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The Role of Robot Body Language on the Perception of Social Qualities and Human-likeness in Robots

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서울대학교 대학원
심리학과 인지심리 전공
김환이

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지도교수 한 소 원

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심리학과 인지심리 전공
김 환 이

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위 원 장 ______ 고성룡 (인)
부위원장 ______ 오성주 (인)
위 원 ______ 한소원 (인)

Abstract

Whani Kim

Graduate School of Psychology

Seoul National University

The present study investigated the role of robots' body language on perceptions of social qualities and human-likeness in robots. In experiment 1, videos of a robot's body language varying in expansiveness were used to evaluate the two aspects. In experiment 2, videos of social interactions containing the body languages in experiment 1 were used to further examine the effects of robots' body language on these aspects. Results suggest that a robot conveying open body language are evaluated higher on perceptions of social characteristics and human-likeness compared to a robot with closed body language. These effects were not found in videos of social interactions (experiment 2), which suggests that other features play significant roles in evaluations of a robot. Nonetheless, current research provides evidence of the importance of robots' body language in judgments of social characteristics and human-likeness. While measures of social qualities and human-likeness favor robots that convey open body language, post-experiment interviews revealed that participants expect robots to alleviate feelings of loneliness and empathize with them, which require more diverse body language in addition to open body language. Thus, robotic designers are encouraged to develop robots capable of expressing a wider range of motion. By enabling complex movements, more natural communications between humans and robots are possible, which allows humans to consider robots as social partners.

Keywords: human-robot interaction, body language, social perception

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Chapter 1. Introduction

1.1. Motivation

It is not uncommon to see robots in public spaces like airports to private areas like living rooms (Tonkin et al., 2018). These robots serve multiple roles, such as guides, security guards, or personal assistants. They mainly have served task-oriented jobs (e.g., cleaning, patrolling, and assembling parts in factories). The main concern of today's robots is that they do not form meaningful relationships with humans but rather exist to serve a specific purpose. This leads humans to regard robots as tools rather than social partners. However, users' needs have expanded towards robots that can continuously interact with humans (i.e., conversations beyond Q&A). This development of users' needs necessitates socially appropriate behaviors from robots. Social interactions demand expressions of emotions, thoughts, attitudes, and intentions; this requires robots to convey messages through verbal and nonverbal means of communication. While research on robots' expressions through the face and voice are more readily available, less is true for body language. However, body language is essential for robots with limited facial and voice features.

Body language conveys information that cannot be expressed verbally. Nearly 70 percent of what we communicate occurs through non-verbal means, including body language (Barnum & Wolniansky, 1989). Currently, robots are capable of expressing basic emotions and intentions through body movements (e.g., expressing excitement by raising arms, pointing at an object). While these expressions are satisfactory for basic social interactions, building long-term relationships require robots to display richer social behaviors (Breazeal, 2004). Robots could benefit from the incorporation of body language that communicates more stable beliefs and attitudes. Robots that show rich social behaviors through body language (i.e., eye contact, synchronizing movements with humans) are perceived as socially intelligent (Salem et al., 2013). In turn, these robots encourage humans to form intimate and trusting relationships (Kahn et al., 2015). Furthermore, the consistent application of body language could endow robots with a personality, which is implicated in social relationships (Asendorpf & Wilpers, 1998).

The main purpose of this research was to explore how a robots' body language affects perceptions of social qualities and human-likeness. Ultimately, the goal was to contribute to a more natural HRI capable of nurturing long-term relationships between humans and robots. By applying body language that is easily interpretable to humans, robots will be beter perceived as socially intelligent with their own attitudes and beliefs, which further amplifies human tendency to anthropomorphize non-human beings. This, in turn, will encourage humans to act in response rather than simply acknowledging their actions.

1.2.Theoretical Background and Previous Research

Physical Embodiment

Current implementations of artificial intelligent systems via Voice User Interface (VUI) provide many functions that make daily tasks easier. However, users' needs are better met through the physical embodiment of an agent, henceforth referred to as robots (Baker et al., 2018). Robots can navigate their surrounding environments through incorporated motors, actuators, sensors, and cameras, which determines the degree of freedom (DoF). The sensorimotor capabilities embedded in a robot determine the level of proficiency and limitations to which the system can sense, navigate, and interact with its environment (Deng et al., 2019). These robot qualities enable them to connect with the physical world in more meaningful ways than non-physically embodied agents (Bainbridge et al., 2011; Wainer et al., 2006; Kidd & Breazeal, 2004). For example, robots are able to locate certain objects, interact with objects in its vicinity (i.e., grabbing, moving, passing, and throwing), and move to its predetermined destination. Furthermore, robots are afforded with social benefits such as increasing compliance in people who are requested to carry out an unusual task (i.e., throw a pile of books in a garbage can) (Bainbridge et al., 2011). In addition, errors (e.g., speech recognition) are forgiven more often with robots compared to screen characters (Bartneck, 2003).

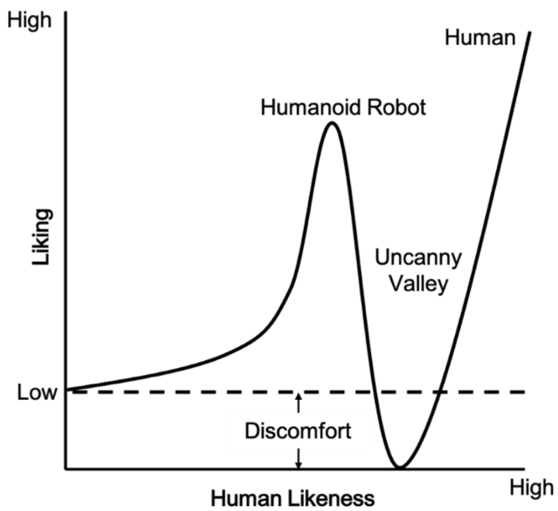
Anthropomorphism

Physical embodiment endows robots with the luxury of incorporating human-like characteristics. The benefits afforded by incorporating human-like characteristics can be owed to anthropomorphism, defined as the tendency to attribute human-like characteristics to non-human objects (Duffy, 2003). Incorporating human-like characteristics exploits this tendency, which further facilitates social understanding and impacts interaction quality (Broadbent et al., 2013; Castro-Gonzalez et al., 2016; Salem et al., 2013). Similar to anthropomorphism, Computers are Social Actors (CASA) paradigm, through a set of experiments, posited that humans mindlessly apply social rules and expectations to computers (Nass & Moon, 2000; Nass et al., 1994). The authors suggested that humans assign gender stereotypic characteristics to robots, even when gender cues are minimalized to voices (Nass et al., 1997). Similar results were obtained by Stroessner & Benitez (2019), where participants evaluated humanoid and non-humanoid's physical features that vary in gender typicality (masculine vs. feminine) and human-likeness. They found that feminine human-like robots were evaluated as warmer compared to masculine robots. Furthermore, masculine robots caused more discomfort in participants, which suggests that a robot's perceived gender impacts how it is evaluated.

Nevertheless, robotic designers are often faced with the pitfall of the Uncanny Valley (Mori et al., 2012) (Figure 1), which suggests that humans' affinity for a robot, as they become human-like, increases until it reaches a valley where it becomes eerie and grotesque. However, it becomes positive again when it very closely resembles humans. Research has argued that too much similarity between a robot and humans triggers concerns because it blurs the boundaries between humans and robots, and thus a robot's appearance should not conflict with the humans' "need for distinctiveness" (Ferrari et al., 2016). Similarly, Strait et al. (2017) found that both category ambiguity (difficulty in determining the category to which an entity belongs) and feature atypicality (presence of features unusual for a robot's category) causes adverse reactions towards robots and discomfort in people.

Figure 1

The Uncanny Valley



It becomes evident that while human-like characteristics in a robot can positively impact human-robot interaction, however, robot designers are encouraged to consider a robot's role and to what degree that agent needs to be human-like to serve its purpose in order to avoid undesirable responses from users.

Trust

As with human-human interaction, trust between a robot and a human is built over time with consistent social interactions (Cassell & Bickmore, 2003). However, errors made by a robot during an interaction will have detrimental effects on trust (Robinette et al., 2017). In addition, errors that are made earlier in the interactions cause a more significant drop in trust as opposed to errors made later in the interactions (Desai et al., 2013). When users are faced with robot errors, their trust will reduce accordingly to the severity of the robots' errors (Lee & Moray, 1992; Muir & Moray, 1996). However, previous research has shown that anthropomorphic robots have the ability to mitigate some of the adverse effects of errors compared to non-anthropomorphic robots in that they are afforded greater trust resilience, which refers to greater resistance to breakdown in trust (de Visser et al., 2016). Moreover, anthropomorphic robots have the potential to enhance trust within humans and towards themselves by showing behaviors of vulnerability (Sebo et al., 2018; Traeger et al., 2020). While reducing the number of errors or getting rid of errors altogether seem ideal, it is more practical for robots to repair any trust broken by any errors.

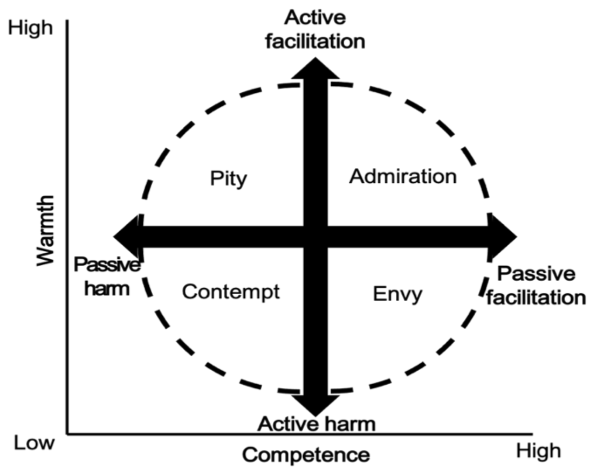
According to Sebo et al. (2019), there are two types of trust repair strategies that effectively repair the trust broken by a robot depending on what type of trust violation framing has occurred: apology and denial. When an agent violates the trust between the human and the agent through a competence-based violation, which occurs due to the lack of technical and interpersonal skill required for a job, apology works better than denial in repairing trust. In contrast, denial works better than apology in repairing trust when the trust is broken through an integrity-based violation, which refers to trust broken intentionally by not adhering to a set of principles. It is noted that participants who made reciprocal promises to an agent are naturally more trusting of an agent, which indicates that an individual's personality characteristics play a role in whether an agent is trusted (Kim, 2004). Thus, depending on what kind of errors are made, robots have options to repair the trust caused by errors.

Basic Dimensions of Social Perception

Warmth and competence compose the two basic dimensions of social perception put forth by the Stereotype Content Model (SCM; Fiske et al., 2002). SCM posits that when individuals first meet others, they judge others based on perceptions of warmth and competence to get a scope of their intentions and capability. These judgments elicit four distinct emotional responses resulting from combinations of high vs. low warmth and competence: admiration (high warmth and competence), contempt (low warmth and competence), envy (low warmth and high competence), and pity (high warmth and low competence) (Cuddy et al., 2011; Fiske et al., 2002). Each emotional response as proposed in the SCM is associated with two behavioral tendencies, which are proposed in the Behaviors from Intergroup Affect and Stereotypes (BIAS) map (Cuddy et al., 2007) (Figure 2). The BIAS map made predictions of behavioral tendencies based on the judgments of warmth and competence: active facilitation, active harm, passive facilitation, and passive harm. Active components of the behavioral tendencies are put along the warmth axis, while passive components are

Figure 2

The Behaviors from Intergroup Affect and Stereotypes map.



aligned along the competence axis. The active and passive components describe the degree of intent to which an individual is willing to execute helping behaviors or harming behaviors. The essence of the difference lies in the explicitness of these behaviors. Active and passive facilitating behaviors include assisting an individual with a task and merely associating with someone, respectively. In contrast, active and passive harming behaviors include verbal harassment and neglect, respectively.

