Creating and Assessing Cozmo Behaviors for Expressing Emotion

By
Lilian Chan

A THESIS

submitted to

Oregon State University

Honors College

in partial fulfillment of
the requirements for the
degree of

Honors Baccalaureate of Science in Electrical and Computer Engineering
(Honors Scholar)

Presented August 27, 2021
Commencement June 2022

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Abstract approved:

Naomi Fitter

As human-robot interaction becomes more commonplace, roboticists should understand how robot behaviors are perceived by people to avoid misunderstandings. In our lab, we are exploring the use of a Cozmo as an interactive, break-taking aid in workplace settings. Before our interactive aid can be released into the wild, we must design accurate and documented Cozmo behaviors for expressing emotions. To do this, our designed emotional behaviors were evaluated through an online video-based study. Our results indicated that participant ratings of Cozmo valence and energy levels match the intended values. The valence of Cozmo's behavior also has a strong correlation with a person's perceived characteristics of the robot (e.g.: interaction appeal, trustworthiness, and safety). People who wish to work with robot expressive behaviors can benefit from this work.

Key Words: Social Robotics, Human-robot Interaction, Cozmo, Emotions

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I understand that my project will become part of the permanent collection of Oregon State University Honors College. My signature below authorizes release of my project to any reader upon request.

Lilian Chan, Author

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1 Introduction

Social robots are able to engage and influence people to achieve social-emotional goals [1]. As social robots expand into environments that require human interaction, such as healthcare, entertainment, and education [2, 3], it is important to design robots with effective communication skills. Without adequate social skills, robots run the risk of being unattractive to people they are supposed to assist [4].

A current focus of our lab is utilizing the Cozmo to encourage break-taking behaviors in the workplace [5]. In order to fully utilize Cozmo in future projects, this study is a preliminary step to document Cozmo behaviors before incorporating them a Markov Decision Process (MDP) model spanning mutliple expressive behaviors. The Cozmo robot is an inexpensive robot with many features, such as programmable and customizable OLED screen, locomotion, vocal sounds, lights, and lift and head movement, which gives it many avenues for social interaction and emotional expression. A Cozmo robot can be seen in Fig. 1. It has many applications from personalizing tutoring [6], fostering collaboration [7], to facilitating in-home human-robot interaction [8]. In order to avoid miscommunication in all these applications, it is important to design recognizable and ideal emotional behaviors for different situations.

Previous studies have also looked into creating behaviors for robots that imitate emotions. Many past studies have based their robot's behavior on either Russell's circumplex model [9] or Ekman's basic emotions [10]. People have been generally able to recognize a robot's emotional behavior in past studies [11, 12, 13, 14, 15, 16]. Depending on a robot's emotional state, people have different perceptions of it (e.g.: Baxter robot [17], Robotceptionist [12]). Additionally, people react differently to robots depending on its perceived mood (e.g.: Cozmo [8], Robotceptionist [12]). This study will add onto previous research by exploring a richer range of emotions instead of a few common categories. Additionally, it will be exploring the use of Cozmo in a new workplace context.

In order to design and validate Cozmo behaviors for future applications, this paper will: (1) investigate how well people can recognize the intended valence and energy levels of Cozmo behaviors and (2) research how a Cozmo's expressive behaviors can affect people's perceptions of it. Section II is an overview of related literature. In the next section, the methods for our study will be elaborated on. The findings from our investigation will then be presented and explained respectively in Section IV and Section V. This work offers well-documented, open-source animations [18]. Additionally, it provides insight into emotional behaviors of robots as this paper covers a rich, comprehensive range of robotic behaviors across Russell's circumplex model [9]. Cozmo is also unique as it has a variety of features from an OLED screen, locomotion, head and lift movement, vocalized sounds, and LED backpack lights.

Figure 1: Examples of Cozmo emotive behaviors used in this study.

2 Related Work

There are similar past studies that look into robotic expressive behaviors and long-term human-robot interaction.

