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RESEARCH ARTICLE

AN ANALYSIS OF THE ACCURACY AND BIAS OF A GENERATIVE AI MODEL

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Abstract

Artificial Intelligence (AI) has become deeply ingrained in the daily lives of ordinary individuals with tools like ChatGPT, Google Bard, and Amazon Alexa playing integral roles. The increasing reliance on AI prompts questions about its true capability to meet diverse needs. Facial recognition and generation stand out as a significant area where AI is still evolving; AI continues to encounter challenges in both the detection and generation of emotions. This study utilizes the popular image generator Midjourney to examine the efficacy of generational AI. Concerns arise about the potential misuse of these tools to disseminate misleading information. The research aims to assess the accuracy and bias of images generated by one of the most advanced image-generating algorithms by seeking evaluations from human volunteers. Results indicate notable biases in gender, race, age, and physical abilities, raising concerns about the inclusivity of AI-generated content. The researchers conclude with insights into the limitations of current AI models and issues of accuracy when generating emotion-based prompts. Suggestions of future research are provided, emphasizing the need for larger sample sizes and focused studies on specific emotions and biases.

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Introduction:-

Artificial intelligence (AI) is a versatile tool that allows individuals to assess how information is integrated, data is analyzed, and the ensuing insights are employed to enhance decision-making; its transformative impact is already evident across various aspects of life. (West & Allen, 2023). AI is not a recent technological development (Robert, 2019). Its origins date back to 1956 when John McCarthy, a computer scientist at Stanford University, first introduced the term while overseeing the Dartmouth Summer Research Project (Robert, 2019). Although there is no uniformly agreed upon definition, AI generally is thought to refer to “machines that respond to stimulation consistent with traditional responses from humans, given the human capacity for contemplation, judgment, and intention” (West & Allen, 2023). While the AI field has experienced many ups and downs, experts consider the current period as an AI boom (Robert, 2019; Hagendorff, 2020). This surge has prompted ongoing discussions about applied ethics aimed at managing and constraining AI (Robert, 2019; Hagendorff, 2020). Consequently, a comprehensive set of ethical guidelines has emerged in recent years, encompassing principles that technology developers are encouraged to follow to the greatest extent possible (Hagendorff, 2020). However, the critical question arises: Do those ethical guidelines have a genuine impact on human decision-making in the field of AI? (Hagendorff, 2020).

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AI is a versatile tool that prompts a reconsideration of how we integrate information, analyze data, and leverage resulting insights to enhance decision-making (West & Allen, 2023). Notably, AI has gained prominence for its strategic value in education (Zhai et al., 2021). It serves as an effective learning tool, alleviating the burdens on both teachers and students while providing impactful learning experiences (Zhai et al., 2021). Moreover, AI extends its influence on domains like nursing, where it assumes certain tasks traditionally performed by nurses today (Robert, 2019). While technology transforms the way nurses allocate their time for patient care, the fundamental need for nursing professionals persists (Robert, 2019). In a similar vein, just as technology reshapes the landscape of healthcare and education, artists are embracing AI tools like Generative Adversarial Networks (GANs) to reshape the boundaries of artistic expression and innovation (Foka, 2023). These tools can be used to generate unique artworks, fostering a dynamic intersection between technology and artistic innovation (Foka, 2023).

The United States has unequivocally emerged as the primary hub for artificial intelligence development, with tech giants like Google, Facebook, and Microsoft leading the way in AI-driven research (Glass, 2023). While the USA currently spearheads the AI arms race, China is rapidly advancing as a close second (Glass, 2023). The Chinese government has made substantial investments in AI research and development, actively striving to surpass the USA in this technological race (Glass, 2023). Major corporations such as Alibaba, Baidu, and Tencent play pivotal roles in elevating China's AI capabilities, yielding groundbreaking results that redefine the boundaries of AI (Glass, 2023).

An intriguing facet of this domain is China's social credit system (SCS) which is heavily reliant on facial recognition technology (Wong & Dobson, 2019). China boasts the world's largest camera surveillance network with millions of cameras (Wong & Dobson, 2019). In pilot cities like Shenzhen, Jinan, and Fuzhou, facial recognition technologies are already employed to track and identify offenders such as jaywalkers, with their names promptly published in local media (Wong & Dobson, 2019). However, the widespread use of facial recognition raises significant ethical concerns, particularly regarding privacy (Smith & Miller, 2021).

Affective computing, an interdisciplinary field, examines computational methods influencing emotion (Foka, 2023). It concludes that basic psychology findings, like color associations, are insufficient for visually generating affect, emphasizing the need to understand structures for producing genuinely novel compositions evoking emotions in generated images (Foka, 2023). The findings of one study suggests that the current approach employed by computer science researchers to construct image datasets for elucidating high-level concepts like emotions is inadequate (Foka, 2023).

Current research has shown clear biases in artificial intelligence (Gupta et al., 2022; Marinucci et al., 2023). Researchers and developers are gaining a growing awareness that certain biases, such as those related to gender and race, are ingrained in the algorithms utilized by certain AI applications (Gupta et al., 2022; Marinucci et al., 2023). AI art generator developers are aware of issues with depicting faces of individuals (Jang, 2022). The makers of DALL-E, a popular AI art generator created by the owners of ChatGPT, released a statement, "As we work to understand and address the biases that DALL-E has inherited from its training data, we've asked early users not to share photorealistic generations that include faces and to flag problematic generations. We believe this has been effective in limiting potential harm, and we plan to continue the practice in the current phase" (Jang, 2022). Other popular AI software, such as Midjourney, has been criticized for societal biased depictions of professions (Ali et al., 2023).

There has been an exploration of the limitations of past research in emotion recognition, which primarily focused on static photographs of posed expressions (Krumhuber et al., 2023). This research highlighted the importance of dynamic information, such as movement direction and speed, in enhancing emotion recognition beyond static images (Krumhuber et al., 2023). The review emphasized the positive impact of dynamic displays, particularly in suboptimal conditions, by engaging cognitive processes, supporting social inferences, and facilitating prompt detection of others' emotional states (Krumhuber et al., 2023). This research suggests that static images may have difficulty in depicting emotions; despite these potential issues, forms of AI are attempting to detect facial emotions (Hussain, S. A., & Al Balushi, 2020; Krumhuber et al., 2023; Mehendale, 2020). Current models in emotion detection achieve a high accuracy of 96% in highlighting emotions making it potentially valuable in applications like predictive learning and lie detection (Mehendale, 2020). Other research in this domain focuses on applications in security by using face detection, analysis of features, and emotion classification (Hussain, S. A., & Al Balushi, 2020).

Despite advancements in emotion detection, a clear gap in the literature on emotions generated by generative artificial intelligence exists (Hussain, S. A., & Al Balushi, 2020; Krumhuber et al., 2023; Mehendale, 2020). Generative artificial intelligence has a history of issues with racial and gender bias (Ali et al., 2023; Gupta et al., 2022; Jang, 2022; Marinucci et al., 2023). In light of the identified gap and historical biases in generative artificial intelligence's depiction of emotions, it is imperative for research to undertake a comprehensive examination of bias mitigation strategies and enhance the accuracy of facial emotion analysis by generative AI.

Methodology:-

The current research has received approval by University of Charleston's Institutional Review Board (IRB) proposal #23-041. Material for the study was created through text prompts using the generative AI Midjourney. Initially, the text prompts used to generate images were one-word emotions. Midjourney creates four images when prompted. The criteria for a generated image to be considered for the survey was that it contained at least one human figure, the figure(s) in the image generated had faces that could easily be seen or inferred based on the image, images did not include text, and each image was distinct enough from other images used. The criteria for a generated image to be used for the bias analysis was that it contained at least one human figure. Since some text prompts did not generate humans by using one-word emotions, other prompts were entered as "A person who is experiencing" followed by the targeted emotion and "A person who is very" followed by the targeted emotion. In total, 152 images were generated. Of those images, 26 were immediately removed due to lack of information. Ultimately, 126 images were used in the bias analysis and 43 images were used in the survey. All images used in the survey along with prompts used to generate them can be found in Appendix A. The generation of images used in the project took place on 30 October 2023. A survey was created using the images with multiple-choice, short answers, and true/false questions. Participants were asked what emotion they believe the character in the photo was expressing. The data collection period began on 11 November 2023 and ended 25 November 2023. The data collected is publicly available at https://docs.google.com/spreadsheets/d/e/2PACX-1vRAuRXsuQyzfhcMX_7BomCLIE7wicFPWVBv_mCJrI-tPVN9va83j5wxPswKkjb17Ss4LDaRk5N7kwQF/pub?output=csv

Results:-

Generation Issues and Bias

One main issue with generation was the similarity between images. Although the prompts were basic, some results contained extremely specific, related images. Due to this, some prompts were entered multiple times to obtain a reasonable sample of images without near-duplication. For example, as seen in Figure 1, the prompt "a very curious person" created an image with a little girl beside a fish tank five times. As previously noted, Midjourney produces four images for each prompt, and therefore, the images in Figure 1 were generated through distinct instances of using Midjourney.





Figure 1:- Prompt: A Very Curious Person.

Researchers determined gender assignments based on conventional gender presentations; individuals whose presentations were ambiguous or did not conform to typical gender assignments were categorized as non-binary. When considering gender based on the 126 images generated, approximately 48% contained only male(s), 44% contained only female(s), 6% contained both male and females, and about 2% were non-binary. The results of racial depiction in the 126 images generated through Midjourney were approximately 96% white, 2% non-white, and 2% unsure; additionally, there was one image of both a white and non-white individual. Lastly, of the individuals depicted in the 126 images generated through Midjourney, about 21% appeared to be pre-teen children, 78% were teens or adults, and 1% were elderly.

Interestingly, one image used in the survey (Figure A9) depicted an individual with a disability who did not have an arm; it is unclear if this was purposefully depicted as an individual with a disability or a fault in the generation of the image. Likely, this was not depicting a disability and instead depicted an incorrect limb (Borji, 2023). Current AI models often depicted humans with an inaccurate number of extremities; this is a known issue (Borji, 2023). Midjourney had issues generating the correct number of limbs, and many of the images generated in this research depicted an inaccurate number of fingers.

Results– Accuracy (Survey)

Of the 167 recorded responses, the mean age of participants was approximately 35.2, and the mode of the ages was 21. The age of participants ranged from 18 to 79. The gender distribution of the participants was 113 female, 49 male, and 4 non-binary/other. The education level showed 76 participants were college graduates, 69 had some college education or other higher education, 21 had a high school degree or equivalent, and one individual had no high school degree or equivalent. Additionally, 162 reported that their first language was English, five participants reported that English was not their first language.

