Mimik: Exploring human likability through non verbal cues and human personality

Neil Russel Fernandes
Department of Mechanical and Mechatronics Engineering
Waterloo, ON, Canada
n24ferna@uwaterloo.ca

***Abstract*—Currently, there is growing uncertainty surrounding engagement in Human-Robot Interaction (HRI) among individuals in society. Recent studies have begun to explore human factors influencing likability and have identified compatibility between human and robot personalities as a key factor in enhancing likability. However, it remains unclear whether specific non-verbal behaviors in robots can enhance likability across different human personalities, and whether a relationship exists between robot non-verbal behaviors and human likability based on personality. In this exploratory study, we investigated the interaction through head nodding behaviors between two human personality types (introverted and extroverted individuals) and a NAO robot using a turn-taking like strategy. Through the use of various questionnaires, the study revealed a discernible link between a robot's non-verbal communication cues and human likability, which is also influenced by human personality traits. The behaviour plans used in Choreographe can be found here: https://github.com/Fatiepie/mimick, which also contains demo videos.**

I. Introduction

In this era of major technological leaps, the landscape within the realm of robots has given rise to the use of commercial and industrial robots that act as social and/or interactive robots. Such robots have been used in educational [1], [2], medical [3], [4] and our household applications [5], [6]. Even though these technologies have been improved over the years, there has been a significant void that is present within the human-robot interaction community, wherein the uncertainty about engaging with the robot and interacting with it due to its safety [7] and uncanniness [8] which researchers fear would generate a negative bias with users [9]. A lot of human-robot interaction literature had concerns about not only developing more human-centric robots but also researching influences of human factors (such as personality) in robotics to minimize these negative biases towards the robots and increase positive feelings/likability towards the robot. A pretend study was designed for this explorative study wherein head nodding behaviours were programmed into the NAO robot platform using the NAOqi API and the Choreographe Interface, in a turn-taking styled startergy. Using the non-verbal cues, the head synchrony between human-robot was analyzed (by analyzing footage captured during the experiment). The pretend study was conducted on University grounds with "pretend" participants for the study to understand the link between human likability on robots through non-verbal cues and their personalities. Along with the human robot interaction, a questionnaire made out of the GODSPEED-IV questionnaire (associated to detecting likeability) was used after the study to collect metrics on how the participants.

The next section will dwell into the related literature in the field of HRI as well as literature based on human-human interaction. In section III, the literature gap and the propose our research questions will be discussed, followed by the experimental design in section IV. This article will also provide and discuss the results of the experiment in section V and section VI respectively, concluding with section VII. section VIII and section IX will look into future work and the acknowledgments for the project.

II. Related Literature

There have been studies in human-human interaction where the communication style of humans was examined and found relationships between the communication style and the specific person's personality. One such example is from A. Thorne's research, wherein she found that "Changes in conduct from one conversation to the next were due to the interacting press of personalities" [10]. Eysneck also studied and found that introverts' higher arousability leads them to avoid from external stimulation and that extroverts' low arousability leads them to seek for external stimulation [11]. Opt et. Al. examined that the communication style (both verbal and nonverbal), does have similarities and differences between introverted and extroverted people in order to enhance the effectiveness and attractiveness in communication between a single person and/or a group of people [12]. In some human-human interactive studies such as Clark et. Al. and Wurtz et Al, personality compatibility can enhance in cases such as the interaction quality of a doctor and patient [13], or even the satisfaction in service employee-customer relationship [14]. These studies on how people interact with each other suggest that we should also look into people's personalities when studying how they interact with robots. As a result, many studies on human-robot interaction now pay attention to how a person's personality can affect their interaction with robots.

In the human-robot interaction realm of research, several studies have been done in the field of human-robot interaction where human personality was the main point of study. Ivaldi et Al. studied whether the dynamics of gaze and speech of a robot performing a specific task are directly related to the extroversion personality of a human and found that extroverted individuals had a higher tendency to interact with a robot [15]. Researchers also turned to other personality traits to discuss the link between human personality traits and human-robot interaction, wherein their research indicated that some personal experience with robots reduced an individual's personal space around a robot [16]. Previous studies in human-robot interaction also demonstrated that personality compatibility between human and robot via both verbal and nonverbal behaviours can enhance human's likability towards the robot. Nass' study showed that introvert participants prefer the interaction with introvert characteristics voices while the extrovert participants prefer extrovert characteristics more [17]. Seaborn et. Al. surveyed a meta-synthesis on agent voice in the design and experience of agents from a human-centered perspective where they found that a robot's voice plays a dramatic role in the human-robot interaction and the experience of a human while interacting with a robot [18].