2.1 User Recognition and Perception of Robotic Emotions

We are investigating human recognition and perception of robot emotions. Past studies investigated human perception of robot emotion. The emotional behaviors of our socially assistive robotic (SAR) system were based upon Russell's circumplex model [9], which proposes that all emotions are created from some combination of valence and activity levels. Other past studies have used this model to design their robot's behaviors [12, 17, 15, 16]. Ekman's basic emotions [10], which are seven proposed basic emotions, is another model of emotions that other studies have based their robotic behaviors on [11, 13, 19, 14]. In our study, Cozmo's expressive behaviors are created to cover the full spectrum of Russell's circumplex model, which makes our study richer than many other studies. This allows our system to imitate a wider range of human behavior.

Other past studies have also done similar robotic experiments to test people's recognition and perception of robot behaviors that imitate emotions. Many past studies have shown that people can identify emotions in a large variety of robots [11, 12, 13, 14, 15, 16]. This ranges from humanoid robots that make use of a face, like the Robotceptionist [12] and EDDIE [15], to simpler robots that make use of lights and movements, such as the Roomba [16] and Maru [20]. People have also been shown to have certain biases and perceptions towards different expressive behaviors in robots. In a previous lab study where people rated different Baxter Robot expressions, different Baxter facial expressions had statistically significantly different ratings regarding pleasantness, energeticness, user personal safety, and user personal pleasedness [17]. Another study that utilized Cozmos in household interactions found that Cozmo happiness responses move the human-robot interaction forward, while the sadness responses make people reconsider and look for problems in their earlier interactions [8]. A study where a Robotceptionist interacted with people showed that people change their interaction patterns with it depending on the robot's mood and people's familiarity with it [12]. Additionally, emotive responses were shown to bias Kismet's behavior so that it either receives the desired stimuli or avoids poor quality stimuli [21]. Cozmo is a very flexible and versatile robot that can show emotions through its OLED expressions, locomotion, and head and arm movements. Few other robots in the above mentioned studies have the combination of all of these traits. This makes Cozmo able to explore new and unique interactions with people.

2.2 Long-Term Human-Robot Interaction

The results of our research will be used to design and validate Cozmo behaviors for a larger study on a workplace break-taking intervention robot. Additionally, the emotional behavior of robots in itself affects aspects of human-robot interaction. For example, the more animated a robot's face, the more likely people will be attracted to it [22]. Therefore, this study has applications to long-term human-robot interaction.

There are many similar research studies in this field involving long-term social robot interaction in hospitals, schools, and homes [2]. One healthcare application of social robotics is PARO, the seal robot, which was found to improve the elderly residents' and nurses' stress levels at a care center [23]. It was also found that when an Autom robot assisted patients in dieting, there were significant impacts on the number of days patients tracked calories and exercise [24]. Robot assistants also have promising educational benefits. When two Robovie robots were used as English tutors, students who kept up the interaction improved their English skills at a better rate than those who did not [25]. A study that deployed SPRITE as personalizable interventions to people on the autistic spectrum disorder found that each child improved their targeted skills [26].

Because of Cozmo's range of behaviors and applications, it is a possible candidate for long-term human-robot interaction. This study contributes to the long-term human-robot interaction field by researching people's perception and interpretation of various Cozmo emotive responses. Conveying intentions accurately is important for long term support roles and creating successful long-term relationships with humans.

3 Methods

To create and validate interactive Cozmo behaviors for future applications, we are investigating user perceptions and recognition of Cozmo animations. The need for socially-interactive behaviors arose from our ongoing investigation of the use of a socially-assistive robotic system to encourage break-taking behaviors in the workplace [5]. By creating recognizable and desired behaviors, we can solve the reoccurring obstacle in pilot studies where participants sometimes had trouble understanding Cozmo's behaviors. This study was approved by the Oregon State University (OSU) Institutional Review Board under protocol #IRB-2019-0172.

3.1 Hypotheses

In our study, we aimed to test people's recognition and perception of different emotional responses of a Cozmo system:

- **H1**: Participant ratings of the valence and energy levels of Cozmo animations will be accurate to their intended placement on Russell's circumplex model [9]. This hypothesis is supported by previous robotic perception studies, which categorized their robot's behaviors through Russell's circumplex model [12, 17]
- **H2**: Compared to negatively-valenced behaviors, positively-valenced behaviors will be perceived as more trustworthy, safe to interact with, and likely for people to interact with. This hypothesis was formulated based on the results of past experiments on robot perceptions [27] and our pilot studies.
- **H3**: Compared to low-energy behaviors, high-energy behaviors will be perceived as more intelligent. This hypothesis was supported by the results of our pilot study.

