# Robots As Stress Relievers

Evaluating the impact of Socially Assistive Robots in reducing stress levels amongst college students

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***Abstract*—This paper evaluates the effectiveness of Socially Assistive Robots (SARs) in lowering stress levels among college students. With college life being exceedingly stressful, we require creative and effective techniques to address this issue. SARs have emerged as a viable tool for offering emotional and social assistance to those suffering from stress. Previous research has demonstrated that these robots work well to help stressed-out teenagers over a prolonged period of time. The present study, however, aims to examine the efficacy of using Socially Assistive Robots (SARs) to reduce stress levels in college students over a short time period. Additionally, the study seeks to investigate the potential benefits and limitations of this intervention strategy. Our study has shown that Socially Assistive Robots (SARs) are a viable method for reducing stress among college students, with effectiveness comparable to other stress-relieving activities like watching YouTube videos. Furthermore, interactions with SARs will enhance their cognitive performance and equip them with better-coping mechanisms to deal with stressors in the future.**

***Index Terms*—Mental Health, Stress reduction, Socially Assistive Robots, Emotional Support, Robot Therapy**

## I. Introduction

College students often experience high levels of stress, which can have negative effects on their mental health and overall well-being. Innovative and effective approaches are needed to address this issue and support students in managing their stress. Socially Assistive Robots (SARs) have been shown to help lower stress levels among college students. First off, SARs can offer students emotional support and company, which can lessen feelings of isolation and loneliness that might increase stress. Second, SARs can be designed to offer guided meditation and relaxation exercises, which can teach students how to successfully regulate their stress levels. Thirdly, because SARs are non-threatening and judgment-free, students may feel more comfortable talking about their stressors. This may help them gain perspective and improve their problem-solving abilities.

This study aims to evaluate the short-term effectiveness of Socially Assistive Robots (SARs) in lowering stress levels in college students while also examining the potential advantages and difficulties of this strategy. We want to investigate how SARs affect college students' mental health and identify the elements that make this intervention effective. Additionally, we want to assess how well SARs work in comparison to other stress-reduction methods like watching funny YouTube videos. The results of this study may have important implications for enhancing students' mental health and well-being. We can create more efficient interventions and support services to better fulfill the needs of those who experience stress by comprehending the potential advantages and difficulties of employing SARs to address stress.

We conducted a within-subjects two-day experiment with a sample of fifteen college students. On day one, participants watched a funny YouTube video as a destressing activity, while on day two, they interacted with Anki Vector, a SAR. To measure the impact of each activity on participants' stress levels, we recorded their beats per minute (BPM) throughout the experiment. Prior to the activities, we informed participants that they would be recorded while playing a time-bound multi-level simple arithmetic computer game, which was intended to induce stress. During the Vector interaction, we created an interface for participants to control the Vector and navigate it through a simple maze. To increase engagement, we also incorporated dialogues within the interaction.

Our hypothesis for this study is that Anki-Vector will be a more effective stress reduction intervention compared to watching a funny YouTube video. We also anticipate that participants will demonstrate a greater improvement in performance after interacting with Anki-Vector. Additionally, we administered questionnaires to the participants to gather their self-perceived stress and relaxation levels before and after the stress-inducing and destressing activities, respectively. We expect to observe a decrease in participants' self-reported stress levels after interacting with Anki-Vector compared to watching the YouTube video. Moreover, we predict that participants will report feeling more relaxed after the Anki-Vector interaction than after watching the video.

The remainder of this paper is structured as follows: Section II provides an overview of relevant literature in this field. Section III describes the study methodology in detail, including the procedures and instruments used in data collection. Section IV presents and analyzes the study results, including statistical data and graphical representations of the findings. Finally, Section V concludes the paper by summarizing the key takeaways from the study and offering suggestions for future research in this area.

## II. Related Work

### A. Mental Health and Stress

The transition of students from the high school level to the college level is inherently stressful for students. It could cause psychological, academic, and social shock to them. Students deal with stress during their time in higher education for a variety of reasons, including living away from their families, a demanding course load, and the inefficiencies of these programs. A study of college students reveals that between 10 and 20 percent of the student body is currently experiencing psychological issues (depression, anxiety, and stress) [1].