Body Language

Human-Human Interaction (HHI). In social interactions, much of what we verbally communicate is supported by nonverbal cues (i.e., gestures, body language, voice tone, facial expressions). Body language, in particular, acts as an intermediary between an individual's emotions and the behavioral outcome providing information about the producer's emotional state and their action intentions (Stock et al., 2007). For example, an individual faced with confrontation assuming a defensive posture (i.e., clenching fists, teeth-bearing) signals that he/she is angry and is ready to fight. Moreover, body language facilitates the understanding of other individuals and make lasting impressions on interpersonal relationships. Numbers of works have shown that individuals who display open body language (i.e., expansive body postures) are perceived more positively (e.g., dominant, open, warm, and competent) in the workplace (Carney et al., 2005), romantic relationships

(Vacharkulksemsuk et al., 2016), and interpersonal relationships (McGinley et al., 1975). On the other hand, those who display closed body language (i.e., contractive body postures) are perceived as submissive, non-empathetic, cold, and incompetent (Carli et al., 1995; Cuddy et al., 2007). Furthermore, higher-status individuals naturally assume these expansive and open postures more readily compared to lower-status individuals who adopt contractive and closed postures (Carney et al., 2005).

Human-Robot Interaction (HRI). Working under the assumptions of SCM and CASA, a robots' first impression should also be based on its perceived warmth and competence. Indeed, Mieczkowski et al. (2019) found that people formed impressions of warmth and competence solely based on robots' physical characteristics. Furthermore, these impressions predicted behavioral tendencies proposed by the BIAS map even though the participants were only shown photographs of robots, and no interaction took place. However, for robots with the limited ability to express emotions and intentions through facial expressions, bodily expressions become particularly important. Research has demonstrated that people interpret body language displayed by robots in a similar manner as body language displayed by humans (Beck et al., 2012; Johnson & Cuijpers, 2019; McColl & Nejat, 2014; Xu et al., 2014). In addition, past research regarding the use of body language and gestures in Human-Robot Interaction (HRI) has shown that using gestures can improve the likeability of a non-human intelligent agent (Salem et al., 2013), communicate dominance (Li et al., 2019), and affect judgments of trustworthiness (DeSteno et al., 2012).

Beyond simple gestures, non-human intelligent agents that synchronize movements of a human interaction partner are perceived as more intelligent. These effects persisted even when the movements were negatively synchronized (doing the opposite movement of humans) compared to when the agent did not move at all, which further demonstrates the importance of using gestures to improve non-verbal communication (Lehmann et al., 2015). Moreover, exhibiting these movement behaviors facilitates the human propensity to ascribe intentions to agents. Furthermore, DeSteno et al. (2012) showed that the partners' trustworthiness is judged through non-verbal signals (e.g., leaning away and crossing arms). Furthermore, the movement characteristics of a robot influence how likable that robot is. Naturalistic motion, resembling that of a human, is evaluated more likable than mechanical motion regardless of the robot's appearance (Castro-Gonzalez et al., 2016). Law et al. (2020) showed that perceptions of emotion expressed by robots through body language are not limited to humanoid robots, extending results from previous studies to non-humanoid robots. The authors further suggested that bodily expressions of emotions are related to movements themselves and not the body morphology.

1.3. Purpose of Study

The current study investigated the role of robots' body language affects the perceived social qualities and human-likeness of NAO. In specific, we measured social dimensions (warmth, likeability, perceived intelligence, competence, discomfort), human-likeness (anthropomorphism, animacy, and perceived safety). We conducted two online experiments to investigate this purpose. The goal of the first experiment was to assess whether body language alone affected the perceptions of social qualities and human-likeness by manipulating its body expansiveness and contractiveness. The goal of the second experiment was to further explore the effect of robot body language on the perceptions of social qualities and human-likeness through social interactions.

Chapter 2. Experiment 1

2.1. Objective and Hypotheses

Experiment 1 aimed to explore the effects of body language alone on the perception of social qualities of NAO. Based on previous research findings from social psychology that suggest that open body language leads to higher perceptions of warmth and competence (Carney et al., 2005; McGinley et al., 1975; Vacharkulksemsuk et al., 2016). It was hypothesized that robots that convey open body language are perceived as warmer and more competent compared to robots that convey closed body language. Given that likeability and perceived intelligence explain similar traits as warmth and competence and that increasing the amplitude of gestures (i.e., spatial extension) leads to higher perceptions of anthropomorphism and animacy (Deshmukh et al., 2018). It was further hypothesized that open body language condition would be more anthropomorphized and perceived as more likeable, animate, and intelligent compared to the closed body language condition.

2.2 Method

Participants

Fifty-eight individuals (35 female, M_{age} = 22.02, SD_{age} = 2.12, range 18-29) from the undergraduate participant pool from Seoul National University who willingly agreed to participate were recruited. Participants were compensated one participation credit for participating in the experiment.

Procedure

Once the participants signed up through the online participation system, they were given a link to a website that contained a description of the experiment, an online consent form, and a Google form that had two videos containing a closed body (contractive) gesturing robot and an open body (expansive) gesturing robot in random order and questionnaires. Each video was approximately one minute long, which consisted of eight gestures and a second pause with a black screen between each gesture: hello, pose, question, suggestion, one-handed question, exclamation, yes, and no (Table 1). Prior to starting the experiment, participants were instructed to create an optimal environment by removing any distractions and complete the experiment in one sitting. Participants were to pay attention to the robot in the video and were not informed of the true purpose of the study. In the video, NAO was situated on a table facing forward to simulate a first-person view. After viewing the video, participants completed the questionnaires that assessed their perceptions of NAO and were asked post-questionnaire interview questions.

Table 1

Keyframes of body gestures in experiment 1

	Hello	Pose	Question	Suggestion
Open				
Closed				

Table 1

Keyframes of body gestures in experiment 1 (Cont.)

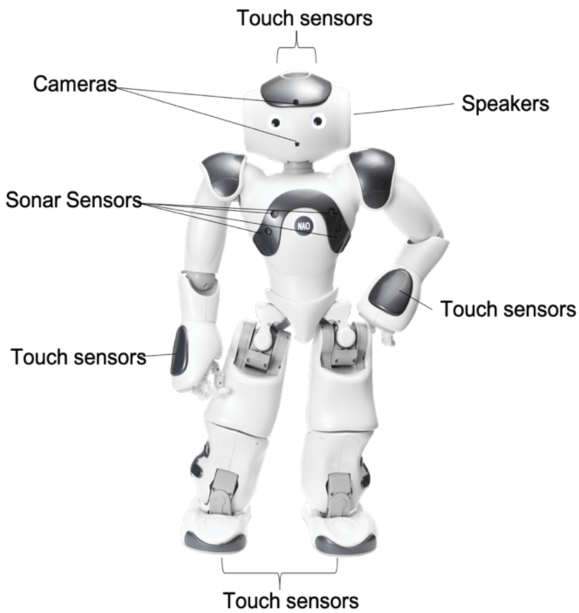
	Question (One hand)	Exclamation	Yes	No
Open				
Closed				

Materials and Measures

Softbank Robotic's NAO was used in both experiments. NAO is a 58 cm tall bipedal humanoid robot with 25 DoF. It includes two cameras on the forehead and mouth, four microphones and speakers, four sonar sensors, seven touch sensors located on the head, hands, and feet (Figure 3). NAO is one of the most commonly used robots in HRI research, including autism (Tapus et al., 2012; Shamsuddin et al., 2012), emotional expression (Alenlijung et al., 2017; Andreasson et al., 2018). The body movements expressed by NAO were programmed through Softbank Robotics' software Choreographe (Softbank Robotics, 2015), a graphical programming tool that houses a Linux-based operating system (OS) named NAOqi (Figure 4). A

Figure 3

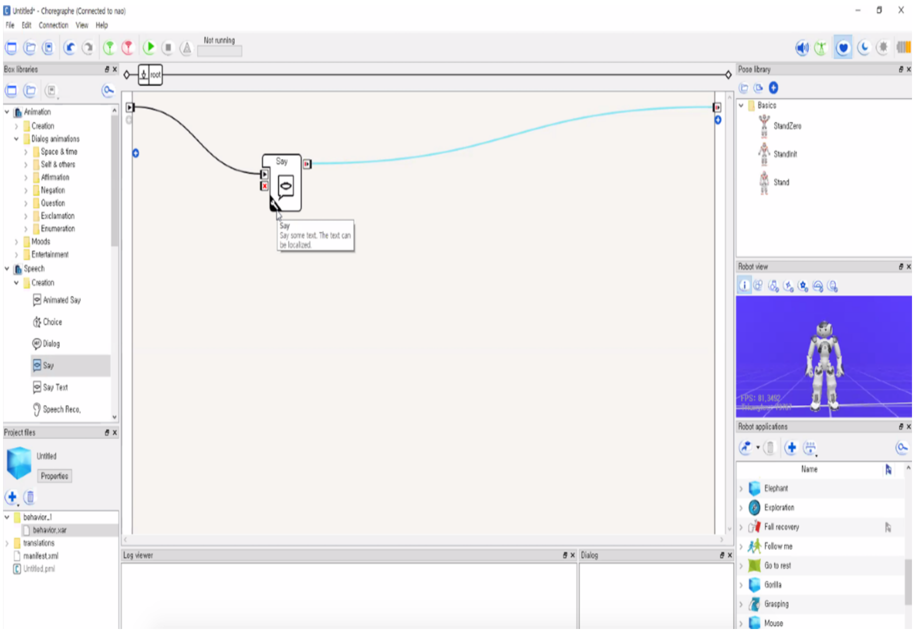
Softbank Robotic's NAO and its specification.



timeline function was used to enable the programmer to individually map out specific movements by 25 frames per second (fps) to create gestures.

Figure 4

Choreographe environment



The Godspeed Questionnaire (Bartneck et al., 2009) was used to assess the human-likeness of NAO. It is one of the most frequently used questionnaires to assess perceptions of intelligent agents in HRI with over 160 citations as of October 2014 (Weiss & Bartneck, 2015). The 5-point Likert scale questionnaire consists of 24 items with five subscales (Table 2). The Korean version of the questionnaire was obtained through the author’s website. Also, it is noted that the last two items of the perceived safety were reverse coded.

The Robotic Social Attributes Scale (RoSAS) (Carpinella et al., 2017) was used to assess participants' perceptions of social qualities of NAO. RoSAS is a recently developed questionnaire with 18 items with three subscales that measures the two fundamental dimensions in social perception as posited by SCM and a dimension specific to HRI (Table 3).

Developing the measure considering evidence from social psychology, it sought to solve and improve upon problematic features identified in the Godspeed questionnaire. Its aim was "to offer a means to assess the central attributes implicated in human perception of robots and ultimately, to provide the robotic community with a tool to determine how perceived attributes affect the quality of interaction with robots" (Carpinella et al., 2017; p. 254). Despite recent development, many researchers have validated and utilized the measure to capture perceptions of robots (Pan et al., 2018; Sebo et al., 2019; Spatola et al., 2019; Stroessner & Benitez, 2019). To date, Korean translations for the questionnaire have not been introduced; thus, the items were translated and shown to the participants alongside the original English items. Participants were asked to input their responses on a 7-point Likert scale.

Table 2

Godspeed questionnaire sub-scales and its descriptions

Sub-scale	Description
Anthropomorphism	The degree to which the robot is attributed human-like characteristics.
Animacy	The degree to which the robot is perceived as being alive.
Likeability	The degree to which the robot is perceived as pleasant.
Perceived intelligence	The degree to which the robot and its behavior are perceived as intelligent, competent, and smart.
Perceived safety	The degree to which the interaction with the robot is considered safe.

Table 3

Robotic Social Attributes Scale (RoSAS) sub-scales and its descriptions

Sub-scale	Description
Warmth	The degree to which the robot is perceived as social and trustworthy.
Competence	The degree to which the robot is perceived as competent and knowledgeable.
Discomfort	The degree to which the robot is perceived as awkward.

Both measures, despite the partial overlap, capture unique aspects of perception of robots and were utilized in the current study. Finally, a question involving manipulation check judgments regarding the robot's body language (1 = Closed to 5 = Open) was included.

2.3. Results

Manipulation Check

Body openness and closed-ness manipulation check item was analyzed using a within-subjects t-test. The analysis showed that the difference between open body language (M=3.59, SD =1.03) and closed body language (M=2.47, SD =1.13) was significant ($t(57) = 5.52$, $p < 0.001$, $d = .72$). This suggests that the body language of NAO was significantly different between open body language condition and closed body language condition.

Reliability

Cronbach's alpha was calculated to measure the internal consistency of the participants' responses to both Robotics Social Attributes Scale (RoSAS) and the Godspeed questionnaire. The 18 items in RoSAS with three subscales produced sufficient levels of reliability, as well as the Godspeed Questionnaire with 24 items with five subscales (Table 4). Results showed that all of the measures, except for perceived safety, were at acceptable levels.