In the first section of the survey, participants were asked seven multiple-choice questions with four options for each answer choice. The participant was asked to select which word they thought best described the image shown. Responses to each question are shown in Figure 1 through Figure A7 in Appendix A. Overall, 1,169 responses were analyzed and only 249 (21.3%) were chosen correctly. The lowest being the first question asked, which only one person (0.005%) answered correctly as shown in Figure A1 in Appendix A. Only one question (question 7) in this section was answered correctly more than half of the time (58% correct) as shown in Figure A7 in Appendix A.

In the second section of the survey, participants were asked to use one word to describe an image that was presented to them. This was presented as a free-response question. An adjustment in the free-response section was made based on semantically related words according to the Oxford dictionary (Oxford University Press, 2023). The instructions asked for the participant to give a one-word response; responses that contained more than one word were removed, while hyphenated single words were kept. After data cleaning the responses from the six questions in this section, 995 of 1002 (99.3%) of total responses were deemed usable. In total, 383 (38.5%) free response answers were considered correct after data cleaning and adjustments for semantically related words. Individual response

results appear in Figure A8 through Figure A13 in Appendix A. It should be noted that the lowest score in this section was the word embarrassed which was the correct answer for two separate questions in the free-response section. Both questions created with a prompt of embarrassment received only 5% of correct answers after data cleaning and adjustments. Other free-response questions received many more correct responses, such as question 8 created with a prompt of a person experiencing happiness (65%) and question 11 created with a prompt of a person who is angry (85%).

In the third section of the survey, participants were asked true or false questions. Each question presented the participant with an image and asked if they thought the image related to an emotion. Four of the six questions had a correct answer of true, while two questions had a correct answer of false. Interestingly, question 14 asked participants, "Would you say this person is Approachable?". The image shown to participants is an old man with a long white beard in a red hoodie staring directly at the participant. This was the only image of an elderly individual. Over half of participants (59.9%) answered "No" to the question. However, the image was generated using the prompt "a person that is very approachable". Results for this section can be seen in Figure A14 through Figure A19 in Appendix A. In the true or false section, 57.6% of responses were correct. In this section, some questions had a high correct response rate, such as question 15 which had 90% correct responses, question 18 which had 74% correct responses, and question 19 which had 71% correct responses.

The final section of the survey, participants were asked seven multiple-choice questions with four options for each answer choice. Participants were asked to pick which image best represents a given emotion. In this section, each option contained an image. In total, 64.5% of questions in this section were answered correctly. These responses are shown in Figure A20 through Figure A25 in Appendix A. Four questions received a high correct response rate; question 20 received 92% correct responses, question 24 received 86% correct responses, question 21 received 82% correct responses, and question 23 received 86% correct responses.

In total, 44% of responses were correct (Note: This total includes the data cleaning and adjustments made to free response questions). In 40% of questions, most participants were able to determine the correct answer.

Conclusions:-

Although gender disparities are not prominently evident, the disconcerting racial inequalities depicted in Midjourney's generational images highlight a pervasive lack of inclusivity. Notably, a singular image featured an elderly individual, another portrayed an individual with a disability (albeit potentially unintentional), and merely three images showcased non-white individuals. These findings align with the conclusions of previous researchers, including Gupta et al. (2022) and Marinucci et al. (2023), affirming the existence of racial and gender biases within artificial intelligence applications.

Given that less than half of the participants provided correct answers, it is reasonable to question the accuracy of AI-generated images. Notably, instances of remarkably high or low correctness, exemplified by the 92% accuracy for question 20 prompted with "Which picture would you say represents the word Shy?" and the 5% accuracy for questions 10 and 13 prompted with "embarrassment," indicate a significant variability in Midjourney's ability to portray emotions accurately. This discrepancy implies that, while the program may proficiently capture certain emotions, it encounters challenges in accurately rendering others.

Overall, the results suggest that artificial intelligence is far from perfect. In addition to the evident racial disparities depicted in Midjourney's generational images, the limited representation of elderly individuals and individuals with disabilities raises concerns about the platform's inclusivity. The underrepresentation, intentional or not, contributes to the growing body of evidence pointing towards systemic biases in artificial intelligence applications. Furthermore, the substantial variation in participant accuracy, as exemplified by the stark contrast in correctness percentages for different emotions, underscores the inconsistency and limitations in Midjourney's ability to accurately portray diverse emotional states. These findings collectively reinforce the notion that the current state of artificial intelligence, exemplified by the examined model, is characterized by notable deficiencies and biases in both visual representation and emotional interpretation.

Limitations and Further Research:-

Sample size was a major issue for issues of bias. While the sample size was large enough to draw conclusions that there are obvious bias issues, a larger number of images could be generated to determine how biased Midjourney is in terms of skin color, gender, and other qualities. One suggestion would be to recreate this experiment with a much larger sample size to focus more on potential biases.

Future studies relating to emotions could focus on a particular subset of emotions included in this study. The emotions depicted in this study included confusion, happiness, pride, sadness, boredom, embarrassment, friendliness, nervousness, shyness, anxiety, amusement, arrogance, curiosity, excitement, love, jealousy, surprise, trustworthiness, guilt, and anger. While this study included a broad range of emotions, exploration into issues caused by generating a certain emotion could warrant its own study. Additionally, there may be further unexplored relationships between the interaction of accuracy and bias of generative AI. While this survey found that the only image of an elderly man had low accuracy, a larger sample size of images depicting elderly individuals would provide more information on this potential issue.

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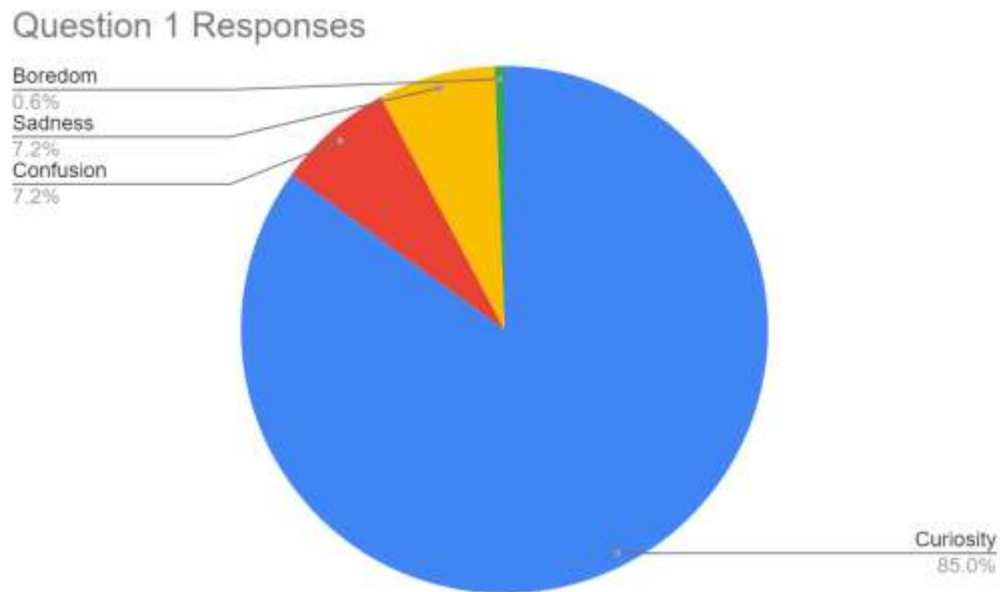
Appendix A:-

Figure A1:- Question 1.



Question: What word would you associate most with this picture?
Photo for Question 1
Prompt: boredom
Correct Answer: Boredom

Figure A2:- Responses to Question 2.



Question: What word would you associate most with this picture?

Photo for Question 2:-



Prompt: jealousy
Correct Answer: Jealousy

Question 2 Responses

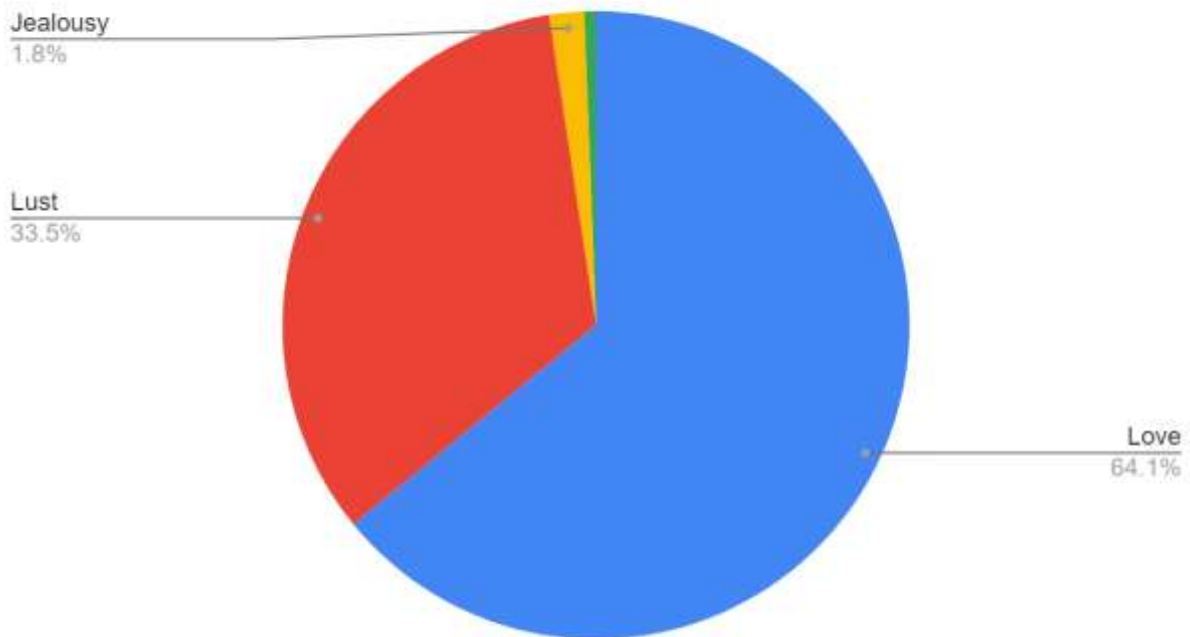


Figure A3:- Responses to Question 3.