3.2 Cozmo Behavior Design

In order to create a comprehensive range of emotional behaviors, four animations were created for eight different categories of Russell's circumplex model. This range of behaviors will let Cozmo react to a fuller range of human emotions rather than just the common ones. The behavior categories are shown below [9] [28]:

- Neutral Valence, High Energy Level [Active]
- Low Valence, High Energy Level [Unpleasant Active]
- Low Valence, Neutral Energy Level (e.g., Fig. 2)[Unpleasant]
- Low Valence, Low Energy Level [Unpleasant Inactive]
- Neutral Valence, Low Energy Level [Inactive]
- High Valence, Low Energy Level [Pleasant Inactive]
- High Valence, Neutral Energy Level [Pleasant]
- High Valence, High Energy Level (e.g., Fig. 3) [Pleasant Active]

Each animation was designed using the Cozmo software development kit (SDK) [29] with a combination of pre-programmed and custom behaviors. The behaviors focused on utilizing Cozmo's locomotion, head movements, lift movements, and OLED facial expressions. Each animation had a similar duration ($M = 13.84$, $SD = 1.65$). The animations were designed to have no intentional sounds (such as vocal utterances) because of the workplace setting, but the sounds of Cozmo's motors and movements were unavoidable.

Creating these animations was a collaborative and research-intensive process. Cozmo had limited movement and facial expressions, so it took multiple trials to design certain behaviors accurately. Because of these limits, it was also difficult to imitate human emotions directly as Cozmo did not have directly analogous parts. A huge help to combat this was Carmen Tiffany, an animation expert. She gave tips on how animators animate emotion-which was an essential concept to apply to Cozmo as much of his behaviors were generally exaggerated and cartoon-like. The categories of Pleasant and Pleasant Inactive were especially difficult to differentiate due to the mechanical limitations of slowing Cozmo's animations past a certain point. Additionally, most of the pre-programmed pleasant behaviors for Cozmo were high energy, so the lower energy pleasant animations required more customization and creativity. Additionally, it was difficult to design the Active behaviors because they were more robotic than any other category due to their neutral valence. This may have impacted participant perceptions of them. What helped the most in creating these behaviors despite the difficulties was peer evaluations. Various meetings with lab members and test trials helped me recognize errors and gain ideas. All these meetings made my Cozmo behaviors more dynamic, varied, and recognizable.

3.3 Measurement

Participants' questionnaire and survey responses were used to gather data on the Cozmo behaviors. The survey included the following parts:

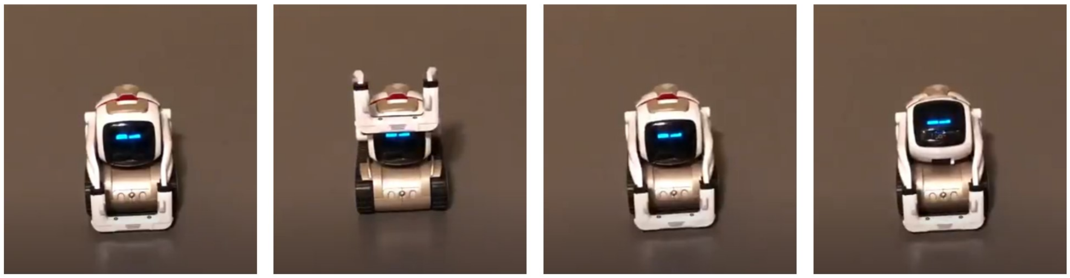

Figure 2: A subset of cropped frames from the "disappointed" behavior.

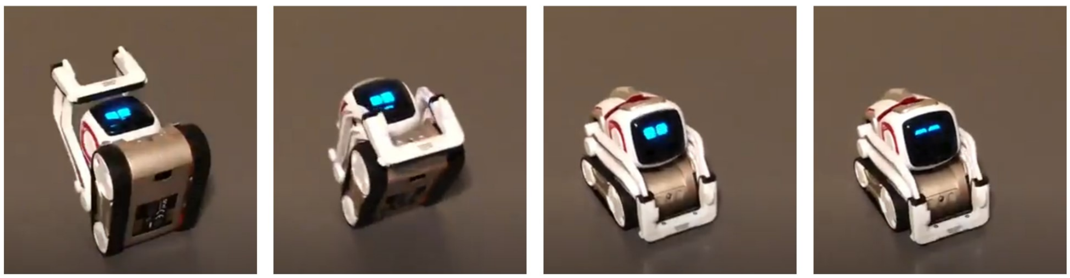

Figure 3: A subset of cropped frames from the "victorious" behavior.

