Robot-Facilitated Trivia for Elder Care: A Pilot Study on Reward Mechanisms and Difficulty Levels on Engagement and Self-efficacy

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Abstract— Social robots have been considered as tools to support cognitive engagement among older adults. For such interventions to be effective and sustainable, motivation and re-engagement are essential. This study investigated how different task conditions, specifically reward and difficulty levels, impact the motivation, engagement, and perceptions of older adult participants in a robot-hosted trivia game. Participants completed trivia under varying conditions, including point-based rewards (vs. no reward), task difficulty (easy vs. hard), and positive or negative feedback depending on their performance. Results showed that reward affected response time but had a limited effect on accuracy, with most participants reporting a higher feeling of satisfaction in easy difficulty conditions.

I. INTRODUCTION

As the growth rate of older adults continues to surpass that of the working-age population, the World Health Organization projects that the global population of people aged 60 and over will increase from 1.1 billion in 2023 to 1.4 billion by 2030 [6]. A rapidly growing older population will continue to apply further pressure on an already shrinking workforce as the demand for caregivers in senior care facilities increases, a 2022 survey conducted by the Agency for Healthcare Administration

Fig. 1. Older adult participant interacting with the SAMI robot

(AHCA) found that out of the 759 surveyed assisted living facilities 63% of them faced "moderate or high staffing shortages" and 87% of them were struggling with hiring new staff [2]. This, in turn, has an immediate effect on the care that residents receive, with the Health Care Financing Administration (HCFA) reporting a direct relationship between the amount of staff and the quality of care that residents receive [1]. Some crucial areas of residential care are physical and cognitive needs, which can be met through recreational activities. Past work has indicated that greater participation in activities could affect function, happiness, and influence a reduction in mortality [3]. The integration of robots within SNF settings, particularly when paired with meaningful activities, has been explored in previous work as a way to support residents cognitively, socially, and physically, especially in light of the growing strain on healthcare services, with older adults often experiencing declines in attention, working memory, and other crucial cognitive resources needed to make complex decisions [9].

However, there remains a gap between the types of robot-facilitated activities that have been studied and the underlying motivations that might encourage residents to engage in these activities more consistently and meaningfully over time. To address this gap, the present pilot study examines how two factors, reward and task difficulty can affect older adults' decision making and willingness to engage in a cognitively stimulating activity of trivia hosted via a custom social robot, SAMI, to gain a better understanding on how these variables might influence motivation and promote sustained engagement which in turn can support cognitive function within SNF contexts.

II. RELATED WORKS

Trivia as a cognitive exercise for older adults: Previous work has explored cognitive stimulation in older adults within senior living environments, using games and thought-based tasks as therapeutic and rehabilitative tools. Among these activities, trivia and games like Hangperson were found to sustain the highest levels of participant attention, encouraging critical thinking and lively discussion around the presented content [8].

Reward Impact on older adults: Previous research has studied the effect of reward on older adults and their working memory, where reward anticipation can act as a valuable motivational tool for older adults by enhancing their accuracy and the efficiency of processing relevant information, along with improving basic processing speed [5].

Robot-mediated trivia excercise: Tangy, a socially-assistive robot, was able to successfully facilitate a team-based cognitive activity, trivia, in a long-term care (LTC) setting. Participants exhibited high levels of engagement and compliance towards Tangy. Tangy fostered social connections amongst participants, made possible by the structure of two competing teams with a point system as a scoring mechanism. As well as high participant enjoyment and positive attitudes towards Tangy, with most participants strongly agreeing to wanting to play trivia with the robot again [4].

Fig. 2. Multiple choice (easy) version of trivia with reward present

III. METHODS

To study the effect of a present reward system, along with varying levels of difficulty, we employed a within-subjects in-person study. We gathered behavioral and self-reported information about the interaction.

A. *Robotic System*

Hardware: The SAMI robotic system is a socially assistive humanoid robot designed for long-term use within an SNF environment and for in situ social robotics research involving older adult populations. For this study we utilized an external speaker to provide auditory output, including positive and negative feedback, generated audio for question and answers and sound effects to support user engagement. In addition, an XPS 13 9310 2-in-1 was used as part of the interaction setup, the touchscreen modality supported the multiple choice (easy) conditions of trivia by allowing participants to answer by pressing or verbally announcing their answer choice as seen in Fig. 2.