Question: What word would you associate most with this picture?
Photo For Question 3

Prompt: a person who is prideful
Correct Answer: Prideful

Question 3 Responses

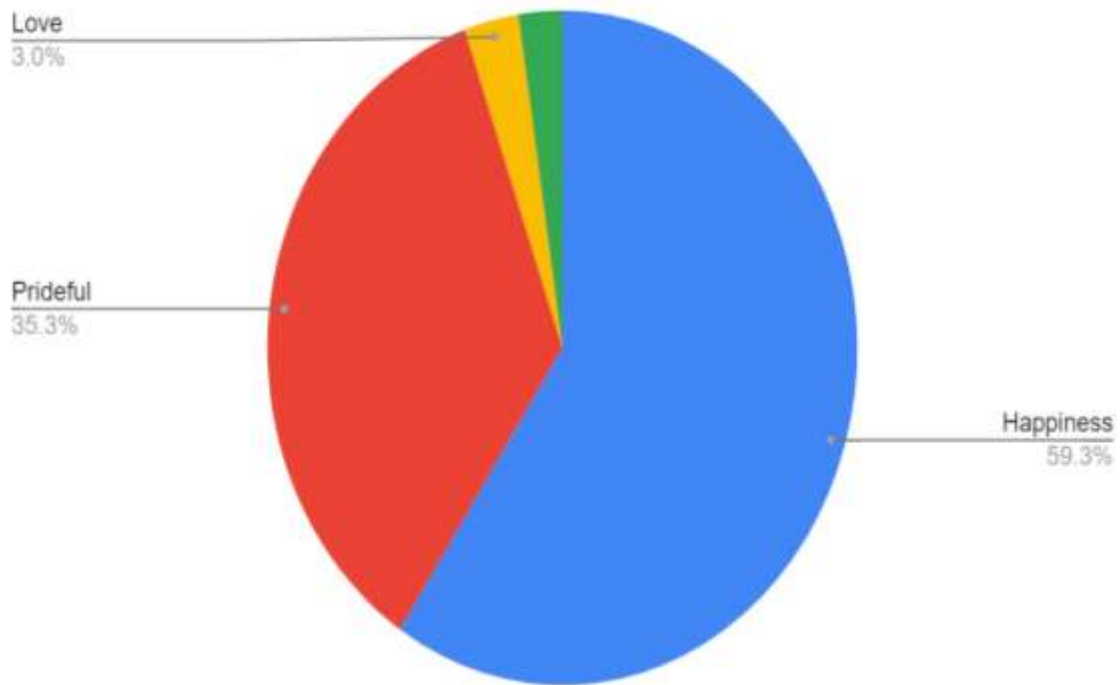


Figure A4:- Responses to Question 4.
Question: What word would you associate most with this picture?



Photo For Question 4

Prompt: a person who is surprised
Correct Answer: Surprise

Figure A4:- Responses to Question 4.

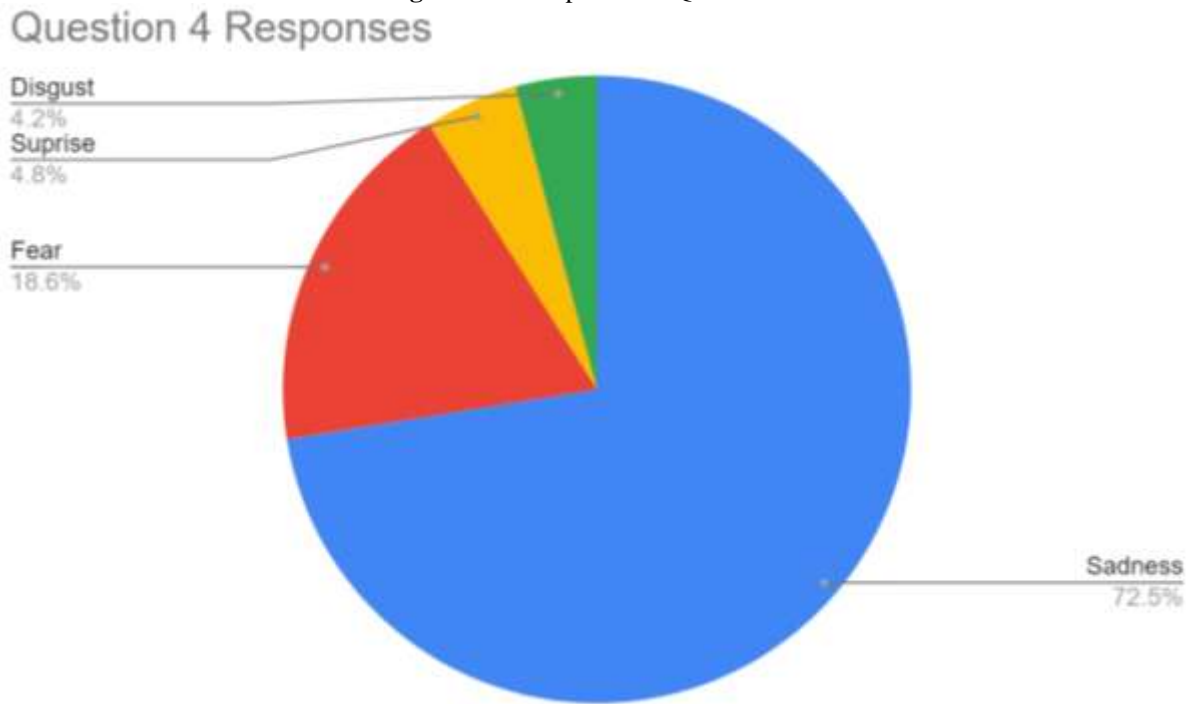


Figure A5:- Responses to Question 5.



Question: What word would you associate most with this picture?

Photo for Question 5

Prompt: someone who appears to be very nervous

Correct Answer: Nervousness

Question 5 Responses

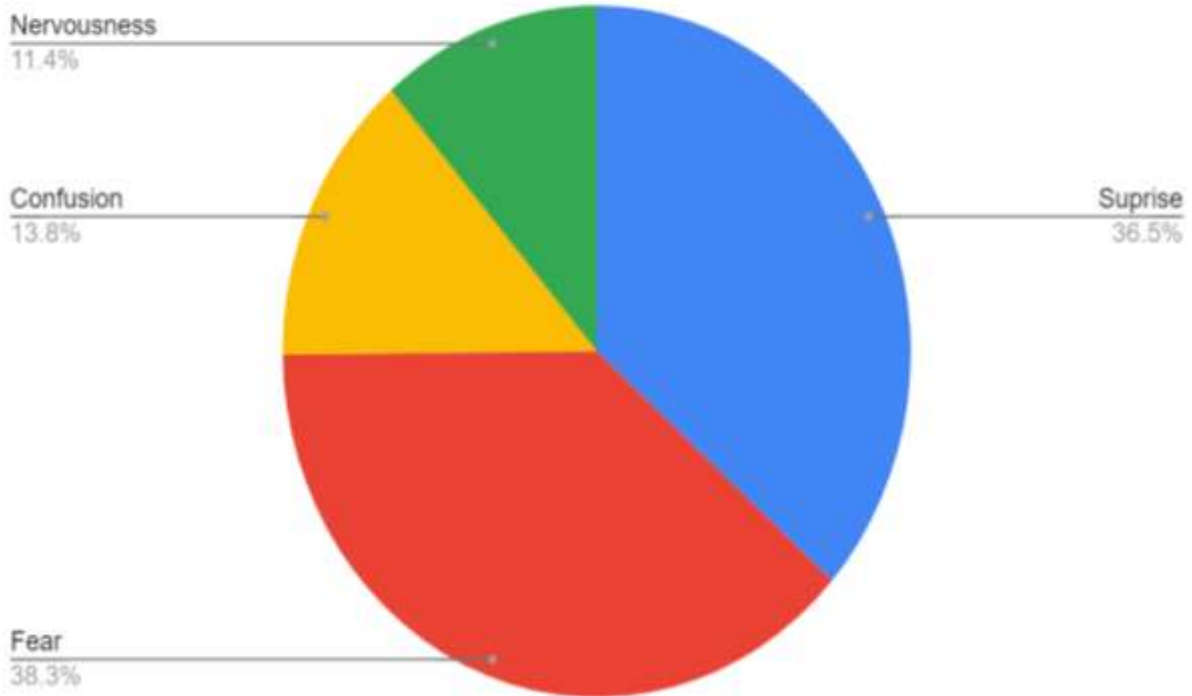


Figure A6:- Responses to Question 6.

Question: What word would you associate most with this picture?



Photo for Question 6
Prompt: friendliness
Correct Answer: Friendliness

Question 6 Responses

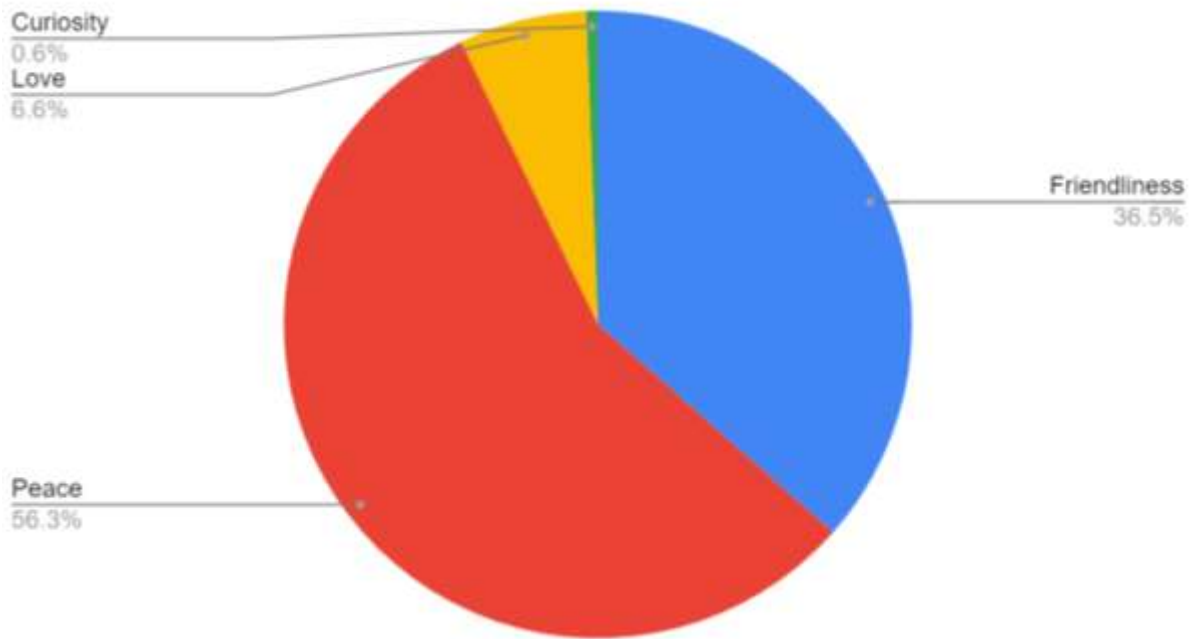


Figure A7:- Responses to Question 7.

Question: What word would you associate most with this picture?



