOVA was not statistically significant, indicating that the kind of intuitive response to the hand offering of the robot did not influence the participants' reaction time, $F(2, 7)= 1.578$, $p = .272$.

2) Handshake Duration: Similarly to the reaction time, we used a one-way between-groups ANOVA to analyze whether the type of intuitive response to the offer of the robot handshake impacted the duration of the handshake with the robot. The conditions for this analysis were also not violated. The ANOVA indicated no significant effect of the initial reaction to the hand offering on the handshake duration, $F(2,6)= 1.578$, $p = .238$.

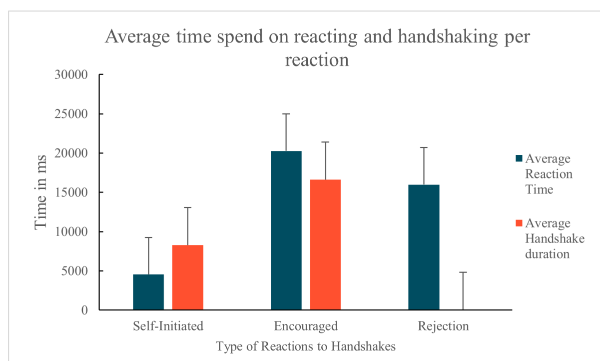

Fig. 4. Overview of initial responses to handshaking with a robot

C. Contributing features to intuitive handshakes

Our findings indicate that several contributing features aid in understanding the invitation to handshake with a robot. Those features are the approaching behavior of the robot (2), the reaching out of the arm and hand (5), and the movement of the arm and hand (2). *"When he comes with an arm like that, he does straight towards you."* (P5). *"He stretched* *out his arm. He opened his hand."* (P8). Other mentioned features are the position of the face (1) and the position of the gripper (1). *"I think there will be more people who react to it when it's open when they are going to shake hands."* (P1). Some participants (4) indicated they knew they were invited to shake hands with the robot. *"It was what I expected, that he would take my hand and say welcome here."* (P5).

D. The end effector: Impressions and Design suggestions

The robot's end effector made different impressions on the participants. One participant regarded the end effector as a claw. Another participant found the gripper quite technically looking, and a last participant mentioned intuitively treating the end effector as a hand. However, they knew it did not look like a hand either. *"I thought it was more like a hand, but then I understood it wasn't like a hand either because then you relate to someone who is a little different than yourself."* (P8). Lastly, one participant mentioned finding it odd to place their hand between the two ends of the end effector.

Participants also had some suggestions for improving the experience of shaking hands. A small majority of the participants (6) argued that the robot should have a more human-like, less mechanical hand with (flexible) fingers. *"It would have been nice if it was more like a hand."* (P1); *"A little softer (material), and I would like it to be shaped like a hand."* (P2). One participant indicated that the material of the end effector should be softer, perhaps made out of rubber. A total of two participants argued that the positioning of the end effector should be turned 180 degrees. *"It would have been best if it could stand the other way around."* (P1).

V. DISCUSSION

Creating nonverbal robot behavior that is intuitively understandable by humans is vital for the ease of interaction and, therefore, its adoption in everyday life. A handshake is a nonverbal cue that can be considered intuitive [14]. Several studies have examined user experience with robot handshakes and how to model it [19]–[21]. However, these studies did not consider the intuitive response of users to handshaking with a robot in the social context with senior adults. Therefore, this paper addresses the research question: *"How do senior adults intuitively understand the nonverbal social cue of handshaking with an assistant robot in a social context?"*. We examined this question by letting senior adults handshake with a robot in social interaction while making video observations, followed by a semi-structured interview.

Our findings suggest that three out of the ten participants intuitively understood from the social context that they could shake hands with the robots. The participants who did not intuitively understand to shake hands either did not understand the robot or its intentions. They thought they were physically incapable of shaking hands with a robot and were afraid of damaging it. Furthermore, the robot's behavior contributed to understanding the handshake intention, particularly the approaching behavior and reaching out. Also, the position of the face and gripper contributed. At the same time, the participant argued that the design and position of the gripper should change to improve the handshake experience.

