NAO Meditation Assistant

Diptanshu Mann
Student id - 22071791, Group 1F
University of West England, Bristol
diptanshu2.mann@live.uwe.ac.uk

***Abstract*—This study examined the effectiveness of a NAO robot versus a mobile app as mediators of meditation practice. The objective was to ascertain whether the robot could augment the quality of meditation and enhance the well-being of the participants. The study employed a user-centred design approach with two experimental conditions: one with the robot as the meditation guide and the other with a video in the mobile app. Data from 16 participants were collected using standardized instruments: the Profile of Mood States (POMS) and the System Usability Scale (SUS). The results indicated that the robot-mediated meditation had a slightly higher positive impact on mood states than the app-mediated meditation. This study contributes to the emerging field of human-robot interaction and underscores the potential of robots in facilitating well-being through meditation support.**

I. Introduction

Meditation is the practice of focusing on something to achieve calmness, awareness, and well-being. It can have numerous mental and physical health benefits, but some individuals encounter difficulties meditating regularly or effectively for various reasons. Hence, we conducted a study to determine if a NAO robotic assistant can aid individuals in meditation and improve the overall quality of their practice compared to a mobile app. The experiments we designed consisted of two parts - the first involved the NAO robot verbally guiding the participants through the meditation routine, while the second part involved a mobile app that presented a video for the participant to follow along. To minimise the risk of data biases, we alternated between two scenarios. In the first scenario, the NAO robot served as the assistant, while in the second scenario, we used the mobile app video first. We measured the participant's mood profiles before and after the experiment to assess the impact of the robot on their mood state.

The study began by giving the participants a comprehensive briefing about their involvement in the experiment and the data collection process. Following this, an information sheet containing all necessary details regarding the experiment, the researchers' particulars, and the experiment's procedure were presented to them. Finally, the participants were asked to give their consent to participate in the experiment by filling out the consent form. We conducted the study in a room with adequate lighting, where the participants could view the screen comfortably. The robot was positioned on a table facing the participant at a suitable height, and the room was silent to avoid any disturbances during the meditation practice. We collected data from 16 participants, ensuring unbiased data collection by dividing them into two groups and alternating the order of the experimental conditions.

In this study, we utilized two distinct questionnaires to assess our participants: the Profile of Mood State (POMS) and The System Usability Scale (SUS). The POMS questionnaire is a well-established psychological tool frequently employed to gauge temporary mood states, while the SUS scale is technology-independent and used to evaluate the usability of systems after usability tests. We administered the POMS questionnaire both before and after each experimental condition and the SUS questionnaire at the end of the study to assess participants' overall impressions of interacting with the robot.

Overall, the results of our study demonstrated that the robot as an assistant was approximately five percent more effective in improving mood states than the mobile app. Considering the increasing amount of research on human-robot interaction and its potential applications in promoting human well-being, this study has the potential to make a meaningful contribution.

II. Related Work

A. Socially assistive robots

In recent years, robots' application has expanded to entertainment, medicine, and mental health enhancement. While research has centered on companion robots, advancements enable them to forge more relationships for targeted well-being [1]. Feil-Seifer D has mentioned in [2] that socially assistive robots are characterized by their capacity to engage in social interactions, comprehend human emotions, and deliver personalized assistance. Consequently, the individualized requirements for assistance in people's daily lives give rise to a diverse array of potential applications for socially assistive robots. These applications encompass supporting the elderly in their daily activities, aiding children with developmental disabilities in therapy, providing psychological counseling assistance, and offering guidance for physical health recovery. As technology evolves and research progresses, socially assistive robots hold the promise of transforming numerous fields and exerting a positive influence on individuals' lives.
The appearance of a robot is a crucial aspect of human-robot interaction, as it contributes to its physical presence and must align with its cognitive and interactive capabilities. The degree to which a robot resembles a human influences people's expectations regarding interaction. In socially assistive robotics, believability outweighs realism in importance. Therefore, for assistive tasks, a child-like appearance or an anthropomorphic but not overly realistic appearance is often deemed more suitable [3].
The NAO robot serves as an exemplary illustration, featuring