Photo for Question 7
Prompt: Trustworthiness
Correct Answer: Trust

Question 7 Responses

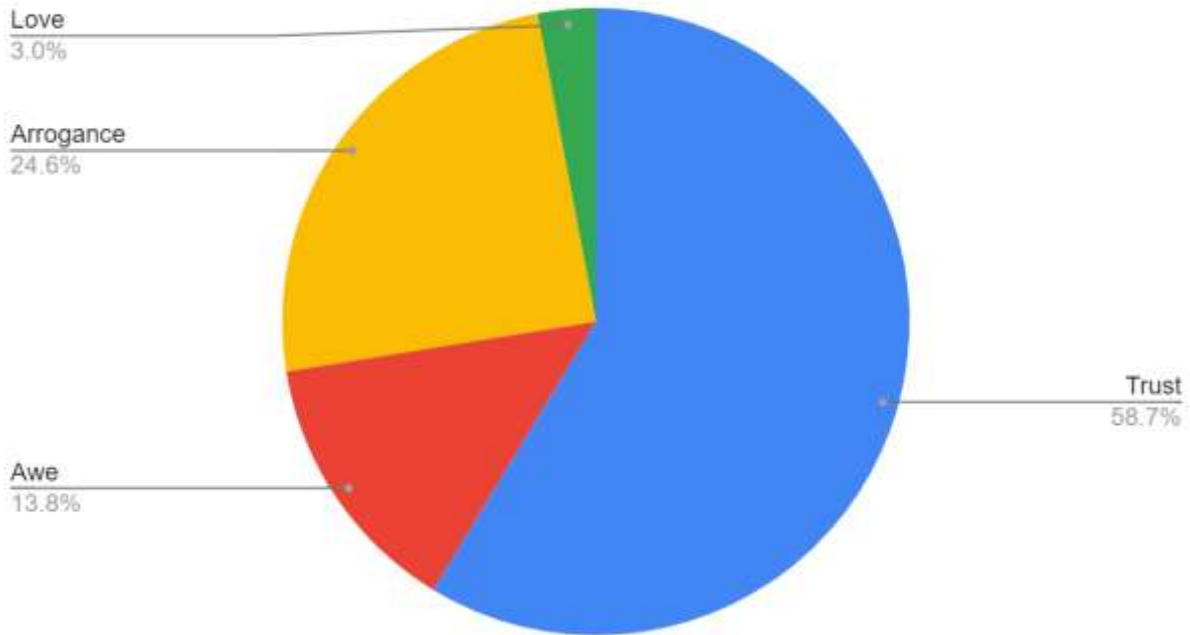


Figure A8:- Responses to Question 8.



Question: Write ONE word you would use to describe this picture

Photo for Question 8

Prompt: a person experiencing happiness

Correct Answer: Happiness

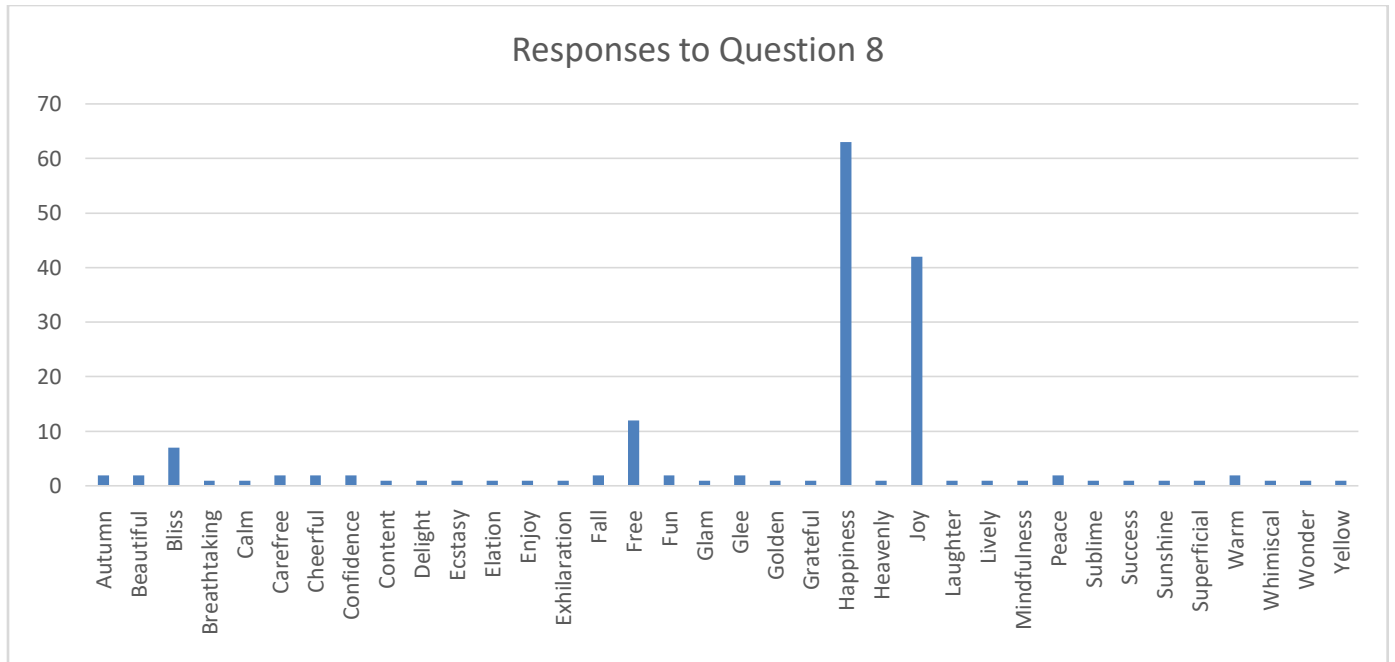


Figure A9:- Responses to Question 9.



Question: Write ONE word you would use to describe this picture

Photo for Question 9

Prompt: a person experiencing pride

Correct Answer: Pride

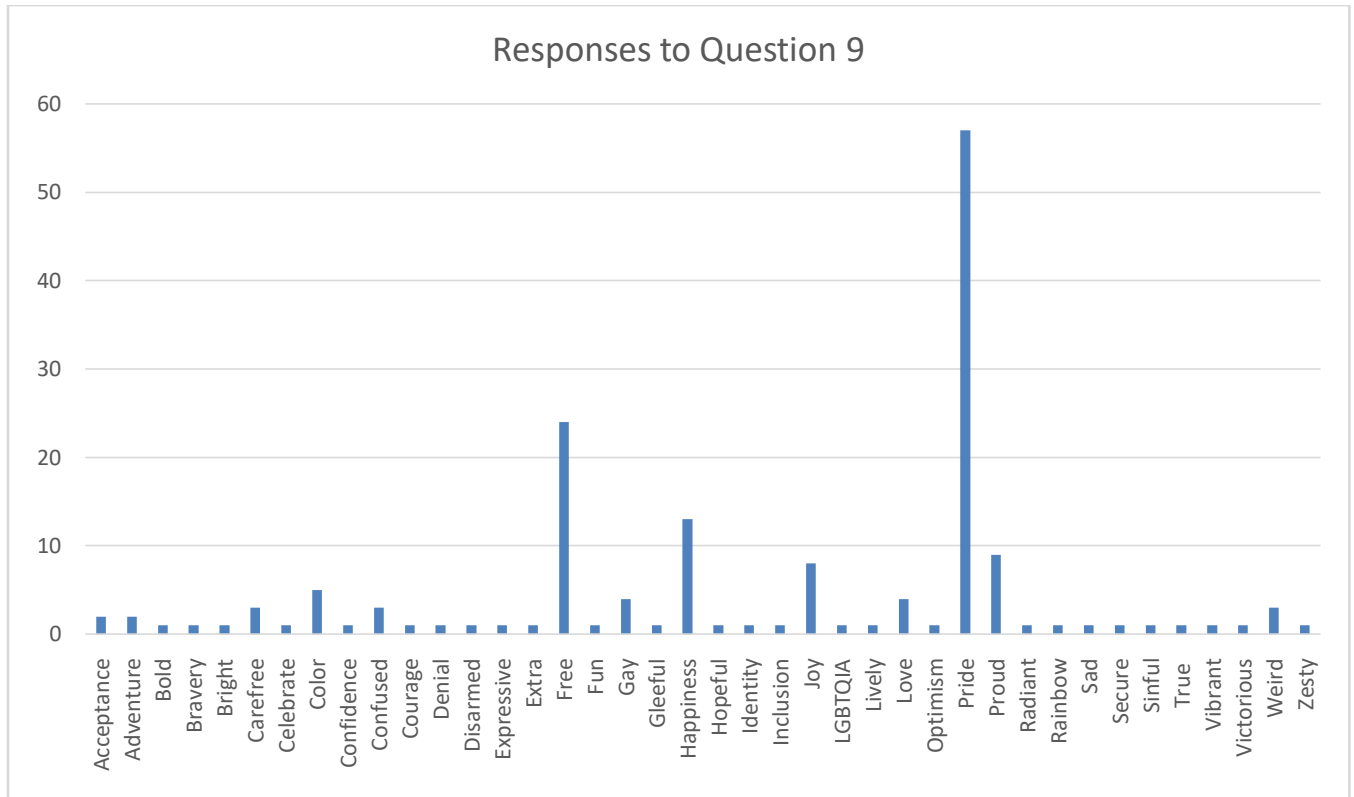


Figure A10:- Responses to Question 10.