Table 4

Internal consistency of measures between conditions

Measure	Open body language	Closed body language
	α	
Warmth (6 items)	.84	.76
Competence (6 items)	.78	.81
Discomfort (6 items)	.87	.78
Anthropomorphism (5 items)	.87	.81
Animacy (6 items)	.83	.78
Likeability (5 items)	.87	.79
Perceived Intelligence (5 items)	.82	.84
Perceived Safety (3 items)	.61	.75

Social qualities of NAO

To test whether NAO's body language affected the participants' social perception of NAO (i.e., warmth, competence, and discomfort), a within-subjects t-test was conducted. Consistent with the hypothesis, the results showed that the NAO with open body language (M = 4.04, SD = 1.19) was perceived as warmer compared to closed body language (M = 3.33, SD = 1.03), ($t(57)$ = 3.59, p < 0.001, d = .47). Similar to results of perceived warmth, open body language (M = 4.17, SD = .97) was perceived as more competent compared to closed body language (*M* = 3.77, *SD* = .98), ($t(57) = 2.81$, $p = .007$, $d = .37$). However, the result of t-test for discomfort was not significant (Figure 5).

Human-likeness of NAO

A within-subjects t-test revealed an effect of body language on anthropomorphism ($t(57) = 2.83$, $p = .006$, $d = .37$). Open body language (*M* = 2.61, *SD* = .82) was anthropomorphized more than closed body language (*M* = 2.25, *SD* = .76). As expected, open body language (*M* = 3.14, *SD* = .77) was evaluated as more animate than closed body language (*M* = 2.53, *SD* = .71) ($t(57) = 5.45$, $p < .001$, $d = .71$). As with other results, body language showed an significant effect on likeability ($t(57) = 2.81$, $p = .007$, $d = .37$), with open body language (*M* = 3.44, *SD* = .81) being rated higher than closed body language (*M* = 3.07, *SD* = .67) (Figure 6). Table 5 and 6 show that likeability and warmth are positively correlated which suggests that likeability subscale in the Godspeed questionnaire is related to one of the two basic social dimensions measured by RoSAS. In addition, positive correlations between perceived intelligence and competence suggest that it is related to the other basic social dimension.

Table 5

Means, standard deviations, and correlations between variables in open body language condition

Variable	*M*	*SD*	1	2	3	4	5	6	7	8
1.Anthropom-orphism	2.61	.82	—							
2. Animacy	3.15	.77	.79**	—						
3. Likeability	3.44	.81	.21	.35**	—					
4. Perceived Intelligence	3.06	.59	.20	.19	.19	—				
5. Perceived Safety	2.98	.70	-.22	-.23	.11	.39**	—			
6. Warmth	4.04	1.19	.64**	.68**	.59**	.13	-.24	—		
7. Competence	4.18	.97	.52**	.63**	.45**	.62**	.14	.57**	—	
8. Discomfort	3.02	1.3	-.08	-.18	-.79**	-.26*	-.25	-.42**	-.32*	—

* $p < .05$. ** $p < .01$.

Table 6

Means, standard deviations, and correlations between variables in closed body language condition

Variable	*M*	*SD*	1	2	3	4	5	6	7	8
1.Anthropom-orphism	2.25	0.78	—							
2. Animacy	2.53	0.71	.71**	—						
3. Likeability	3.07	0.67	.32*	.52**	—					
4. Perceived Intelligence	2.92	0.56	.23	.25	.35**	—				
5. Perceived Safety	3.18	0.83	-.24	-.19	.30*	.28*	—			
6. Warmth	3.33	1.03	.70**	.66**	.49**	.35**	-.16	—		
7. Competence	3.77	0.98	.38**	.55**	.56 **	.63**	.17	.57**	—	
8. Discomfort	2.93	0.95	-.42**	-.51**	-.15	-.15	-.09	-.39**	-.29*	—

* $p < .05$. ** $p < .01$.

Figure 5

Mean scores of social qualities of NAO between body language conditions. Error bars represent 95% confidence intervals.

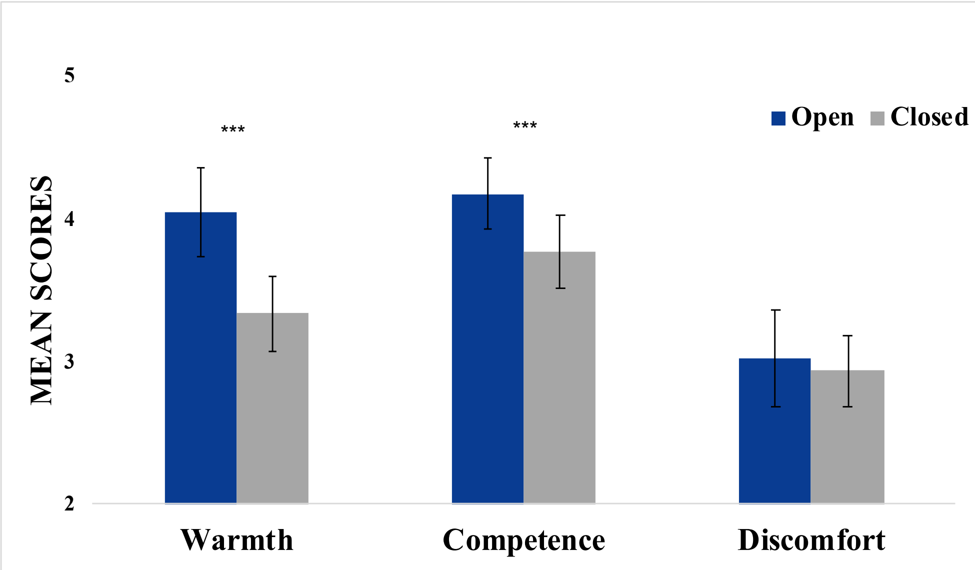
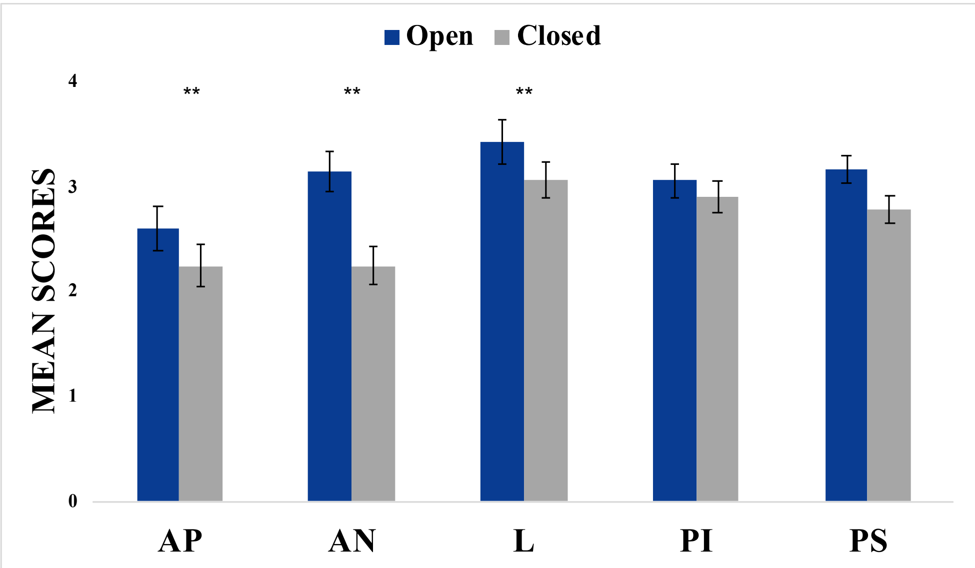


Figure 6

Mean scores of human-likeness of NAO between body language conditions. Note: AP = Anthropomorphism, AN = Animacy, L = Likeability, PI = Perceived Intelligence, PS = Perceived Safety. Error bars represent 95% confidence intervals.



Qualitative results regarding expected functions (experiment 1)

Participants were asked, "what functions do you expect if social robots were a part of your daily life?" after viewing the video and completing questionnaires to gather information on whether what kinds of body language might be required for a robot to successfully carry out a task or social interaction. Seven participants chose not to give a response to this question. Three categories were deducted from 51 responses: Service (N = 22), companion (N = 18), and conversational (N =11) (See Table 7 for summary).

The service category was the most mentioned relative to other categories. Responses regarding house chores (N = 11), daily schedule (N = 4), information (N = 4), and other roles relating to service (N =3) were included in this category. Many participants expected robots to unburden them from daily activities like "cleaning and alarm functions because sophisticated movements seem difficult so functions that ask the robot for simple actions." However, specific roles have been expected from robots: "Robots seem to be able to do a given job well, but it will take more time to communicate effectively compared to human-human interaction. It seems that the lack of change in facial expressions seems to be both an advantage and a disadvantage. I think it would be suitable for administrative work. If robots are able to use more sophisticated language, and if they can express demands and expressions like humans, I can expect a function that plays an emotional role," and another mentioned "restaurant waiter" as an expected role of robots.

Responses related to advice (*N* = 7), emotion (*N* = 5), friend (*N* = 4), and loneliness (*N* = 2) were included in the companion category. This category demanded a more intricate role from robots requiring empathy as a core function. Most participants hoped for an interaction partner that goes beyond simple conversations; they wanted someone to empathize with them and have someone to talk to about private matters that they have trouble telling others. For example, participants reported, "It would be nice to have an emotional care function. In Korea, where suicide rate is still high, I thought that if we could provide mental treatment through these robots, it would be helpful to society as a whole", "I think it would be good to have a companion function in your free time or while you eat. It will be especially good for the elderly. I'd like to have a function that understands my feelings and make me feel better. For example, robots that know that I'm in a bad mood or angry and teach me effective ways to calm down", and "I want it to be a friend who gives me strength. I hope it feels like a pet that listens to concerns that I can't easily share with others and comforts me."

Responses that contained the words "conversational partner" and "conversation" (*N = 7)* and responses related to speech characteristics (*N*

=4) were included in the conversational category. Apart from simple conversation-related responses, the conversational category emphasized natural-ness of speech and fluid and continuous conversations between robots and humans. Participants expected “robots that take intonations and accents into consideration while speaking” and stated that “it would be fascinating if the interaction was so smooth that it made it seem like a real conversation.”

Table 7
Post-experiment interview regarding expected functions of robots

Theme	*N*	Sub-categories(*N*)	Example
Service	22	Chores (11)	"I think I would make it run errands when I'm alone."
		Schedule (4)	"Wake me up in the morning, take me home at night."
		Information (4)	"I hope it works in conjunction with other programs besides KakaoTalk or the basic performance of the robot."
		Other (3)	"Waiter at a restaurant."
Companion	18	Advice (7)	"To comfort and sympathize with me when I talk about my hardships."
		Emotion (5)	"Show a variety of emotional reactions when I say simple things or show actions."
		Friend (4)	"I would want a robot that can communicate, share our daily lives together, and give me reminders like a secretary and a friend."
		Loneliness (2)	"Listen to my stories and respond to me, recommend songs, and make me feel like I'm with someone when I feel really lonely."

Table 7

Post-experiment interview regarding expected functions of robots (cont.)

Theme	*N*	Sub-categories(*N*)	Example
Conversational	11	Conversational partner (7)	"I hope it is a robot that can have daily conversations and access various information such as weather and news."
		Speech (4)	"I hope it makes fewer mechanical sounds, has a variety of expressions and can express itself through text as well. I hope it's made of cushion material rather than hard mechanical material."

