Comprehensive Comparative Analysis of Emotional Support Delivery by NAO Robots and Humans Across Varied Emotional States

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1 Introduction

Emotional support is a crucial element in our overall well-being, providing comfort in difficult times and a compassionate presence when we're facing distress. Traditionally, this support has primarily come from human interactions, involving friends, family, and professionals who offer empathy and sympathy. However, in recent times, there has been a significant shift in how emotional support is provided, with robots emerging as a transformative addition. These mechanical companions have made their presence felt across various sectors, including healthcare, education, customer service, and entertainment, serving as dependable sources of emotional comfort for individuals.

2 Motivation

Robots have the unique capacity to provide consistent and non-judgmental assistance, a trait highly valued by individuals in search of emotional support. While humans can be compassionate, they can also be fallible, occasionally clouding interactions with judgments or biases, intentional or otherwise. In contrast, robots, devoid of personal opinions and prejudices, can offer unwavering emotional support, a feature that appeals to those who value confidentiality and impartiality in their interactions. This is why robots are increasingly being employed as providers of emotional support, exemplifying the ever-evolving synergy between technology and human emotions, which in turn opens up new and promising pathways to fulfill our emotional well-being requirements.

By focusing on the unique attributes of robots – their capacity to provide unwavering, non-judgmental support – we aim to explore how these mechanized companions can address the emotional needs of individuals effectively compared to humans.

3 Literature Review

The integration of affective computing and robotics in education is explored in [1], with a focus on utilizing the NAO robot to enhance the learning experience through the recognition and response to students' emotions. The study introduces a game designed to raise environmental awareness, employing DeepFace for emotion recognition. Real-life testing yielded positive

results in both emotion analysis and user engagement. The paper innovatively combines robotics in education and emotion recognition to create a unique pedagogical experience. It offers a novel approach that has not been explored in the literature, addressing the potential of robotics and affective computing in tailoring educational content to individual emotional states.
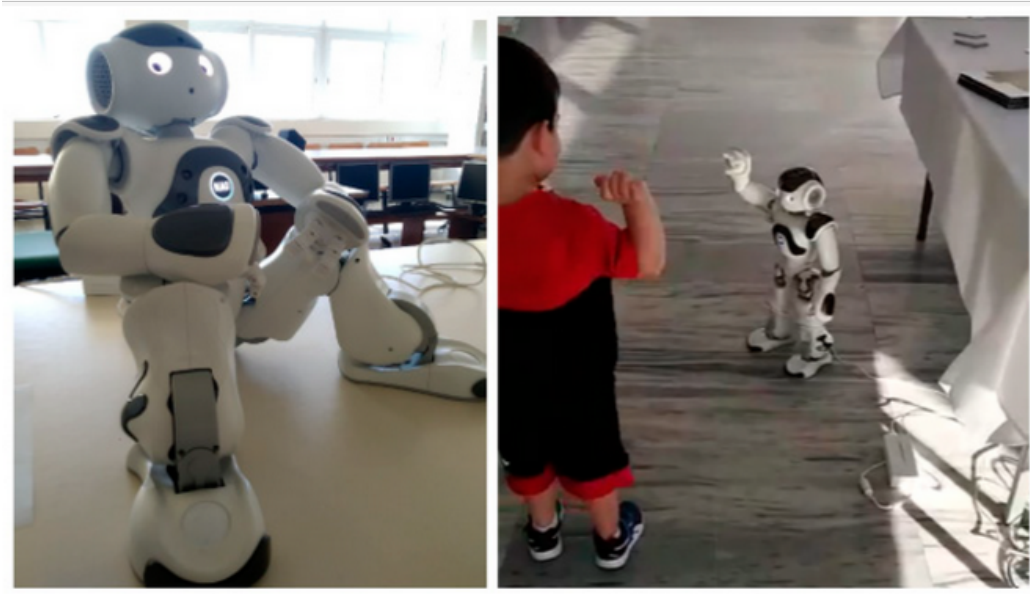

Figure 1: (a) The humanoid robot NAO; (b) NAO greeting a child.[1]

The paper[2] addresses the use of social robots to provide emotional support to otherwise healthy older adults dealing with social isolation and loneliness. While much research focuses on robot assistance for older adults with serious health issues, this work emphasizes the mental health challenges faced by socially isolated seniors. The proposed robot design prioritizes simplicity and robustness, aiming to deploy empathetic behaviors that can improve emotional well-being. Unlike pet-like robots, this conversational robot offers expanded support possibilities. The study focuses on creating practical, deployable solutions for enhancing the mental health of older adults, filling a gap in current research on social robots for this demographic.