Question: Write ONE word you would use to describe this picture

Photo for Question 10

Prompt: a person who is Embarrassed

Correct Answer: Embarrassed

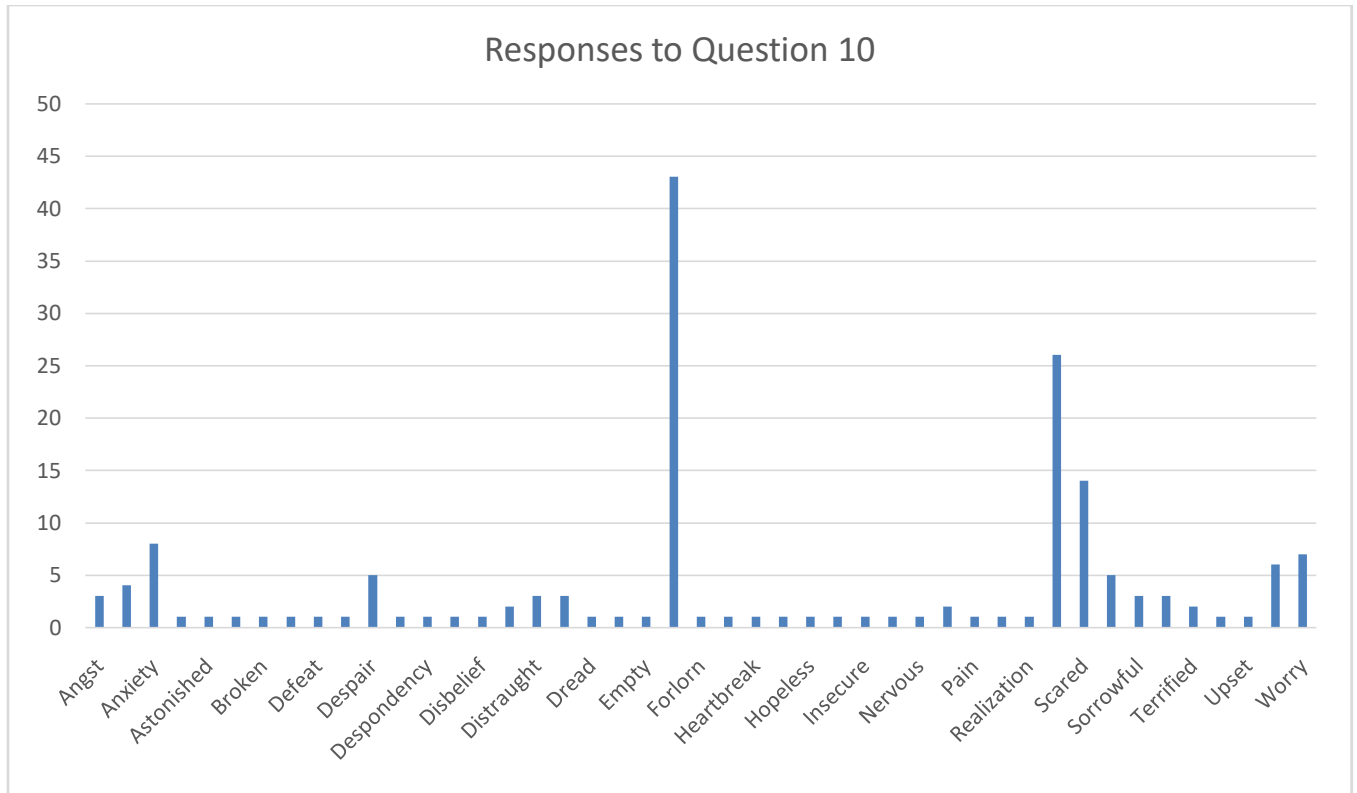


Figure A11:- Responses to Question 11.

Question: Write ONE word you would use to describe this picture



Photo for Question 11

Prompt: a person who is angry
Correct Answer: Anger

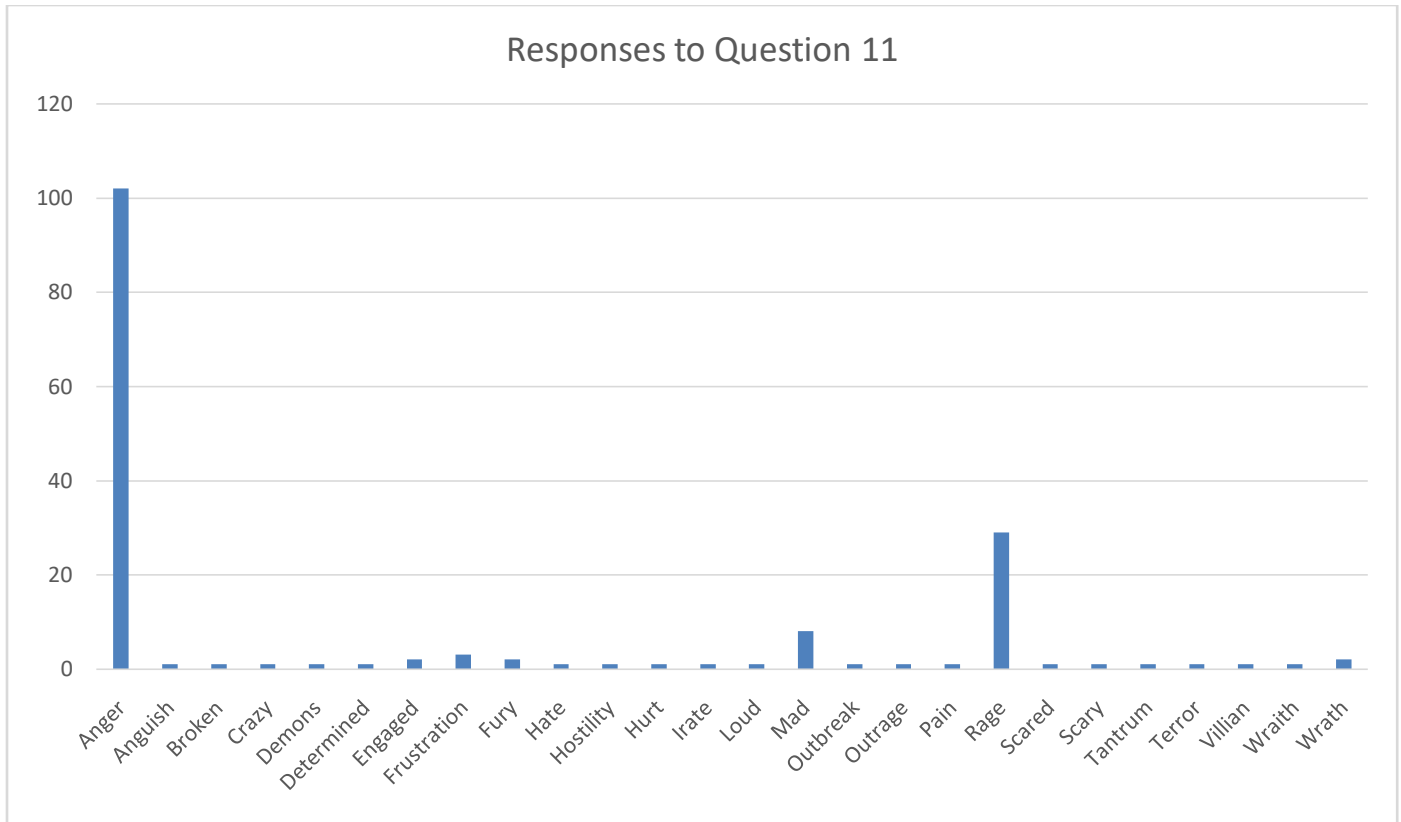


Figure A12:- Responses to Question 12.

Question: Write ONE word you would use to describe this picture



Photo for Question 11

Prompt: a person experiencing confusion
Correct Answer: Confusion

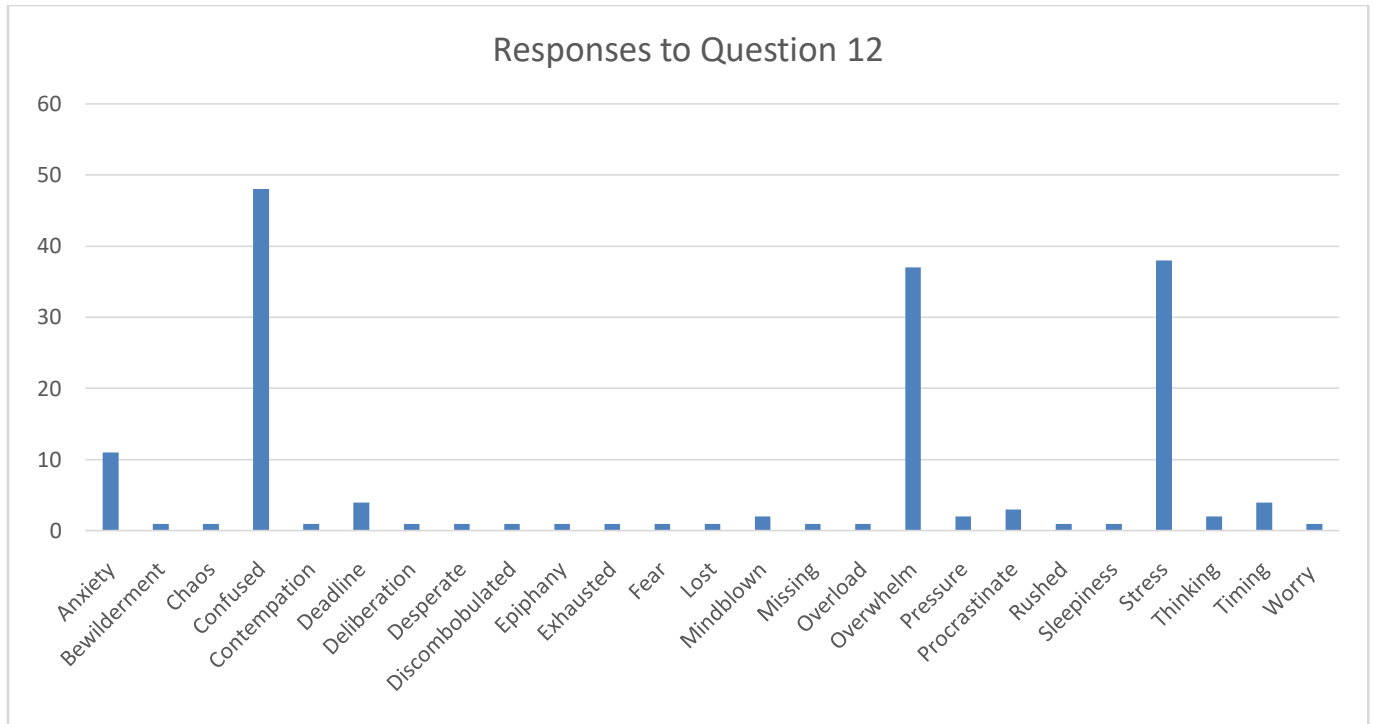


Figure A13:- Responses to Question 13.