Attitudes, Biases, and Experience questionnaire: the survey began with the Negative Attitudes towards Robots Scale (NARS) questionnaire in order to measure the participants' attitudes and biases towards robots, which is an important covariate to measure data against. User agreed or disagreed with a seven-point likert scale on 14 questions related to *interactions with robots*, *social influence of robots*, and *emotions in robots* as described in [30]. There were also two additional questions regarding the user's experience level of robots and Cozmo, which were answered with a seven-point likert scale.

Demographic questionnaire: the participants then answered questions related to their demographics and occupation.

Post-stimulus questionnaire: this section measured the participants' recognition and perception of various Cozmo animations. Each participant was given eight out of 32 randomized animations of a Cozmo behavior. After watching the video, users must agree or disagree to a series of statements related to the robot behavior seen in the video in the form of a seven-point likert scale. These statements are:

1. This robot seems pleasant.
2. This robot seems energetic.
3. I would interact with a robot that behaves this way.
4. A robot that behaves this way seems trustworthy.

5. A robot that behaves this way seems safe to interact with.
6. A robot that behaves this way seems intelligent.

The pleasantness and energeticness questions are based on the axes of Russell's circumplex model [9]. The remaining questions were based on themes from the Robotic Social Attributes (RoSAS) Scale (warmth, competence, and discomfort) [31], common social robotics metrics [32], and the Godspeed survey [33].

The user then answers a follow-up question of which factors most strongly influenced their response to the questions above. The options included "facial expressions," "locomotion of robot," "other robot motion (head, lift)," "sounds of robot," or "other" (user input).

Overall perceptions questionnaire: the participant then answered various questions related to Cozmo's perceived gender, relationship with the participant, and comparable animal in terms of behavior.

Free-response question: the participants answered a free response question about what characteristics of the videos most strongly influenced their responses. These responses were later coded to find common themes.

3.4 Participants

A total of 113 Oregon State University students answered the survey. The participants consisted of 79 (69.9%) cisgender women and 34 (30.1%) cisgender men. Their ages ranged from 18 to 45 years old ($M = 22.0$, $SD = 5.9$). A majority of the participants (66.4%) pursued a science, technology, engineering, or mathematics (STEM) degree. The participants also had little experience with Cozmo (M = 1.09, SD = 0.39) and robotics ($M = 1.75$, $SD = 0.74$) as shown in their responses to a seven-point likert scale. They also had fairly neutral attitudes regarding attitudes towards *interactions with robots* ($M = 3.53$, $SD = 1.09$), *social influence of robots* ($M = 4.58$, $SD = 1.14$), and *emotions in robots* ($M = 4.53$, $SD = 1.21$), as seen from their responses to the NARS questionnaire.

3.5 Procedure

The participants were gathered from an introductory psychology course where consenting students completed the survey for extra credit. The students were given a Qualtrics survey with questions regarding their biases towards robots, demographics, 8 randomly assigned Cozmo perception questions out of 32, and a free response question.

Each of the questions were timed to make sure participants viewed the full videos and/or had sufficient time to answer the questions. Several attention check questions were also included to ensure students were reading what they were being asked. Additionally, required fields must be filled to move onto the next question.

3.6 Analysis

The data collected from the online surveys were analyzed through linear mixed models (LMMs) with $\alpha = 0.05$. Each of the participants answered a subset of the questions to avoid burnout, so the LMMs were chosen to be able to analyze this data within-subject. To account for each participant's question answering biases and habits, the participant number was used as the random effect in the LMMs. Using the Holm-Bonferroni method, which identifies differences and resulting p values between each pair [34], we were able to further explore the significant differences between the different behavior categories. We determined the effect size through the marginal r^2. We followed this scale for the r^2 values: $r^2 = 0.010$ is a small effect, $r^2 = 0.040$ is a medium effect, $r^2 = 0.090$ is a large effect, and $r^2 = 0.16$ is a very large effect [35]. We used Jamovi to analyze the results [36, 37, 38].