Figure 2: A person sits at home with an emotional support robot and has a conversation about their day. [2]

3.1 Observations from Related Works

While several studies have explored the use of NAO robots for providing emotional support, a noticeable gap exists in the literature regarding comprehensive comparative analyses between NAO and human emotional support. Many of these studies have focused on demonstrating the feasibility and potential of robot-assisted emotional support. However, few have delved into in-depth evaluations of how NAO's support measures up against human interactions in various scenarios and emotional contexts. This critical gap highlights the need for more comprehensive research that not only showcases the capabilities of NAO but also rigorously assesses its effectiveness, ultimately helping us understand where and how NAO robots can complement or enhance human emotional support.

4   Problem Statement

As we encapsulate the essence of this project, we encounter the following pivotal questions that serve as the focal points we aim to address and answer:

1. What is the comparative effectiveness of emotional support provided by NAO robots and humans when prompted with predefined emotions?

2. How do recipients of emotional support perceive the empathetic qualities and comfort provided by NAO robots compared to support from humans?

3. How do individuals' preferences for emotional support sources (NAO robots vs. humans) vary based on their specific emotional needs and the non-judgmental nature of the robot compared to the empathetic qualities of a human?

5   Methodology

5.1   Proposed Work

We will focus our comparative analysis on the following basic emotions:

1. Happiness

2. Sadness

3. Fear

4. Excitement

Designing choreographed actions for the NAO robot to respond to each of the six basic emotions involves a skillful blend of movements, gestures, sounds, and facial expressions. Below, we outline comprehensive action sets within the NAO Choreograph modules, crafted to provide empathetic emotional support tailored to the specific emotional states:

- Happiness

  - ☐ Conveying a sense of joy and positivity.
  - ☐ Wave or give a friendly gesture to celebrate.
  - ☐ Play cheerful music or engage in a dance routine to uplift spirits.

- Sadness

  - ☐ Offer a comforting gestures.
  - ☐ Play soothing music or dance to uplift participants mood.
  - ☐ Provide gentle words of encouragement and empathy.

- Fear

  - ☐ Use a reassuring tone of voice to calm anxiety.
  - ☐ Stand still or offer a hand to hold for stability.

- Excitement

  - ☐ Display an element of curiosity.
  - ☐ Engage in a dynamic, inquisitive movement or gesture.
  - ☐ Offer a friendly explanation or reassurance, helping to process the surprise.

In the critical data collection phase, the questionnaire is thoughtfully distributed to a carefully selected group of participants. A crucial aspect of this process is ensuring that each participant encounters emotional support from both NAO robots and humans, uniformly addressing identical specific emotions. This strategic approach minimizes bias and allows for a rigorous comparative analysis. Participants are encouraged to provide genuine and candid feedback, thus forming the foundation of our study's comprehensive evaluation of emotional support. By uniformly exposing participants to both sources, we aim to extract valuable insights into the nuances of emotional support delivery by NAO robots and humans across various emotional states.

The collected data is gathered to do a qualitative assessment. To conduct a comprehensive comparative analysis and assess the effectiveness of emotional support provided by NAO robots and humans , the following structured steps can be done:

1. Emotional Impact Analysis: Calculate the average scores for NAO and human emotional support for each specific emotion. This quantifies the effectiveness of support and offers a numeric measure of its impact.

2. Assess Comfort Levels: Compute the average comfort scores for both NAO and human interactions. This provides insights into the comfort levels experienced by participants.

3. Evaluation of Communication and Interaction: Analyze the average scores for the clarity of communication and interaction from both NAO and human support providers. This step reveals how effectively each source expresses itself.

4. Overall Satisfaction Measurement: Determine the overall satisfaction scores for emotional support received from NAO and humans. This comprehensive assessment captures participants' general contentment with each source.

5. Personal Preference Insights: Ascertain the participants' future inclinations for seeking emotional support. Quantify the number of participants who favor NAO robots over humans or vice versa.

6. Comparative Analysis: Compare the averaged scores and discern patterns between NAO and human emotional support across all questionnaire items. Look for trends, similarities, and differences in terms of effectiveness, comfort, communication, and overall satisfaction.

7. Drawing Conclusive Insights: Based on the analysis, arrive at clear conclusions regarding which source, whether NAO robots or humans, appears to be more proficient in delivering emotional support. Additionally, pinpoint specific emotions where one source outperforms the other. Moreover, gather information about areas where both NAO and human providers may benefit from improvements in delivering emotional support. This additional data will guide the refinement and enhancement of support systems for individuals seeking emotional assistance.