Question: Write ONE word you would use to describe this picture



Photo for Question 13

Prompt: a person expressing guilt

Correct Answer: Guilt

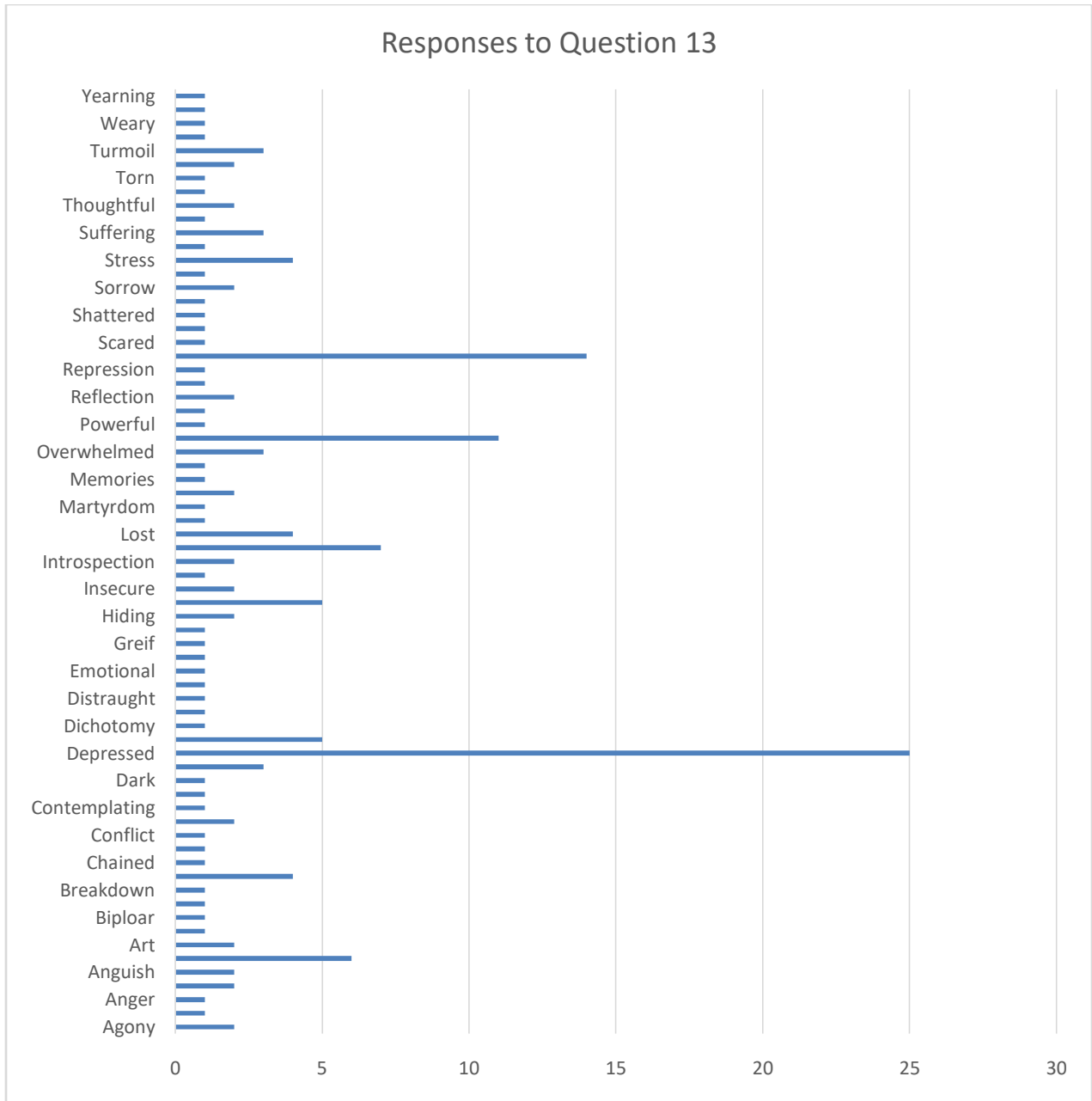


Figure A14:- Responses to Question 14.



Question: Would you say this person is Approachable?
Photo for Question 14

Prompt: a person that is very approachable
Correct Answer: Yes

Responses to Question 14

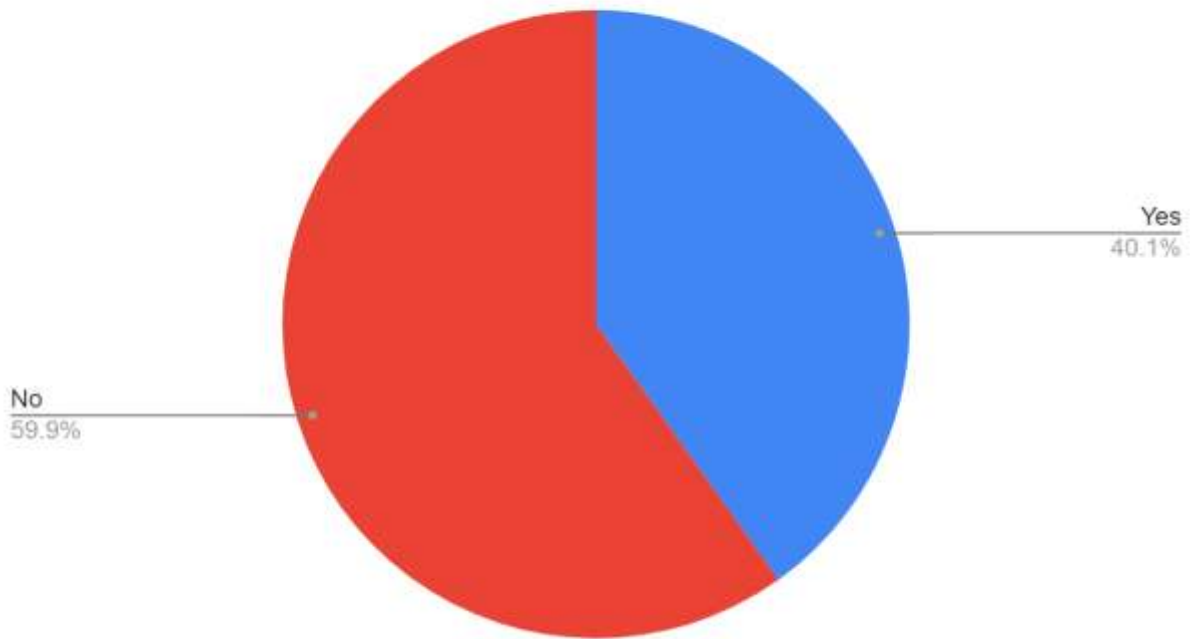


Figure A15:- Responses to Question 15.

Question: Would you say this person is Sad?



Photo for Question 15

Prompt: a person experiencing sadness
Correct Answer: Yes

Responses to Question 15

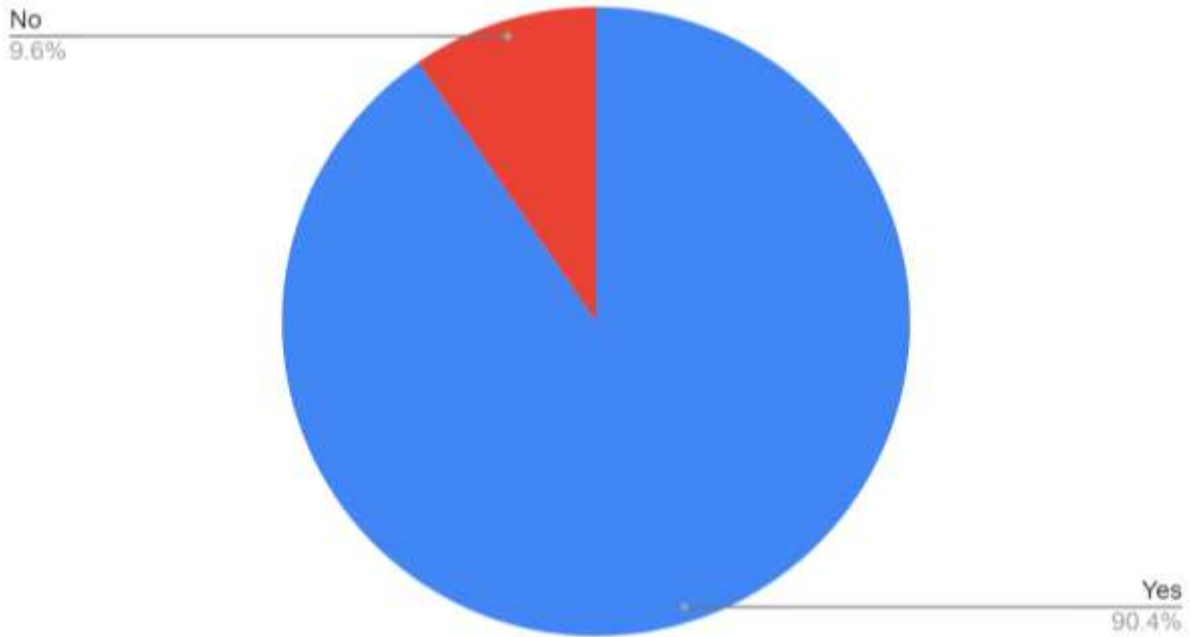


Figure A16:- Responses to Question 16.

Question: Would you use the word Love to describe this picture?



Photo for Question 16:-

Prompt: friendliness
Correct Answer: No

Responses to Question 16

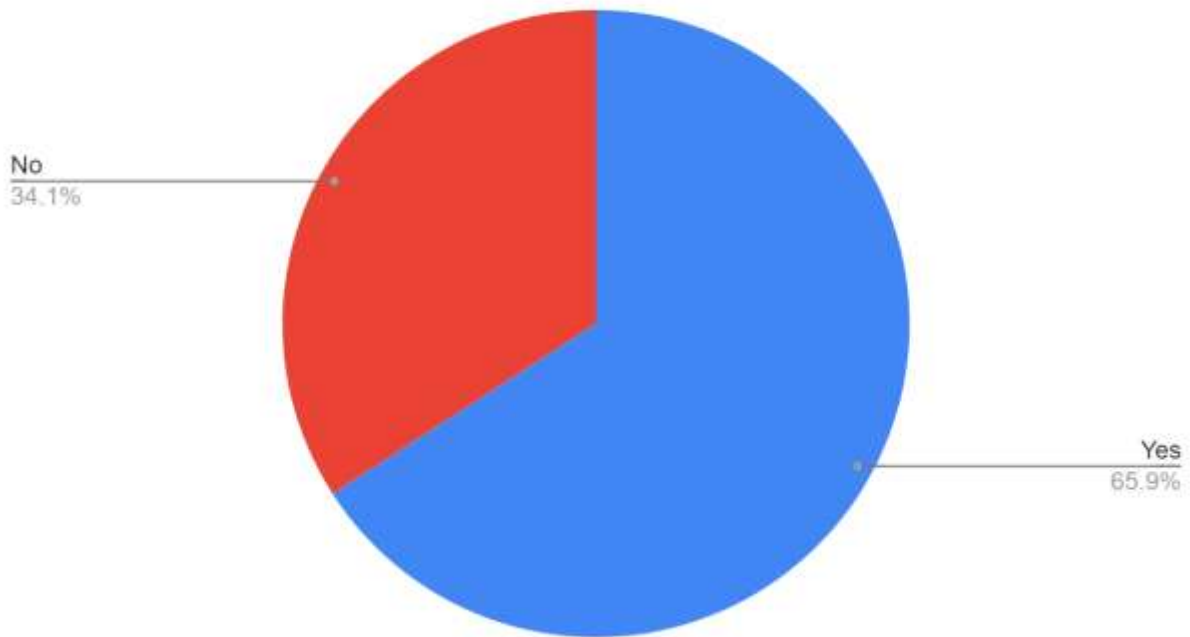


Figure A17:- Responses to Question 17.

Question: Would you say this person is feeling Embarrassed?



