Productivity CoachBot: a Social Robot Coach for University Students with ADHD

Himanshi Lalwani
New York University
Abu Dhabi, UAE
hl3937@nyu.edu

Maha Elgarf
New York University
Abu Dhabi, UAE
mae9866@nyu.edu

Hanan Salam
New York University
Abu Dhabi, UAE
hs4461@nyu.edu

ABSTRACT

Attention-Deficit Hyperactivity Disorder (ADHD) has profound effects on the academic, social, mental, and psychological well-being of young adults. Despite the availability of therapies and medications, there is a lack of direct tools to assist the diagnosed individuals in overcoming their daily challenges. To address this gap, our research focuses on the development of software tools that are integrated into a social robot acting as a coaching companion to university students struggling with ADHD. These tools aim at assisting students with task management and completion and are organized into the following modules: Conversation, Schedule Generation, Voice Note Reminders, the Pomodoro Technique, and Engagement Detection. By integrating these modules, our coaching robot aims to provide tailored support to young adults with ADHD, helping them navigate daily activities and enhance their overall quality of life. We conducted a preliminary evaluation of our system with three college students, all of whom expressed challenges in time and task management, despite lacking an official ADHD diagnosis. The results emphasised the robot's effectiveness in assisting students with these challenges, thereby highlighting the system's potential for future usability and effectiveness in addressing the needs of individuals with ADHD who encounter similar difficulties.

CCS CONCEPTS

• **Human-centered computing → User studies**; **Accessibility technologies**; • **Computing methodologies → Intelligent agents**.

KEYWORDS

socially-assistive robots, human-computer interaction, robot-assisted therapy, attention deficit hyperactivity disorder

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1 INTRODUCTION

Attention-Deficit Hyperactivity Disorder (ADHD) is a chronic mental disorder that can have a profound impact on individuals affected by it. It is characterized by functionally harmful levels of inattention, hyperactivity, and impulsivity, which can have detrimental effects on daily functioning [6]. While ADHD is commonly observed in children, longitudinal studies have consistently shown that a substantial portion of individuals diagnosed with ADHD in childhood continues to experience symptoms into their adolescence and adulthood [1, 15].

A study conducted by DuPaul et al. revealed a concerning trend: approximately 25% of college students receiving disabilities services have been diagnosed with ADHD [4]. These young individuals with ADHD face numerous challenges in academic, psychological, social, and mental domains. They often experience higher levels of depression and anxiety, struggle to build meaningful relationships with their peers, and achieve lower academic performance [19]. Additionally, they grapple with issues related to self-esteem, social functioning, and sleep disturbances, all of which can significantly impact their day-to-day functioning [8]. To summarize the various difficulties faced by young adults with ADHD, a study conducted in Korea aptly categorizes them into four main areas: lack of a consistent daily routine, unsatisfactory academic performance and achievement, difficulties in establishing interpersonal relationships, and a tendency to experience constant worrying [11].

Socially Assistive Robotics (SARs) is a rapidly expanding field of robotics that focuses on improving the quality of lives of individuals by providing them with therapeutic support and assistance in daily activities. While SARs' research has found application in clinical settings to aid individuals with behavioural disorders, there is a notable emphasis on Autism Spectrum Disorder (ASD) in the existing literature. However, research pertaining to ADHD remains limited, particularly in the context of individuals beyond childhood. Consequently, although treatment options such as therapy and medication exist to address ADHD, there remains a notable lack of tools designed to directly assist individuals with the challenges previously discussed.

Our research minimizes this gap by utilizing LuxAI's QTrobot and enhancing its capabilities through tailored software tools for the unique needs of young adults. In this context, young adults are defined as individuals aged 18 to 24 who are college students and have been diagnosed with ADHD. By interacting with the QTrobot, the aforementioned tools enable the students to access daily schedules based on their listed tasks, receive timely reminders, initiate focused sessions to complete tasks punctually, and even engage in conversation with the robot in case they encounter difficulties.

Through the interaction with the robot, our study aims at offering targeted assistance, promoting personal growth and enhancing the overall quality of life for young adults struggling with ADHD. In summary, the contribution of our paper can be summarized as follows:

- We introduce customized software tools integrated into LuxAI's QTrobot, offering a targeted solution to directly support young adults with ADHD. The software tools entail five modules: Conversation, Schedule Generation, Voice Note Reminders, the Pomodoro Technique, and Engagement Detection; specifically designed to address the time and task management needs of young adults diagnosed with ADHD.
- We report on our preliminary evaluation of these tools with three participants, presenting promising results regarding the future usability of the system.