a human-like appearance and design. With 25 degrees of freedom, it possesses the ability to maneuver and adjust within its surroundings. Additionally, equipped with 2 2D cameras, 7 tactile sensors, and 4 directional microphones, along with integrated speakers for human and environmental interaction, the NAO robot provides a comprehensive array of sensory capabilities. Moreover, it offers voice recognition and supports dialogue in 20 diverse languages [4]. These remarkable features collectively establish NAO as a well-suited Socially Assistive Robot (SAR).

B. Human emotions and meditation

Tang, Hölzel, and Posner [5] conducted a comprehensive review of the neuroscience of orthomolecular meditation, providing valuable insights into its impact on emotion regulation and cognitive function. Their work elucidated the neural correlates associated with meditation practices, shedding light on its effects.

In a study by Zeidan et al. [6], the cognitive effects of orthomolecular meditation were examined, demonstrating the efficacy of brief mental training through meditation. The findings revealed improvements in cognitive performance, as well as positive effects on emotion regulation and attention.

A randomised controlled trial conducted by Hoge et al. [7] investigated the effects of orthomolecular meditation on individuals with generalised anxiety disorder. The results revealed a positive impact on reducing anxiety and stress reactivity, suggesting its potential as an effective intervention for anxiety-related symptoms.

Keng, Smoski, and Robins [8] conducted a comprehensive review of empirical research on positive meditation and its impact on mental health. Their analysis underscored the positive effects of meditation on emotion regulation, coping skills, and self-awareness, highlighting its potential for enhancing overall mental well-being.

Collectively, these studies enhance our understanding of the relationship between meditation and emotions. They provide valuable insights into the effects of meditation on neurological processes, cognitive functioning, anxiety reduction, and psychological well-being. These findings suggest that meditation practices, such as positive meditation, hold promise for promoting emotional well-being and improving psychological outcomes. As the field continues to evolve, further research is warranted to elucidate the underlying mechanisms of meditation's effects on mood and explore its potential in diverse populations and settings.

C. Meditation Robot

The trend towards automated devices or intelligent machines serving humans is mainstream today and mainly used in manufacturing and industry. However, with medical and neuroscience technology advances, barriers to integrating robots with human perception systems will also be filled. Meditation robots refer to intelligent devices that can assist participants in meditation exercises and positive thinking interventions aimed at improving mental health and reducing symptoms of stress and anxiety. [9] A study by Oliveira focused on examining HRI used to enhance pro-social behavior. Approximately 50% of the studies analyzed the positive changes induced by HRI in pro-social behavior. [10] Hudlicka (2013) assessed the impact of virtual positive thinking coaching on the performance of positive thinking meditation. Data was collected in the form of a Likert scale survey, which was completed by participants. The results demonstrate that positive meditation guided by a virtual agent is achievable and may be more advantageous than unsupervised meditation. [11] Björling's research revealed that individual user characteristics, including personality, stress levels, and perceptions of the robot, influence the mental health interventions of HRI. [12]

III. Methods

Our study aimed to investigate whether using a robot to guide short meditation exercises and rhythmic breathing can enhance the quality of meditation. The experiment consisted of two parts. The first involved the robot verbally guiding the participant through the meditation routine, while the second part featured a video that the participant followed along with. To assess the impact of the robot on the participant's mental state, we measured their emotional state before and after the experiment.

We alternated between two cases to ensure that the data collected was unbiased. In the first case, the robot is first used as an assistant; in the second case, the video is used first. We administered a questionnaire to the participants at the beginning of both parts of the experiment and at the end of the entire study to compare their emotional states. These questionnaires, in addition to the system usability scale, constitute our entire database.

