Robotic Coaches Delivering Group Mindfulness Practice at a Public Cafe

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ABSTRACT

Group meditation is known to keep people motivated and committed over longer periods of time, as compared to individual practice. Robotic coaching is a promising avenue for engaging people in group meditation and mindfulness exercises. However, the deployment of robotic coaches to deliver group mindfulness sessions in real-world settings is very scarce. We present the *first* steps in deploying a robotic mindfulness coach at a public cafe, where participants could join robot-led meditation sessions in a group setting. We conducted two studies with two robotic coaches: the toy-like Misty II robot for 4 weeks ($n = 4$), and the child-like QTrobot for 3 weeks ($n = 3$). This paper presents an exploratory qualitative analysis of the data collected via group discussions after the sessions, and researcher observations during the sessions. Additionally, we discuss the lessons learned and future work related to deploying a robotic coach in a real-world group setting.

CCS CONCEPTS

• **Human-centered computing** → *User studies*; **HCI design and evaluation methods**.

KEYWORDS

robotic coach, human-robot interaction, mental well-being, meditation, mindfulness, public space, group interaction

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1 INTRODUCTION

Mindfulness meditation involves paying attention, on purpose, to the present moment, non-judgmentally [13] and can be conducted individually or in a group. Mindfulness interventions have largely been shown to help improve general mental health [8, 19], reducing stress and anxiety symptoms and enhancing the quality of life and interpersonal relationships [12]. Usually, this practice consists of multiple sessions and, despite the acknowledged benefits of the mindfulness meditation, individuals can find it challenging to keep being motivated, committed, and engaged in the long term. Group mindfulness helps people to address those challenges, giving them a *space* and a *time* to meditate [23] and enabling mutual support to sustain motivation and commitment, and reduction of distraction to maintain concentration and engagement. In the last decade, the demand for mental health support has increased exponentially [1], and - given the lack of personnel and resources available in the healthcare sector - many tech companies responded by offering affordable and accessible mental health services for individuals, such as mindfulness meditation apps (e.g., HeadSpace, Calm) [20]. However, recent studies [18, 31] showed that a high dropout rate and lack of engagement with apps represent well-known barriers, and participants struggled to make time for using a meditation app [21]. On top of that, those apps do not enable people to experience group meditation by providing *dedicated space and time*.

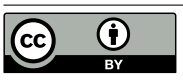
Robotic coaches have recently been explored to teach mindfulness meditation demonstrating their efficacy in engaging participants during long-term in-lab user studies [9, 33]. Such robots have been shown to be viewed positively longitudinally by participants in a five-week-study [9], and have been observed to have an influence on the meditators' brain activity in a way that indicates achieving a state of mindfulness [33]. Those studies suggest that robotic coaches are promising solutions for delivering group mindfulness sessions, keeping participants motivated, committed and engaged in a *dedicated space and time*. Nevertheless, research examining such robots in real-world settings is still scarce.

This paper presents the *first work* that deploys robotic coaches for group mindfulness. We conducted two empirical studies involving two groups of volunteers who interacted respectively with a Misty II robot for 4 weeks ($n = 4$), and a QTrobot for 3 weeks ($n = 3$) in group mindfulness sessions at a public cafeteria. We present a thematic analysis of qualitative data generated from post-session group discussions with participants. From this analysis, we extract the lessons learned as a contribution for future studies in this area, and highlight directions for future work. This work represents the first step towards understanding of how autonomous robotic coaches can be deployed in public spaces accessible to everyone to deliver group practice sessions and promote people's mental health.