III. Research Questions

As seen in the previous section, there have been a significant number of surveys and explorative studies done in the area of HRI to understand human-robot interaction with a keen interest of seeing how a person's personality influences the interaction with the agent. However, it still is an ambiguous topic on whether non-verbal cues from robots are linked between humans and their personalities. There also is a gap in terms of understanding whether a specific groups of personalities are affected by a specific form of non-verbal cues in social robots. Understanding this would lead to a higher likability for robots and further would lead to even rich human-robot interactions. Most of the studies, although abundant, do not provide concrete evidence of either one of the aforementioned strategies, but do comment on a lot of the human factors that might influence human's likability on robots. This leads to the research questions that I propose would be answered by this explorative study:

Q1*: Is there a relationship between human personality and head nodding?*

As the question suggests, would the human factors within the conversation between the human and the robot be related to the number of times the human and/or robot nods their head? I hypothesize that the more extroverted you are, the more you would nod your head and be in synchrony with the robot's own head nodding. Answering this question would lead us to the second research question.

Q2*: Is there any relationship or link that correlates a robot's non-verbal cues to human likability based on the human's personality?*

The second question digs a little deeper into figuring out if the non verbal communication (in the form of head synchrony) correlates to the humans liking the robot via the personality traits they possess.

Using the answers from ***Q1*** leading into ***Q2***, we hypothesize that people with introverted personalities would have less head synchrony with the robot leading to less robot likability, whereas people with extroverted personalities would have more head synchrony with the robot leading to more robot likability.

IV. Experimental Analysis

A. Setting

To answer the proposed questions, a pretend user study was designed where the NAO robot would speak to the participant with several non-verbal cues. If this were a real study with real participants, the approval of the research ethics system of the University of Waterloo would be acquired first. The experiment was designed to be a between-subjects study, where groups of people with different personalities would look at one single scenario of a robot acting as the leader in the conversation. More details about the experiment will be discussed in the next section. These groups were refined into just two personalities - introverted and extroverted peoples. In this study, we then aim to investigate whether specific means (such as head nodding) and strategies (such as turn-taking) of a robot's non-verbal cues influences and enhances likability in human with specific a personality (i.e. Introvert and Extrovert). For my study, I selected head nodding behaviour (check for head nodding synchrony) as the main focus for the means of communicating non-verbally as head nodding was claimed to be one of the most effective means to indicate the success and involvement with an interactional partner [19]. This head nodding was also coupled with gaze-shifting to make the conversation between the human and the robot, as gaze shifts are something that are performed in human-human interaction, where speakers characteristically avert their gaze as they begin to speak, and they signal releasing their turn by directing their gaze back to the listener [20]. It was also found that in gaze behaviour (in human-human interaction), the humans tend make and break eye contact and take turns whenever someone joins or averts during mutual gaze convergence [21].

Head nodding behavior is also purported to be one of the prominent nonverbal cues that the conversational partner can readily discern, indicating attentiveness, comprehension, and agreement with the conversational partner [22] [23]. Head nodding has also been examined in prior research endeavors, where synchronization of head movements between two conversational partners promotes a positive attitude enhancement [24], and contributes to an increase in satisfaction [25]. The robotic actions of head gesturing with sporadic shifts in gaze were incorporated into the NAO robotic platform. A depiction of the implemented approach can be observed in Figure 1. Given that the robot assumed the role of conversation leader, the majority of head gesturing was initiated solely by the robot itself and was not monitored by the robot. This was executed solely to ascertain whether the robot-initiated head gesturing would elicit reciprocation from the human (who acted as the listener). This approach closely resembles the master-slave paradigm introduced by Thurn [26], commonly employed in robotics where the robot assumes the role of the subordinate and follows the lead of its human counterpart during interactions. The head nodding was also conducted at

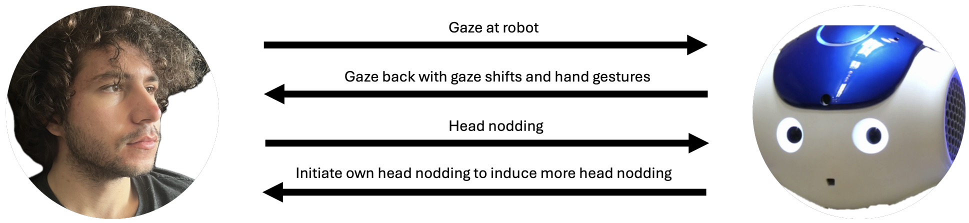


Fig. 1: Turn taking styled strategy used for the human-robot interaction

random intervals in the anticipation that it would encourage synchronization of head movements between the participant and the robot, drawing inspiration from the turn-taking like strategy frequently observed in human conversations.