2.4. Discussion

The results of the experiment suggest that gestures that convey certain body language alone affect the perception of social qualities and human-likeness of NAO. Building upon Mieczkowski et al. (2019) research, the current study provides evidence that people form robots' impressions of warmth and competence similar to forming impressions of other individuals. Another goal of this study was to assess whether the different body language affected the perception of human-likeness of NAO. While there was a significant difference between anthropomorphism, animacy, likeability, no significant difference was observed in perceived intelligence and perceived safety. Higher animacy scores in the open body condition can be attributed to the expansiveness of gestures (Deshmukh et al., 2018), and because the likeability scores are linked to a social dimension; it can be interpreted with caution that the "inherent quality" of the robot was not affected by the body language. However, participants tended to anthropomorphize the open body language condition more, which is not a social dimension. Deshmukh et al. (2018) suggested that movements in lower amplitude and speed are less similar to human movements, which caused movements higher in amplitude and speed to be rated higher on anthropomorphism. Interestingly, despite positive correlations between competence and perceived intelligence, no significant difference between body language conditions was found in perceived intelligence. Through qualitative data, we were able to extract three categories of robots that people desire in the future when robots are in daily use. It seems necessary for robots to convey more than just simple emotions to accomplish a successful HRI in all of those categories. For example, those who expect robots to act as a companion look for empathy and complex emotional responses. Robots in the field today are capable of expressing range of emotions, however, the propensity to create robots that behave positively due to matching the demand of service roles such as personal assistants have led to less suitability of robots expressing emotions that show signs of uncertainty, disapproval, and discomfort. However, those individuals who are willing to self-disclose personal thoughts and concerns are often discussing negative matters. If a robot was to show signs of happiness and excitement, it would not be a proper response to the situation, which would lead the user to believe that the robot is not socially present or not able to empathize with the user. A proper response of robots, then, would be to show signs of discomfort or concern (i.e., arms crossed, leaning forward). Thus, robots would benefit from being able to express a more diverse range of body movements.

In experiment 2, we further investigate findings from experiment 1 and explore whether participants' personality might play a role in the perception of robots based on robot body language. Lee et al. (2006) found complementary attraction effects in HRI; specifically, participants had higher evaluations of interactions when the robot's personality was the opposite of their own personality compared to when they interacted with a robot with a similar personality. Joosse et al. (2013) found the opposite effect, although not statistically significant, that extroverted participants tend to trust an extroverted robot if the robot's task demands an outgoing personality (i.e., tour guide). Their research manipulated the amplitude, speed and frequency of body movements, pitch and volume of voice, and rate of speech. However, the participants' perception of the robot might have been more biased towards the task context in which they were geared towards a more functional context rather than in a social context. An individual's judgments of a robots' impression vary depending on the context in which the robot is situated, and thus differ in social interactions compared to in functional context and viewing gestures alone (Wang & Krumhuber, 2018). Taking previous literature into consider, we aimed to further explore our findings through social interaction in experiment 2.

Chapter 3. Experiment 2

3.1. Objective and Hypotheses

The main objective of experiment 2 was to replicate the findings from experiment 1 and applying the same body language to social interaction. Although gestures conveying a certain body language shows that it affects the way NAO is perceived, it does not seem fully convincing, considering that no interaction took place. To further demonstrate that body language affects perceptions of social qualities and human-likeness, we applied the gestures from experiment 1 to a more natural social setting.

In experiment 2, the hypothesis was similar to the one's made in experiment 1 in that open body language condition would be evaluated higher in perceptions of warmth, competence, anthropomorphism, animacy, likeability, and perceived intelligence compared to the closed body language condition and the static condition. It further was hypothesized that closed body language condition would be rated higher in perceptions of warmth, competence, anthropomorphism, likeability, and perceived intelligence compared to the static condition. In addition, previous research came up with mixed results on whether users prefer a robot that is similar to one's own personality or the opposite (Craenen et al., 2018; Joosse et al., 2013; Lee et al., 2006). Some have found complementary effects of personality, while some found the opposite. Craenen et al. (2018) tested whether a robot's gestures have any correlation with the Big-Five Inventory and found both similarity attraction and complementary attraction applied. However, the results suggested that the similarity attraction had a stronger correlation. In line with the previous research, it was hypothesized that participants high in extraversion would show a preference for NAO with open body language, and those low in extraversion would show a preference for NAO with closed body language condition.

3.2 Method

Participants

One-hundred nineteen individuals (52 female, M_{age} = 20.43, SD_{age} = 1.92, range 18-26) from the undergraduate participant pool from Seoul National University who willingly agreed to participate were recruited. Participants were randomly assigned to either open body language (N = 34), closed body language (N = 42), or static condition (N = 45). Participants were compensated one participation credit for participating in the experiment.

Procedure

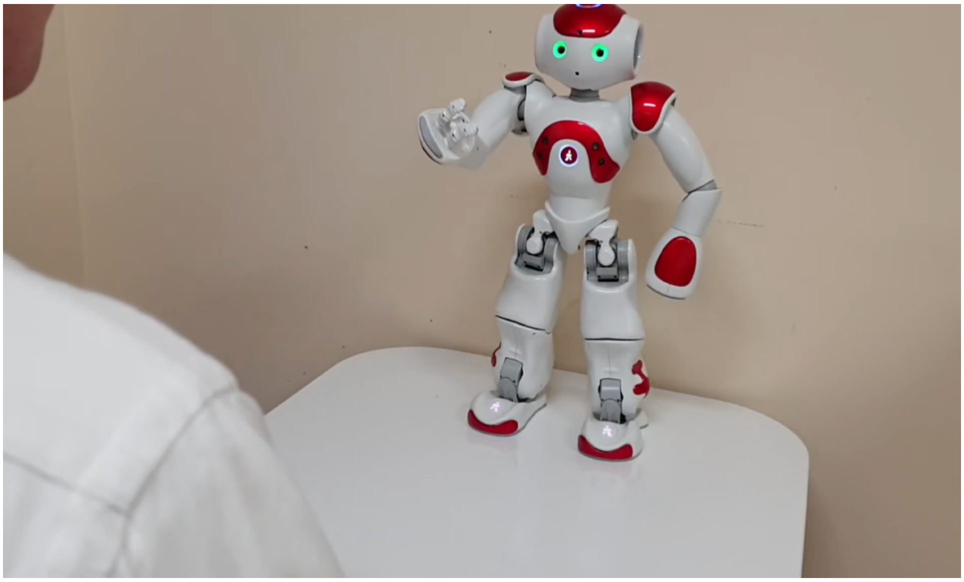
The procedure for experiment 2 closely mirrored experiment 1 in that participants were to view a video and then rate their perception of NAO. The primary difference was the inclusion of no body language condition on top of closed, and open body language conditions. The videos in experiment 2 entailed a full social interaction between a person and NAO with dialogues. In addition, participants' personality was measured before viewing the video to probe whether participants' personality correlated with increased preference for a certain body language. Prior to starting the experiment, participants were instructed to create an optimal environment by removing any distractions and complete the experiment in one sitting. Participants were to pay attention to the robot in the video and were not informed of the true purpose of the study. In the video, NAO was situated on a low table to match the eye level of the seated person (Figure 7). In contrast to experiment 1, the legs of NAO were fixed in its natural position in experiment 2 due to the nature of NAO shifting unwantedly from contracting its legs back and forth. Thus, the body language was limited to the torso.

The interaction consisted of the following: a game of charades (i.e., acting out an elephant, gorilla, and mouse) followed by a question answering then a picture taking session which resulted in 5-minute videos. During the question answering portion of the interaction, NAO produced one to two gestures per question and replied depending on the length of the sentence. In the picture taking session, NAO posed in an expansive way (i.e., hand raised above its shoulder and arms positioned apart from its torso) or in a contractive way (i.e., hand below the shoulder and arms close to its torso).

After viewing the video, participants completed questionnaires that assessed their perceptions of NAO.

Figure 5

Experiment 2 video example



Materials and Measures

The questionnaires included the Godspeed questionnaire (Bartneck et al., 2009) and the Robotic Social Attributes Scale (RoSAS) (Carpinella et al., 2017). In experiment 2, participants' personalities were measure by the Big Five Inventory-Korean Version (BFI-K) (Kim et al., 2010). Seven items included in the BFI-K were changed due to some items being inappropriately translated from the original; the changes made in the scale are noted in the appendix.

3.3. Results

Manipulation Check

Three body openness and closedness manipulation check items wer analyzed using a one-way ANOVA. The analysis showed that the difference between open body language (M = 4.00, SD = .73), closed body language (M = 3.72, SD = .85), and static (M = 3.55, SD = .68) conditions were significant ($F(2,116) = 3.48$, $p = 0.03$). The result suggest that the manipulations of the body language were successful.

Social qualities of NAO

A one-way between-subjects ANOVA was conducted to compare the effects of body language on perceptions of social qualities of NAO. Results revealed no significant differences of social qualities of NAO across body language conditions: warmth ($F(2,116) = .24$, $p = .79$), competence ($F(2,116) = .09$, $p = .91$), likeability ($F(2,116) = .49$, $p = .62$), perceived intelligence ($F(2,116) = .55$, $p = .58$), and discomfort ($F(2,116) = .28$, $p = .76$). Results are summarized in table 8 and figure 8. Hypothesis that NAO's body language would significantly affect perceptions of social qualities was not supported.

Human-likeness of NAO

A one-way between-subjects ANOVA was conducted to compare the effects of body language on perceptions of human-likeness of NAO. Results revealed no significant differences in perception of human-likeness across body language conditions: anthropomorphism ($F(2,116) = 1.31$, $p = .28$), animacy ($F(2,116) = .09$, $p = .91$), and perceived safety ($F(2,116) = 2.71$, $p = .07$). Results are summarized in table 9 and figure 9. The hypothesis that NAO's body language would significantly affect perceptions of human-likeness was not supported.

Table 8

Means, standard deviations, and one-way analyses of variance in social qualities

Measure	Open		Closed		Static		F (2, 116)	η^2
	M	*SD*	*M*	*SD*	*M*	*SD*		
Warmth	4.04	1.15	4.09	1.15	4.20	.95	.24	.004
Competence	5.38	.74	5.11	1.12	5.36	.86	.09	.001
Discomfort	2.43	1.01	2.42	1.06	2.33	.93	.28	.004

Figure 6

Mean scores of social qualities of NAO across body language conditions. Error bars represent 95% confidence intervals.