2 RELATED WORK

Studies on robotic coaches for mental well-being have recently been increasing [7, 27, 29]. Few works have focused on mindfulness and meditation specifically: Bodala et al. [9] created a teleoperated robot coach for mindfulness and compared it with a human coach in a group setting, and Alimardani et al. [4], Yoon et al. [33] examined neurophysiological responses to robot-led meditation via EEG measurements. Previous work has examined how a robotic

[1] https://www.who.int/health-topics/mental-health



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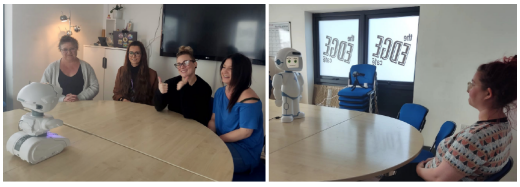

Figure 1: Set-up of the study for G1 (on the left) and G2 (on the right). The robot is on the table, and the participants sit facing it frontally. Two cameras were used to record the interaction from behind the robot, and behind the participants.

mental well-being coach, including a mindfulness coach, should be designed [5]. Matheus et al. [24] used a robot specifically designed to teach deep breathing techniques to people aiming to improve their wellness, and people aiming to reduce anxiety, at a local wellness center. However, previous work has not examined a robotic meditation coach for a group in a public space.

3 ROBOT DEPLOYMENT AT A PUBLIC CAFE

3.1 Participants

We recruited participants via posters at the cafe and online. We invited any adults interested in doing mindfulness practices with a robotic coach to join, without further criteria. People who signed up for the study were local to the area. Group 1 (G1, $N_{G1} = 4$, interaction with a Misty robot) had four women, aged 18-25 (1), 26-35 (1), 36-45 (1), and 56-65 (1). Group 2 (G2, $N_{G2} = 3$, interaction with a QTrobot) had two women and one man, aged 26-35 (1), 36-45 (1), and 56-65 (1). The two participant groups came to the Edge Cafe once a week, over four weeks, for a mindfulness session conducted by the robotic coach. G1 completed all four sessions, while G2 completed three sessions due to a COVID-19 cancellation on the scheduled fourth session. Participants P1, P2, P3 and P4 were in G1, and P5 P6 and P7 were in G2. The attendance of each session was as follows: **S1**: P1, P2, P3, P4 (G1) & P5, P6, P7 (G2); **S2**: P2, P3, P4 (G1) & P5, P7 (G2); **S3**: P2, P4 (G1) & P5, P6 (G2); **S4**: P2, P3, P4 (G1).

3.2 Robotic Systems

We used the Misty II robot by Misty robotics[2] and the QTrobot by LuxAI S.p.A.[3] as they have been used in previous HRI studies [26, 30]. The Misty II is a small toy-like robot and the QTrobot is a tabletop child-like robot. We collaborated with a well-being professional to pick the robots' voices and gestures (the same for both platforms). We used the synthesised AWS Polly's Amy voice, and Amazon Polly visemes to synchronise (lip-sync) the robot's mouth positions with the spoken voice. The robots' eyes were animated to look around the room. In addition, we designed movements for the robot's arms (e.g., lifting and waving the right arm to greet the participants in the beginning of the interaction). No other gestures were used as the noise from them could be potentially distracting for a mindfulness practice. The interaction flow was pre-scripted using the HARMONI framework [28].

[2]https://www.mistyrobotics.com/
[3]https://luxai.com/

3.3 The Mindfulness Exercises

The four mindfulness exercises (one exercise/session) were adapted from existing resources, and were reviewed by a mindfulness meditation instructor before the interactions. The four meditation sessions were: (1) *Short body scan, 10 mins* - Meditation introducing participants to meditative breathing and body awareness [14]; (2) *Mindfulness of Breathing, 13 mins* - Meditation developing awareness of breath and breathing mindfully (adapted from a recording of the professional mindfulness instructor we interviewed [32]); (3) *Long body scan, 25 mins* - Meditation on becoming aware of and relaxing different parts of the body [2]; (4) *Loving kindness, 30 mins* - Meditation on cultivating feelings of kindness toward a loved one, the meditator themselves, and all beings [1].