Software: The software utilizes the python PyQt library to implement the trivia UI. Speech input transcription is handled using the Vosk vosk-model-en-us-daanzu-20200905 Model.

Each question initiates a listening thread which actively monitors for participants' spoken responses. Participants are given 20 seconds to answer each question. If no answer is given, whether it be verbal or manual, within this time frame a "cricket" sound effect is triggered to indicate inactivity. Following each response, SAMI provides verbal feedback. If the answer is correct, SAMI acknowledges this but if it is incorrect the correct answer is announced via audio output. The program tracks streaks of consecutive correct or incorrect answers, when the number of consecutive responses is an even number a corresponding action and audio cue is triggered and selected from an array of pre-made behaviors and audio, based on the nature of the streak. In the point based versions, a participants' current score is displayed and updated throughout the interaction. After each question, a "score screen" is displayed and announced to summarize progress.

B. *Study Design*

In order to obtain preliminary data we recruited 8 participants from the Corvallis, OR area. For this study, we asked participants to engage with 4 rounds of robot-hosted trivia, each consisting of 10 questions which ranged from topics such as geography to history. Participants were provided a countdown timer for each question, informing them of the amount of time left to respond.The robot informed them on whether their answer choice for a question was correct or incorrect. During each round, participants experienced robot behaviors which were positive in nature if they consecutively responded accurately or negatively otherwise. Each participant engaged with different orders of the 4 rounds, and these orders were pre-determined beforehand.

C. *Stimulus/ Reward Design*

The robot's audio and behavioral feedback was designed to correspond to the accuracy of the participants' responses, with the aim of reinforcing correct answers and addressing incorrect ones. Speech output was generated using Amazon Web Services (AWS) Polly with the "Matthew" voice.

1) *Positive Feedback:* When a participant provided a correct answer as part of a continuous sequence of correct responses, the robot delivered positive feedback through a combination of verbal and non-verbal behaviors such as nodding or clapping gestures. Including, "positive" sound effects after answering such as a ping.
2) *Negative Feedback:* For incorrect responses, the robot employed more neutral and corrective feedback. Verbal responses included phrases such as "Better luck next time!" along with a head shaking behavior. Including, "negative" sound effects after answering such as a sad trombone.

D. *Procedure*

Prior to the start of the study, participants were asked to sign a consent form and complete the General Attitudes Towards Robots Scale (GAToRS) assessment. Upon initiating each round of trivia, the robot introduced itself and provided an overview of the trivia task at which point we would start recording video of the participant as well as audio. Participants were instructed on how to interact with the system, either by responding verbally or by selecting answers using the laptop's touchscreen interface. Each participant completed 4 rounds, with each lasting around 10 minutes. After the introduction, participants were presented with 10 consecutive multiple-choice or open ended trivia questions. The robot would verbally notify participants at the conclusion of each round.

Following each round, participants were asked to answer and complete questions about their experience regarding each round through the

Self-Assessment Manikin (SAM). When closing the study, participants completed the Robotic Social Attributes Scale (RoSAS) assessment, a demographic questionnaire and a voice-recorded post-study interview to gather feedback on the experience and perceptions of the participants' feelings towards the task.

E. *Participants*

We planned to recruit 10 participants from the surrounding Corvallis, Oregon area. Eligibility criteria included being a native English speaker and aged 55 years and older. This sample size and target population were selected due to limitations in accessing participants at the Oregon Veteran's home as a result of an ongoing COVID-19 outbreak at the facility during the study period. A total of 8 participants were recruited. However, data from one participant was excluded from the final analysis due to incomplete qualitative responses.

F. *Measurements*

Quantitative: During each trivia round, our software automatically created and kept a log of each participant's performance with the following data points recorded: the submitted response, seconds taken to respond, and response accuracy.

Qualitative: To establish baseline perceptions and attitudes toward robotic agents, participants completed the GAToRS assessment. Between each round of trivia, participants completed the SAM to capture participants' emotional and motivational states throughout. Upon completion of the trivia activity, RoSAS was administered to assess perceptions of the robot's social attributes across dimensions such as warmth, competence, and discomfort.

G. *Hypothesis*

H1: Participants who receive point-based feedback during a trivia game will demonstrate higher response accuracy and longer response times compared to the conditions where they do not receive points.

H2: Participants will report higher levels of engagement and satisfaction after completing hard trivia tasks compared to easy ones.