Finally, this experiment was done on university grounds, specifically in the RoboHub facility where the NAO robots are available for undergraduate students [27]. The venue was also decided to be in the RoboHub due to the presence of other robots within the vicinity of the study, and ease of reaching the location, since the facility is on university grounds. A snapshot of the venue from the participant's POV can be seen below in Figure 2.

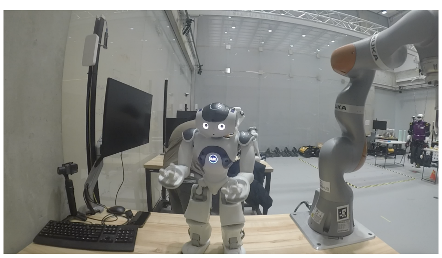


Fig. 2: Setting of the experimental study

B. Participants

In this pretend user study, 20 pretend participants, consisting of friends and family, were recruited to help with the study, aged either 22 or 23. These participants were characterized into two groups based on their personality, which resulted in 10 introverts and 10 extroverts. This characterization was done with the help of the MBTI personality test, where if the persons score (introverted or extroverted score) was greater than 60%, the person would be characterized as introverted (or vice-versa) [28]. Additionally, participants were also asked about their familiarity with robots and robot technologies, where 8 participants were well versed with robots, 7 had moderate exposure to robots and 5 were not at all exposed to robots. The participants were also asked what their nationalities, majority of who were Canadian and rest being International participants.

C. Artifacts

For this study, we utilized the NAO robot platform to incorporate head nodding as a non-verbal behavior aimed at inducing head synchrony during human-robot interaction. This platform, available through the RoboHub at the University of Waterloo, offers three NAO robots for student use. The selection of the NAO robot was based on its reliable sensors, including gyroscopes, accelerometers, and toque sensors, along with its microphone, speaker, and camera systems. Additionally, the robot features a user-friendly software suite, including the NAOqi SDK and the intuitive Choreographe programming suite. For ease of implementation, we employed the Choreographe platform to integrate head nodding and gaze shifting into the NAO robot. This involved capturing head movements using a timeline (to capture head joint values) and incorporating animated gestures with speech using Choreographe's animated say blocks. Moreover, the robot's sitting and standing actions were programmed using default blocks available on the platform. These blocks were stringed together so that the program plays a single cohesive interaction. There was also a single choice block of a simple yes/no scenario to provide some interaction from the human side. See Figure 5 and Figure 6 in the Appendix to see the implementation of the robot behaviours on the Choreographe interface.

D. Procedures and Measures

In this study, we conducted an experiment on one-sided, face-to-face, human-robot interaction. Prior to the experiment, the participants were asked to complete a pre-study questionnaire where participants had the chance to include information about their age, nationality, familiarity with robot technologies and their MBTI personality score. To minimize the external factors that might affect the participant's attention and judgment, I had asked the participant to mainly focus on the robot's non-verbal behaviours programmed into the robot during the interaction. To also minimize the saliency effects of the experiment, the opaque windows of the RoboHub was switched on. Unfortunately, due to the unstable nature of the robot while gesturing some of the behaviours, the experimenter had to be behind the robot spotting it if for any case the robot lost stability.

During the experiment, the robot took the role of being the speaker while the human took the role of listener. The participants interacted with the robot and were asked to pick out on the head nodding and gaze shifting performed by the robot. The duration of the experiment was $\tilde{5}$ minutes, where the robot conveyed the biography of Vincent van Gogh, a famous Dutch painter, considered one of the greatest of the Post-Impressionists [29], with gestures to the participants, along with the head nodding and random gaze shifts added in the robot behaviour (which were added using the animated