3.4 Experiment protocol

The study was conducted in a room dedicated to the study at the Edge Cafe, where either robot was placed on a table and participants were seated facing it (Fig. 1). Before the session, participants were greeted by one of the researchers when they arrived at the cafe for their group session. Once all participants had arrived, the researcher told the participants that the session would begin soon, and left the room. The robot then started the session by greeting and welcoming the participants. This is illustrated in the storyboard in Fig. 2. In the first session, the robot introduced itself, the concept of mindfulness, the importance of a good meditation posture and how to achieve such a posture, and the importance of breathing (3 mins). Then, the robot guided the participants to relax, assume a meditation position (which it described to them), close their eyes and started guiding them through the weekly practice. In the following sessions, the robot first greeted the participants, and then gave them brief reminders on the definition and the goals of the mindfulness practice, as well as meditation posture. At the start of each session, the robot informed the participants about the current session number, and how many sessions were left. Then, the robot started guiding participants through the corresponding meditation exercise verbally, following the scripts adapted from the literature and reviewed with a meditation coach. At the end of each session, the robot gently invited participants to return to the room and open their eyes. After this, the robot thanked the participants for joining the session, recapped what the session was about, and reminded them that mindfulness is a skill that is developed through practice. Then it informed the participants that the researcher would now enter the room to ask them some questions.

The researcher then conducted a semi-structured group discussion, with the following questions as a guideline: (1) How did interacting with the robot feel this week? (2) How did this week's exercise feel? (3) How was it in comparison with the previous session? (4) How appropriate do you think the robot was as a mindfulness coach? (5) How useful do you think the robot was as a mindfulness coach? (6) What did you like and not like about the robot and the practice?

3.5 Data Analysis

The aim of this analysis was to explore aspects of the robotic coach as a conductor of mindfulness practice in a public cafe. We collated the data from both groups into one analysis (instead of comparing

Figure 2: Interaction storyboard: 1 - introduction to mindfulness and today's session, 2 - the exercise, & 3 - ending the session.

the two) because we wanted to conduct a deeper analysis of participant experiences over time, rather than compare perceptions across robots. We find this analysis to be more informative for a study which emphasises the depth of qualitative data, rather than quantity of participants. We conducted an exploratory Thematic Analysis (TA) [10, 11] on the transcribed group discussions, as well as researcher observations noted down after the sessions. Our observations consisted of notes taken during and immediately after the discussions (e.g., what participants agreed and disagreed on), and during video viewings in the data analysis phase. TA consists of reviewing the data, creating codes based on initial observations, collating codes into overarching themes, reviewing those themes, defining the themes in relation to the story the whole dataset was conveying, and finally creating a report. We applied the reflexive TA process [10] and did not define a code book beforehand — instead we refined the codes and themes throughout the process. The researchers' prior experiences in developing and evaluating robotic coaches for well-being, as well as our personal prior experiences with well-being practices, has affected how data has been elicited, interpreted and analysed in this paper. We view this as a resource rather than a hindrance [16] since our familiarity with HRI concepts and research streams enabled us to identify and meaningfully connect what the participants were discussing (e.g., their experience of the robot enabling social discussions) to HRI concepts.

4 FINDINGS

This section reports our findings from participants' feedback and researchers' observations from both studies. We found three main themes in our analysis, which we discuss below.