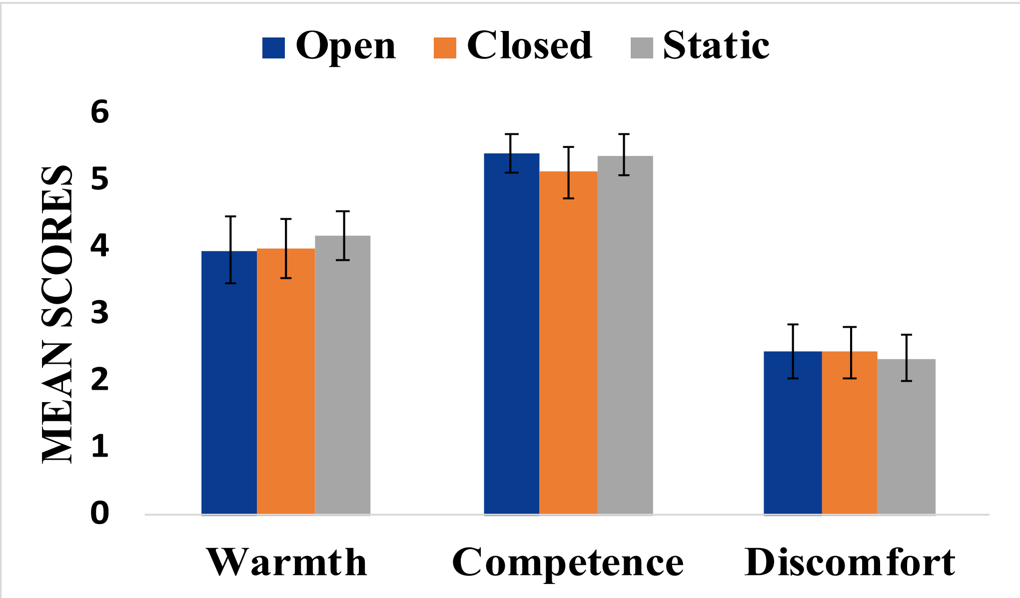


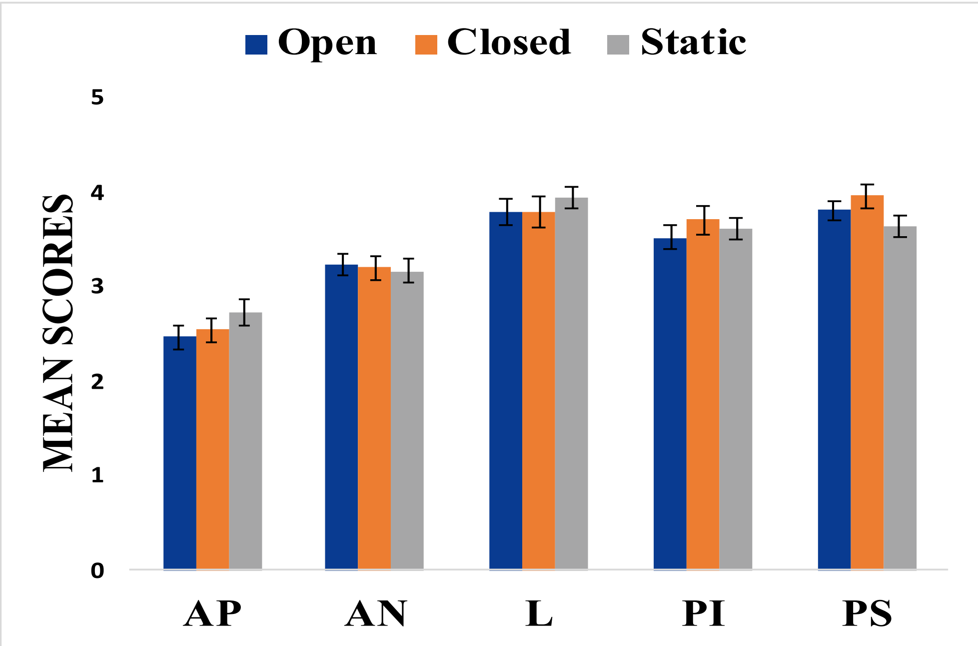
Table 9

Means, standard deviations, and one-way analyses of variance in human-likeness

Measure	Open		Closed		Static		F (2, 116)	η^2
	M	SD	M	SD	M	SD		
Anthropomorphism	2.47	.71	2.54	.74	2.72	.79	1.31	.02
Animacy	3.24	.64	3.20	.75	3.17	.69	.09	.002
Likeabilty	3.80	.79	3.79	.92	3.95	.64	.49	.008
Perceived Intelligence	3.52	.71	3.71	.86	3.62	.68	0.55	.009
Perceived Safety	3.81	.58	3.96	.66	3.64	.67	2.71	.04

Figure 7

Mean scores of human-likeness of NAO. Note: AP = Anthropomorphism, AN = Animacy, L = Likeability, PI = Perceived Intelligence, PS = Perceived Safety. Error bars represent 95% confidence intervals.



Personality

A multiple regression analysis was conducted to test whether personality traits significantly predicted social qualities of NAO. To test this hypothesis, warmth, competence, likeability and perceived intelligence measures were tested separately between conditions. The results for warmth were not significant across conditions: open body language condition (R^2 = .02, F(5,28) = .14, p = n.s.), closed body language conditions (R^2 = .11, F (5,35) = .83, p = n.s.), and static condition (R^2 = .14, F (5,37) = 1.28, p = n.s.) (Table 10). Regression analysis for competence also showed no significant across conditions: open body language (R^2 = .21, F (5,28) = 1.45, p = n.s.), closed body language (R^2 = .12, F (5,35) = .95, p = n.s.), and static (R^2 = .13, F (5,37) = 1.09, p = n.s.) (Table 11).

Regression analysis for likeability also showed no significant across conditions: open body language (R^2 = .14, F (5,28) = .93, p = n.s.), closed body language (R^2 = .14, F (5,35) = 1.12, p = n.s.), and static (R^2 = .16, F (5,37) = 1.45, p = n.s.) (Table 12). Finally, regression analysis for perceived intelligence showed no significant across conditions: open body language (R^2 = .14, F (5,28) = .89, p = n.s.), closed body language (R^2 = .09, F (5,35) = .70, p = n.s.), and static (R^2 = .09, F (5,37) = .77, p = n.s.) (Table 13). Results suggest that personality measures do not predict perceptions of social qualities of NAO. Hypothesis that participants high in extraversion would show a preference for NAO with open body language, and those low in extraversion would show a preference for NAO with closed body language condition was not supported.

Table 10
Regression analysis for warmth across conditions

Measure	Open				Closed				Static			
	β	*SE*	*t*	*p*	*β*	*SE*	*t*	*p*	*β*	*SE*	*t*	*p*
Extraversion	.06	.31	.32	.75	.02	.43	.08	.94	.25	.34	1.41	.17
Agreeableness	-.15	.61	-.71	.48	.33	.54	1.58	.12	.26	.27	1.51	.14
Conscientious-ness	.06	.37	.31	.76	-.04	.36	-.22	.83	-.05	.26	-.27	.79
Openness to Experience	-.03	.35	-.13	.90	.19	.25	1.04	.31	.19	.20	1.17	.25
Neuroticism	.04	.34	.21	.84	.02	.26	.08	.93	-.15	.23	-.97	.34

Table 11

Regression analysis for competence across conditions

Measure	Open				Closed				Static			
	β	*SE*	*t*	*p*	*β*	*SE*	*t*	*p*	*β*	*SE*	*t*	*p*
Extraversion	-.12	.18	-.69	.49	-.19	.38	-.92	.37	-.31	.29	-1.71	.10
Agreeableness	-.01	.35	-.04	.97	.32	.47	1.57	.13	.29	.24	1.70	.10
Conscientious-ness	.19	.21	1.04	.31	.14	.31	.70	.49	.14	.22	.82	.42
Openness to Experience	-.34	.20	-1.64	.11	.14	.22	.80	.43	.08	.18	.48	.64
Neuroticism	-.13	.20	-.71	.49	.0	.23	-.02	.99	.05	.20	.30	.76

Table 12

Regression analysis for likeability across conditions

Measure	Open				Closed				Static			
	β	*SE*	*t*	*p*	*β*	*SE*	*t*	*p*	*β*	*SE*	*t*	*p*
Extraversion	-.23	.20	-1.23	.23	-.09	.34	-.45	.65	.33	.22	1.86	.07
Agreeableness	.15	.39	.74	.46	.22	.43	1.09	.29	.19	.18	1.13	.27
Conscientiousness	.17	.24	.89	.38	.02	.29	.13	.90	-.27	.17	-1.61	.12
Openness to Experience	-.12	.22	-.55	.59	.04	.20	.20	.84	.25	.14	1.59	.12
Neuroticism	.13	.22	.67	.51	.35	.21	2.04	.05	-.16	.16	-1.04	.31

Table 13

Regression analysis of perceived intelligence across conditions

Measure	Open				Closed				Static			
	β	*SE*	*t*	*p*	*β*	*SE*	*t*	*p*	*β*	*SE*	*t*	*p*
Extraversion	-.26	.18	-1.40	.17	-.21	.33	-.97	.34	-.21	.33	-.97	.34
Agreeableness	.14	.35	.71	.49	.26	.41	1.25	.22	.26	.41	1.25	.22
Conscientiousness	.15	.21	.77	.45	.16	.27	.80	.43	.16	.27	.80	.43
Openness to Experience	.03	.20	.12	.91	.13	.19	.72	.48	.13	.19	.72	.48
Neuroticism	-.17	.20	-.86	.40	.05	.20	.30	.76	.05	.20	.30	.76

Qualitative results regarding expected functions (experiment 2)

Participants were asked, "what functions do you expect if social robots were a part of your daily life?" after viewing the video and completing questionnaires to gather information on whether what kinds of body language might be required for a robot to successfully carry out a task or social interaction. Seven participants chose not to give a response to this question. Four categories were deducted from 119 responses: Service (N = 76), companion (N = 9), conversational (N = 32), and other (N = 2) (See Table 14 for summary).

The majority of the responses were included in the service category. Responses regarding house chores (N = 14), daily schedule (N = 40), and information (N = 22) were included in this category. Most participants in this group expected robots to simplify daily tasks. For example, a participant mentioned, “I look forward to functions that help people in their daily lives, such as telling them what they forgot and didn't do.” Most of the functions mentioned in this category are already available, but participants expected higher functionality and automation. Participants in this group perceived robots as tools rather than interaction partners.

Responses related to advice (N = 2), loneliness, and depression (N = 7) were included in the companion category. Again, this category demanded a more intricate role from robots requiring empathy as a core function. For example, a participant reported “I think it can be a friend of the elderly or children who live alone. It would be more useful for natural interactions than for information delivery.” Most of the participants expected robots to be a companion for people who lived alone or were sick.

The conversational category ($N = 32$) was not divided into smaller categories because most of the responses fell into a similar category. An overwhelming number of responses in the conversational category emphasized natural-ness of conversation. Participants in this category also expected “casual” conversations with robots. Responses included: “To chat and play with me when I’m bored”; “I think it could play simple games, tell a funny story, or have conversations”; “I think small talk to pass the time when I’m really bored would be good.”

Two responses were classified into the other category. These two responses were: “I don't think I can trust robots yet” and “I wish to see more fluency in their movements and the voices they make while moving.”

Table 14

Post-experiment interview regarding expected functions from experiment 2

Theme	*N*	Sub-categories(*N*)	Example
Service	76	Chores (14)	"I can expect simple physical work based on voice recognition. Bringing delivery food and drinks to me"
		Schedule (40)	"I expect scheduling and alarm functions. I don't think I'll expect much of the chat function."
		Information (22)	"I'd like to leave business-related matters to robots. At least it'll be more accurate than me, but I don't want to talk about emotional stories, worries, etc. I don't want to feel that I'm being recognized and loved by non-human beings."
Companion	9	Advice (2)	"I hope it acts as a friend who tries to go through worries and problems together, not just giving an answer. The robot asks a lot of questions, so I think it can come up with good solutions."

Table 14

Post-experiment interview regarding expected functions from experiment 2 (cont.)

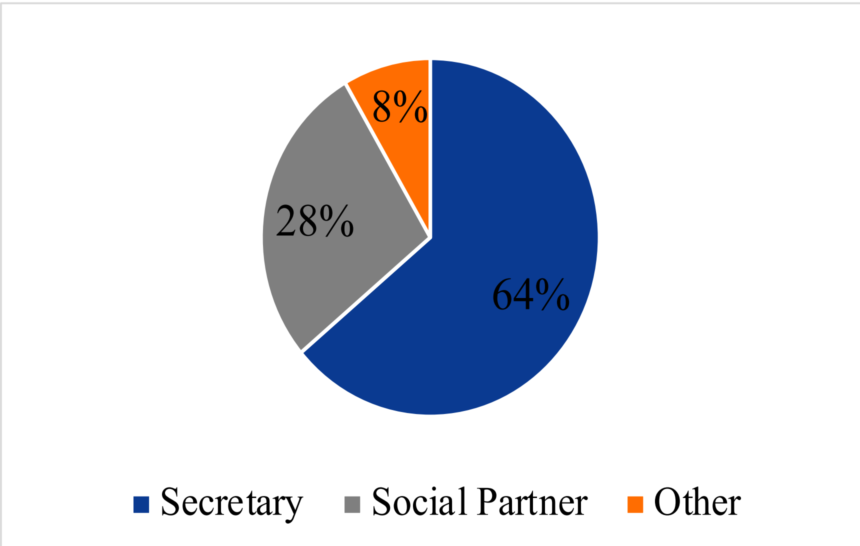
Theme	*N*	Sub-categories(*N)*	
Companion	9	Loneliness (7)	"I think it can be a friend for the elderly or children who live alone. It would be more useful for natural interactions than for information delivery."
Conversational	32	N/A	"Natural and creative conversations." "a casual conversation, not just positive."
Other	2	N/A	"I don't think I can trust robots yet."

Qualitative results regarding expected roles

When asked, "what roles do you expect if social robots were a part of your daily life?" 76 participants answered secretary, 30 answered friend or conversation partner, and 13 mentioned roles such as manager, industry, and guide (Figure 10). This suggests that participants mostly see robots as a means to make tasks easier, which corresponds to the responses gathered from the question regarding expected functions. However, participants also expect robots to act as social partners that they can share their lives and worries with. In particular, participants expect that robots can aid in people who are living alone and/or feel lonely. As of today, smart speakers are assuming these roles as friends or social partners. But we expect that physically embodied robots that convey complex emotions, attitudes, and intentions through body language will bring more satisfaction to those who are currently utilizing smart speakers.