4 Results

This section will explain where participants rated different behaviors on the pleasantness and energy axes of Russell's circumplex model [9]. Afterwards, it will go into the how different behavior categories and objective metrics change the perception of Cozmo's characteristics. Finally, it will go over the general perceptions of Cozmo.

4.1 Response Alignment with Expected Valence and Energy Axes

Using the Cozmo behavior category as the fixed effect, the LMMs showed differences in both perceived *valence levels* ($p < 0.001$, $F(7, 1707.07) = 76.17$, $r^2 = 0.190$) and *energy levels* ($p < 0.001$, $F(7, 1712.70) = 165.78$, $r^2 = 0.353$). There were 23 out of 28 significant pairwise comparisons for valence levels (18 being very significant) and 25 out of 28 significant pairwise comparisons for energy levels (24 being very significant) in the post-hoc analysis. The pairwise comparisons that were not significant for valence levels were between Active and Pleasant Active, Active and Pleasant Inactive, Pleasant Active and Pleasant Inactive, Unpleasant and Unpleasant Inactive, and Pleasant and Pleasant Inactive. The pairwise comparisons that were not significant for energy levels were between Active and Unpleasant Active, Inactive and Unpleasant Inactive, and Unpleasant Active and Pleasant. Consult Fig. 4 for the placement of the animations on Russell's circumplex model [9].

4.2 Perceptions of Different Behavior Categories

The LMMs indicated that Cozmo's behavior category did have a significant difference regarding perception of Cozmo's *trustworthiness* ($p < 0.001$, $F(7, 1707.07) = 76.17$, $r^2 = 0.104$), *safety* ($p < 0.001$, $F(7, 1707.07) = 76.17$, $r^2 = 0.100$), and *intelligence*

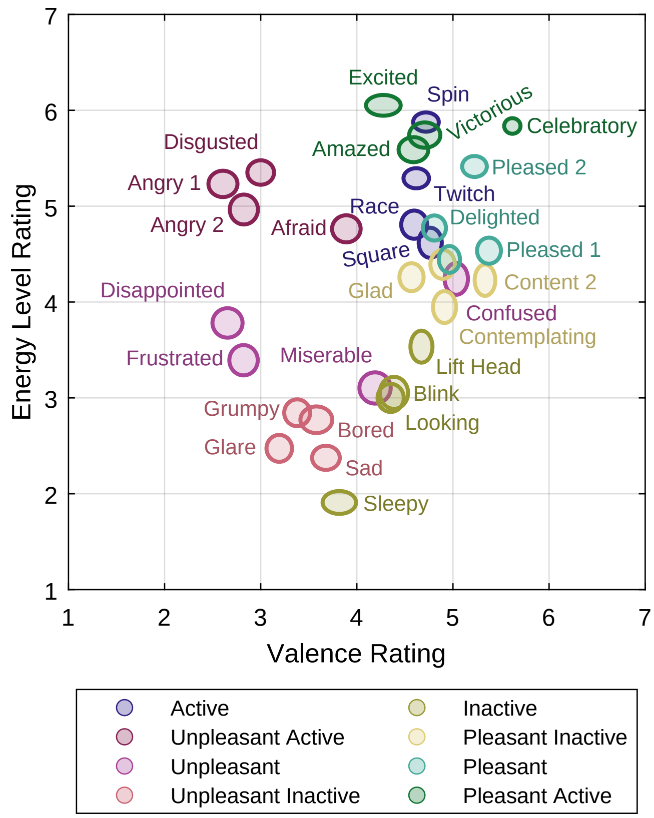

Figure 4: Participants ratings of each expressive behavior on Russell's circumplex model. Each centeroid falls on the coordinates of the mean rating for that particular behavior. The oval's width and the height correspond to one-tenth of the standard deviations of the valence and energy-levels, respectively. For visibility, the "Content 1" (Pleasant Inactive) and "Happy" (Pleasant) behaviors remain unlabeled [28]. © 2021 IEEE

($p < 0.001$, $F(7, 1707.07) = 76.17$, $r^2 = 0.032$), and participants' *willingness to interact* ($p < 0.001$, $F(7, 1697.97) = 43.26$, $r^2 = 0.096$). The results are illustrated in Figure 5.

