Experiments and Evaluation of the Impact of Yoga Demonstration Robots on User Satisfaction, Involvement, and Relaxation Compared to Video-based Demonstration

Edouard Rolland
University of the West of England
Student ID: 22071789
MSc. Robotics, Bristol, UK
edouard2.rolland@live.uwe.ac.uk

Adip R. Das
University of the West of England
Student ID: 22071780
MSc. Robotics, Bristol, UK
adip2.das@live.uwe.ac.uk

Ziniu Wu
University of the West of England
Student ID: 22071766
MSc. Robotics, Bristol, UK
ziniu2.wu@live.uwe.ac.uk

Tunwu Li
University of the West of England
Student ID: 22071758
MSc. Robotics, Bristol, UK
tunwu2.li@live.uwe.ac.uk

Yifan Zhang
University of the West of England
Student ID: 22071734
MSc. Robotics, Bristol, UK
yifan6.zhang@live.uwe.ac.uk

***Abstract*—This study examines the impact of human-robot interaction in yoga, specifically comparing user experiences with a robot instructor (NAO) versus a video instructor. Sixteen male participants aged 20 to 30 were divided into two groups, with Group A following the NAO robot's instructions and Group B following a pre-recorded video instructor. Post-session questionnaires assessed physical comfort, enjoyment, and participant opinions. Data analysis utilized the User Experience Questionnaire (UEQ), and ethical guidelines were adhered to. The findings contribute to understanding user engagement and satisfaction when utilizing a robot as a yoga instructor.**

I. Introduction

Yoga, a widespread practice for physical and mental well-being, has gained attention in human-robot interaction research. This study focuses on exploring user experiences and engagement during yoga sessions led by a robot instructor (NAO) compared to a video instructor. The research aims to fill the existing gap in understanding the user experience specific to yoga practice with robots.

Previous studies have examined the use of robots in physical activities and their potential to motivate participants (1; 2). They have also highlighted the influence of social interactions and robot embodiment on user perception and experience (2).

However, limited research has delved into user engagement during yoga sessions with a robot instructor. Most studies have primarily focused on using robots as sports coaches, neglecting the unique aspects of yoga practice (3). Consequently, a comprehensive investigation into the user experience within the context of yoga is needed.

The user study included 16 male participants aged 20 to 30, divided into two groups. Group A followed the yoga instructions provided by the NAO robot instructor, while Group B followed instructions from a pre-recorded video instructor. The NAO robot, developed by SoftBank Robotics, guided participants through yoga poses using appropriate prompts. The video session was carefully designed to match the duration and content of the robot-led session.

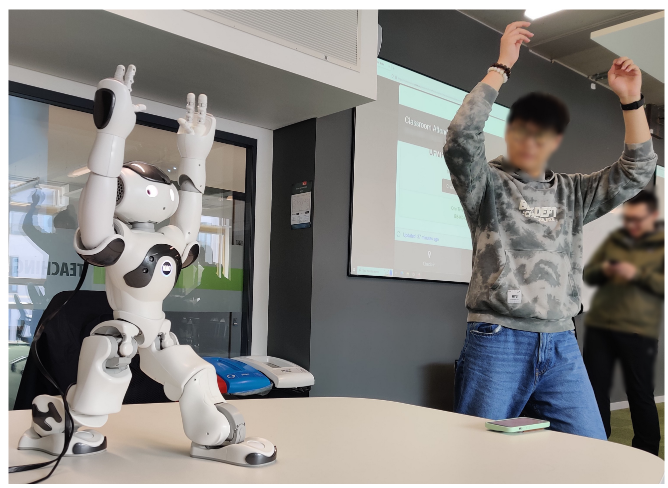


Fig. 1. Field experiments

To assess the user experience, a post-study questionnaire was administered, evaluating participants' physical comfort, enjoyment of the yoga session, and opinions on the instructor (robot or video). The User Experience Questionnaire (UEQ), a validated tool measuring various dimensions such as attractiveness, perspicuity, efficiency, dependability, stimulation, and novelty, was employed for data analysis.

This report provides a concise and descriptive overview of the user study procedure, including participant selection, session instructions, and data collection methods. The findings from this research contribute to the understanding of the impact of human-robot interaction on user engagement and satisfaction, specifically within the domain of yoga.

II. Related Work

It is possible to find several studies in the literature that report on the use of robots to practice yoga. For example, (4) have developed a robot capable of analysing the performance and progress of yoga practitioners by analysing their movement using machine learning.