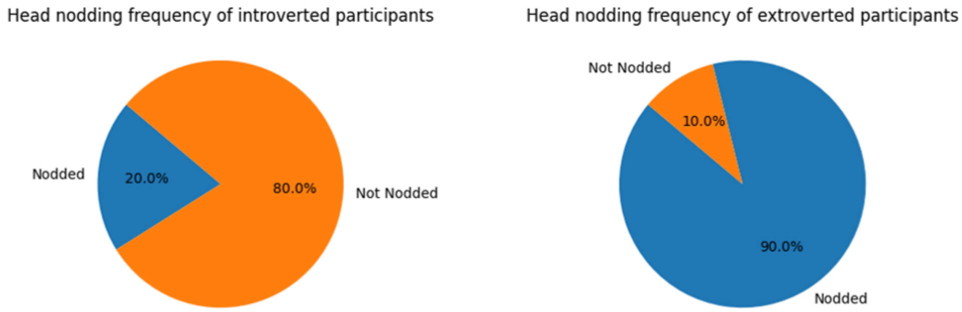


Fig. 3: Head nodding frequency between introverted & extroverted participants

say feature on Choreographe). Also during the experiment, there was one GoPro camera seated on the table to capture head movement from the participants. There was also another GoPro with a head attachment, that was attached to random participants.

Finally, the participants were asked to fill out a post-study questionnaire (using Google Forms) about their likability of the robot based on their interaction, how friendly they thought the robot was, how kind the robot was, how elegantly the robot moved, how uncanny the robot was perceived to be and how the overall experience of the interaction of the robot was. These metrics were recorded with the help of the GODSPEED questionnaire, specifically with the likeability section [30]. Apart from the questionnaire, I also measured head nodding synchrony between human and robot by conducting offline video analysis and counting how many times participants nodded their head after seeing the robot nods its head.

V. Results

In this section, the aforementioned metrics that were collected after the experiment was conducted will be presented. Each subsection will provide insight into each of the metrics from each participant group.

A. Results on Head nodding synchrony

To address ***Q1*** from the research questions, the frequency of head nodding (corresponding to head synchrony bteween robot and participant) was recorded through offline video analysis. The reults are illustrated in Figure 3. Observing the said figure, we can see that the head nodding percentage in extroverts are much higher than the introverted participants, which further indicates better head nodding synchrony between extroverted people and the robot as compared to introverted people.

B. Results with Introverted Group

Since it was established that human-robot head synchrony was absent for introverted participants, we delved into the next research question (***Q2***). Our analysis of questionnaire responses from introverted participants (n=10) revealed that 90% (n=9) expressed dislike towards the robot (as depicted in Figure 4). Most participants also appeared neutral regarding the robot's friendliness (n=6), with only one participant expressing a favorable view. Regarding kindness, 60% (n=6) remained neutral, while 30% (n=3) perceived the robot as kind, and 10% (n=1) viewed it as unkind. In terms of pleasantness, 30% (n=3) found the robot unpleasant, while 60% (n=6) remained neutral. Additionally, 40% (n=4) felt the robot lacked elegance, while 60% (n=6) remained neutral. The majority of participants felt neutral towards the robot's uncanniness (90%, n=9), with a small portion finding it not uncanny at all (10%, n=1). Lastly, a majority of participants disliked the overall interaction experience with the robot (60%, n=6), while some felt they did not like the interaction but wanted to remain neutral (10%, n=1), and a small number felt neutral towards the interaction (30%, n=3).

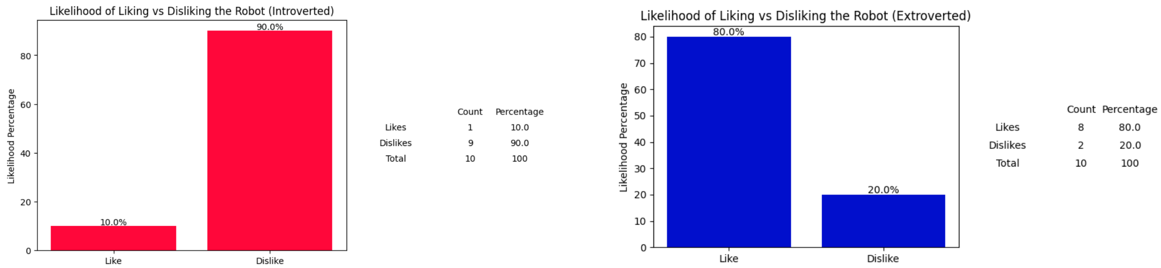
C. Results with Extroverted Group

In the extroverted group (n=10), a majority of participants liked the robot based on the human-robot interaction taken place during the experiment (80%, n=8). This was taken directly from the questionnaire responses of the extroverted participants, as illustrated in Figure 4. This directly correlates to the strong head synchrony that was observed in the previous section (see Figure 3).