Pleasant behaviors were consistently rated highest in perceived trustworthiness, safety, and willingness to interact. Unpleasant Active behaviors, on the other hand, were consistently rated the lowest in all four categories. High-valence behaviors consistently rated higher than low-valence behaviors in willingness to interact, trustworthiness, and safety. The ratings for intelligence did not have a clear trend.

4.3 General Perceptions of Cozmo

On the post-stimulus questionnaire, participants indicated which factor(s) influenced their perceptions of Cozmo. The percentage of the time each one was chosen are 35.7% for facial expressions, 29.1% for overall locomotion, 24.7% for head and lift

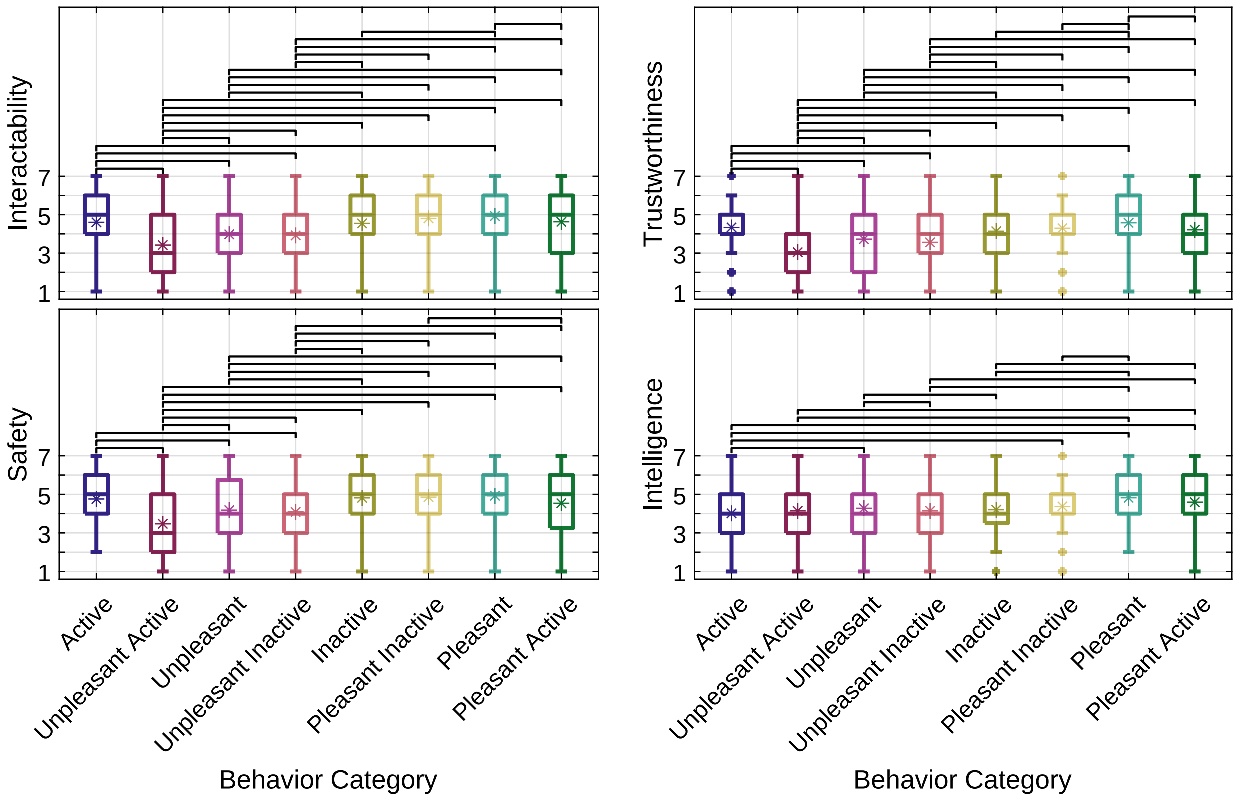

Figure 5: Results of the post-stimulus questions. The brackets represent significant pairwise differences. The boxplots contain asterisks for the means, plus signs for the outliers, and whiskers that are up to 1.5 times the inter-quartile range [28].

motion, 9.6% for sound, and 1.0% for "other."