Prior literature has investigated approaches for mitigating stress. [2] conducted an extensive literature review on stress management and identified a wide range of techniques that are used for its management. [3] links emotion regulation to the ability to manage stress effectively. Physical activities like yoga and aerobic exercises [4] are one of the most prevalent methods used for regulating emotions which in turn helps in managing stress. Practicing mindfulness which involves meditation and deep breathing exercises is also recognized as an effective tool for managing stress. Technology-assisted activities such as apps for guided meditation have especially become popular. Additionally, Cognitive Behavioral Therapy (CBT) [5] is another powerful tool that helps people in managing stress. However, all of these techniques are very broad and need to be tailored for each individual to actually have an overall positive impact on an individual.

### B. Socially Assistive Robots

Previous works [7] have explored the use of robots as companions and have found that robots having a human-like behavior are seen positively by people. Some [8] [9] others have also looked into the acceptance of socially assistive agents for the care of elderly people. Certain studies have shown robot therapy has same effect on people as animal therapy. A study in which participants in elderly care houses were made to live with seal robots [10], showed improvements in stress of their vital organs. Infact, a lot of previous research has focused on SARs for healthcare treatment for the elderly.

In [11], a comprehensive review of the effectiveness of the inclusion of SARs for elderly care has been done. It looks at various publications that evaluate the effect on socio-psychological parameters like mood as well as physiological parameters like stress. While some other studies like [12] have focused on immediate psychological and neurophysiological effects of Robot Assisted Activity. Reviews like [13] also provide many examples of robot therapy for elderly patients. However, there aren't many studies that evaluate the impact of these robots on young adult population.

Some studies [14] review the use of socially interactive robots to assist in the therapy of children with autism. Some recent studies in a library setting [15] have also revealed the benefit of robot support animals to reduce stress and increase happiness of students experiencing acute stress. The study shows a significant decrease in acute stress, as well as a significant increase in happiness and relaxation for the participants. The study serves to be a promising foundation for using robots to help alleviate stress amongst university students.

## III. Methodology

We conduct an experiment aimed at assessing the efficacy of stress reduction through the use of a robot amongst college students. The experiment starts with an initial survey to determine the stress profile of the participants. Initially, we get a Perceived Stress Score (PSS) of the participants to gauge their stress levels in the past 2 weeks. Values closer to 5 imply a higher level of stress. As visible in figure 1, the participants who took part in our study generally scored high on the PSS scale.

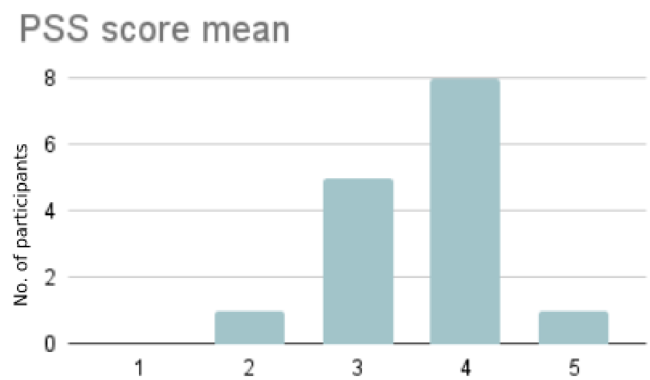


Fig. 1. PSS score of participants. 5 is more likely to be stressed.

Over a period of two separate days, the participants go through a series of exercises that modulate their stress levels. The stress levels are recorded at various stages of the experiment via self evaluation as well as heart-rate readings. The activities include stress inducing sessions as well as de-stressing sessions which involve interacting with a robot. Each participant goes through a total of 30 minutes of activities over the two day period.