Most participants perceived the robot as friendly (70%, n=7), while a minority chose to remain neutral towards its friendliness (30%, n=3). Similarly, the majority saw the robot as kind (80%, n=8), with a few expressing neutrality (20%, n=2). Opinions were split on the robot's pleasantness, with half finding it pleasant (50%, n=5) and the other half considering it unpleasant (50%, n=5). Regarding elegance, there was a mixed response, with most finding the robot elegant (70%, n=7), some staying neutral (20%, n=2), and a few strongly disagreeing (10%, n=1). Additionally, the majority found the robot not uncanny at all (90%, n=9), while a minority felt neutral (10%, n=1). Overall, most participants reported a positive experience with the human-robot interaction (80%, n=8), while a minority found it less favorable (20%, n=2).

VI. Discussion

The results from head nodding synchrony seen between the robots and participants demonstrate that the extroverted group has a significantly higher head nodding synchrony as compared to the introverted group. Further, this means that the extroverted group seems to have a better social connection with the human participant, which agrees with the results from



(a) Responses from Introverted participants

(b) Responses from extroverted participants

Fig. 4: Robot likability metrics from questionnaire responses

Foley et. Al. [19]. There is also also a clear observation that the likelihood of liking the robot is higher in extroverted group as compared to the introverted group of participants (see in Figure 4).

The extroverted group largely perceived the robot as kind and friendly, contrasting with the introverted participants who varied in their perceptions, with some remaining neutral and others finding the robot unkind. This disparity could be linked to introverted individuals' tendency to refrain from initiating social bonds unless prompted [19]. Conversely, the extroverted participants demonstrated a different inclination. Regarding the robot's elegance, a noticeable trend emerges among both groups, albeit with distinctions. While perceptions of elegance vary starkly within the introverted group, the extroverted participants exhibit a mixed response. This discrepancy may arise from the robot's mechanical movements, noted for being overly rigid. Participants cited the NAO robot's noisy motors as a hindrance to clear dialogue comprehension, alongside the robotic quality of its speech. Consequently, despite clear non-verbal cues, the robot was predominantly viewed as an object rather than an interactive partner. That being said, the robot was still liked by a majority of the extroverted group, and vice-versa for the introverted group. The robot was not perceived as uncanny, with most participants in both groups remaining neutral or voting for the robot not being uncanny at all. This might stem from the NAO robot's physical features which were perceived to be robot like. Some participants also commented that "the robot looked more like a baby robot as compared to a full humanoid robot like TALOS". Furthermore, some participants were neutral towards the robot's uncanniness only because the robot would be perceived uncanny according to certain situations, as shown by the biphasic relationship proposed by Thepsoonthorn et. Al. [31]. These results might have also stemmed from the the fact that the participants were distracted by the motor sounds emitting from the NAO robot's motors during the interaction.

In assessing the overall participant experience of the experiment, it becomes evident that the introverted group predominantly expressed dissatisfaction, while only a minority remained neutral. This discontent stemmed from several factors, notably the noisy motors of the robot and perceived imperfections in its hand gestures, which were deemed excessive and lacking in human-like qualities. Additionally, participants pointed out inconsistencies in the synchronization of gestures with speech, highlighting the absence of necessary pauses and intonations. Conversely, the extroverted group generally reported contentment with the interaction, possibly reflecting their generally optimistic disposition as suggested by Seth et al. [32]. However, a subset of participants within this group echoed concerns similar to those of the introverted participants, indicating a shared dissatisfaction with certain aspects of the interaction.

Several limitations of the study, such as the venue and experimental setting, may have influenced participants' choices. The presence of the author behind the robot, potentially causing distraction and diverting focus from the robot's non-verbal behaviors, is one notable concern. Additionally, the presence of other researchers conducting experiments with different robots in the same facility could have further contributed to participant distraction. If the venue were a classroom, it might have presented an unusual setting for a robot experiment, potentially impacting human-robot engagement, given the unconventional dynamic of having a robot in a teaching role. Another possible limitation is the sample size of the pretend participants. While 20 participants with a half-half split in personality groups is great for this explorative study, more datapoints (meaning more participants) would help in building a bigger sample size to make better conclusive remark on answering the research questions proposed by this article.

VII. Conclusions

In conclusion, this study examines the complex interplay between human likability, non-verbal communication cues, and personality traits, offering interdisciplinary insights. From a psychological viewpoint, a subgroup displaying heightened head synchronization with a robot's non-verbal cues, corroborated by both experiment interactions and offline video analysis, was identified. Additionally, the research underscores the correlation between robot cues and human likability, as evidenced by GODSPEED-IV questionnaire responses, indicating a desire for social connection. From a robotics perspective, the study's findings inform the design of behavior models tailored to enhance likability in human-robot interactions by targeting specific personality triggers. Thus, this explorative study highlights the association between human likability of robots and robot non-verbal cues, contingent upon human personality traits.