A. Research Question and Hypothesis

We have had this question, "Would a robot be able to do this better? " since we formed this group. So, what could be a better comparison to a robot than a smartphone we use daily? We decided to compare a meditation routine application and replicate the same in our robot, Nao.

Research Question - "Can a robot be more helpful than a smartphone app as a meditation assistant?"

Hypothesis - "A robot can be more helpful than a smartphone app as a meditation assistant because it can provide more human-like gestures, physical presence, and emotional support."

B. User Study Design

The study necessitates a room with adequate lighting where the participant can view the screen. The participant should sit in a position that is comfortable for them. The robot will be positioned on a table facing the participant at a suitable height. The room will be silent to avoid any disturbances during the meditation practice, and there will be gentle music playing in the background to create a soothing atmosphere.

We aspire to create a comfortable and soothing atmosphere that will support the meditation practice and enhance the participant's well-being.

Following the meditation routine in the video, the robot will imitate the rising and falling of its upper limbs per the instructions. We have two experimental conditions: one with a smartphone app where the app will lead the user through the form of a video, and another where the NAO robot will act as the guide for the routine. We will compare the effects of these two conditions on the participant's mood, stress level, and mindfulness.

C. User Study Procedure

The study commenced with the participants being provided with a comprehensive briefing regarding their involvement in the experiment, the data collection process, and the lack of any adverse impact on them. Following this, an information sheet was presented to them containing all the requisite details concerning the experiment, the researchers' particulars, and the experiment's procedure. We presented the participants with some pertinent information and then solicited their assent to partake in the experiment by affixing their signatures to the consent document. They all complied with our request.

Subsequently, an online questionnaire was administered to gauge the participants' emotional state. This measure was the sole data we collected since anything else was removed from the data. Following this, the participants were requested to make themselves comfortable before the experiment commenced.

At this juncture, the experiment was ready to begin. Data were collected from 16 participants. We ensured that the data collected remained unbiased; thus, we divided the participants into two groups. One group viewed the video before the robot performed the meditation routine, while the other group had the robot perform the routine first, followed by the video. The impact of this arrangement on the participants is elaborated on in the subsequent results section.

We asked the participants to fill out another questionnaire about how they felt right now after they watched the video and before they met the robot. The questionnaire was meant to capture their emotions after meditating. When they finished the second session, we asked them to fill out one last questionnaire about how they felt after the whole experiment. This questionnaire enabled us to evaluate how the meditation routine, either from the video or the robot, affected the participants. Additionally, we requested that the participants fill out a system usability scale to measure their impressions of interacting with the robot.

This entire study was conducted over four hours or two practical sessions of the Human-Robot Interaction Module. We ensured that the experiment duration was at most five minutes to prevent overburdening the participants. Furthermore, we ensured that our research adhered to all ethical guidelines regarding human participants.

D. Dependent Measures

In research studies, there are typically two types of measurements - subjective measurements, such as questionnaires or interviews, and objective measurements, such as the time and location of the experiment. However, our study only considered subjective measurements.

We utilized two questionnaires for our participants. The first questionnaire measured the emotional state of the participants at that particular moment using the Profile of Mood State (POMS) [19]. McNair, Lorr, and Droppleman initially developed the POMS in 1971, and it is a validated psychological test consisting of 65 words and statements that describe feelings. We only utilized the related mood states for our experiment from the comprehensive list of states. In sports, the POMS is widely utilized to measure an athlete's transient, distinct mood states over time.

The second questionnaire, The System Usability Scale (SUS) [20] was released into this world by John Brooke in 1986. It was originally created as a "quick and dirty" scale for administering after usability tests on systems like VT100 Terminal ("Green-Screen") applications. SUS is technology independent and has since been tested on hardware, consumer software, websites, cell phones, IVRs and even the yellow pages. This aimed to evaluate how the participants felt about interacting with the robot, including whether they felt uncomfortable during the interaction.