2 RELATED WORK

2.1 SARs for Neurodevelopmental Disorders

SARs are being extensively researched to investigate their effectiveness in supporting individuals with neurodevelopmental and mental disorders. For instance, Kip3, a small social robot developed by Zuckerman et al., was designed to provide immediate feedback for inattention or impulsivity events in students with ADHD. It worked by displaying pre-programmed gestures triggered by participants' errors in a Continuous Performance Test (CPT) test, which is a common assessment tool for ADHD. The majority of participants found Kip3 helpful in regaining focus, attributing its effectiveness to the real-time feedback provided. However, concerns were raised about its efficacy in more complex real-life situations beyond the controlled laboratory environment [21].

In a different study, Tleubayev et al. investigated the impact of robot-assisted therapy on non-verbal children with ASD and ADHD. The children interacted with the NAO robot through applications such as "Follow Me," "Touch Me," and "Dance with Me." The study concluded that even a few sessions with the robot appeared to be effective in improving social traits and concentration in children with ASD and ADHD [17]. Rakhymbayeva et al. conducted a similar study but with a longer duration. They recorded videos of therapy sessions to analyze and measure children's engagement, valence, and eye gaze duration over time. The study found that robots can be valuable in sustaining engagement, especially when the activities performed with the robot are tailored to each child's preferences and interests [13].

In another study, Bhat et al. developed a prototype of a home device called PlantBot, a plant-shaped SAR equipped with an Amazon Echo voice agent. PlantBot aims to assist young adults dealing with anxiety and depression by reminding them of their behavioural activation therapy-related tasks [2].

MARCo Health Inc., a New Jersey based company, developed MARCo, a low-cost robot that serves as a mental healthcare companion. MARCo aims to help improve patients' moods, reduce stress, and approach anxiety by acting as a peer to listen to and comfort the patient [10].

In summary, while there are SARs available to support children with ADHD and SARs with a subset of features targeting the needs of individuals with ADHD, there is currently no comprehensive solution readily available for young adults dealing with ADHD. Our study fills this gap by developing integrated software tools within the QTrobot. These tools aid college students grappling with ADHD in efficiently managing their time and tasks.

2.2 Prompt Engineering Techniques

Prompt engineering is a powerful tool for honing interactions between Large Language Models (LLMs) and users. Prompting an LLM to adopt a persona makes it assume a particular viewpoint; aiding in the selection of the types of output to generate and the details to emphasize on [20]. Furthermore, temperature and token control adjustments are found to greatly optimize the model's output [5]. Some studies suggest utilizing explicit constraints such as format and length to ensure responses maintain consistency throughout different iterations of a conversation [5, 18]. Lastly, providing step-by-step instructions to the model makes it easier for it to follow them and provide consistent responses [12]. Overall, the positive impacts of prompt engineering compelled us to incorporate it within our system to make the interactions more effective and relevant.

For our purposes, we implemented prompt engineering on the gpt-3.5-turbo model. This model was tasked with assuming the identity of a social robot coach designed to aid young adults diagnosed with ADHD. Our approach involved providing the model with detailed instructions on how to create personalized schedules for students, include regular breaks in the schedule, and generate timely reminders. The use of these prompting techniques played a crucial role in tailoring the model's responses to meet the unique requirements of individuals with ADHD.

3 METHODOLOGY

3.1 Scenario

In our scenario, the robot assists the student in managing and completing their tasks. The robot generates a schedule by taking into account the student's deadlines and priorities. Subsequently, it vocally reminds the student of the day's tasks. When a student decides to enter a focused work session, indicating their commitment to complete their personal tasks on their desktop and to remain within their workspace, the robot activates a Pomodoro timer to structure their work time effectively. The Pomodoro timer is a technique that structures work time into short intervals, traditionally 25 minutes in length, followed by brief breaks, aiming to enhance productivity. Throughout the session, the student can interact with the robot for assistance if needed. Additionally, engagement detection mechanisms are employed during the focused sessions to gauge the student's involvement levels. If disengagement is detected, interventions are initiated to redirect the student's focus back to their tasks.

3.2 Interview with a Counselor

After finalizing the scenario, an interview was conducted with a wellness counselor and clinical psychologist who works with college students at the local institution to ensure the viability of our designed scenario. Some of the major takeaways from the interview included recognising the differences between prior and first-time

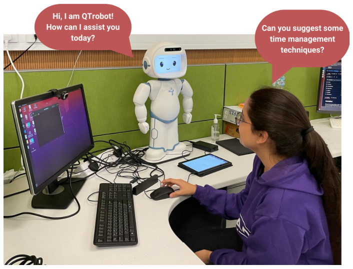

Figure 1: Sample interaction between a student and the robot.

diagnoses, emphasizing the need for stimulation to combat procrastination, preventing the robot from being a nagging presence, and distinguishing between concentration and anxiety. Overall, the counselor affirmed that our focus on addressing the challenges faced by college students with ADHD in our scenario was accurate and aligned with the intended objectives.