VIII. Future work

In this study, we focused solely on implementing head nodding as a non-verbal behavior in the NAO robot platform, with minimal gaze shifting involved in the interaction. Consequently, our study is limited in scope, resembling a narrow investigation into head nodding behaviors in robots. Future research should expand to include additional non-verbal elements like facial expressions, proxemics, posture, and speech across multiple robotic platforms within a single experiment to offer a comprehensive view of the subject within other robots. Additionally, enhancements to the questionnaire, such as integrating aspects of affinity and closeness, would provide deeper insights into participant perceptions of robot interactions. Moreover, future studies should consider observing additional human-robot interactional behaviors such as gaze convergence. Expanding the participant pool would yield more significant and generalized findings, necessitating further research in this area.

IX. Acknowledgments

I would like to acknowledge Professor Kerstin Dautenhahn for sharing her knowledge and expertise in the field of HRI. I would also like to thank Pourya Aliasghari for helping me in implementing the non-verbal behaviours into the NAO robot. I would also like to thank my family friends in taking part in this experiment and for supporting me throughout this project.

References

[1] D. Bernstein, K. Mutch-Jones, M. Cassidy, and E. Hamner, "Teaching with robotics: creating and implementing integrated units in middle school subjects," *Journal of Research on Technology in Education*, November 2020.

[2] F. Ouyang and W. Xu, "The effects of educational robotics in stem education: a multilevel meta-analysis," *International Journal of STEM Education*, vol. 11, 02 2024.

[3] S.-J. Kim, J. Park, Y. Na, and H. Won, "Autonomous driving robot wheelchairs for smart hospitals," in *2022 IEEE International Conference on Consumer Electronics-Asia (ICCE-Asia)*, pp. 1–2, 2022.

[4] H.-M. Gross, A. Scheidig, K. Debes, E. Einhorn, M. Eisenbach, S. Mueller, T. Schmiedel, T. Q. Trinh, C. Weinrich, T. Wengefeld, A. Bley, and C. Martin, "Roreas: robot coach for walking and orientation training in clinical post-stroke rehabilitation—prototype implementation and evaluation in field trials," *Autonomous Robots*, vol. 41, pp. 679–698, 2 2017. This is one of several papers published in Autonomous Robots comprising the "Special Issue on Assistive and Rehabilitation Robotics".

[5] K. Dautenhahn, S. Woods, C. Kaouri, M. Walters, K. L. Koay, and I. Werry, "What is a robot companion - friend, assistant or butler?," in *2005 IEEE/RSJ International Conference on Intelligent Robots and Systems*, pp. 1192–1197, 2005.

[6] M. Ye, E. Schneiders, W.-Y. Lee, and M. Jung, "The future of home appliances: A study on the robotic toaster as a domestic social robot," in *2023 32nd IEEE International Conference on Robot and Human Interactive Communication (RO-MAN)*, pp. 477–482, 2023.

[7] G.-E. Yu, S.-T. Hong, K.-y. Sung, and J.-h. Seo, "A study on the risk investigation and safety of personal care robots," in *2017 17th International Conference on Control, Automation and Systems (ICCAS)*, pp. 904–908, 2017.

[8] F. Gee, W. Browne, and K. Kawamura, "Uncanny valley revisited," in *ROMAN 2005. IEEE International Workshop on Robot and Human Interactive Communication, 2005.*, pp. 151–157, 2005.

[9] C. Bartneck, T. Kanda, H. Ishiguro, and N. Hagita, "Is the uncanny valley an uncanny cliff?," in *RO-MAN 2007 - The 16th IEEE International Symposium on Robot and Human Interactive Communication*, pp. 368–373, 2007.

[10] A. Thorne, "The press of personality: A study of conversations between introverts and extraverts.," *Journal of Personality and Social Psychology*, vol. 53, no. 4, pp. 718–726, 1987. Place: US Publisher: American Psychological Association.

[11] H. J. H. J. Eysenck, *The biological basis of personality*. New Brunswick, N.J: Transaction Publishers, 2006 - 1967.

[12] S. K. Opt and D. A. Loffredo, "Communicator image and myers—briggs type indicator extraversion—introversion," *The Journal of Psychology*, vol. 137, no. 6, pp. 560–568, 2003. PMID: 14992348.