E. Participants

Our original plan was to have a diverse group of people from 20 to 60 years old in our study, but we encountered some obstacles that hindered us from achieving that. So we ended up with only people from 20 to 30 years old as our participants. That's the age range of participants we had to work with.

IV. Results

The study was completed by 16 participants, with a mean age of 22 years. The primary objective of the research was to examine whether NAO Robot acting as a meditation assistant could result in a more significant improvement in meditation experience compared to utilizing a meditation video alone. To accomplish this, participants were instructed to follow the two conditions: NAO Robot-assisted meditation and smartphone app-assisted meditation in random order.

The POMS [19] results of the study, as demonstrated in figure 1, display that participants who utilized the NAO Robot-assisted meditation technique reported a substantial enhancement in mood levels, with an overall mean improvement of 75.22%, and a standard deviation of 14.31%. Conversely, when utilizing the smartphone app-assisted meditation technique, the overall mean improvement in mood was 68.83%, with a standard deviation of 16.14%. The table I presents the mean and standard deviation of the change in score for each parameter of the questionnaire, which ranged from 0 to 4.

Moreover, based on the SUS ratings, the participants in the NAO Robot-assisted meditation condition reported a high level of engagement with mean ratings of 77.69% and a standard deviation of = 7.31%. This rating falls in the B+ rating category on the SUS scale [20].

Method	Parameter	Tense	Angry	Worn out	Unhappy	Hopeless	Uncertain	Uneasy	Restless	Annoyed	Resentful	Nervous	Exhausted	Anxious	Furious
App	Mean	1.19	1.44	0.94	1.13	1.38	1.00	1.00	0.25	1.00	0.81	1.25	1.06	1.06	1.38
	SD	0.73	1.17	0.97	0.78	1.22	0.71	0.79	0.43	0.79	0.88	1.03	0.75	0.75	1.05
Robot	Mean	1.06	0.94	1.31	0.69	1.44	1.63	0.63	0.88	1.56	0.75	1.00	1.44	0.81	1.63
	SD	0.83	0.66	0.68	0.46	1.17	0.86	0.78	0.99	0.79	0.90	0.87	0.93	0.88	1.17

TABLE I: Mean and Standard deviation of change in each parameter of the questionnaire

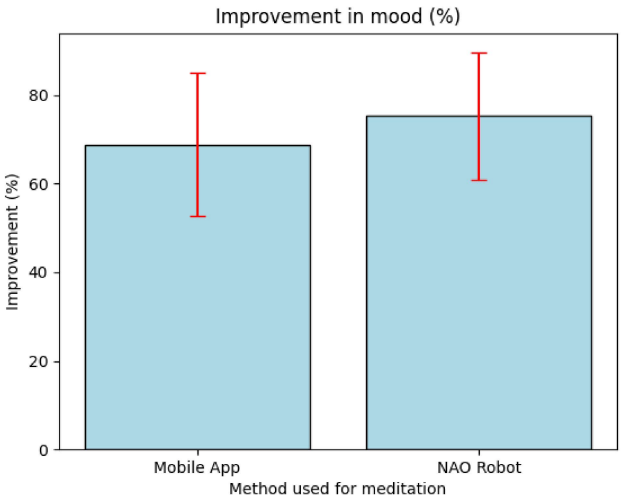

Fig. 1: Comparison of the mean improvement in mood percentage between the mobile app and the robot as a meditation assistant.

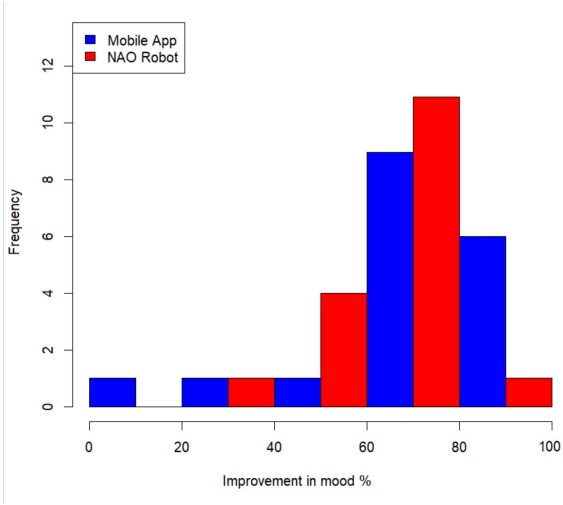

Fig. 2: Histogram plot of change in mood scores for both the experiment conditions