Figure 8

Post-experiment interview regarding expected roles of robots



3.4. Discussion

The effects present in experiment 1 did not carry over to experiment 2, where social interaction took place in the video. This suggests that other factors other than body language play significant roles in perceptions of social qualities and human-likeness during social interactions. Furthermore, while previous research has found evidence for both similarity attraction and complementary attraction effect, the present study did not show any patterns for such effects. We raise several concerns and offer several possible explanations as to why the results were not significant. In experiment 2, the video consisted of a continuous interaction that lasted approximately 5-minutes, and because the contracting motion of the legs in the closed body language movements caused NAO to shift around unwantedly, which may cause safety hazards to the robot and the individual in the video, the manipulations were limited to the torso only. This change in experiment 2, thus, enabled NAO to convey its movements through arm articulations, which mostly varied in amplitudes (i.e., raising its arms, contractive gesture through arms close to the body), which could have affected the results. Also, the static condition stayed mostly constant throughout the interaction; however, it also contained the game of charades, which consisted of sets of highly articulated movements provided by the robot manufacturer.

Consequently, this could have resulted in participants relying heavily on judgments based on those movements during the questionnaire portion of the experiment.

Furthermore, in the post-experiment interview questions, several participants stated that the interaction seemed scripted and seemed aware that NAO was pre-programmed to execute what was intended. This could have caused the perceptions of social qualities and human-likeness to be similar across conditions because NAO was seen as a robot serving its purpose rather than a socially intelligent robot. Nonetheless, the qualitative data provided several insights into what roles and functions are expected to fill, which yielded valuable information regarding what sorts of body language should be considered when developing robots. People still mostly expected robots to take on roles that are more task-oriented like secretaries or managers. Normally, people who serve these roles are often perceived as calm and collected. Thus, body language that conveys excitement or disapproval would not be helpful to robots that assume these roles. Rather, it would be more socially appropriate for these robots to convey warmth and competence through a more subtle body language.

Chapter 4. Conclusion

In experiment 1, we manipulated the gestures of NAO to either convey open body language and closed body language. It was hypothesized that robots that convey open body language are perceived as warmer and more competent, anthropomorphized, likeable, animate, and intelligent compared to robots that convey closed body language. Results showed that the hypothesis was supported. Furthermore, three categories of expected functions were identified from the qualitative data in experiment 1: Service, companion, and conversational. Among these categories, service functions were most expected from participants followed by companion and then conversational. All three categories seem to encourage robot developers to recognize a richer range of movements to allow robots to express diverse attitudes, emotions, and intentions for a better HRI.

In experiment 2, we used the gestures from experiment 1 and applied it to a social interaction with the addition of a static condition, which did not convey any body language. It was hypothesized that robots that interact with open body language are perceived as warmer and more competent, anthropomorphized, likeable, animate, and intelligent compared to robots that interact with closed body language. The same was hypothesized for robots that interacted with closed body language compared to robots that did not convey any body language. Furthermore, it was hypothesized that participants high in extraversion would rate NAO with open body language higher on social qualities and human-likeness, and those low in extraversion would rate NAO with closed body language higher on these dimensions. The hypotheses were not supported. Social qualities perceptions of NAO did not change between the conditions.

The results of experiment 1 suggest that a robot's body language significantly affects social qualities and human-likeness perceptions of a robot. The qualitative data showed that participants expected robots to take on more interactive roles, such as a conversational partner, companion, and service roles. This suggests that empathy is a crucial component in robots, which implicates a more diverse range of movements to fulfill such signs of empathy. The results of experiment 2 suggest that body language requires the incorporation of the whole body to fully exert its effect during social interactions. Moreover, other factors, such as a robot's voice play a significant role in perceptions of social qualities and humanlike-ness in a robot.

Chapter 5. General Discussion

The current research explored how a robot's body language affected its perceptions of social qualities and human-likeness. It is noted that in experiment 1, apart from head nodding and shaking, the torso and legs were manipulated in this study, while only the torso was manipulated in experiment 2. The results seem to suggest that body language does indeed play a significant role in perceptions of social qualities and human-likeness. Experiment 1 confirmed that robots that convey gestures with an open body language are rated higher on social qualities and human-likeness compared to robots that convey gestures with a closed body language. However, these effects were only present when the body language incorporated the body, and when no social interaction was present. This seems to suggest that other factors such as voice (Song et al., 2020), eye gaze (Pereira et al., 2014), and head positions (Knight & Simmons, 2016) might override the effects that body language may have.

With current technological advancements, robots are expected to displace 20 million manufacturing jobs by 2030 and further stated that service robots are gaining popularity and jobs are being automated. (Oxford Economics, 2019). However, they also stated that it would take some time for robots to replace humans for occupations that demand compassion, creativity, and social intelligence. One of the major blockades in this endeavor is the limited expressiveness of these robots. Endowing robots with social intelligence may seem far in the future, but recent progress seems to indicate that it is not so far from the future with researchers introducing computational methods to predict nonverbal social signals to endow robots with “social artificial intelligence.” This research seeks to further improve non-verbal communication between humans and non-human intelligent agents by introducing new datasets and research tasks (Joo et al., 2019). Furthermore, past research has already developed affect detection from body language, which estimates body pose and identify affect from them (McColl, & Nejat, 2012).

As of now, smart speakers are the most prevalent in the area of personal assistants with 60 million individuals owning a smart speaker in the U.S. (NPR & Edison Research, 2020). With advancements in robotics and trends leaning towards automation, more robots will appear in individuals’ homes carrying out a wider variety of tasks. Single-person households or the elderly experiencing loneliness could benefit from interacting with robots, which is afforded greater social presence than the non-physically embodied artificial intelligent robots. In addition, robots have the potential to make daily tasks easier for individuals by utilizing the benefits from physical embodiment. Achieving natural HRI is half-way accomplished with robots being able to detect and predict emotions and actions from body language.

Robots could now benefit from how to respond to those stimuli in a socially appropriate manner. Discovering further insights into how nonverbal communication methods affect perceptions of compassion, creativity, and social intelligence will determine how fast and successful the integration of robots in our daily lives would be.

5.1. Limitations and Future Works

The main limitation of the current study was that experiments were conducted online. The effects present in the current study may be amplified or reduced depending on the environment the experiment took place in. While video-based methods provide easier means of collecting data and are useful in informing researchers regarding prototyping, testing, and developing successful HRI (Woods et al., 2006), a number of research have shown that HRI with physically present robots offer multiple advantages over video displayed robots. One of the main concerns is regarding the level of engagement of the participants, Kidd & Breazeal (2004) showed that participants showed higher levels of engagement and higher evaluations of robots compared to animated robots. On a similar note, interactions with physically present robots are rated more positively and afforded greater social presence, trust, and compliance (Bainbridge et al., 2011; Wainer et al., 2006). Since the current study employed video-based methods, participants might not have been fully engaged throughout the 5-minute HRI video in experiment 2, which could have impacted the results. Furthermore, post-experiment interview data seems to indicate that some participants were aware that NAO was only behaving a certain way because of the programming. This suggests that video-based methods are not adequate for evaluating perceptions of robots.

Another point of concern is the inherent limitation of the robot in expressing and conveying proper body language due to its DoF. NAO features 21 DoF which controls its range of motion, and it is certainly sufficient for expressing basic emotions and intentions. However, it is better suited toward expansive gestures rather than contractive gestures. For example, it might benefit NAO to show signs of modesty or timidity during first time interactions and adapt a more closed body language (i.e., legs together and arms crossed) to show those attitudes. However, NAO is not able to cross its arms or legs, which limits that ability. Although it is counter-intuitive to design robots that show negative emotions, it is becoming important for robots to express their own intentions and emotions for their own sake (Bršćić et al., 2015; Connolly, 2020) as they become more automated and related robotic technologies become more advanced.

Future works are encouraged to conduct in-person experiments to further investigate the effects of robots' body language on perceptions of the robots in in-person laboratory settings and in-the-wild environments (Jung &

Hinds, 2018). Moreover, while initial research on applying SCM and BIAS map to social robots saw promising results (Mieczkowski et al., 2019), future works exploring the effects that body language has on social perceptions as proposed by the SCM and the consequent behavioral tendencies predicted by the BIAS map could provide further insights on whether the models are fully generalizable to robots.

5.3. Research Implications

Our findings demonstrate the importance of a robot's body language in perceptions of social qualities and human-likeness in a robot. These qualities are relevant as being perceived as socially warm and competent determines how users will feel and, consequently, behave towards the robot. Perception of social qualities and human-likeness become particularly important for first time interactions as initial impressions of a robot determine the quality of the relationship in the long run. Robots that convey proper body language in certain social situations will leave impressions of social intelligence, which encourages humans to build intimate and trusting relationships with robots. While measures of social qualities and human-likeness favor robots that convey open body language, users expect robots to alleviate feelings of loneliness and empathize with them. In these situations, it is necessary for robots to express feelings of discomfort and sympathy, which at times require contractive gestures (e.g., arms and legs crossed, head down, subtle gestures). Our findings show that one-dimensional gesture expressions are not sufficient for successful integration of robots. The current research provides useful evidence that contributes to answering the question of "how to apply socially appropriate behaviors to robots and how will that be perceived to users?"

5.2. Design Implications

Robotic technologies provide precise movements, which offer the benefits of delivering accurate body gestures that leave less room for misinterpretation. The use of this quality in robots can bring tremendous benefits to research that seeks to pick apart bodily movements, gestures, and its effects on perception compared to using human stimuli, which, admittedly, is harder to manipulate. However, the inherent capabilities of robots provided by the number of actuators, and sensors, limit the range of possible movements, which affect the expressivity of intended meaning behind the movements. With current trends of robots leaning towards roles that are less task-oriented, its ability to communicate nonverbally is becoming essential for a more gracious HRI. Robots with higher DoF are afforded greater capabilities to express emotions and intentions, which utilize the full potential of the precise movements' robots offer. Furthermore, participants are more likely to consider robots with higher DoF a more human-like communication partner as evidenced by addressing the robot by its name more frequently and using understanding checks (Fischer et al., 2012). By making robots capable of using dynamic range of motion, users will perceive them as socially intelligent, which will enhance long-term relationships between humans and robots.

References

Alenljung, B., Andreasson, R., Billing, E. A., Lindblom, J., & Lowe, R. (2017, August). User experience of conveying emotions by touch. In *2017 26th IEEE International Symposium on Robot and Human Interactive Communication (Ro-Man)* (pp. 1240-1247).

Andreasson, R., Alenljung, B., Billing, E., & Lowe, R. (2018). Affective Touch in Human–Robot Interaction: Conveying Emotion to the NAO Robot. *International Journal of Social Robotics, 10*(4), 473-491.

Asendorpf, J. B., & Wilpers, S. (1998). Personality effects on social relationships. *Journal of Personality and Social Psychology, 74(*6), 1531–1544.

Bainbridge, W. A., Hart, J. W., Kim, E. S., & Scassellati, B. (2011). The Benefits of Interactions with Physically Present Robots over Video-Displayed Agents. *International Journal of Social Robotics*, *3*(1), 41-52.

Baker, A. L., Phillips, E. K., Ullman, D., & Keebler, J. R. (2018). Toward an Understanding of Trust Repair in Human-Robot Interaction: Current Research and Future Directions. *ACM Transactions on Interactive Intelligent Systems (TiiS)*, *8*(4), 1-30.

Barnum, C., & Wolniansky, N. (1989). Taking cues from body language. *Management Review*, *78*(6), 59-61.

Bartneck, C. (2003, June). Interacting with an Embodied Emotional Character. In *Proceedings of the 2003 International Conference on Designing pleasurable products and interfaces* (pp. 55-60).

Bartneck, C., Kulić, D., Croft, E., & Zoghbi, S. (2009). Measurement Instruments for the Anthropomorphism, Animacy, Likeability, Perceived Intelligence, and Perceived Safety of Robots. *International Journal of Social Robotics*, *1*(1), 71-81.

Beck, A., Stevens, B., Bard, K. A., & Cañamero, L. (2012). Emotional Body Language Displayed by Artificial Agents. *ACM Transactions on Interactive Intelligent Systems (TiiS)*, *2*(1), 1-29.

Breazeal, C. (2004). Social Interactions in HRI: The Robot View. *IEEE Transactions on Systems, Man, and Cybernetics, Part C (Applications and Reviews)*, *34*(2), 181-186.

Broadbent, E., Kumar, V., Li, X., Sollers 3rd, J., Stafford, R. Q., MacDonald, B. A., & Wegner, D. M. (2013). Robots with Display Screens: A Robot with a More Humanlike Face Display Is Perceived to Have More Mind and a Better Personality. *PloS ONE*, *8*(8), e72589.