H. *Analysis*

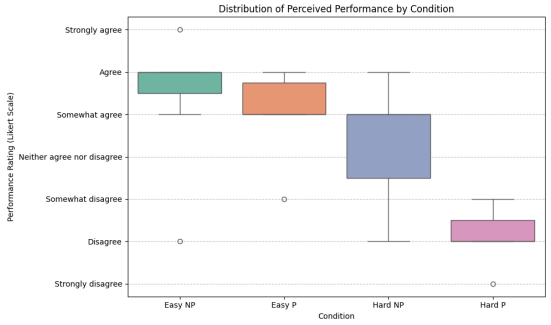

Fig. 3. Distribution of participant's responses on perceived performance by condition

To examine the effects that reward and task difficulty had on participants' performance and self-reported satisfaction amongst other factors, both one-way and two-way analyses of variance (ANOVAs) were conducted.

The effect of difficulty on engagement was not statistically significant , $F(1, 25.8) = 0.156$, $p = 0.696$, indicating that task difficulty did not influence how participants felt. In contrast, there was a significant effect of difficulty on satisfaction, $F(1, 23.2) = 12.86$, $p = 0.002$. Contrary to the original hypothesis, participants reported higher satisfaction in the easy condition than in the hard condition as seen on Fig.5.

Although the one-way ANOVA indicated that participants felt more satisfied in the easy condition, a two-way ANOVA revealed a significant interaction between reward and difficulty, $F(1, 24) = 5.62$, $p = 0.026$. This interaction might suggest that the effect of reward on satisfaction varied depending on task difficulty.

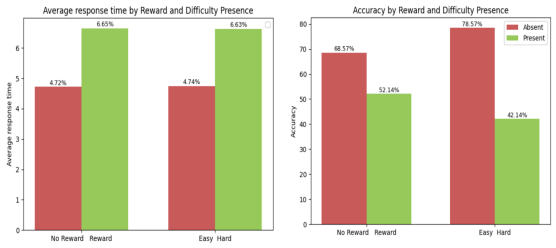

Fig. 4. Average response time and accuracy by reward and difficulty presence

The hypothesis that point-based feedback would lead to longer response times was supported, suggesting participants might have taken more time to respond when a reward was at stake. However, reward did not seem to increase the accuracy at which participants responded as seen on Fig. 4.

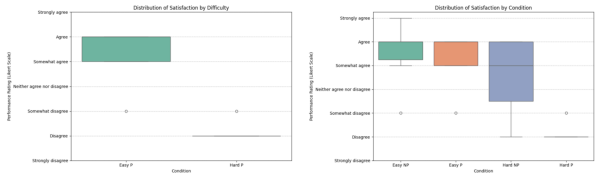

Fig. 5. Distribution of participant's responses on satisfaction by difficulty and condition

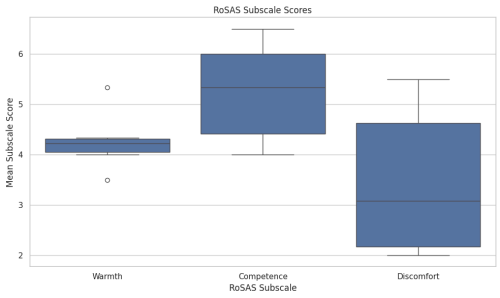

Fig. 5. RoSAS Subscale Scores for warmth, competence, and discomfort

Participants' ratings on the RoSAS scale were analyzed across the dimensions of warmth, competence, and discomfort. On average the robot was perceived as moderately warm,(M = 4.27, SD = 0.60), highly competent (M = 5.24, SD = 1.00), and moderately low in discomfort (M = 3.44, SD = 1.51).

Further work could explore how perceived competence or discomfort varies depending on the context, such as reward and difficulty level.

LIMITATIONS AND FURTHER WORK

While factors such as satisfaction were higher in easier tasks than in hard difficulty levels, several participants noted that reward "didn't really matter" and that it felt "arbitrary" at times. With only one participant viewing it as "motivating". Suggesting a need for a more dynamic and meaningful reward system. One possible limitation of the current study is that the point-based reward system only provided positive reinforcement without any negative consequences such as losing points for poor performance. It is possible that the absence of penalties reduced the motivational impact of the rewards, as participants faced no risk of losing progress or status. Further research could investigate whether incorporating both positive and negative consequences, such as a system where points can be lost as well as gained might influence motivation, engagement, and performance outcomes.

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