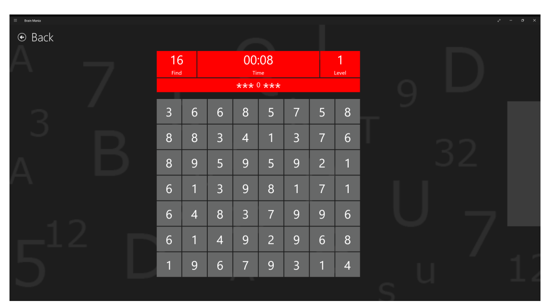


Fig. 2. Brain-mania (Game) interface

### A. Experimental Setup

*1) Stress Inducing Activity:* The participants go through a stress-inducing activity to induce artificial stress during the experiment. They are made to play an arithmetic game called Brain-mania for 2 minutes. Figure 2 shows the interface of the game. The top-left number is the target and the subjects have to choose the numbers from the grid that sum to the target. The goal for the participants is to score as much as possible in 2 minutes. During each game, more stress will be induced by letting three people watch them play and they will also be made to believe that they are being recorded by standing behind them with a camera. All of the participants were asked for their consent before recording and none of the participants are actually recorded.

*2) Stress Reducing Interactions:* We aim to understand how effective robot-interaction will be in reducing the stress compared to everyday stress reducing methods. We will be using following interactions for reducing the stress.

- **Youtube video:** We used a 5 minute youtube video as the representation for the everyday stress-relieving activity.

Fig. 3. Anki Vector robot

- **Anki-Vector Interaction:** We use an Anki-Vector (figure 3) as the robot to be used for the robot interaction in the study because it comes with an easy-to-use Python Software Development Kit (SDK). The Anki-Vector Python SDK also provides a remote-control interface which was modified for our study such that it can be used by the participants to play the maze game with Anki-Vector which is the activity for Anki-Vector interaction. The maze game layout can be seen in figure 4. The arrow in the top-left is the starting point and the circle marks the end of the maze. The cross in the maze marks the checkpoints and there are a total of three checkpoints in the maze. The participants guide the Anki-Vector through the maze and stop at each checkpoint along the way. At each checkpoint, they can stop and make Anki-Vector give out a clue by pressing a button on the interface. All the clues point to one object that participants have to guess upon reaching the end of the maze. Whether the participants are able to guess the object is irrelevant and this aspect was introduced to keep the participants engaged throughout the maze activity. We told the participants that the activity is not timed to remove any sort of pressure but participants were able to finish this activity within 5 minutes.

### B. Study Design

A two-day within-subject study was conducted with a group of 15 college students between the age of 21-25 years. All the participants were asked to first fill out the Perceived Stress Scale (PSS) questionnaire on Day 1. This was used to gauge their initial stress levels.

*1) Day 1:* For the first day, the participants had to follow the following procedure:

- Step 1: Play the stress-inducing game. (2 minutes)
- Step 2: Watch a bloopers video on YouTube for stress-reducing activity. (5 minutes)
- Step 3: Finally, they take part in the same stress-inducing game. (2 minutes)

*2) Day 2:* For the second day, the same participants followed the following procedure:

- Step 1: Play the stress-inducing game. (2 minutes)
- Step 2: Interact with Anki vector for reducing stressing. (5 minutes)
- Step 3: Finally, they take part in the same stress-inducing game. (2 minutes)

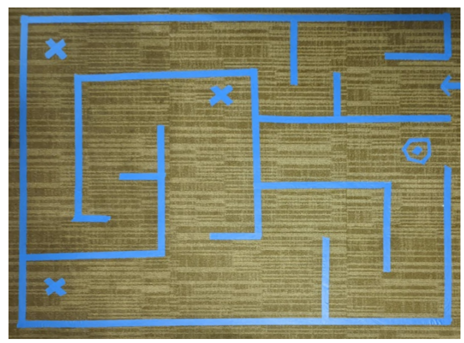

Fig. 4. Anki Vector Interaction Maze.