5.2   Preliminary Precautions

In the context of our emotional support project, there are several key preliminary precautions to consider:

- Consent from Participants: Before conducting the study, it's essential to secure consent from the participants. In this project, the emotional support will be provided to individuals, and their willingness to participate is paramount. Clear and informed consent should be obtained from each participant.

- Presence of a Caregiver or Observer: To ensure the safety and well-being of participants, especially if they are emotionally vulnerable, it's advisable to have a caregiver or observer present during the interactions. This person can provide assistance or support if needed, adding an extra layer of safety and comfort.

- Controlled Environment: The study environment should be controlled and free from distractions that could interfere with the emotional support sessions. Minimizing external disturbances will help create a conducive atmosphere for the study.

These precautions are vital for conducting a responsible and ethical comparative analysis of emotional support provided by NAO robots and humans. They ensure that the study is conducted in a manner that respects participants' autonomy, safety, and emotional well-being.

5.3   Work Done Thus Far

We have coded the emotional response by the NAO robot for different emotions.

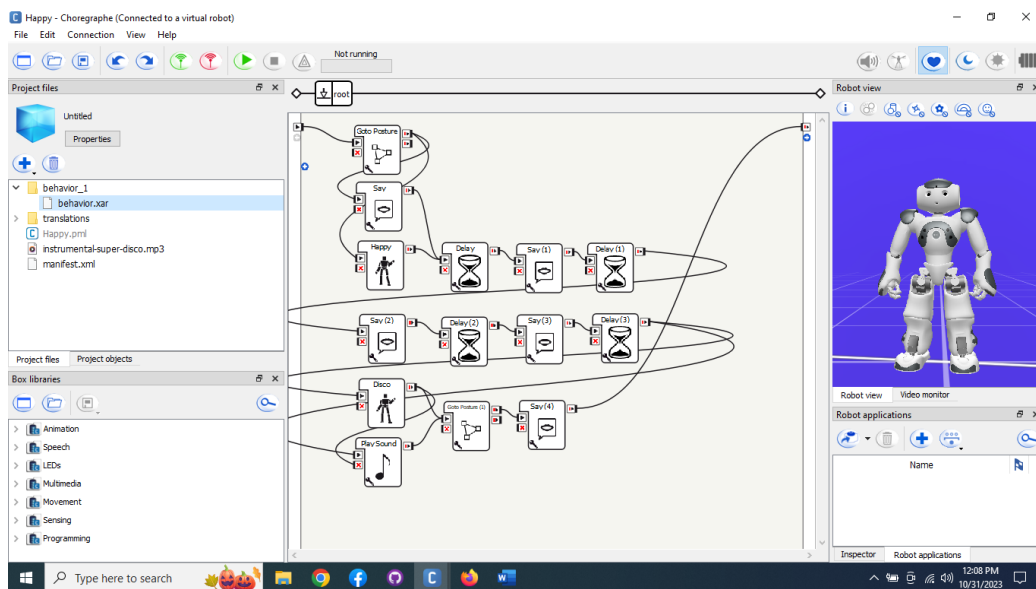Emotional response by the NAO robot for happiness:

Figure 3: Emotional response by NAO for happiness

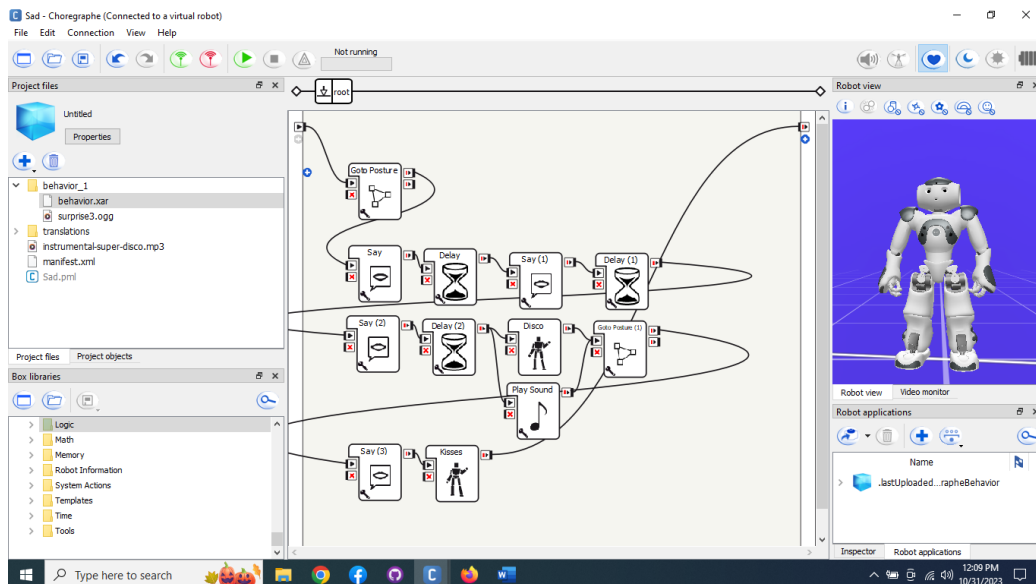Emotional response by the NAO robot for sadness:

Figure 4: Emotional response by NAO for sadness

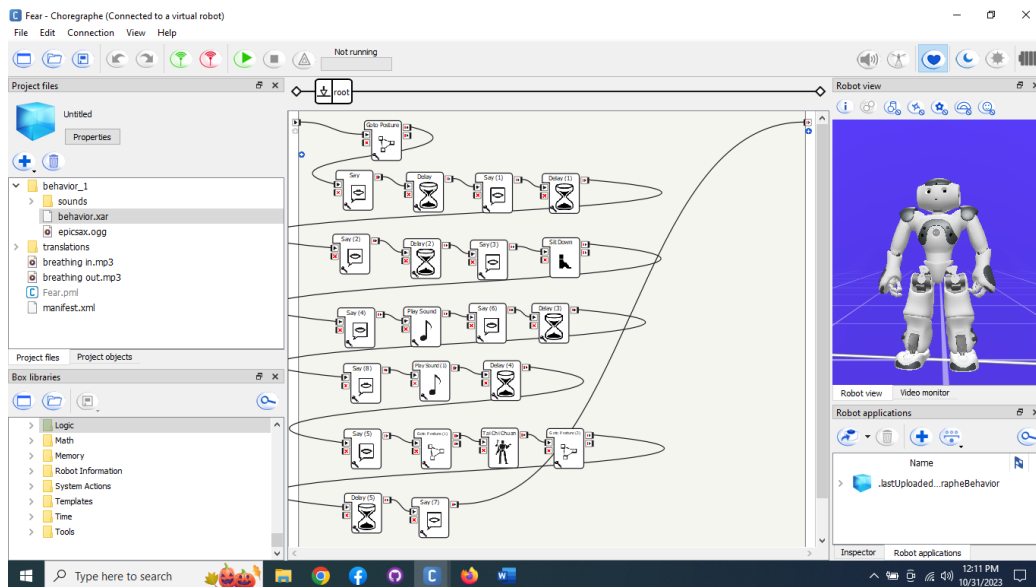Emotional response by the NAO robot for fear:

Figure 5: Emotional response by NAO for fear emotion

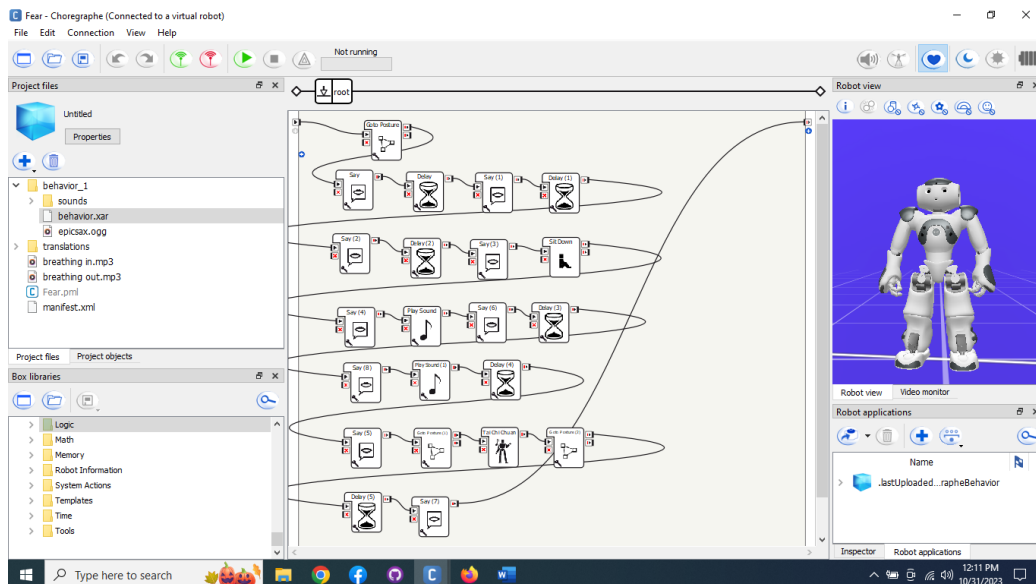Emotional response by the NAO robot for excitement:

Figure 6: Emotional response by NAO for excitement

The detailed code can be found in this github link:

[Code for HRI Project on Emotional Response by NAO robot](#)
We made a participants list that we need for the project:

Emotion	From the department	From outside the department
Happiness	6	6
Sadness	6	6
Fear	6	6
Excitement	6	6
Total Participants Needed	24	24

We will select students from both the department itself and from other departments who are in their first and second years of study. These first and second-year students will be chosen from various departments outside of our own.