Participants also disclosed their perceived relationship with Cozmo if they were to own one. The results showed that participants indicated "toy" 48.0% of the time, "pet" 26.0% of the time, "friend" 14.5% of the time, "peer" 4.6% of the time, "child" 3.5% of the time, and "other" 3.5% of the time. The majority of participants perceived Cozmo as male (59.3%). The rest of the participants thought the gender of Cozmo to be "androgynous" (15.9%), "no gender" (8.9%), "male-androgynous" (8.0%), or they were "unsure" (8.0%). When participants answered what Cozmo's behavior resembled, they answered "mammal" (38.0%), "[not] like any animal" (35.7%), "bird" (3.9%), "invertebrate" (3.1%), "reptile" (2.3%), "amphibian" (2.3%), "fish" (0.8%), and "other" (14.0%).

5 Discussion

H1 was found to be supported by the results as behavior categories generally fell as expected on the valence and energy axes of Russell's circumplex model. However, the categories of Pleasant Inactive and Active did not fall quite as expected on the model. Past work also had trouble designing these categories [17]. Participants responses also indicated that Cozmo was "able to portray a variety of moods" and that its behavior 'resembled emotions such as energetic, sad, mad, or happy."

H2 was also found to be supported by the results. Generally, we found that higher-valence behaviors rated higher in the categories of perceived interaction appeal, trustworthiness, and safety. Significant pairwise differences appeared most frequently between low-valence and other valence level behavior categories. Therefore, "negative" behaviors seem to have the most significant distinction out of all the behaviors. The participants' feedback supported this as they expressed, "I would feel more comfortable interacting with a robot that had [...] happy facial characteristics," and "when the robot had [a] happier facial expression I considered it more trustworthy and safe."

However, our results did not support **H3**. In general, the intelligence rating did not have any strong correlations or direction with the energy level. There were six significant pairwise differences between high-energy categories and other behavior types. However, no clear pattern appeared. This could be because intelligence is perceived based on the situation rather than the energy level, which could explain the lack of a pattern. For example, a high-valence behavior can be interpreted as both as playful (e.g., "egging you on to play with them") and aggressive (e.g., "it acted crazy, it was not very pleasant," "[it] seems to throw fits"). Low-valence behaviors can also be interpreted in multiple ways, such as either lazy (e.g., "it seemed lazy it made me not want to trust it") or pleasant (e.g., "I prefer more subtle or smooth movements").

We also collected valuable data on general perceptions of Cozmo. The majority of people thought of Cozmo as male and no people thought of Cozmo as female. Cozmo's facial expressions were also consistently chosen as the most important contributing factor to people's post-stimulus responses. Compared to the other options, people most popularly described Cozmo's relationship with them as a toy or pet. Cozmo is also most commonly related to a mammal or "no animal at all". These perceptions support future behavior designs to resemble either that of a pet or an electronic device.

5.1 Design Implications

Because people were able to recognize each Cozmo behavior's valence and energy levels roughly as intended, it confirms that we are able to design new, recognizable Cozmo behaviors. This allows us to add variety to Cozmo outside of the limited pre-programmed behaviors. By changing the affective display of Cozmo, we are able to alter Cozmo's perceived characteristics (e.g., trustworthiness, safety, user willingness to interact with Cozmo). Our findings will also help future Cozmo applications by reducing the ambiguity of Cozmo's behaviors. This study will be able to provide a rich range of documented behaviors and design principles to use in the proposed future Cozmo MDP.

5.2 Key Strengths and Limitations

This study has many key strengths that differentiate it from previous studies. One of its key strengths was the use of the resident animation expert, Carmen Tiffany, to give feedback on the animations. Her feedback, along with those of other lab members, had heavy involvement in the direction and design of the final animation products. Their opinions and efforts contributed to the success and results of this study. Another key strength of this study is its benefit and influence on future SAR projects involving Cozmo. The findings from this study can possibly influence future behavior designs of Cozmo behaviors in both our lab and other applications. Because our animations are open-source [18], another benefit to this study is the accessibility for others to use our documented Cozmo behaviors.