### C. Data Collection

We collected the following data during our study:

- **Beats Per Minute (BPM)**: An oximeter was used to take the BPM readings after each game and each stress-relieving activity on both days
- **Score**: The score of each participant for each game was recorded.
- **Questionnaires**: We used 3 types of questionnaires to estimate the subjective measures.
  - Post Game Assessment: Participants filled out this questionnaire after each game on both days. It consists of 5 questions each on a 5-point Likert scale. It is used to estimate the perceived stress after each game.
  - Post Activity Assessment: Participants filled out this questionnaire after the youtube activity on Day 1. It consists of 5 questions each on a 5-point Likert scale and is used to measure the perceived relaxation after the activity.

– Post Vector Assessment: Participants filled out this questionnaire after the interaction activity with Vector on Day 2. It consists of 5 questions each on a 5-point Likert scale and is used to measure the perceived relaxation after the activity.

### D. Evaluation Metrics

#### 1) Objective Measures:

**i. Percentage change in BPM:** The ratio of the difference in BPM (before and after the stress relieving activity) to the original BPM, expressed as a percentage.

**ii. Percentage change in score:** The ratio of the difference in scores (before and after the stress-relieving activity) to the original score, expressed as a percentage.

#### 2) Subjective Measures:

**i. Perceived stress reduction:** The decrease in perceived stress after the stress-inducing activities reported by the participants on a 5-point Likert scale.

**ii. Perceived relaxation:** The reduction in stress after the de-stressing activity reported by the participants on a 5-point Likert scale.

### E. Hypothesis

- **H1**: Interactions with Anki-Vector will show a greater percentage decrease in BPM in participants as opposed to watching the video.
- **H2**: Interactions with Anki-Vector will show a greater percentage increase in scores in participants as opposed to watching the video.
- **H3**: Interactions with Anki-Vector will make the participant report higher perceived stress reduction as opposed to watching the video.
- **H4**: Interactions with Anki-Vector will make the participant more relaxed as opposed to watching the video.

## IV. Results

### A. Analysis

We conduct the two-day experiment and obtain values for BPM and the points the participants scored in the game. Along with this we also use the perceived stress reduction and perceived relaxation to evaluate the effectiveness of the robot interaction as compared to the baseline.

We run a normalization test to determine if the continuous dependent variables of % bpm reduction and % change in-game scores are normally distributed or not. As per the preliminary test results, we fail to reject the hypothesis that the data is normally distributed.

Since we have performed a within-subjects study, assuming our data to be normally distributed, we perform a paired t-test on these variables to determine the statistical significance of our results for the vector interaction compared to the baseline video. The p-values (Table I) for those are as follows:

Since we are not sure of the normal distribution of our data, we also perform a Wilcoxon signed rank test on our data to determine the statistical significance of our results. The p-values (Table II) for these are as follows.

| variables | % bpm change | % score change |
|---|---|---|
| p-value | 0.7762 | 0.6041 |

TABLE I
STATISTICAL SIGNIFICANCE AS PER PAIRED T-TEST FOR % BPM CHANGE AND % SCORE CHANGE

| variables | % bpm change | % score change |
|---|---|---|
| p-value | 0.6516 | 0.4775 |

TABLE II
STATISTICAL SIGNIFICANCE AS PER WILCOXON SIGNED RANK TEST FOR % BPM CHANGE AND % SCORE CHANGE

For our Likert-scale questionnaire results for perceived relaxation, since the data we obtained is ordinal data, we transform the data into two dichotomous variables by dividing the values at the mean point of all the relaxation scores for each of the questions for each of the participants. The following (Table III) table gives an overview of the number of questions that received a score above the mean (am) and below the mean (bm).

| variables | score bm | score am |
|---|---|---|
| robot bm | 14 | 13 |
| robot am | 17 | 31 |

TABLE III
DISTRIBUTION OF PERCEIVED RELAXATION SCORES ABOVE AND BELOW MEAN

We perform a McNemar's test on this data to get the following (Table IV) values for the statistical significance of the data.

| | |
|---|---|
| $X^2$ | 0.3000 |
| p-value lt | 0.6269 |
| p-value rt | 0.5839 |

TABLE IV
STATISTICAL SIGNIFICANCE AS PER MCNEMAR'S TEST FOR PERCEIVED RELAXATION SCORES

For the perceived stress reduction scores, we initially take mean of each participant's scores across all the questions. This is done because we need to compare the reduction in means. We repeat the above process with the deltas of means and obtain a distribution of dichotomous variables. We obtain the following distribution. (Table V)

We perform a McNemar's test on this data to get the following (Table VI) values for statistical significance of the data. But this time, we use the formula for binomial distribution to get the $X^2$ value, since our data points are less in number.