We've crafted a questionnaire that will facilitate our in-depth comparative analysis between NAO and human interactions when it comes to delivering emotional support while keeping different aspects in mind. This instrument will be instrumental in exploring and evaluating the distinctions and similarities in the support offered by both NAO robots and human counterparts.

Questionnaire

Demographic Information

- How old are you? _____

- What is your gender identity? (Please check one)

  ☐ Female

  ☐ Male

  ☐ Prefer not to say

- Have you had any prior experience of interacting with robots? (Please check one)

  ☐ Yes

  ☐ No

Emotional Impact

- How effectively did the emotional support by NAO aid in managing the particular emotion you were going through? (1 - Not effective, 5 - Very effective)

    ☐ 1

    ☐ 2

    ☐ 3

    ☐ 4

    ☐ 5

- How successful was the emotional support provided by the human in assisting you in coping with the specific emotion you were experiencing? (1 - Not successful, 5 - Very successful)

    ☐ 1

    ☐ 2

    ☐ 3

    ☐ 4

    ☐ 5

Comfort

- On a scale of 1 to 5, how comfortable did you feel with NAO? (1 - Not comfortable, 5 - Very comfortable)

    ☐ 1

    ☐ 2

    ☐ 3

    ☐ 4

    ☐ 5

- On a scale of 1 to 5, how comfortable did you feel with the Human? (1 - Not comfortable, 5 - Very comfortable)

    ☐ 1

    ☐ 2

    ☐ 3

☐ 4

☐ 5

Communication and Interaction

- How well NAO expressed itself during the interaction, on a scale of 1 to 5? (1 - Not well, 5 - Very well)

    ☐ 1

    ☐ 2

    ☐ 3

    ☐ 4

    ☐ 5

- How effectively did the human express themselves during the interaction, on a scale of 1 to 5? (1 - Not effective, 5 - Very effective)

    ☐ 1

    ☐ 2

    ☐ 3

    ☐ 4

    ☐ 5

Overall Satisfaction

- On a scale of 1 to 5, rate your overall satisfaction with emotional support from NAO. (1 - Not satisfied, 5 - Very satisfied)

    ☐ 1

    ☐ 2

    ☐ 3

    ☐ 4

    ☐ 5

- On a scale of 1 to 5, rate your overall satisfaction with emotional support from Human. (1 - Not satisfied, 5 - Very satisfied)

    ☐ 1

$\square$ 2

$\square$ 3

$\square$ 4

$\square$ 5

Personal Preference

- In the future, who or what would you be more inclined to seek emotional support from: NAO or a human? (Please check one)

    $\square$ NAO

    $\square$ Human

Additional Feedback

- Is there anything specific you liked or disliked about the interaction with NAO?

    _____

- Is there anything specific you liked or disliked about the interaction with the human?

    _____

The responses will be collected through a Google Form that we have designed. The link of the Form is shared here:

[Qualitative evaluation comparing NAO and Human](#)

5.4 Expected Work To Be Done

- Data Collection: As of now, we have developed the questionnaires, and the process of gathering data from participants is still pending.

- Data Analysis: Once the data from the questionnaires and observations during emotional support sessions are obtained, we will proceed with the analysis.

- Comparative Analysis: We will then undertake a comparative analysis to assess the efficacy of emotional support offered by both NAO robots and human interactions. This analysis will involve employing statistical methods to scrutinize the gathered information.

- Conclusions and Recommendations: Following the analysis, we will draw conclusions regarding the effectiveness of emotional support from these two sources. We will also identify specific situations or emotions where one source excels over the other. Subsequently, we will formulate recommendations for enhancement based on the findings

References

[1] I. A. Valagkouti, C. Troussas, A. Krouska, M. Feidakis, and C. Sgouropoulou, "Emotion recognition in human–robot interaction using the nao robot," *Computers*, vol. 11, no. 5, p. 72, 2022.

[2] A. N. Baecker, D. Y. Geiskkovitch, A. L. González, and J. E. Young, "Emotional support domestic robots for healthy older adults: Conversational prototypes to help with loneliness," in *Companion of the 2020 ACM/IEEE International Conference on Human-Robot Interaction*, pp. 122–124, 2020.