Bršćić, D., Kidokoro, H., Suehiro, Y., & Kanda, T. (2015, March). Escaping from Children's Abuse of Social Robots. In *Proceedings of the Tenth Annual ACM/IEEE International Conference on Human-Robot Interaction* (pp. 59-66).

Carli, L. L., LaFleur, S.J., & Loeber, C.C. (1995). Nonverbal Behavior, Gender, and Influence. *Journal of Personality and Social Psychology*, *68*(6), 1030-1041.

Carney, D.R., Hall, J.A., & Smith-LeBeau, L. (2005). Beliefs about the nonverbal expression of social power. *Journal of Nonverbal Behavior*, *29*(2), 105-123.

Carpinella, C. M., Wyman, A. B., Perez, M. A., & Stroessner, S. J. (2017). The Robotic Social Attributes scale (RoSAS) Development and Validation. In *Proceedings of the 2017 ACM/IEEE International Conference on Human-Robot Interaction,* 254-262.

Cassell, J., & Bickmore, T. (2003). Negotiated Collusion: Modeling Social Language and its Relationship Effects in Intelligent Agents. *User Modeling and User-Adapted Interaction*, 13(1-2), 89-132.

Castro-Gonzalez, A., Admoni, H., & Scassellati, B. (2016). Effects of Form and Motion on Judgments of Social Robots' Animacy, Likability, Trustworthiness and Unpleasantness. *International Journal of Human-Computer Studies, 90,* 27-38.

Connolly, J. (2020, March). Preventing Robot Abuse through Emotional Robot Responses. In *Companion of the 2020 ACM/IEEE International Conference on Human-Robot Interaction* (pp. 558-560).

Craenen, B., Deshmukh, A., Foster, M. E., & Vinciarelli, A. (2018, August). Do We Really Like Robots that Match Our Personality? The Case of Big-Five Traits, Godspeed Scores and Robotic Gestures. In *2018 27th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN)* (pp. 626-631). IEEE.

Cuddy, A. J., Fiske, S. T., & Glick, P. (2007). The BIAS map: behaviors from intergroup affect and stereotypes. *Journal of Personality and Social Psychology*, *92*(4), 631.

Cuddy, A. J., Glick, P., & Beninger, A. (2011). The dynamics of warmth and competence judgments, and their outcomes in organizations. *Research in Organizational Behavior*, *31*, 73-98.

Deng, E., Mutlu, B., & Matarić, M.J. (2019). Embodiment in Socially Interactive Robots, *Foundations and Trends in Robotics*, *7*(4), 251–356

Desai, M., Kaniarasu, P., Medvedev, M., Steinfeld, A., & Yanco, H. (2013). Impact of robot failures and feedback on real-time trust. In *2013 8th ACM/IEEE International Conference on Human-Robot Interaction (HRI)*, 251-258.

Deshmukh, A., Craenen, B., Vinciarelli, A., & Foster, M. E. (2018, December). Shaping Robot Gestures to Shape Users' Perception: The Effect of Amplitude and Speed on Godspeed Ratings. In *Proceedings of the 6th International Conference on Human-Agent Interaction* (pp. 293-300).

DeSteno, D., Breazeal, C., Frank, R. H., Pizarro, D., Baumann, J., Dickens, L., & Lee, J. J. (2012). Detecting the Trustworthiness of Novel Partners in Economic Exchange. *Psychological Science, 23*(12), 1549-1556.

de Visser, E. J., Monfort, S. S., McKendrick, R., Smith, M. A. B., McKnight, P. E., Krueger, F., & Parasuraman, R. (2016). Almost human: Anthropomorphism increases trust resilience in cognitive agents. *Journal of Experimental Psychology: Applied, 22*(3), 331–349.

Duffy, B.R. (2003). Anthropomorphism and the social robot. *Robotic and Autonomous Systems*, *42*, 177-190

Economics, O. (2019). How Robots Change the World. *What Automation Really Means for Jobs and Productivity, June*.

Ferrari, F., Paladino, M. P., & Jetten, J. (2016). Blurring Human–Machine Distinctions: Anthropomorphic Appearance in Social Robots as a Threat to Human Distinctiveness. *International Journal of Social Robotics, 8*(2), 287-302.

Fischer, K., Lohan, K., & Foth, K. (2012, March). Levels of Embodiment: Linguistic Analyses of Factors Influencing HRI. In *2012 7th ACM/IEEE International Conference on Human-Robot Interaction (HRI)* (pp. 463-470). IEEE.

Fiske, S. T., Cuddy, A. J., Glick, P., & Xu, J. (2002). A Model of (Often Mixed) Stereotype Content: Competence and Warmth Respectively Follow From Perceived Status and Competition. *Journal of Personality and Social Psychology*, *82*(6), 878.

Johnson, D. O., & Cuijpers, R. H. (2019). Investigating the Effect of a Humanoid Robot's Head Position on Imitating Human Emotions. *International Journal of Social Robotics*, *11*(1), 65-74.

Joo, H., Simon, T., Cikara, M., & Sheikh, Y. (2019). Towards Social Artificial Intelligence: Nonverbal Social Signal Prediction in a Triadic Interaction. In *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition*, 10873-10883.

Joosse, M., Lohse, M., Perez, J. G., & Evers, V. (2013, May). What You Do is Who You Are: The Role of Task Context in Perceived Social Robot Personality. In *2013 IEEE International Conference on Robotics and Automation* (pp. 2134-2139). IEEE.

Jung, M, & Hinds, P. (2018). Robots in the Wild: A Time for More Robust Theories of Human-Robot Interaction. *ACM Transactions on Human-Robot Interaction (THRI)*, *7*(1), 1-5.

Kahn Jr, P. H., Kanda, T., Ishiguro, H., Gill, B. T., Shen, S., Gary, H. E., & Ruckert, J. H. (2015, March). Will People Keep the Secret of a Humanoid Robot? Psychological Intimacy in HRI. In *Proceedings of the Tenth Annual ACM/IEEE International Conference on Human-Robot Interaction* (pp. 173-180).

Kidd, C. D., & Breazeal, C. (2004, September). Effect of a robot on user perceptions. In *2004 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)* (Vol. 4, pp. 3559-3564). IEEE.

Kim, P.H., Ferrin, D.L., Cooper, C.D., & Dirks, K.T. (2004). Removing the Shadow of Suspicion: The Effects of Apology Versus Denial for Repairing Competence- Versus Integrity-Based Trust Violations. *Journal of Applied Psychology, 89*(1), 104.

Kim, S. Y., Kim, J. M., Yoo, J. A., Bae, K. Y., Kim, S. W., Yang, S. J., ... & Yoon, J. S. (2010). Standardization and validation of Big Five Inventory-Korean version (BFI-K) in elders. *Korean Journal of Biological Psychiatry*, *17*(1), 15-25.

Knight, H., & Simmons, R. (2016, May). Laban Head-Motions Convey Robot State: A Call for Robot Body Language. In *2016 IEEE International Conference on Robotics and Automation (ICRA)* (pp. 2881-2888). IEEE.

Law, T., de Leeuw, J., & Long, J. H. (2020). How Movements of a Non-Humanoid Robot Affect Emotional Perceptions and Trust. *International Journal of Social Robotics*, 1-12.

Lee, J., & Moray, N. (1992). Trust, control strategies and allocation of function in human-machine systems. *Ergonomics, 35*, 1243–1270.

Lee, K. M., Peng, W., Jin, S. A., & Yan, C. (2006). Can Robots Manifest Personality?: An Empirical Test of Personality Recognition, Social Responses, and Social Presence in Human–Robot Interaction. *Journal of Communication*, *56*(4), 754-772.

Lehmann, H., Saez-Pons, J., Syrdal, D.S., Dautenhahn, K. (2015). In Good Company? Perception of Movement Synchrony of a Non-Anthropomorphic Robot. *PLoS ONE 10*(5), e0127747.

Li, J., Cuadra, A., Mok, B., Reeves, B., Kaye, J., & Ju, W. (2019). Communicating Dominance in a Nonanthropomorphic Robot Using Locomotion. *ACM Transactions on Human-Robot Interaction (THRI)*, *8*(1), 1-14.

McColl, D., & Nejat, G. (2012). Affect Detection from Body Language during Social HRI. In *2012 IEEE RO-MAN: the 21st IEEE international symposium on robot and human interactive communication*, 1013-1018.

McColl, D., & Nejat, G. (2014). Recognizing Emotional Body Language Displayed by a Human-like Social Robot. *International Journal of Social Robotics*, *6*(2), 261-280.

McGinley, H., LeFevre, R., & McGinley, P. (1975). The Influence of a Communicator's Body Position on Opinion Change in Others. *Journal of Personality and Social Psychology*, *31*(4), 686-690.

Mieczkowski, H., Liu, S. X., Hancock, J., & Reeves, B. (2019, March). Helping Not Hurting: Applying the Stereotype Content Model and BIAS Map to Social Robotics. In *2019 14th ACM/IEEE International Conference on Human-Robot Interaction (HRI)* (pp. 222-229). IEEE.

Mori, M., MacDorman, K. F., & Kageki, N. (2012). The Uncanny Valley [from the field]. *IEEE Robotics & Automation Magazine*, *19*(2), 98-100.

Muir, B. M., & Moray, N. (1996). Trust in automation. Part II. Experimental studies of trust and human intervention in a process control simulation. *Ergonomics*, 39, 429–460.

Nass, C., & Moon, Y. (2000). Machines and Mindlessness: Social Responses to Computers. *Journal of Social Issues, 56*(1), 81-103.

Nass, C., Moon, Y., & Green, N. (1997). Are Machines Gender Neutral? Gender-Stereotypic Responses to Computers with Voices. *Journal of Applied Social Psychology*, *27*(10), 864-876.

Nass, C., Steuer, J., & Tauber, E. R. (1994, April). Computers are Social Actors. In *Proceedings of the SIGCHI conference on Human Factors in Computing Systems* (pp. 72-78).

NPR and Edison Research. (2020). *The Smart Audio Report.* Retrieved from npr.org/smartaudio

Pan, M. K., Croft, E. A., & Niemeyer, G. (2018, February). Evaluating Social Perception of Human-to-Robot Handovers Using the Robot Social Attributes Scale (RoSAS). In *Proceedings of the 2018 ACM/IEEE International Conference on Human-Robot Interaction* (pp. 443-451).

Pereira, A., Prada, R., & Paiva, A. (2014, April). Improving Social Presence in Human-Agent Interaction. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 1449-1458).

Robinette, P., Howard, A. M., & Wagner, A. R. (2017). Effect of Robot Performance on Human–Robot Trust in Time-Critical Situations. *IEEE Transactions on Human-Machine Systems, 47*(4), 425-436.

Salem, M., Eyssel, F., Rohlfing, K., Kopp, S., & Joublin, F. (2013). To Err is Human(-like): Effects of Robot Gesture on Perceived Anthropomorphism and Likability. *International Journal of Social Robotics*, *5*, 313-323.

Sebo, S. S., Krishnamurthi, P., & Scassellati, B. (2019, March). "I Don't Believe You": Investigating the Effects of Robot Trust Violation and Repair. In *2019 14th ACM/IEEE International Conference on Human-Robot Interaction (HRI)* (pp. 57-65). IEEE.

Sebo, S.S, Traeger, M., Jung, M., & Scassellati, B. (2018). The Ripple Effects of Vulnerability: The Effects of a Robot's Vulnerable Behavior on Trust in Human-Robot Teams. In *Proceedings of the 2018 ACM/IEEE International Conference on Human-Robot Interaction*, 178-186.

Shamsuddin, S., Yussof, H., Ismail, L. I., Mohamed, S., Hanapiah, F. A., & Zahari, N. I. (2012). Initial response in HRI-a case study on evaluation of child with autism spectrum disorders interacting with a humanoid robot NAO. *Procedia Engineering*, *41*, 1448-1455.

Smith-Hanen, S. S. (1977). Effects of Nonverbal Behaviors on Judged Levels of Counselor Warmth and Empathy. *Journal of Counseling Psychology*, *24*, 87–91.

Spatola, N., Anier, N., Redersdorff, S., Ferrand, L., Belletier, C., Normand, A., & Huguet, P. (2019). National Stereotypes and Robots' Perception: The “Made in” Effect. *Frontiers in Robotics and AI*, *6*, 21.