### B. Results & Discussion

Based on the results of the statistical significance test for all % change in scores, % change in BPM, perceived stress score reduction, perceived stress relaxation score, our results do not provide statistically significant evidence to support our hypotheses. We failed to reject the null hypothesis, which suggests that our hypotheses is not supported by the data.

| variables | score bm | score am |
|---|---|---|
| robot bm | 4 | 2 |
| robot am | 1 | 8 |

TABLE V
DISTRIBUTION OF PERCEIVED STRESS DELTAS ABOVE AND BELOW MEAN

| | |
|---|---|
| $X^2$ | 0.3482 |
| p-value lt | 0.5680 |
| p-value rt | 0.5551 |

TABLE VI
STATISTICAL SIGNIFICANCE AS PER MCNEMAR'S TEST FOR PERCEIVED STRESS REDUCTION

However, we can draw several useful insights from the results we obtained. Firstly, we do see certain greater increase in the participant's scores, when the participant's interacted with the robot (Fig. 5). This shows that interacting with the robot is more likely to help the participant's be less stressed as compared to the baseline video.

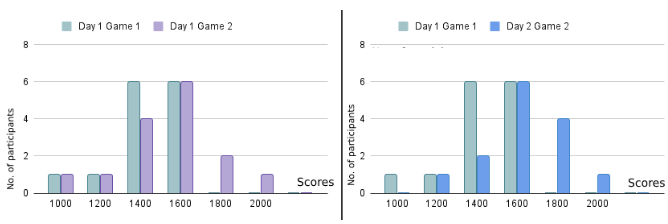


Fig. 5. Scores of games played by the participants

For the % reduction in BPM values (Fig. 6), we do not see any major differences in mean, when comparing the baseline video to the robot interaction. This could possibly be attributed to the fact that watching a video is more of a passive activity as compared to actively interacting with the robot.

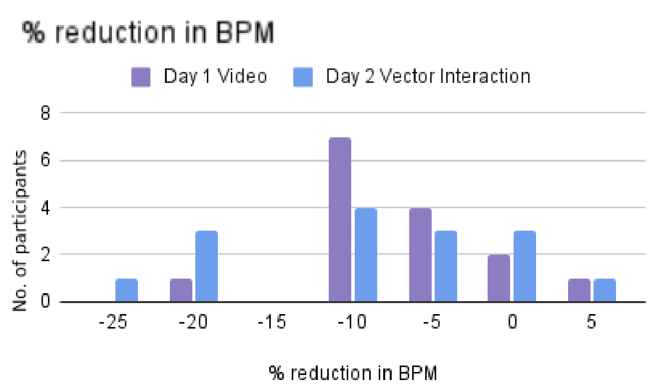


Fig. 6. Percentage change in BPM after vector interaction / youtube video

However, we do observe the self reported relaxation scores (Fig. 7) of the participant's to be higher for the vector interaction when compared to the baseline video. This could indicate that interacting with the robot makes the participant's more relaxed. A similar trend is also seen with the perceived stress score reduction (Fig. 8), where interacting with vector seemed to make the participants feel they were less stressed. However it must be noted that these could also be due to the novel nature of the interaction as it was the first interaction with the robot for most participant's.

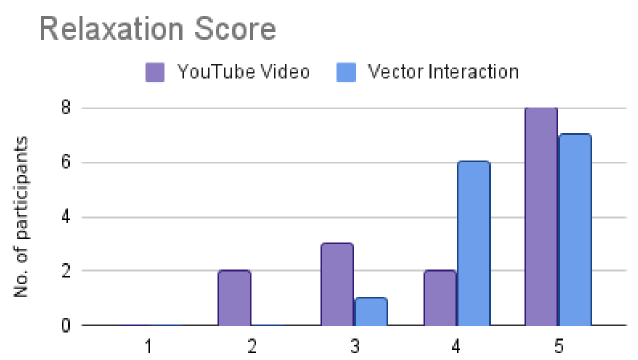


Fig. 7. Relaxation score of participants after the activity. 5 is more likely to be relaxed.