Another study carried out by (5), use a NAO robot and a group of 16 people to quantify the impact of the robot's social interactions on the quality of the training session. The results show that a robot with a social character increases its appreciation rate among users. Its naturalness and relevance appear to be better. Social interactions increase the quality of the yoga session. However, there are no other studies that specifically evaluate the user experience in the context of yoga when it is conducted by a robot.

Therefore, it appears that studies related to the use of robots in the field as coaches are relevant to be considered. The research conducted by (6) and (7) suggests that the use of a robot as part of a physical activity can be a source of motivation. These studies show that most exercisers express increased engagement when physical activity is coached by a robot. In particular, (7) conducted an experiment with 15 participants where the robot was able to adapt its behaviour by detecting the user's engagement based on their facial expressions and vital parameters such as their heart rate. After the experiment, the participants were asked to complete a questionnaire. The results show that users are in favour of the use of robots in the field of sport and that they feel more motivated when the session is led by a robot.

(8) make a significant contribution to this area of research by considering the impact of the physical representation of the robot on the user experience. The researchers considered two distinct experimental groups: High-level sportsmen and sportswomen and people practising a leisurely sporting activity. The experiments focused on two distinct types of activities: reflex games and squats. The perception of the robot and the user experience are evaluated using two questionnaires. The first, given before the experiment, assesses the participant's relationship with the technology and allows for the collection of demographic data. The second, after the experiment, assesses the participant's acceptance of the robot and also the motivation generated and its persuasiveness. The results of the study based on 70 participants show that the majority of the participants have a positive perception of the robot and its physical representation regardless of the type of experiment performed. Nevertheless, it was not possible to find in the literature comparative studies of user engagement between a physical activity coached by a robot or by a video.

The study presented in this paper will aim to describe in depth the method used to determine whether the robotic embodiment of the robot can increase the quality of the user experience compared to a yoga session followed through a video.

III. Method

A. Research Question & Hypothesis

The research question of our study is interested in evaluating the experience of a user practicing yoga in two distinct scenarios. The yoga session is delivered either by a robot or by a video lesson. An enhanced user experience during a yoga class results in increased user engagement in the session and consequently an increased sense of relaxation at the end of the session.

The following hypotheses are made regarding the outcome of the study:

- **H1:** The embodiment of the robot will allow a better physical representation of the movements to be made, the user experience will be improved.
- **H2:** Yoga training guided by a robot is more interactive and engaging than video lesson.

B. User Study Design

The aim of this section is to provide a detailed description of the set-up of the two experiments carried out in the study: the experiment in which the yoga session is conducted with the help of a video, and the experiment in which it is conducted by the robot.

1) Creation of the Yoga Video Session: A suitable yoga class video needed to be found for the study. A 30-minute video from the YouTube channel ”Yoga With Adrienne” was chosen (9). This video provides an introduction to yoga for beginners and includes a series of accessible yoga poses.

To streamline the video, it was decided to retain only four consecutive poses, as illustrated in Fig.2. The coach guides the participant on transitioning between the movements and managing their breathing throughout the session.

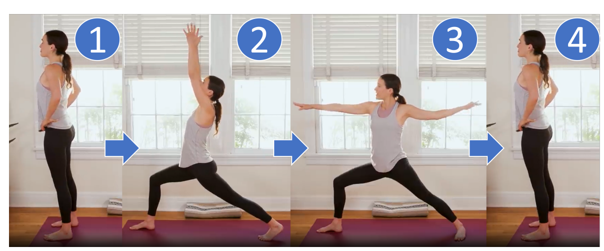


Fig. 2. Yoga training steps

Finally, the duration of the video shown during the experiment is 1 minute and 41 seconds.

2) Programming the NAO Robot: To perform the experiment with the robotic coach, a NAO-type robot developed by SoftBank Robotics is used (10). In order to test the embodiment hypotheses outlined in Section II, the oral instructions given by the robot are directly derived from the sound of the video. Thus, the robot and the video provide the same audio instructions, only the physical representation of the coach differs. It is thus possible to measure the impact of the embodiment of the robot on the user experience without introducing bias by modifying the audio nature of the instructions. Subsequently, in the Choregraphe software, the different postures and transitions are implemented and synchronised to match the sound of the video. Fig.3.