Photo for Question 17

Prompt: a person who is embarrassed

Correct Answer: Yes

Responses to Question 17

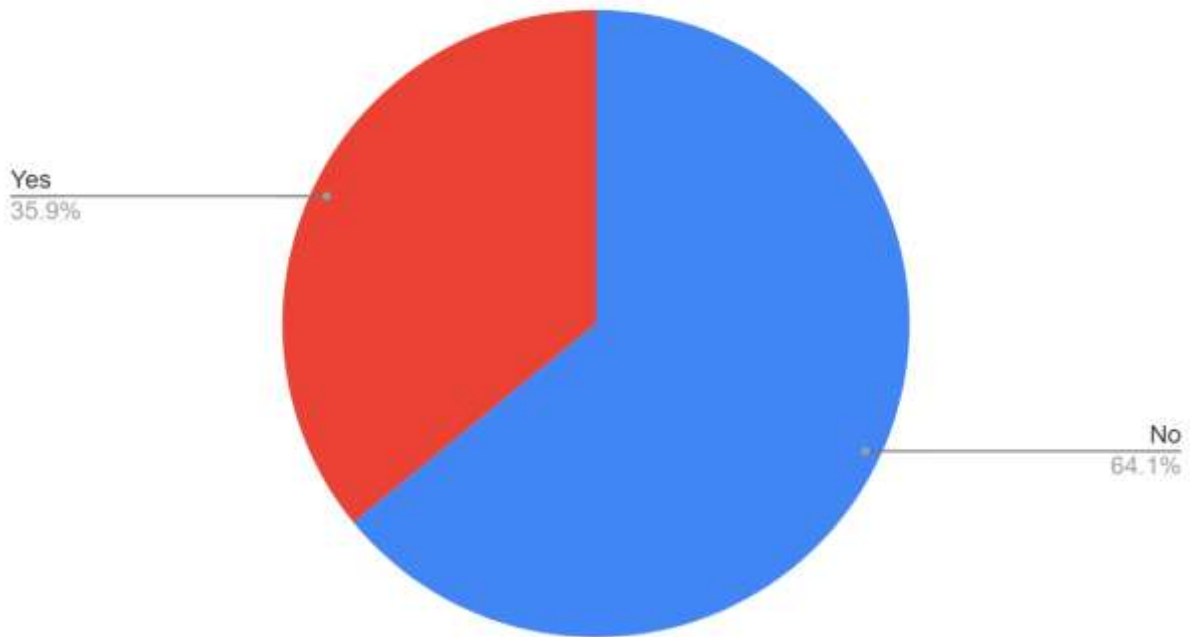


Figure A18:- Responses to Question 18.

Question: Would you say this person is experiencing Boredom?

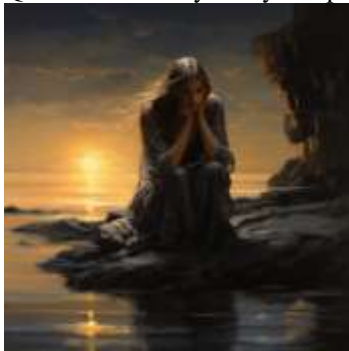


Photo for Question 18

Prompt: guilt

Correct Answer: No

Responses to Question 18

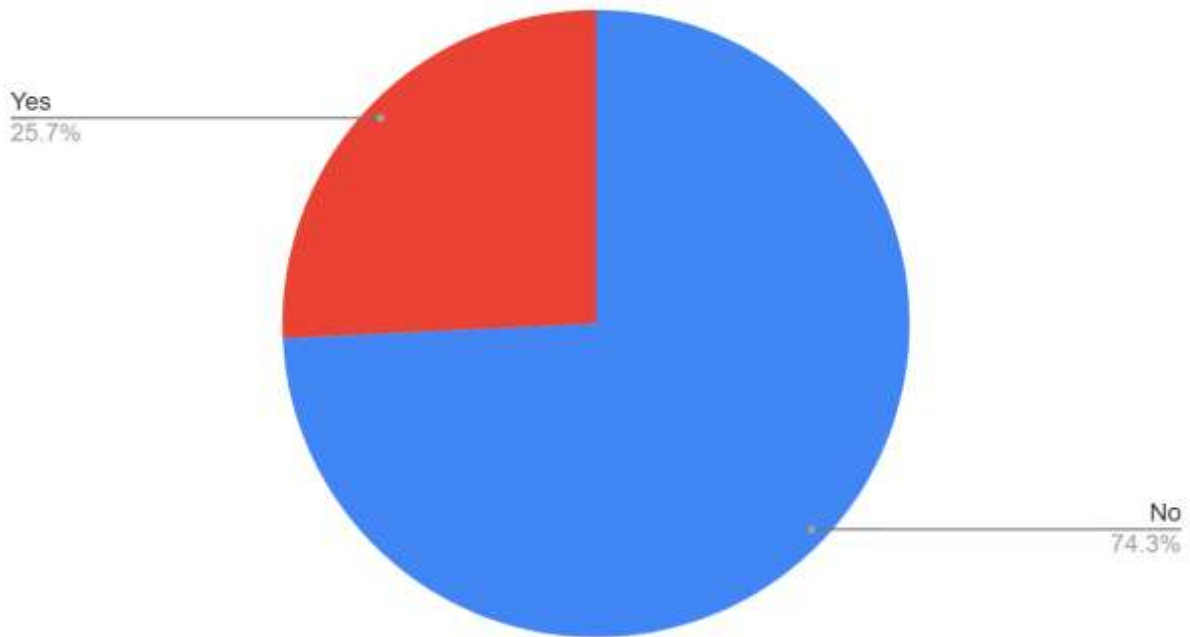


Figure A19:- Responses to Question 19.

Question: Would you say this person is Prideful?



Photo for Question 19

Prompt: a person experiencing the emotion pride

Correct Answer: Yes

Responses to Question 19

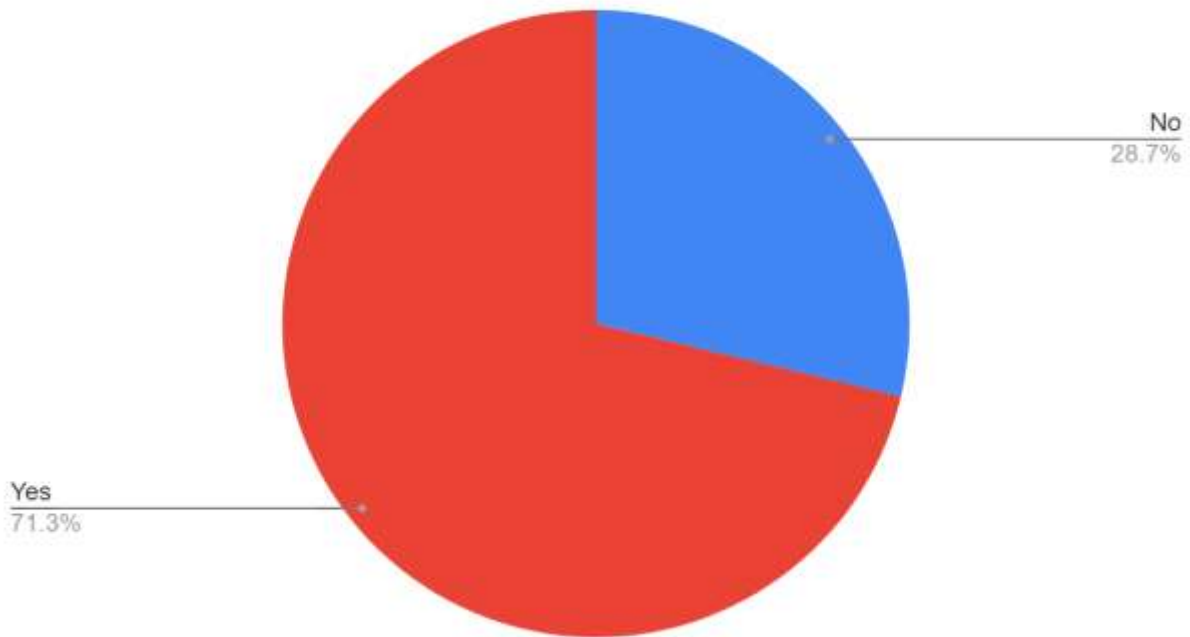


Figure A20:- Responses to Question 20.

Question: Which picture would you say represents the word Shy?



Photos for Question 20

Prompts: arrogance, a person who is bored, love, a shy person

Correct Answer: Option 4

Responses to Question 20

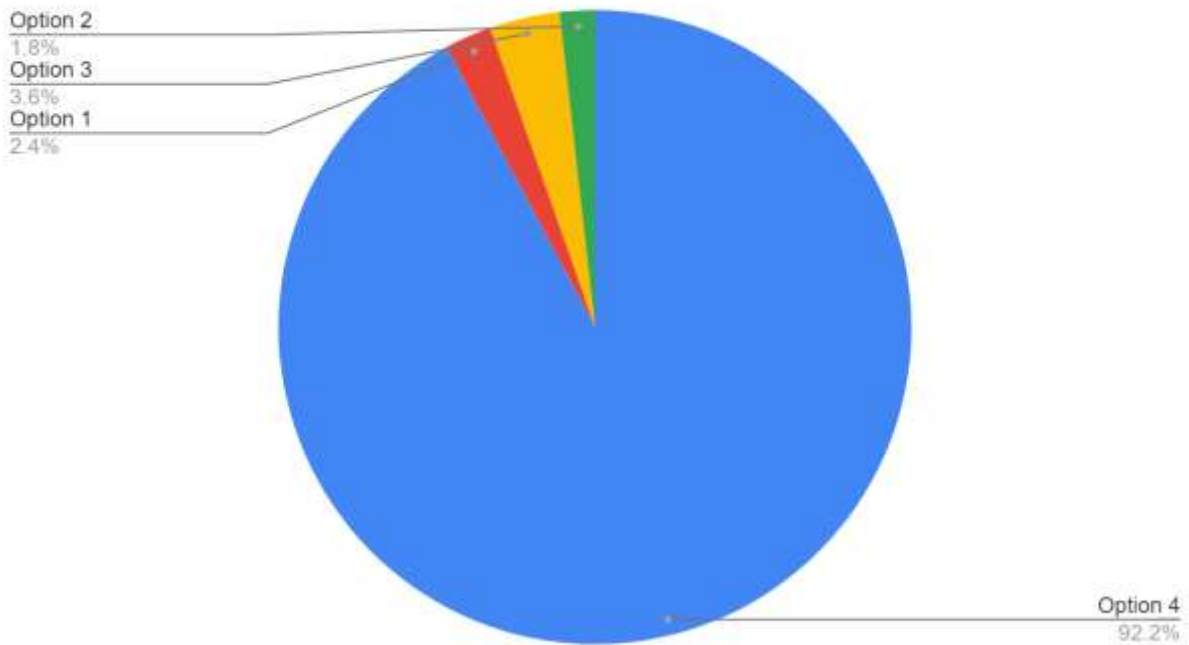


Figure A21:- Responses to Question 21.

Question: Which picture would you say represents the word love the most?