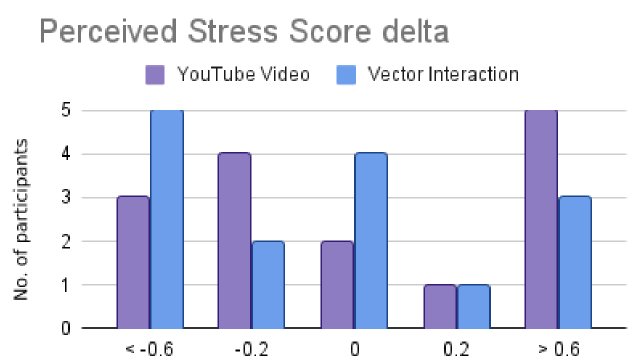


Fig. 8. Relaxation score of participants after the activity. 5 is more likely to be relaxed.

We also tried to look for correlation in perceived stress reduction score deltas and % reduction in bpm of the participants, however we did not find any such correlation between these variables.

## V. CONCLUSION

This study sought to investigate the effectiveness of Socially Assistive Robots (SARs) in reducing stress levels among college students over a short time frame. Our results indicate that SARs may be effective in reducing stress levels among college students when compared to conventional stress-relieving methods such as watching YouTube videos. However, statistical significance was not achieved, possibly due to various factors such as a small sample size of fifteen participants, which may have limited our ability to detect significant differences. Other factors that may have contributed to this result include confounding variables, such as familiarity with the game and prior experience with robots, which could have influenced the outcome. Additionally, the accuracy of our BPM measuring device may have been a possible source of error in data measurement, leading to statistical insignificance.

After identifying the limitations of our study, we have come up with potential improvements to enhance future iterations. One way to overcome the issue of familiarity with the computer game on day two is to replace it with a new game of comparable difficulty or introduce a completely different stress-inducing task. To mitigate the effect of confounding variables like prior experience with robots, we can recruit participants with no prior experience or familiarity with SARs. Additionally, we can conduct a pre-study survey to collect data on participants' familiarity with SARs and their attitudes towards them, and use this data to control for any potential biases. Increasing the number of participants would also provide us with more data points, leading to more definitive conclusions. Moreover, incorporating additional objective measures such as blood pressure levels, in addition to BPM, could improve our assessment of stress levels and allow for more statistical analyses.

To further explore potential future avenues, it would be valuable to determine the specific modality of Anki-Vector that most effectively contributed to destressing and relaxation in participants. To achieve this, we gathered feedback from the participants regarding which feature of Anki-Vector they found most enjoyable, whether it was communicating with Anki-Vector, controlling its movements, or both. This information has been presented in the form of a pie chart in figure 9.

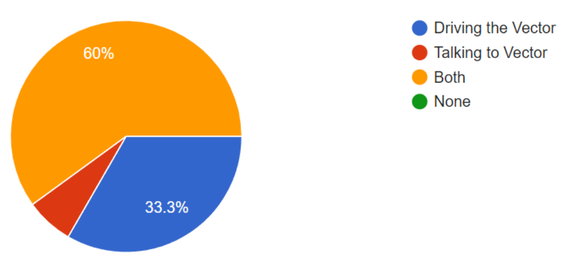


Fig. 9. Responses of participants showing which aspect of Anki-Vector they enjoyed the most.

The participants' feedback reveals that most of them found both features of Anki-Vector enjoyable, although driving the robot was more preferred than talking to it. Furthermore, none of the participants reported disliking either modality of interaction, indicating that Anki-Vector is an effective SAR. These results encourage further exploration of Anki-Vector to uncover which specific aspect of the robot contributes to stress reduction. Such investigation would not only help in identifying its weaknesses and challenges but also provide insight into ways of improving its functionality.

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