The figure 2 displays the histogram plot for change in mood scores of both the experiment conditions, which follows a normal distribution. Based on the t-test to check the difference between the two datasets, the test reported the p-value for change in overall mood scores of both the experiment conditions to be 0.0013. However, the Cohen-d test for the same dataset gave a value of 0.28, suggesting that the effect size is small.

V. Discussion

The research aimed to examine the efficacy of utilizing a NAO robot as an assistant during meditation as opposed to a mobile application. The study's findings provide significant insights into the potential advantages of integrating robots into meditation practices.

The findings indicate that participants who engaged in NAO robot-assisted meditation reported a slightly greater improvement, around five per cent, in mood levels compared to those utilizing the smartphone app-assisted meditation technique. The mean improvement in mood for the NAO robot condition was 75.22%, with a standard deviation of 14.31%, whereas the mean improvement for the smartphone app condition was 68.83%, with a standard deviation of 16.14% as illustrated in figure 1. This suggests that the presence of a physical robot during meditation sessions may contribute to a more positive and enhanced experience for individuals.

The histogram plot (Figure 2) illustrating the change in mood scores for the two experimental conditions displayed a normal distribution, signifying the reliability and representativeness of the collected data. The t-test results revealed a statistically significant difference between the two conditions, with a p-value of 0.0013. Despite the small effect size, as measured by Cohen's d test, the NAO robot still had a noticeable impact on participants' mood states during meditation.

Furthermore, the System Usability Scale (SUS) ratings reported by participants in the NAO robot-assisted meditation condition support the notion that interacting with a physical robot can enhance the overall meditation experience. The mean SUS rating of 77.69%, falling within the B+ rating category, suggests a positive reception of the NAO robot's usability as a meditation assistant. However, there is room for improvement in this regard, like adding personalized greetings and routines based on the user profile.

However, it is imperative to acknowledge certain limitations of the study. Firstly, the sample size was comparatively small, containing only 16 participants, which may restrict the extent to which the findings can be generalized. Subsequent research might strive to include a more extensive and diverse cohort of participants to obtain a more comprehensive understanding of the impact of NAO robot-assisted meditation. Furthermore, the study solely examined short-term effects on mood states, and further investigations could explore the long-term benefits and sustained impact of using robots as meditation assistants.

VI. Conclusion

In conclusion, this study investigated the effectiveness of utilizing an NAO robot as a mediation aid in comparison to a mobile application. The results indicated that introducing a physical robot in meditation sessions could slightly enhance an individual's mood. Those who took part in NAO robot-supported meditation experienced a higher level of mood improvement compared to those using a smartphone app. These findings endorse the idea that including a robot in meditation practice can heighten the overall experience and advance an individual's well-being.

The study's findings augment the growing body of research on human-robot interaction and its prospective possibilities in promoting psychological and emotional well-being. Through its verbal guidance and physical presence, the NAO robot serves as a companion to assist individuals in attaining a state of calm, mindfulness, and relaxation. Furthermore, the reported level of engagement further confirms the robot's practicality and acceptance as a tool for meditation.

Overall, The results of this study indicate the potential of incorporating robots in meditation routines to enrich the quality of practice and enhance well-being. Further research is required to explore the underlying mechanisms and long-term implications of robot-assisted meditation. As technology advances, understanding the role of robots in promoting human well-being becomes increasingly vital, and this study contributes to this evolving field of research.