Intuitive reactions are automatic responses that rely on emotions and impressions influenced by how a stimulus is represented, someone's mood, feelings, experiences, and familiarity [25]. Arguably, the participants who understood to shake hands with the robots gained enough information from the robot's behavior and the gestural cue presented to them. This understanding seems to count for human-human and human-robot handshakes and supports the argument that shaking hands is an intuitive gesture [14]. However, since most of the participants had to be encouraged to shake hands with the robot, the social cue of the robot was not entirely intuitive. This lack of intuitiveness could be due to a lack of familiarity with interacting with a robot since all these senior adults were recruited because they were new to robots. It could also be because the priming or representation of the handshake cue was not clear enough for the participants, arguing for improved interaction design. Participants who did not want to shake hands mentioned fear of the robot. This emotional response and disgust [31], [32] are evolved mechanisms that will help humans in self-preservation caused by interacting with organisms with human-like traits [33]. The defects in the human-like robot could intuitively trigger these aversive responses. Thus the mechanism for self-preservation [31] does not make the user willing to shake hands with or interact with the robot. Also, the deficiencies in the robot's human-like appearance could intuitively trigger a fight-or-flight response [34], which will also stop the user from interacting with the robot.

Lastly, our findings emphasize that the end effector used for handshaking with humans should look more like a human hand and be made of softer material. These suggestions would align with how a product's design influences the user's perception [35]. Like a human hand, more rounded shapes and soft and squishy material would evoke a more playful, comfortable, and warm impression of the robot [35].

A. Future Work

In future studies, it could be interesting to analyze the participants' gaze behavior and pupil responses while shaking hands with a robot. These measurements could provide information about attentional focus [29], [30], and cognitive effort [36]. Consequently, it provides us with greater insight into both the features of the interaction that make it easy and intuitive to understand. For example, a second research angle could be to use wearable sensors to measure the user's physiological data, such as heartbeat or skin conductivity, to investigate the user's stress level when handshaking with the robot. A third approach would be to recruit more participants to gain a more in-depth understanding of this population or a different one entirely. For instance, one could also recruit another population, such as young adults, to see whether they focus on the same features of the robot for intuitive understanding of the handshake gesture or if they understand robot motion more easily. A fourth possible study could be done on how users understand the intention of a robot while performing a (care) task because that is a likely application for which robots could be used in the future with this user group.

B. Limitations of the study

A limitation of the study is, firstly, the relatively small sample size, which makes it hard to draw firm conclusions about how intuitive the handshake cue of the robot was to understand the senior adults. As a result, statistically significant results are more challenging to find. However, we tried to gain more insights through short interviews to compensate for the small sample. A second limitation is the lack of visibility of the faces of the users in the video material, which made it hard to identify the direction of attention during the interaction. As a result, this lack makes it harder to conclude what the participants were paying attention to and, thus, what other design features contribute to the intuitive understanding of the handshake cue. A third limitation is that the findings of this study might be limited to western culture, where handshakes are an appropriate and well-adapted form of greeting. In contrast, Asian or Arab cultures, representing the most significant part of the world population, use different greetings, such as bowing or head nodding [37]. A fourth limitation could be that the participants felt like they were being observed, which could have influenced their reaction to the robot. Perhaps the responses would have differed if the researchers were not around and the senior adults had been alone with the robot.

VI. CONCLUSION

This study investigated how senior adults intuitively understand and respond to the nonverbal social cue of handshaking with a robot assistant in a social context of greeting. Our findings suggest that users who understand the intuitive gestures of a robot respond to the behavior automatically without a clear definition. Participants who did not self-initiate the handshake with the robot either did not understand the cue, were afraid to damage the robot, or were scared of the robot. The approaching robot, its arm and hand, and their movement and position aid users in understanding the nonverbal cue of handshakes. Furthermore, our results showed no statistically significant relationship between the type of initial response of the participants and either the reaction time or duration of the handshake. By designing the gripper and the robot itself in a more familiar, less fear-eliciting way, senior adults might understand the gesture of shaking hands more intuitively.

VII. ACKNOWLEDGEMENT

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