Fig. 3. Yoga pose (Video vs Robot)

3) Selection of the participants: The ideal group of participants for our study should represent, on a small scale, the population of yoga practitioners. According to (11), this population is 76% female, with an average age of 39.5 years in the US.

Thus, for both the video and robot experiments, it is relevant that the group of participants replicate these characteristics. It will also be necessary to ensure that the number of people carrying out each experiment is the same.

4) Data collection methods: The experimental data collected includes quantitative elements. Participants are asked to complete a questionnaire to provide information on their gender, age and previous experience with yoga. This last question will allow the detection of possible selection effects. Thereafter, data collection is continued using a UEQ-S questionnaire, the details of which will be discussed in Section II.D.

C. User Study Procedure

All the instructions given to the participants are given through an instruction sheet. The instructions given to all participants are identical, so no experimental bias is introduced. For each participant the following experimental protocol is applied:

- The participant is welcomed into the experiment room and provided with the instruction sheet, which he or she is asked to read.
- The participant scans a QR code which links to a digital consent form (this document can be found in the appendix)
- If the participant is willing, the experiment can be started (either the video or the demonstration of the robot). The experimental team moves away from the area so that the participant is comfortable and does not feel observed.
- Once the experiment is over, the participant fills in an online questionnaire.
- An informal discussion can be held with the experimenters to gather qualitative feedback on the experience
- The participant is thanked and can leave.

D. Dependent Measures

In order to quantify the quality of the participants' user experience, the UEQ-S (User Experience Questionnaire - Short) is used. This type of questionnaire is often used in the field of human-robot interaction. It is used to evaluate the feelings, impressions and attitudes of users regarding a product. Its relevance has been demonstrated by (12). Furthermore, UEQ provides valuable insights into the quality of HRI products as it not only covers a wide range of aspects such as attractiveness, efficiency and reliability, but also provides standardised measurements of the user experience (13).

The 8 items in the UEQ-S exhibit differences in their semantic form. Each item is represented by two opposing semantic expressions, as illustrated in Fig. 4 (12). These variations are measured using a five-point Likert scale (14), ranging from -2 to +2. A rating of -2 indicates the most negative sentiment, 0 represents neutrality, and +2 reflects the most positive sentiment. The first four items pertain to the Practical Quality Scale, while the remaining four items relate to the Hedonic Quality Scale.

obstructive	○ ○ ○ ○ ○	supportive
complicated	○ ○ ○ ○ ○	easy
inefficient	○ ○ ○ ○ ○	efficient
clear	○ ○ ○ ○ ○	confusing
boring	○ ○ ○ ○ ○	exiting
not interesting	○ ○ ○ ○ ○	interesting
conventional	○ ○ ○ ○ ○	inventive
usual	○ ○ ○ ○ ○	leading edge

Fig. 4. The items in the UEQ-S (12).

Afterwards, there are six indicators based on the participants' rating of the experiment: attractiveness, perspicuity, efficiency, dependability, stimulation, and novelty to assess their attitude towards the robot's guidance or video guidance.

The explanation of the terms is shown in Fig. 5. Attractiveness, as a composite indicator, is defined by two categories: pragmatism and hedonism, which include indicators of efficiency, perspicuity, and novelty, respectively.

The scores for each of these indicators are derived from a certain number of items in Fig. 4, specifically, as shown in Table I.

The UEQ-S questionnaire is supplemented with additional questions provided in the appendix. Each new question is

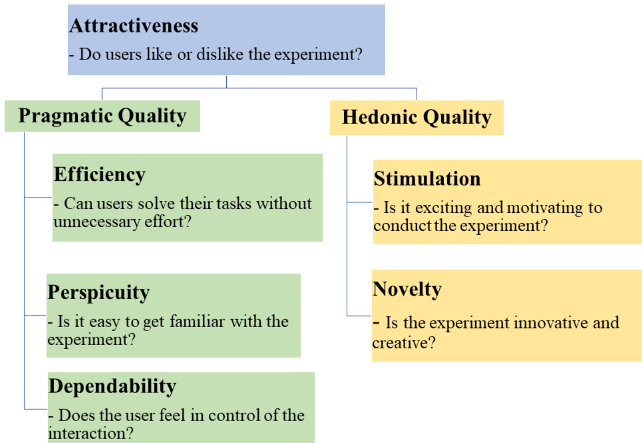


Fig. 5. The structure of the indicators of the UEQ-S

associated with a specific section of the original UEQ-S test. The inclusion of these new questions aims to capture an additional attribute, namely attractiveness, which was not originally covered in the questionnaire.