Despite its strengths, there were some limitations to our study. One limitation is that the data was collected through an online survey rather than in-person. This limitation made it easier for people to rush through or give inaccurate information. Another limitation was the demographics of the study participants: all of them were college students. Different demographics might have had different opinions that we were unable to capture. To remedy these limitations, we have future plans to conduct a more diverse, in-person study.

5.3 Transformative Sound Study

When designing the Cozmo behaviors, the sound was muted to keep it workplace-friendly. Throughout the process, however, we were curious about the possible effects of transformative sound on people's perceptions of Cozmo. To investigate this question more in-depth, we made two batches of all the animations: one with and one without Cozmo's vocalizations.

This question was explored in another lab research paper that I coauthored [39]. It was found that the behavior versions with sound were perceived as significantly more pleasant, energetic, warm, and competent than the versions without sound.

6 Conclusion

Throughout this project, we evaluated various Cozmo behaviors for future use in an assistive robotic system. Through an online video study, we determined that people were able to rate the valence and energy levels of robot expressive behaviors similar to their intended ratings. Additionally, we were able to obtain important design considerations, such as how people perceive different Cozmo behaviors and Cozmo in general. This work will benefit other roboticists who wish to design expressive behaviors for robots. We are also able to utilize these findings to design future Cozmo behaviors effectively. One possible continuation of this study is to research the effect of Cozmo behaviors in-person with and without transformative sounds. This in-person study can lead to many new nuanced insights that are not apparent online. Additionally, it would be useful to study the behaviors with context, such as the robot trying to communicate with a person, instead of behaviors with no human interactant. Overall, this project cultivated my passion for social robotics and interest in research. It has given me the opportunity to collaborate with many different experts in an interdisciplinary field. It was an amazing opportunity to lead a project and learn throughout the process.

7 Appendix

Our lab conducted a within-subjects study to better understand the effects of transformative sounds on people's perceptions of robots. Five different robots were chosen for the experiment: Cozmo, NAO, UR5e, Baxter, and TurtleBot 2. Each robot had its own study. In each study, the robot was recorded performing four different behaviors with and without transformative sound.

Participants ($N = 100$) would then complete a Qualtrics survey with one of the five robots. The survey began with an introduction and practice question. Afterwards, participants would watch and evaluate all eight of the videos specific to their robot on valence, energy level, warmth, competence, and comfort. A free-response question about what influenced the participants' responses was given afterwards. The participants also completed an attitude and demographic questionnaire at the end.

Based on the data, videos with transmformative sound were perceived as significantly happier, warmer, and competent in all the studies. It was rated as more energetic in all the studies except for the one involving the NAO robot. In the Baxter video, the transformatie sound version was rated as significantly less discomforting than the one without. In particular, this showed that transformative sound was significant in increasing the perceived valence, energy, warmth, and competence of a Cozmo, as seen in Fig. 6.

8 Acknowledgements

This study was helped greatly by Brian Zhang, who helped analyze the results, Carmen Tiffany, who gave feedback on the robot animations, and Christopher Sanchez,

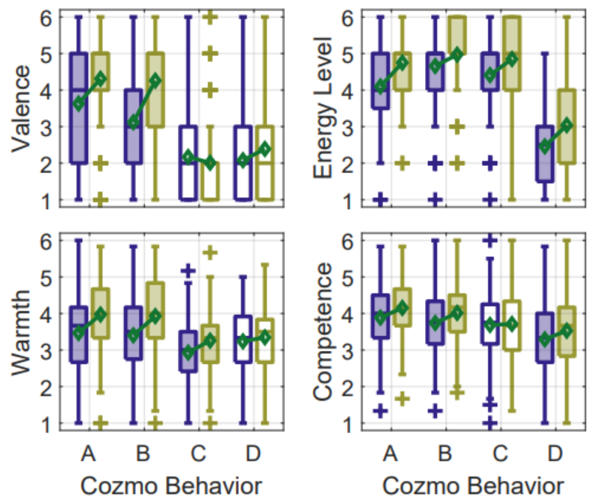

Figure 6: Significant post-stimulus responses for Cozmo. [39]. © 2021 IEEE

who offered data collection support. Most of all, thank you very much to Naomi Fitter, who gave me the opportunity to write this research paper.

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