Photos for Question 21

Prompts: a person who is friendly, jealousy, a person experiencing love, amusement

Correct Answer: Option 3

Responses to Question 21

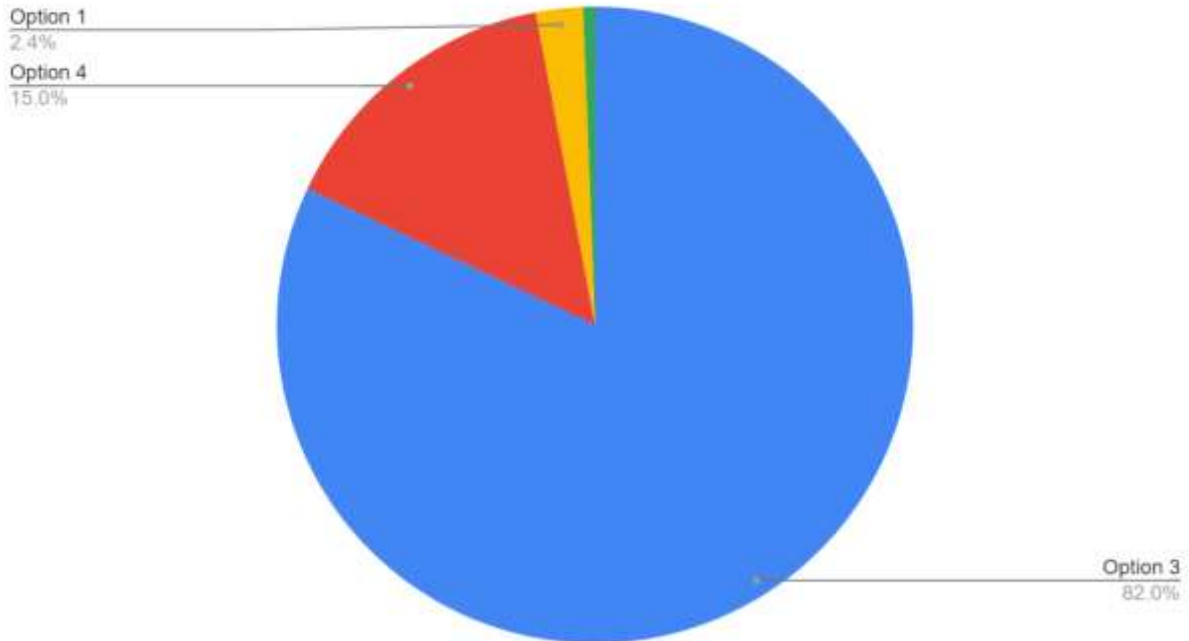


Figure A22:- Responses to Question 22.

Question: Which picture would you say represents the word Sadness the most?



Photos for Question 22

Prompts: a person expressing guilt, a person who is bored, anxiety, a person experiencing sadness

Correct Answer: Option 4

Responses to Question 22

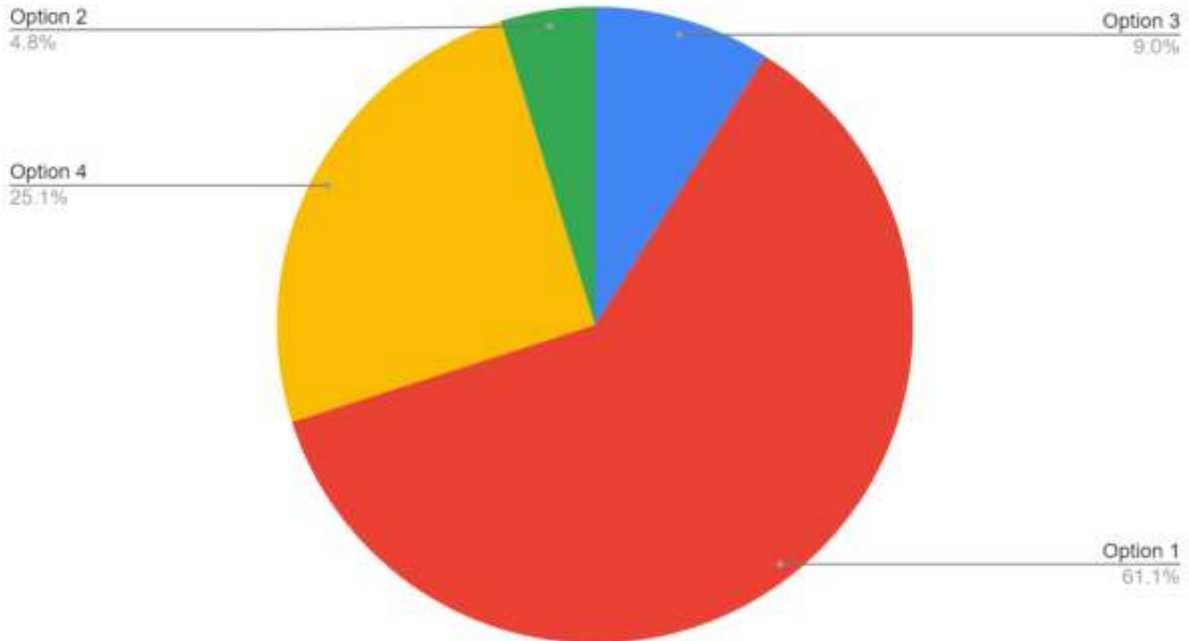


Figure A23:- Responses to Question 23.

Question: Which picture would you say represents the word Confusion.



Photos for Question 23

Prompts: a very curious person, a person experiencing confusion, a person who is embarrassed, anxiety

Correct Answer: Option 2

Responses to Question 23

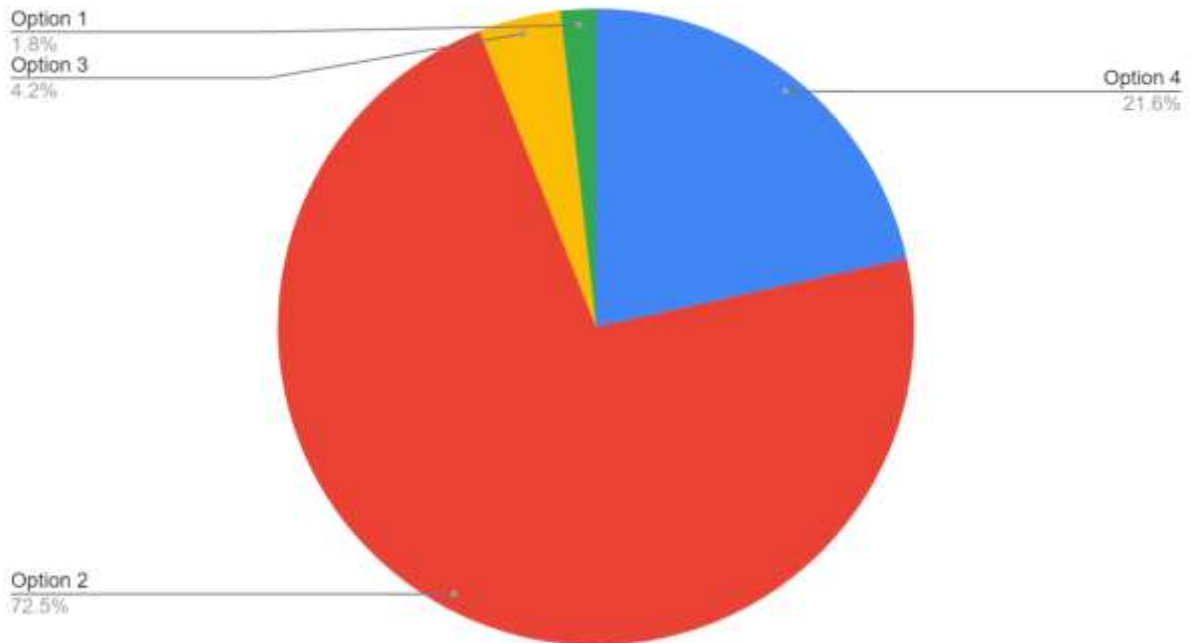


Figure A24:- Responses to Question 24.

Question: Which picture would you say represents the word Excitement the most?



Photos for Question 24

Prompts: excitement, a person experiencing happiness, surprise, friendliness

Correct Answer: Option 1

Responses to Question 24

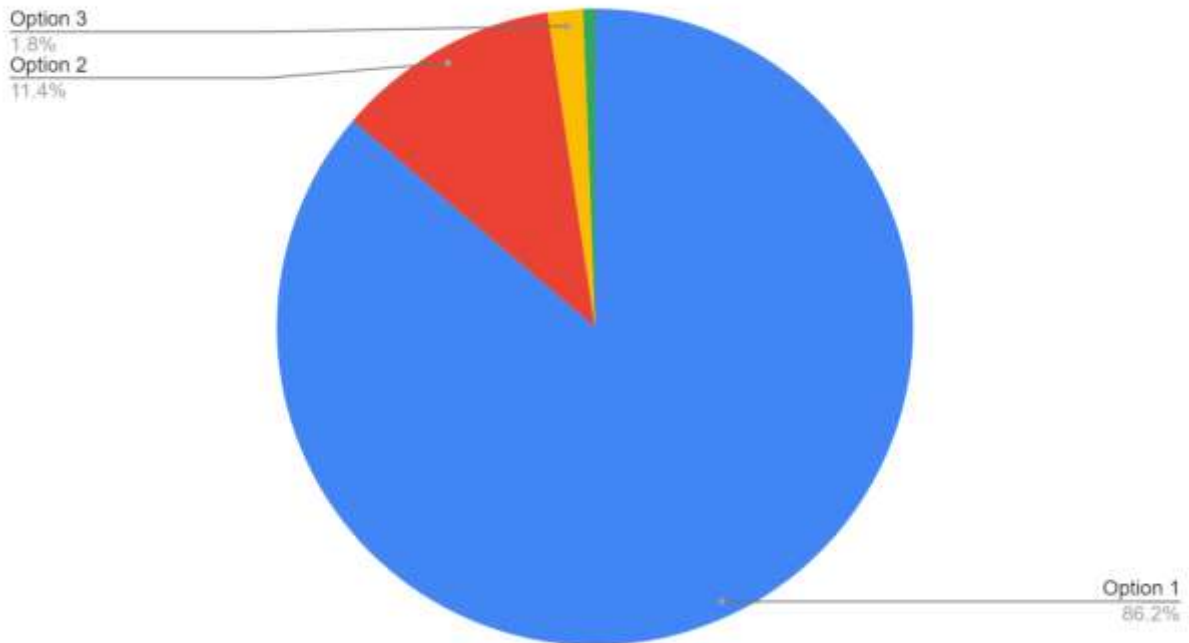


Figure A25:- Responses to Question 25.

Question: Which picture would you say represents the word Approachable the most?



Photos for Question 25

Prompts: a person who is friendly, a person who is friendly, a person that is very approachable, a shy person

Correct Answer: Option 3

Figure A25: Responses to Question 25

Responses to Question 25