TABLE I
ASSUMED SCALE STRUCTURE

Attributes	Allocated Items
Attractiveness	Q1 Q4 Q7
Perspicuity	U2 U4 Q3 Q8
Efficiency	U3 Q2 Q10
Dependability	U1 Q5 Q9
Stimulation	U5 U6 -Q6
Novelty	U7 U8

This addition of questions makes for a more comprehensive questionnaire and will better capture the quality of the user experience in the case of the two separate experiences.

E. Participants

The study enrolled male participants between 20 and 30 years old using a random sampling process. The goal was to include a diverse group of individuals within this age range to explore how young adult males perceive the interaction with a humanoid robot during a yoga session. The age criteria were chosen to minimize any potential age-related influences on the study outcomes.

IV. RESULTS

As shown in Table II, all participants are male. 25% of the participants in each group have practiced yoga before. 75% of the participants in the robot group are aged between 20-25, while 25% of the participants are aged between 25-30 in the robot group.

The results of collected questionnaires in a five-point Likert scale are visualized using a box plot in Figure 6 (a) and (b). If a box is symmetrical, then it is normally distributed. Above one-half of the boxes are symmetric, so we assume our data

TABLE II
DISTRIBUTION OF PARTICIPANTS

Index	Robot (Group A)	Video (Group B)
Gender is male	100%	100%
Have practiced yoga before	25%	25%
Age: 20-25	75%	100%
Age: 25-30	25%	0

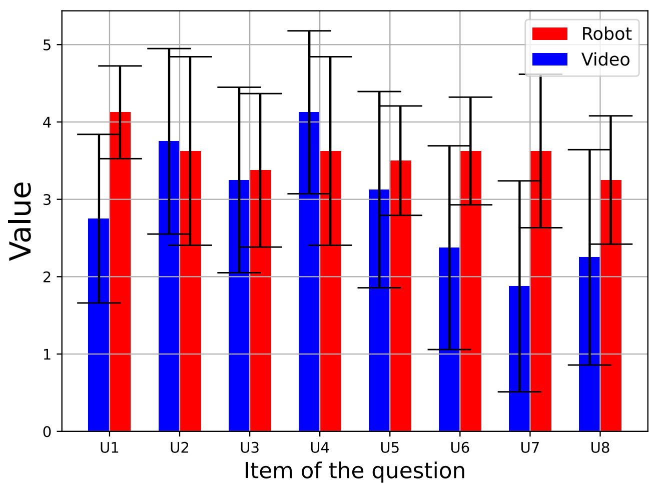
were normally distributed. Therefore, we can apply a t-test to compare two independent groups for each attribute.

The comparison of two experimental groups of each attribute is evaluated by a modified UEQ analysis tool (12). The aim of this tool is to simplify the analysis of questionnaire data based on our modified version of the structure of the indicator. The significant change is to convert the 7-point to the 5-point version. The tool comprises several worksheets, where the first (Data1 and DT1) is Group A and the second (Data2 and DT2) is Group B. And then two data are arranged in a randomized order of the items to minimize order effect for further calculations. As shown in Figure 6 (c), the bar plot displays the six attributes for the two groups. Furthermore, the T-Test shows whether the means of the two measurements differ significantly for each attribute or not. Assumptions are the samples are normally distributed and the standard deviation of each group is not equal.