[13] G. B. Clack, J. Allen, D. Cooper, and J. O. Head, "Personality differences between doctors and their patients: implications for the teaching of communication skills," *Medical education*, vol. 38, no. 2, pp. 177–186, 2004.

[14] J. Wirtz and C. Jerger, "Managing service employees: Literature review, expert opinions, and research directions," *The Service Industries Journal*, vol. 36, no. 15-16, pp. 757–788, 2016.

[15] S. Ivaldi, S. Lefort, J. Peters, M. Chetouani, J. Provasi, and E. Zibetti, "Towards engagement models that consider individual factors in HRI: On the relation of extroversion and negative attitude towards robots to gaze and speech during a human–robot assembly task: Experiments with the iCub humanoid.," *International Journal of Social Robotics*, vol. 9, no. 1, pp. 63–86, 2017. Place: Germany Publisher: Springer.

[16] L. Takayama and C. Pantofaru, "Influences on proxemic behaviors in human-robot interaction," in *2009 IEEE/RSJ International Conference on Intelligent Robots and Systems*, pp. 5495–5502, 2009.

[17] C. Nass and K. M. Lee, "Does computer-synthesized speech manifest personality? experimental tests of recognition, similarity-attraction, and consistency-attraction.," *Journal of experimental psychology: applied*, vol. 7, no. 3, p. 171, 2001.

[18] K. Seaborn, N. P. Miyake, P. Pennefather, and M. Otake-Matsuura, "Voice in human–agent interaction: A survey," *ACM Computing Surveys (CSUR)*, vol. 54, no. 4, pp. 1–43, 2021.

[19] G. N. Foley and J. P. Gentile, "Nonverbal communication in psychotherapy," *Psychiatry (Edgmont)*, vol. 7, no. 6, p. 38, 2010.

[20] M. Çakır and A. Huckauf, "Reviewing the social function of eye gaze in social interaction," in *Proceedings of the 2023 Symposium on Eye Tracking Research and Applications*, pp. 1–3, 2023.

[21] D. G. Novick, B. Hansen, and K. Ward, "Coordinating turn-taking with gaze," in *Proceeding of Fourth International Conference on Spoken Language Processing. ICSLP'96*, vol. 3, pp. 1888–1891, IEEE, 1996.

[22] C. Darwin, *The Expression of the Emotions in Man and Animals: The Expression of the Emotions in Man and Animals: Charles Darwin's Seminal Study on Emotional Expression*. Prabhat Prakashan, 1948.

[23] L. Tickle-Degnen and R. Rosenthal, "The nature of rapport and its nonverbal correlates," *Psychological inquiry*, vol. 1, no. 4, pp. 285–293, 1990.

[24] S. Kita and S. Ide, "Nodding, aizuchi, and final particles in japanese conversation: How conversation reflects the ideology of communication and social relationships," *Journal of Pragmatics*, vol. 39, no. 7, pp. 1242–1254, 2007.

[25] T. Yokozuka, E. Ono, Y. Inoue, and K.-I. Ogawa, "The relationship between head motion synchronization and empathy in unidirectional face-to-face communication," *Frontiers in psychology*, vol. 9, p. 384418, 2018.

[26] S. Thrun, "Toward a framework for human-robot interaction," *Human–Computer Interaction*, vol. 19, no. 1-2, pp. 9–24, 2004.

[27] U. of Waterloo, "Robohub," 2023.

[28] D. J. Pittenger, "The utility of the myers-briggs type indicator," *Review of educational research*, vol. 63, no. 4, pp. 467–488, 1993.

[29] T. E. of Britannica *Encyclopædia Britannica*, Mar 2024.

[30] C. Bartneck, D. Kulic, E. Croft, and S. Zoghbi, "Measurement instruments for the anthropomorphism, animacy, likeability, perceived intelligence, and perceived safety of robots," *International Journal of Social Robotics*, vol. 1, pp. 71–81, 01 2008.

[31] C. Thepsoonthorn, K.-i. Ogawa, and Y. Miyake, "The exploration of the uncanny valley from the viewpoint of the robot's nonverbal behaviour," *International Journal of Social Robotics*, vol. 13, pp. 1443–1455, 2021.

[32] S. Margolis and S. Lyubomirsky, "Experimental manipulation of extraverted and introverted behavior and its effects on well-being.," *Journal of Experimental Psychology: General*, vol. 149, no. 4, p. 719, 2020.