3.3 System Architecture

Based on our scenario, our system consists of the following modules: Conversation, Schedule Generation, Voice Note Reminders, the Pomodoro Technique, and Engagement Detection. Each of these modules has been described in detail below.

3.3.1 Conversation Module. This module enhances QTrobot's functionality by integrating a voice-based interaction system using the Google Speech-To-Text API and OpenAI's ChatGPT API, enabling students to engage in conversations with the robot on any subject of their choice, ranging from academic challenges to mindfulness practices and more, as can be seen in figure 1. Through the Google Speech-To-Text service, students can communicate with the robot via speech input. Meanwhile, ChatGPT can generate natural language responses to the student's input, enabling multi-turn conversations. The model's prompt guides QTrobot to fulfill the role of a social assistant tailored for students with ADHD, ensuring that conversations remain relevant and supportive. Additionally, the system performs emotion analysis during both user input interpretation and response generation to enable the robot to respond with appropriate gestures and emotions, aligning with the emotional context of the conversation. Overall, this module transforms QTrobot into a dynamic social assistant, elevating the quality of interactions through meaningful conversations with the user.

3.3.2 Schedule Generation Module. Implemented in Python, the schedule generation module eases cognitive load for students with ADHD by providing an efficient task schedule. Users input their tasks, deadlines, and priorities as text input to the robot as shown in figure 2. The input is then relayed to ChatGPT to initiate the schedule generation process. The model generates a feasible schedule utilizing prompt engineering techniques. The robot then communicates the schedule to the user, offering encouraging comments. The schedule, saved as a Python array, is stored locally for use by the Voice Note Reminder Module to generate task reminders. Overall, this module helps alleviate the stress and anxiety associated with task management. By offering comprehensive schedules, the

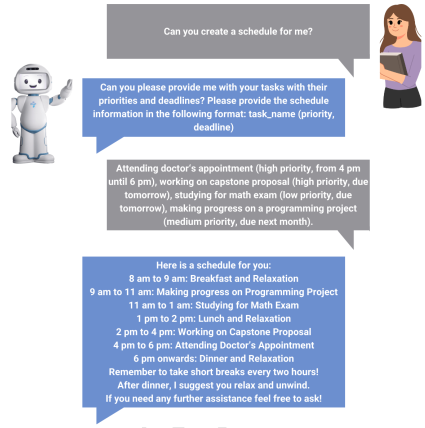

Figure 2: Sample input for schedule generation and the generated schedule.

robot serves as a valuable tool in supporting students to effectively navigate their academic responsibilities.

3.3.3 Voice Note Reminders Module. The voice note reminder module delivers timely spoken reminders, aiding students in combating procrastination and staying organized with their tasks. Implemented in Python, it first reads the nested array of task names and their start times from the text file created during the schedule generation process. Subsequently, it monitors the start times and prompts the robot to provide a clear reminder ten minutes before each scheduled task. Additionally, it can adapt to schedule changes as per user's request, ensuring updated reminders. This module complements QTrobot's role as a conversational companion, enabling students to fully engage without distraction or anxiety about forgotten tasks.

3.3.4 The Pomodoro Technique. The QTrobot's functionality is further enhanced with a Pomodoro timer, crucial for addressing time management challenges among students with ADHD. Implemented in Python, our timer features 25-minute work intervals followed by 5-minute breaks, repeating for 2 cycles before a longer 15-minute break. The session is initiated upon the student's request for a focused session. Throughout the session, the robot actively supports the student by providing timely notifications of upcoming intervals, ensuring effective task management and promoting necessary periods of rest. The timer's visual representation is displayed on QTrobot's emotion interface, aiding users in monitoring intervals. Overall, this module combines time management techniques with QTrobot's interactive capabilities to encourage focus and productivity.

3.3.5 Engagement Detection Module. Individuals diagnosed with ADHD often face attention-related challenges. To address this, our platform integrates an engagement monitoring feature that operates in sync with the Pomodoro module. This feature assesses engagement during 25-minute work cycles using a dual-model approach, incorporating machine learning and rule-based techniques.

The machine learning model, named Engagement Detection with Multi-Task Training (ED-MTT), is a pre-existing tool designed for detecting engagement levels in e-learning environments [3]. Chosen for its readily available source code, ED-MTT analyses eye gaze, head pose, and action units, assigning an engagement score from 0 to 1, where 0 indicates no engagement and 1 indicates full engagement. Despite its promising design, performance testing for our specific use case revealed sub-optimal results, possibly due to the model's training and testing on longer videos compared to our 10-second video requirement for near real-time engagement detection. To address this, we introduced a rule-based model as a strategic complement to the machine-learning approach.