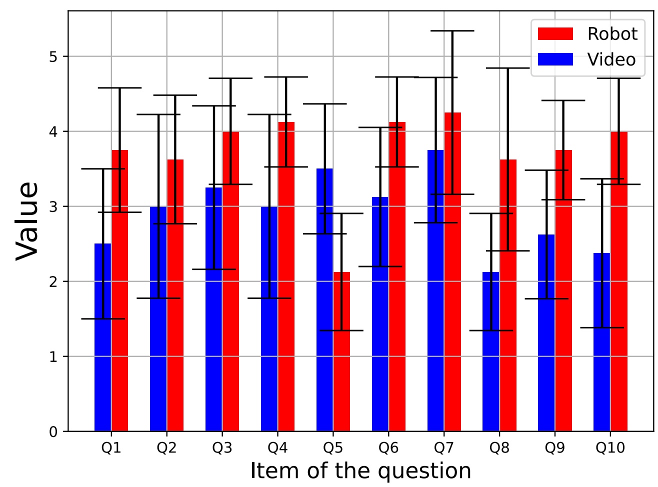
As shown in Figure 6 (c), the results denmonstrated that the average of attributes of Group A rated higher in attractiveness (mean=1.04, SD=0.72), perspicuity (mean=0.72, SD=0.86), efficiency (mean=0.67, SD=0.50), dependability (mean=0.33, SD=0.62), stimulation (mean=0.00, SD=0.50), and novelty (mean=0.44, SD=0.86) than Group B, where attractiveness (mean=0.08, SD=0.64), perspicuity (mean=0.31, SD=0.59), efficiency (mean=-0.13, SD=0.67), dependability (mean=-0.04, SD=0.60), stimulation (mean=-0.21, SD=0.83), and novelty (mean=-0.94, SD=1.43). However, group B rated slightly higher than Group A in perspicuity, efficiency, and dependability. Considering of standard deviation, group A has a lower deviation than Group B in the attributes of novelty and stimulation, whereas the deviations are about the same for the other attributes. To conclude, it suggest that group A generally better than the evaluated attributes more positively than group B.

Table III shows a simple T-Test to check if the scale means of two measured groups differ significantly. As default, we used the threshold 0.05.

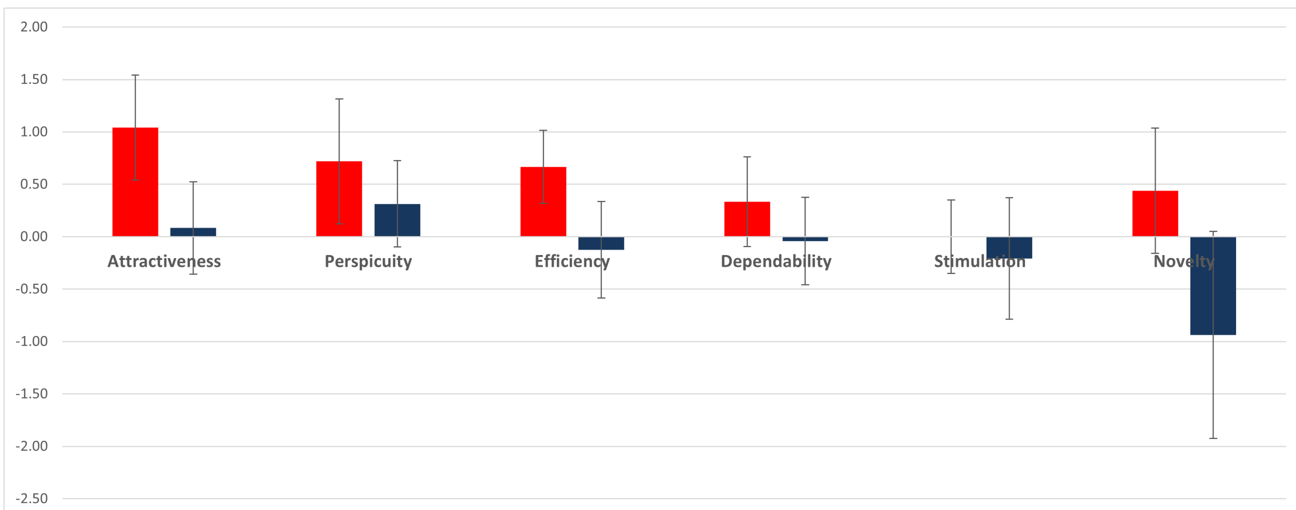
The results of the two-sample t-test, as listed in Table III, revealed that there are significant differences between the two groups in terms of attractiveness, efficiency, and novelty, where the p-values of 0.0139, 0.0187, and 0.0386, respectively. However, there were no significant differences in perspicuity, dependability, and stimulation, with p-values of 0.2925, 0.2391, and 0.5573, respectively.



(a) UEQ-S Result. The red box is the robot. The blue box is the video.



(b) Question Result. The red box is the robot. The blue box is the video.



(c) Comparable Result. The red box is the robot. The blue box is the video.

Fig. 6. Result of user study.

TABLE III
TWO SAMPLES T-TEST ASSUMING UNEQUAL VARIANCES.

Attribute	T-test	Difference*
Attractiveness	0.0139	Significant Difference
Perspicuity	0.2925	No Significant Difference
Efficiency	0.0187	Significant Difference
Dependability	0.2391	No Significant Difference
Stimulation	0.5573	No Significant Difference
Novelty	0.0386	Significant Difference

*threshold of p-value is 0.05.