Appendix

A. Choreographe workspace

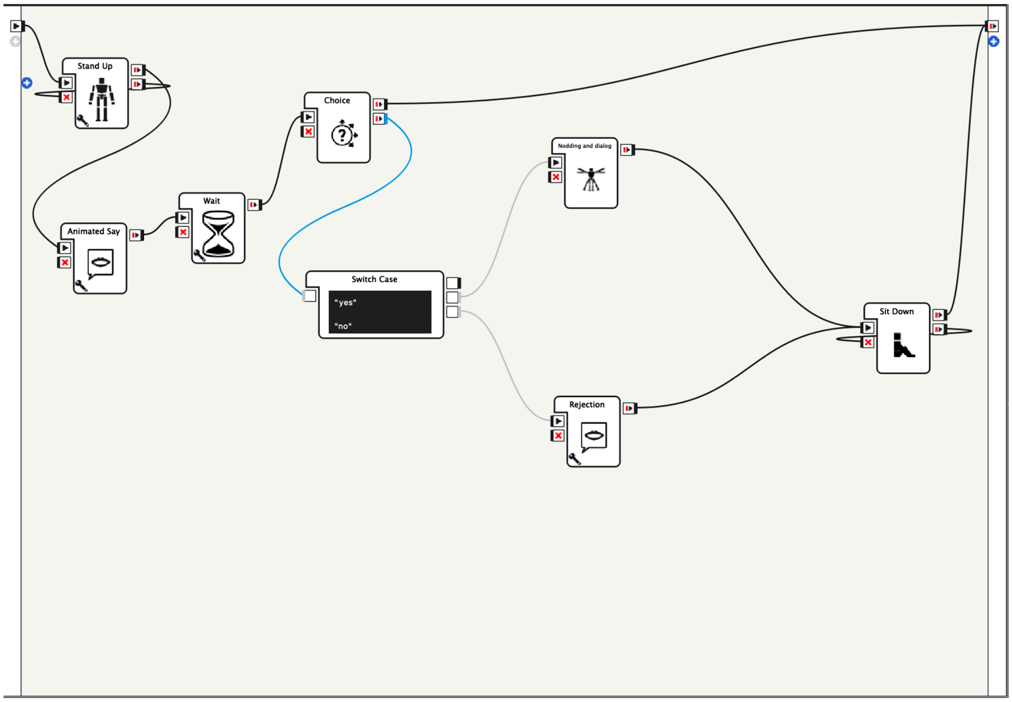


Fig. 5: Complete choreographe code used for the experiment

B. Head nodding timeline in Choreographe

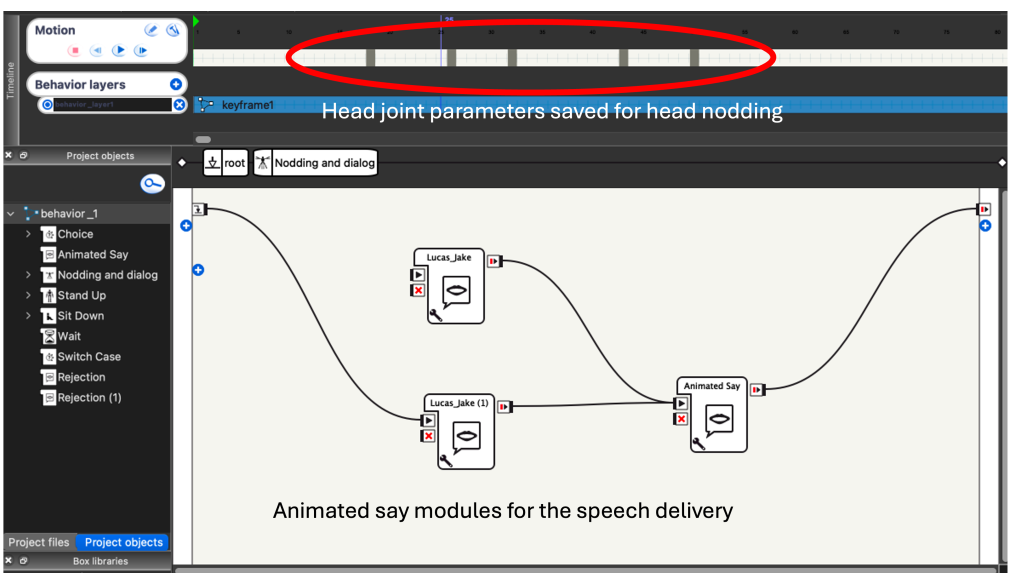


Fig. 6: Head nodding implementation in Choreographe using the timeline block