The rule-based approach processes input video frame by frame, analyzing eye gaze and head movements to assess engagement. The relationship between these two features and engagement is well-established and frequently utilized in existing works for detecting engagement levels [7, 9, 14, 16]. Drawing inspiration from these studies, our model solves the Perspective-n-Point problem in OpenCV to estimate the rotation vector and calculates the average eye-aspect ratio, a metric reflecting the ratio of eye width to eye height, for identifying disengagement indicators. This integrated approach enhances the accuracy of assessing user engagement.

Both models operate on a 20-second interval, with 10 seconds for video capture and an additional 10 seconds for processing. The machine learning model considers an engagement score above 0.3 as the threshold for engagement. Despite limitations, this threshold was identified through internal qualitative testing as the most effective point for distinguishing engaged from disengaged states. Conversely, the rule-based model flags disengagement if the subject exhibits more than 10 eye blinks or fails to maintain direct eye contact for over 75% of the recording. The latter criterion is calculated by dividing the number of frames with a straight face by the total number of frames in the video. These criteria were also established through internal testing.

To initiate interventions for re-engaging the user, consensus from both models indicating disengagement is relied upon. Alternatively, if the rule-based model independently signals disengagement, it is considered sufficient for prompting timely interventions due to its relatively high accuracy.

Upon determining that the individual is disengaged during the focus session, the system notifies the conversation module, prompting the robot to initiate a dialogue with the person. The robot, during this interaction, offers support and suggests quick activities, such as breathing exercises or meditation, aiming to swiftly re-engage the person in their work. A sample response generated by the robot in response to user disengagement during internal testing is as follows: "Hey there! I noticed you seem a bit disengaged from your task. Don't worry, it happens to the best of us. Take a deep breath and remember why this task is important to you. If you need any help or guidance, don't hesitate to ask. You've got this! Let's refocus and make progress together."

4 EVALUATION

To evaluate our proposed system, we conducted a preliminary evaluation with three students from the local institution. The testing took place at the university premises within an empty room. An experimenter was present to assist participants with any inquiries. The setup involved placing a desktop in front of the participants, with the robot positioned adjacent to the desktop and diagonally across from the participant. Upon the participant's arrival, the experimenter greeted them and provided a briefing on the interaction, introducing the scenario and explaining the functionalities of the robot. Subsequently, the participant engaged with the robot without interference from the experimenter, unless assistance was requested. The duration of the interaction ranged from 25 to 30 minutes. Following the interaction, participants completed a short questionnaire regarding their experience with the robot. Finally, the experimenter thanked the participants and concluded the encounter.

Our findings revealed that the participants, aged between 21 and 22 at the time of testing, struggled with organizing their tasks and managing their time effectively, even though they did not have an official ADHD diagnosis. All three participants strongly agreed that the robot accurately captured their priorities and deadlines during schedule generation, and they found the voice note reminders beneficial in staying on track with tasks. Additionally, the Pomodoro sessions were deemed useful, and the robot's ability to accurately gauge engagement levels was appreciated. However, one participant agreed with the statement regarding the robot's generation of a realistic and manageable schedule, without expressing strong agreement as the others did. Despite this, the majority of participants expressed satisfaction with their overall experience using the robot and indicated a willingness to recommend it to others. Suggestions for improvement included implementing weekly schedules instead of daily ones, incorporating blocking certain websites to prevent distractions during focused sessions, and enhancing the clarity and user-friendliness of the schedule generation input interface. These insights provide valuable feedback for refining and optimizing the system for better user experience.

5 LIMITATIONS AND FUTURE WORK

Our work equips students with ADHD with a practical and innovative tool to support their academic needs. Taking on the role of a productivity coach bot, the robot engages in conversations, generates daily schedules, sends task reminders, and monitors pomodoro sessions. Preliminary evaluation of our system showcases promising performance. However, our system faces a notable limitation where LuxAI's speech parameters hinder the schedule generation module from receiving a to-do list via voice input by causing timeouts with extended pauses. To address this, we are exploring alternative voice recognition techniques compatible with QTrobot's conversational capabilities. Additionally, in the future, we intend to fine-tune ChatGPT's conversational skills and integrate advanced models like GPT-4. Moreover, recognizing the common struggle among students with ADHD in prioritizing tasks, we aim to incorporate task prioritization strategies and collaborative schedule generation. Lastly, for timing constraints, we only managed to conduct a preliminary evaluation of the system with 3 students that were not officially diagnosed with ADHD. Therefore, in the future, we plan to enhance evaluation methods by conducting further usability testing, especially with students diagnosed with ADHD and conducting long-term studies to guide our ongoing efforts to refine the system.

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