The robotic coach had multiple functions while conducting group mindfulness practice - In general, participants noted that the exercises conducted by the robot were successful and that they worked for a group setting. In this setting, the robot was attributed multiple functions throughout the interactions, across both groups. The functions were not exclusive of each other, and are indicative of the multiple social contributions that a robot can make as a conductor of a group mindfulness session. *(1) Robot as a social entity*: Participants felt that the robot had a social presence, e.g. P2 felt they were "bad-mouthing" the robot when giving it critical feedback, and felt "the urge to say 'thank you' and 'bye' to the robot at the end of each session". P7 noted the same feeling, saying they "kept looking back over to the robot" during the group discussion, and "I wonder if that's part of the anthropomorphizing". P2 also noted that the robot was different from an app, in that there was "something present". *(2) Robot as a guiding voice*: P3 and P7 mentioned forgetting about the robot (and its visual elements) after closing their eyes for the meditation. In session 2, P2 and P4 felt that the robot could ideally be a guiding voice that "took them on a journey", especially with longer exercises. In the final session, P4 said: "it's definitely improved over time. A longer time works better for it. [...] You are in that meditative state and I think we get used to the lully voice there and then you just [get into it]". P2 noted that it was good that the robot "kept asking to refocus" on the meditation, and P5 noted it was good that "it spoke about you wandering off and bringing you back" — i.e., the robot brought the group members back to the *space and time* of the mindfulness session. This emphasis on the robot's voice during meditation exercises places importance on the future design of less syntax and pacing-error prone robotic voices. Participants, particularly in G1, found the robot's voice to be of central importance, returning to it in each discussion after the mindfulness sessions. P4 found the syntax and pacing of the robot's voice "awkward". However, P4 noted also getting used to this aspect of the robot over the sessions. Other participants found the robot's voice "soothing" (P2) and "calming" (P1). *(3) Robot as a focal point*: In session 3, P4 noted that the robot was "a focal point" for the exercises. P2 said that having it as "something that's physical" would work in a residential / workplace context: "if there's a mindfulness place and that [robot] is there delivering this hour meditation [...] [it would be] quite useful". P6 thought the robot could help those who are anxious about being in a group or around other people: "it immediately allows you to, if you want, connect with people and have a conversation". As a focal point, the robot could facilitate the gathering of the group for mindfulness practice.

Over time, participants experienced the robot-led mindfulness practice to be more helpful - In sessions that occurred after the initial introductory session, P5, P7, P4 and P1 all mentioned feeling calm or relaxed during or after the exercise. P5 and P7 noted in session 2 having looked forward to the exercise: "I felt like I needed one on the way in, [...] I was looking forward to it" (P7). In the third session, P2 mentioned that as the sessions progressed, they were becoming more "present" and they were connecting more with the practice. After having these experiences, the participants envisioned the robot as being potentially useful in several group environments: at a busy workplace (such as the council) (P4), or a residential setting or day centre for elderly people (P2, P4). In general, the robot would have to be easily accessible in both these settings, and could be "something people could actively look forward to doing" (P4). It was also described as being useful for specific groups of people: "lonely people [...] who could have it in their house and chat with it" (P1), and "if you were trying to teach kids some mindfulness, that would be really attractive" (P6), for people who are new to meditation (P3), and for people who "have trouble relating to other people" (P7) or were "anxious about being in a group" (P6). These improved experienced may be explained by

participants getting used to the mindfulness practice and the robot delivering it. In session 2 of G1, P4 noted they "got more beneficial results [once I got] my head around the syntax [of the speech]", and P2 said "last time I was thinking about what the robot will look like [...] [this time] I kind of already knew what the situation [would be]". G1 discussed the same feelings in session 3 and 4, especially describing "accepting what it's going to be, so it's not so strange" (P4). G2 also discussed this feeling, with P7 remarking (session 2): "I feel like it was better in that I kind of knew what to expect more".

The practice environment and the robot's behaviour did not match participants' expectations - Behaviour and environment are both design dimensions of a social robot [5]. In this study, we did not modify the cafe environment, in order to explore how a robot could function in such a community space without disruption. However, participants wished for the environment to be modified to better match their expectations of a meditative environment. Participants wanted "soothing background sounds" such as the waves of the sea (P1), or jungle / quiet white noise (P4), noting the noise from the environment to be distracting (P1, P2, P4, P5, P7). P4 noted that designing the entire room to be "zen", e.g., with "waterfall features" would be useful to "go in there and know what you are doing". In terms of behaviour, participants expected the robot to be more interactive and responsive in order to be a mindfulness coach. While conducting mindfulness exercises does not necessarily require these behaviours, they could help participants feel received into the meditative space and settle into the practice. They imagined an interaction happening before the meditation session, where the robot could greet them, and ask for and use their names (P4, P5). Interestingly, participants' perceptions of the robot's current behaviours diverged between the groups. In G1, P2 and P3 wanted the robot to look at people when they were talking, and react to those people. P2 noted that they did not think the "robot cared about how you're feeling" because there were no interactive elements, and that there was "disconnection". In contrast, in G2, P6 noted the robot "looking at them" with acknowledgement. P7 perceived the robot to be tracking the group with its eye movements, which P6 agreed with. P7 noted that this tracking worked quite well, but it should be better integrated with the robot's speech.