References

[1] Chris Krägeloh;Jaishankar Bharatharaj. 2021, 'Robots for meditation and mindfulness: A scoping review of the literature', 마음공부, (), 81-102.

[2] Feil-Seifer D, Mataric M J. Defining socially assistive robotics[C]//9th International Conference on Rehabilitation Robotics, 2005. ICORR 2005. IEEE, 2005: 465-468.

[3] Tapus A, Maja M, Scassellatti B. The grand challenges in socially assistive robotics[J]. IEEE Robotics and Automation Magazine, 2007, 14(1): N/A.

[4] Robaczewski, A., Bouchard, J., Bouchard, K. et al. Socially Assistive Robots: The Specific Case of the NAO. Int J of Soc Robotics 13, 795–831 (2021). https://doi.org/10.1007/s12369-020-00664-7

[5] Tang Y Y, Hölzel B K, Posner M I. The neuroscience of mindfulness meditation[J]. Nature reviews neuroscience, 2015, 16(4): 213-225.

[6] Zeidan F, Johnson S K, Diamond B J, et al. Mindfulness meditation improves cognition: Evidence of brief mental training[J]. Consciousness and cognition, 2010, 19(2): 597-605.

[7] Hoge E A, Bui E, Marques L, et al. Randomized controlled trial of mindfulness meditation for generalized anxiety disorder: effects on anxiety and stress reactivity[J]. The Journal of clinical psychiatry, 2013, 74(8): 16662.

[8] Keng S L, Smoski M J, Robins C J. Effects of mindfulness on psychological health: A review of empirical studies[J]. Clinical psychology review, 2011, 31(6): 1041-1056.

[9] Ruth A Baer. 2003. Mindfulness training as a clinical intervention: A conceptual and empirical review. Clinical psychology: Science and practice 10, 2 (2003), 125.

[10] Oliveira, R., Arriaga, P., Santos, F. P., Mascarenhas, S., Paiva, A. (2021). Towards prosocial design: A scoping review of the use of robots and virtual agents to trigger prosocial behaviour. Computers in Human Behavior, 114(September 2020), 106547.

[11] Hudlicka, E. (2013). Virtual Training and Coaching of Health Behavior: Example from Mindfulness Meditation Training. Patient education and counseling, 92(2), 160–166.

[12] Ling, H. Björling, E. (2020). Sharing Stress With a Robot: What Would a Robot Say? Human-Machine Communication, 1, 133–158.

[13] Maryam Alimardani; Linda Kemmeren, "Robot-Assisted Mindfulness Practice: Analysis of Neurophysiological Responses and Affective State Change" 2020 29th IEEE International Conference on Robot and Human Interactive Communication

[14] T. Lomas, I. Ivtzan and C. H. Fu, "A systematic review of the neurophysiology of mindfulness on EEG oscillations", Neuroscience and Biobehavioral Reviews, vol. 57, pp. 401-410, 2015.

[15] A. A. Fingelkurts, A. A. Fingelkurts and T. Kallio-Tamminen, "EEG-guided meditation: a personalized approach", Journal of Physiology-Paris, vol. 109, no. 4-6, pp. 180-190, 2015.

[16] C. Kaur and P. Singh, "EEG derived neuronal dynamics during meditation: progress and challenges", Advances in preventive medicine, 2015.

[17] C. Braboszcz, B. R. Cahn, J. Levy, M. Fernandez and A. Delorme, "Increased gamma brainwave amplitude compared to control in three different meditation traditions", PLoS One, vol. 12, no. 1, 2017.

[18] R. J. Davidson, "Asymmetric brain function affective style and psychopathology: The role of early experience and plasticity", Development and Psychopathology, vol. 6, no. 4, pp. 741-758, 1994.

[19] McNair, D. M. et al. (1971) EITS manual for the Profile of Mood States. Educational and Industrial Testing Service.

[20] Brooke, John. (1995). SUS: A quick and dirty usability scale. Usability Eval. Ind.. 189.