Softbank Robotics. (2015). *Choreographe* [Computer Software]. https://developer.softbankrobotics.com/nao6/downloads/nao6-downloads-windows.

Song, S., Baba, J., Nakanishi, J., Yoshikawa, Y., & Ishiguro, H. (2020). Mind The Voice!: Effect of Robot Voice Pitch, Robot Voice Gender, and User Gender on User Perception of Teleoperated Robots. In *Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems*, 1-8.

Strait, M.K., Floerke, V.A., Ju, W., Maddox, K., Remedios, J.D., Jung, M.F., Urry, H.L. (2017). Understanding the Uncanny: Both Atypical Features and Category Ambiguity Provoke Aversion toward Humanlike Robots. *Frontier in Psychology, 8*, 1366

Stroessner, S.J., & Benitez, J. (2019). The Social Perception of Humanoid and Non-Humanoid Robots: Effects of Gendered and Machinelike Features. *International Journal of Social Robotics, 11*(2)*,* 305-315.

Tapus, A., Peca, A., Aly, A., Pop, C., Jisa, L., Pintea, S., ... & David, D. O. (2012). Children with Autism Social Engagement in Interaction with Nao, An Imitative Robot: A Series of Single Case Experiments. *Interaction studies*, *13*(3), 315-347.

Tonkin, M., Vitale, J., Herse, S., Williams, M. A., Judge, W., & Wang, X. (2018, February). Design Methodology for the UX of HRI: A Field Study of a Commercial Social Robot at an Airport. In *Proceedings of the 2018 ACM/IEEE International Conference on Human-Robot Interaction* (pp. 407-415).

Traeger, M. L., Sebo, S. S., Jung, M., Scassellati, B., & Christakis, N. A. (2020). Vulnerable Robots Positively Shape Human Conversational Dynamics in a Human–Robot Team. In *Proceedings of the National Academy of Sciences, 117*(12), 6370-6375.

Wainer, J., Feil-Seifer, D., Shell, D.A., Mataric, M.J. (2006). The Role of Physical Embodiment in Human-Robot Interaction. In *ROMAN 2006 – The 15th IEEE International Symposium on Robot and Human Interactive Communication* (pp. 117-122). IEEE.

Wang, X., & Krumhuber, E. G. (2018). Mind Perception of Robots Varies with their Economic Versus Social Function. *Frontiers in Psychology*, *9*, 1230.

Weiss, A., & Bartneck, C. (2015, August). Meta Analysis of the Usage of the Godspeed Questionnaire Series. In *2015 24th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN)* (pp. 381-388). IEEE.

Woods, S., Walters, M., Koay, K. L., & Dautenhahn, K. (2006, March). Comparing Human Robot Interaction Scenarios using Live and Video Based Methods: Towards a Novel Methodological Approach. In *9th IEEE International Workshop on Advanced Motion Control, 2006.* (pp. 750-755). IEEE.

Vacharkulksemsuk, T., Reit, E., Khambatta, P., Eastwick, P.W., Finkel, E.J., & Carney, D.R. (2016). Dominant, open nonverbal displays are attractive at zero-acquaintance. *Proceedings of the National Academy of Sciences*, *113*(15), 4009-4014

Van den Stock, J., Righart, R., & De Gelder, B. (2007). Body expressions influence recognition of emotions in the face and voice. *Emotion*, *7*(3), 487.

Xu, J., Broekens, J., Hindriks, K., & Neerincx, M. A. (2014, May). Robot Mood is Contagious: Effects of Robot Body Language in the Imitation Game. In *Proceedings of the 2014 International Conference on Autonomous Agents and Multi-agent Systems* (pp. 973-980).

Appendix

Appendix 1: Robotic Social Attributes Scale (RoSAS) (Carpinella et al., 2017)

방금 시청하신 영상에 등장한 로봇에 대한 질문에 응답해주세요.

행복한

매우 그렇지 않다 1 2 3 4 5 6 7 매우 그렇다

감정 있는

매우 그렇지 않다 1 2 3 4 5 6 7 매우 그렇다

사회적인

매우 그렇지 않다 1 2 3 4 5 6 7 매우 그렇다

유기적인

매우 그렇지 않다 1 2 3 4 5 6 7 매우 그렇다

동정하는

매우 그렇지 않다 1 2 3 4 5 6 7 매우 그렇다

감정적인

매우 그렇지 않다 1 2 3 4 5 6 7 매우 그렇다

유능한

매우 그렇지 않다 1 2 3 4 5 6 7 매우 그렇다

반응하는

매우 그렇지 않다 1 2 3 4 5 6 7 매우 그렇다

상호적인

매우 그렇지 않다 1 2 3 4 5 6 7 매우 그렇다

신뢰할 수 있는

매우 그렇지 않다 1 2 3 4 5 6 7 매우 그렇다

능숙한

매우 그렇지 않다	1	2	3	4	5	6	7	매우 그렇다

지식이 많은

매우 그렇지 않다	1	2	3	4	5	6	7	매우 그렇다

무서운

매우 그렇지 않다	1	2	3	4	5	6	7	매우 그렇다

이상한

매우 그렇지 않다	1	2	3	4	5	6	7	매우 그렇다

어색한

매우 그렇지 않다	1	2	3	4	5	6	7	매우 그렇다

위험한

매우 그렇지 않다	1	2	3	4	5	6	7	매우 그렇다

끔직한

매우 그렇지 않다	1	2	3	4	5	6	7	매우 그렇다

공격적인

매우 그렇지 않다	1	2	3	4	5	6	7	매우 그렇다

Appendix 2: Godspeed Questionnaire (Bartneck et al., 2009)

방금 시청하신 영상에 등장한 로봇에 대한 질문에 응답해주세요.

가짜같은	1	2	3	4	5	자연스러운
기계같은	1	2	3	4	5	인간같은
의식이 있는	1	2	3	4	5	의식이 있는
인공적	1	2	3	4	5	생물적
어색한 움직임	1	2	3	4	5	정교한 움직임
죽어있는	1	2	3	4	5	살아있는
활기가 없는	1	2	3	4	5	생기있는
기계적인	1	2	3	4	5	유기적인
인공적인	1	2	3	4	5	생물적인
상호적이지 않은	1	2	3	4	5	상호적인
무관심한	1	2	3	4	5	반응을 하는
싫음	1	2	3	4	5	좋음
친해지기 어려운	1	2	3	4	5	친해지기 쉬운
불친절한	1	2	3	4	5	친절한
불쾌한	1	2	3	4	5	유쾌한
형편없는	1	2	3	4	5	좋은

무능한	1	2	3	4	5	유능한
무지한	1	2	3	4	5	박식한
무책임한	1	2	3	4	5	책임감 있는
무식한	1	2	3	4	5	지적인
어리석은	1	2	3	4	5	현명한
불안한	1	2	3	4	5	안정된
냉정한	1	2	3	4	5	동요되는
평온한	1	2	3	4	5	놀란

Appendix 3: Big Five Inventory-Korean Version (BFI-K) (Kim et al., 2010)

본인의 성격과 관련될 수 있는 질문을 드리겠습니다. 문항 내용에 대하여 평소 성격과 가장 일치한다고 생각되는 정도에 따라 대답하여 주십시오.

1 전혀 그렇지 않음	2 그렇지 않은 편	3 보통	4 그런 편	5 항상 그런 편

"나는 나 자신이 이런 사람이라고 생각한다."

1. ______ 말이 많다.
2. * ______ 다른 사람의 흠을 잘 잡는다.
3. ______ 맡은 일을 철저히 한다.
4. ______ 마음이 우울하고 가라 앉았다.
5. ______ 독창적이고 새로운 아이디어를 생각해낸다.
6. * ______ 보수적이다.
7. ______ 다른 사람을 잘 도와준다.
8. * ______ 경솔할 때가 있다.
9. * ______ 느긋한 편이고, 스트레스를 잘 해소한다.
10. ______ 여러 가지에 대하여 호기심이 많다.
11. ______ 활기가 넘친다. (원문 = 정력적이다(활기가 넘친다).)
12. * ______ 다른 사람과 자주 다툰다.
13. ______ 믿음직한 일꾼이다.
14. ______ 잘 긴장하는 편이다. (원문 = 긴장하곤 한다)
15. ______ 기발하고 생각이 깊다. (원문 = 머리가 좋다.)
16. ______ 매사에 매우 열심이다.
17. ______ 너그럽다.

18. * ______ 무질서한 경향이 있다.

19. ______ 걱정이 많다.

20. ______ 상상력이 풍부하다.

21. * ______ 말수가 적은 편이다.

22. ______ 믿음직스럽다.

23. * ______ 게으른 편이다.

24. * ______ 감정적으로 안정적이고 쉽게 동요하지 않는다. (원문 = 차분하고, 쉽게 화를 내지 않는다.)

25. ______ 창의적이다.

26. ______ 자기주장이 강하다.

27. * ______ 차갑고 냉담한 성격이다.

28. ______ 인내심 있게 맡은 일을 끝까지 해낸다. (원문 = 일을 끝까지 마친다.)

29. ______ 변덕스러운 편이다.

30. ______ 예술적, 미적 경험을 중시한다.

31. * ______ 가끔 부끄럼을 타고 감정을 숨긴다.

32. ______ 사려 깊고 거의 모든 사람에게 친절하다.

33. ______ 효율적으로 일을 처리한다. (원문 = 능률적으로 일을 처리한다.)

34. * ______ 긴장된 상황에서도 침착하다.

35. * ______ 규칙적인 생활을 좋아한다.

36. ______ 어울리기를 좋아하고 사교적이다.

37. * ______ 때로 다른 사람에게 무례하다.

38. ______ 계획을 세워 일을 처리한다.

39. ______ 쉽게 불안해 한다. (원문 = 쉽게 신경질을 낸다.)

40. ______ 생각하기를 즐긴다.

41. * ______ 예술에 대한 관심이 별로 없다.

42. ______ 다른 사람과 협력하기를 좋아한다.

43. * ______ 쉽게 주의가 산만해진다.

44. ______ 미술, 음악, 문학에 대한 세련된 감각이 있다

* 표시 항목은 역산할 것.

국문 초록

본 연구는 로봇의 신체 언어가 사회적 특성과 인간과의 유사성에 대한 인간의 인식에 미치는 영향을 탐색하였다. 실험 1 에서는 로봇의 개방적 신체 언어가 묘사된 영상과 폐쇄적 신체 언어가 묘사된 영상을 통해 이러한 세 가지 측면을 살펴보았다. 실험 2 에서는 실험 1 의 신체 언어가 포함된 로봇과 사람 간의 상호작용 영상을 활용하여 로봇의 신체 언어가 위 두 가지 측면에 미치는 영향을 탐색하였다. 결과적으로, 사람들은 폐쇄적 신체 언어를 표현하는 로봇에 비해 개방적 신체 언어를 표현하는 로봇을 사회적 특성과 인간과의 유사성에 대한 인식 면에서 더 높게 평가한다는 것을 확인하였다. 그러나 사람과의 상호작용을 담은 영상을 통해서는 이러한 효과가 발견되지 않았으며, 이는 실험 2 에 포함된 음성 등의 다른 특징이 로봇에 대한 평가에 중요한 역할을 한다는 것을 시사한다. 그럼에도 불구하고, 본 연구는 로봇의 신체 언어가 사회적 특성 및 인간과의 유사성에 대한 인식의 중요한 요인이 된다는 근거를 제공한다. 사회적 특성과 인간과의 유사성의 척도에서는 개방적 신체 언어를 표현하는 로봇이 더 높게 평가되었지만, 실험 후 인터뷰에서는 로봇이 외로운 감정을 완화하고 공감하기를 기대하는 것으로 나타나 이 상황들에 적절한 폐쇄적 신체 언어 또한 배제할 수

없다고 해석할 수 있다. 이에 따라 본 연구에서는 로봇 디자이너들이 더욱 다양한 범위의 움직임을 표현할 수 있는 로봇을 개발하도록 장려한다. 그렇다면 섬세한 움직임에 따른 자연스러운 의사소통을 통해 인간이 로봇을 사회적 동반자로 인식할 수 있을 것이다.

키워드: 인간-로봇 상호작용, 신체 언어, 사회적 인식

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