5 LESSONS LEARNED & FUTURE WORK

This paper presents the *first work* to deploy robotic coaches to deliver mindfulness exercises to groups in a public space. From our analysis, we found that participants perceived the robotic mindfulness coach to: (i) have multiple functions while delivering the practices, (ii) be more helpful over time (due to getting used to the robot and its exercises), and (iii) show behaviors and be in an environment that did not match their expectations.

Our observations show that robots have been perceived as a social entity, a guiding voice, and/or a focal point. As a guiding voice, it was fulfilling its designed function of a mindfulness instructor. As a social entity and focal point, the robot was contributing to the group dynamics by providing an experience that a mindfulness exercise recording alone would not.

Lesson Learned and Future Work 1: Robot's perceived functions can be crucial in facilitating a group mindfulness practice. Literature suggests that robots influence group dynamics when they are active participants in that group [25], and they can be perceived differently by the group individuals, as our findings suggest. Future research should investigate how such perceived real-world functions can be further emphasized (e.g., giving the robot more capabilities to act as a *guiding voice*, to put their strengths to work in group interactions).

In our studies of multiple sessions (4 and 3, respectively), participants got used to the robot as a mindfulness coach after the second session and were more open to embracing the moment.

Lesson Learned and Future Work 2: Long-term investigation is important for gaining insight about robotic coaches' usefulness and adoption. Most past HRI studies focusing on social robotics for healthcare are limited to single-session interactions due to e.g., participants dropping out or participants' lack of sustained engagement over time [22]. Future robotic coach works should continue to investigate the long-term effects of human-robot interactions to understand whether the perceived improvements in interactions persist, and how this can be sustained.

Our findings also show that participants did expect the robot to greet them by name and acknowledge them with gaze and gestures. While mindfulness meditation does not necessarily require acknowledgement or adaptation to specific participants (a fact also noted by the participants), participants had higher expectations in terms of robot's capabilities for acknowledgement and adaptation. Robotic coaches have been shown to be successful in promoting mental well-being for students [15], adults [9], and children [3], however understanding how to design and deploy autonomous robots to deliver well-being exercises is still an open challenge. Robotic coaches should understand human behaviours, including their verbal and non-verbal cues (e.g., facial expressions), and adapt to human behaviours by personalizing the interaction according to the person's needs [29], while preserving the content of the well-being exercise [6]. Such robot capabilities are desired by potential users and should be improved for future research. This may involve the implementation of voice recognition (understanding participant names), facial recognition (matching names to specific people), and long-term memory (recalling specific names across sessions). Also, participants of both groups placed great emphasis on the need for ambiance for meditation. This could further help participants with adjusting to the *space and time* needed for mindfulness practice.

Lesson Learned and Future Work 3: Improvements in robot capabilities and environment are needed to match participants' expectations of a robotic coach in a real-world setting. HRI works are mostly limited to lab settings [17] because many challenges are yet to be addressed for real-world deployment, including availability of public spaces for robot deployment, robotic hardware and enviromental challenges (e.g., stable wi-fi connection, battery life etc.). Future work should examine how a robot's perceived usefulness for well-being in the real world could be improved by reasonable modifications to the environment (e.g., lighting and soundscape), and capabilities (e.g., responsiveness and memory).

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