V. DISCUSSION

The results of this study are aligned with previous research on the interaction between humans and robots, and they are valuable to our understanding of how robots can enhance the experience of physical activity for users.

One key finding is that Group A participants who interacted with a physical robot rated attributes such as attractiveness, perspicuity, efficiency, dependability, stimulation, and novelty higher than Group B, which involved video-based interaction. This suggests that the presence of a robot positively impacted participants' perceptions of these attributes.

The concept of embodiment, rooted in social presence theory, offers a lens to interpret these findings. Embodiment refers to the sense of being present and connected physically, which can influence attitudes and behaviours towards technology. In this study, the physical presence of the robot likely enhanced participants' engagement and novelty, leading to more positive ratings in attractiveness, efficiency, and novelty. This aligns with prior studies showing the positive impact of embodiment on user experiences and attitudes towards technology.

Additionally, the findings underscore the role of context in shaping user perceptions. While Group A rated higher in most attributes, there were no significant differences in perspicuity, dependability, and stimulation between the two groups. This suggests that the video-based intervention effectively conveyed these aspects, indicating that specific attributes may not heavily rely on the presence of a physical robot. This finding aligns with the cognitive processing perspective, emphasising cognitive processes and information processing capacity in shaping user perceptions.

Practically, these results have implications for designing interactive robotic systems in wellness and physical activity domains. The positive ratings in attractiveness, efficiency, and novelty highlight the potential of robots as engaging companions or facilitators in yoga practice. By leveraging the embodied nature of robots, designers can enhance user experiences and foster positive attitudes towards technology. However, it is crucial to consider that different attributes may be influenced to varying degrees by the embodiment factor.

VI. Conclusion

In conclusion, the study demonstrated that Group A participants who interacted with a robot rated the evaluated attributes more positively than Group B, which involved participants interacting with a video. Group A showed higher ratings in attractiveness, perspicuity, efficiency, dependability, stimulation, and novelty, indicating a more favourable perception of these attributes. The presence of a physical robot in the yoga experience enhanced participants' engagement and novelty, contributing to positive ratings.

The findings suggest the potential benefits of using robots as interactive companions or facilitators in yoga and similar contexts. The embodied nature of the robot likely played a role in enhancing attractiveness, efficiency, and novelty, creating a more engaging and novel experience. However, there were no significant differences in perspicuity, dependability, and stimulation between the two groups, suggesting that the video-based intervention was still perceived satisfactorily in these aspects. Long-term studies could assess the sustained effects of human-robot interactions in yoga practice.

To advance the field, future research should address the limitations of this study. A more diverse participant sample would improve generalizability. Additionally, incorporating a control group would provide a comprehensive understanding of the unique contributions of robot-assisted interaction. Long-term studies examining sustained effects and user adherence would yield valuable insights. Qualitative research methods could complement the quantitative findings, offering more profound insights into participants' subjective experiences and preferences.

This study highlights the positive impact of robot-assisted interaction on participants' perceptions of attractiveness, efficiency, and novelty in yoga. These findings open avenues for further research and development of interactive robotic systems in wellness and physical activity domains to enhance engagement and well-being.

References

[1] S. Schneide and F. Kummert, "Comparing robot and human guided personalization: Adaptive exercise robots are perceived as more competent and trustworthy,"

[2] J. Fasola and M. J. Mataric, "Using socially assistive human–robot interaction to motivate physical exercise for older adults,"

[3] K. Tsiakas, M. Dagioglou, V. Karkaletsis, and F. Makedon, "Adaptive robot assisted therapy using interactive reinforcement learning,"

[4] K. Tsiakas, M. Papakostas, B. Chebaa, D. Ebert, V. Karkaletsis, and F. Makedon, "An interactive learning and adaptation framework for adaptive robot assisted therapy," in *Proceedings of the 9th ACM International Conference on PErvasive Technologies Related to Assistive Environments*, pp. 1–4, 2016.

[5] C. Park, J. Kim, and J.-H. Kang, "Robot social skills for enhancing social interaction in physical training," in *2016 11th ACM/IEEE International Conference on Human-Robot Interaction (HRI)*, pp. 493–494, IEEE, 2016.

[6] S. Schneider and F. Kümmert, "Exercising with a humanoid companion is more effective than exercising alone," in *2016 IEEE-RAS 16th International Conference on Humanoid Robots (Humanoids)*, pp. 495–501, IEEE, 2016.

[7] M. Shao, S. F. D. R. Alves, O. Ismail, X. Zhang, G. Nejat, and B. Benhabib, "You are doing great! only one rep left: an affect-aware social robot for exercising," in *2019 IEEE International Conference on Systems, Man and Cybernetics (SMC)*, pp. 3811–3817, IEEE, 2019.

[8] A. Sackl, D. Pretolesi, S. Burger, M. Ganglbauer, and M. Tscheligi, "Social robots as coaches: How human-robot interaction positively impacts motivation in sports training sessions," in *2022 31st IEEE International Conference on Robot and Human Interactive Communication (RO-MAN)*, pp. 141–148, IEEE, 2022.

[9] A. Mishler, "30-minute yoga for beginners," April 2022.

[10] I. Spectrum, "Nao," May 2018.

[11] G. S. Birdee, A. T. Legedza, R. B. Saper, S. M. Bertisch, D. M. Eisenberg, and R. S. Phillips, "Characteristics of yoga users: results of a national survey," *Journal of general internal medicine*, vol. 23, pp. 1653–1658, 2008.

[12] M. Schrepp, A. Hinderks, and J. Thomaschewski, "Design and Evaluation of a Short Version of the User Experience Questionnaire (UEQ-S)," vol. 4, p. 103, Jan. 2017.

[13] B. Laugwitz, T. Held, and M. Schrepp, "Construction and Evaluation of a User Experience Questionnaire," in *HCI and Usability for Education and Work* (A. Holzinger, ed.), Lecture Notes in Computer Science, (Berlin, Heidelberg), pp. 63–76, Springer, 2008.

[14] Martin Schrepp, "User Experience Questionnaire Handbook," May 2023.

APPENDIX

1. How did you find the overall experience of doing yoga with the robot?

	1	2	3	4	5	
Very unenjoyable	o	o	o	o	o	Very enjoyable

2. How well did the robot guide you through the yoga poses?

	1	2	3	4	5	
Not at all well	o	o	o	o	o	Extremely well

3. Did you find it easy to follow the robot's movements during the yoga session?

	1	2	3	4	5	
Not at all easy	o	o	o	o	o	Extremely easy

4. How satisfied were you with the robot's performance during the yoga session?

	1	2	3	4	5	
Very unsatisfied	o	o	o	o	o	Very satisfied

5. How challenging did you find the yoga poses with the robot?

	1	2	3	4	5	
Not at all challenging	o	o	o	o	o	Extremely challenging

6. How do you think you have reproduced the robot's poses?

	1	2	3	4	5	
Not at all well	o	o	o	o	o	Extremely well

7. Did you feel like the robot's movements were smooth and natural during the yoga session?

	1	2	3	4	5	
Not at all	o	o	o	o	o	Extremely well

8. How likely are you to use the robot for future yoga sessions?

	1	2	3	4	5	
Very unlikely	o	o	o	o	o	Very likely

9. How would you rate the robot's ability to enhance your yoga experience?

	1	2	3	4	5	
Not at all	o	o	o	o	o	Extremely

10. How much would you recommend this approach to yoga to a friend?

	1	2	3	4	5	
Not at all	o	o	o	o	o	Extremely

Fig. 7. The ten questions

TABLE IV
COMPARISON OF SCALE MEANS.

Scale	Data Set 1						Data Set 2					
	Mean	SD	N	Confidence	Confidence Interval		Mean	SD	N	Confidence	Confidence Interval	
Attractiveness	1.04	0.72	8	0.50	0.54	1.54	0.08	0.64	8	0.44	-0.36	0.52
Perspicuity	0.72	0.86	8	0.60	0.12	1.31	0.31	0.59	8	0.41	-0.10	0.72
Efficiency	0.67	0.50	8	0.35	0.32	1.02	-0.13	0.67	8	0.46	-0.59	0.34
Dependability	0.33	0.62	8	0.43	-0.09	0.76	-0.04	0.60	8	0.42	-0.46	0.38
Stimulation	0.00	0.50	8	0.35	-0.35	0.35	-0.21	0.83	8	0.58	-0.79	0.37
Novelty	0.44	0.86	8	0.60	-0.16	1.04	-0.94	1.43	8	0.99	-1.93	0.05