333

The Impact of Differences in Virtual Human Characteristics on User Emotion - EEG Data Investigation

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Background

Virtual Humans (VH's) are advanced 3D Graphical User Interfaces (GUIs) with human-like characteristics, with significant potential across various application domains. VH effectiveness may be evaluated on the trust rapport with users, a factor influenced by attributes such as, voice modulation, eye contact, and facial expression. Preliminary research highlights the importance of human-like characteristics in VH, emphasizing their potential to enhance user experience and foster trust. However, concerns persist regarding algorithmic versus human judgement, emphasizing the importance of comprehending the nuanced dynamics of human - VH interactions.

Research Hypothesis

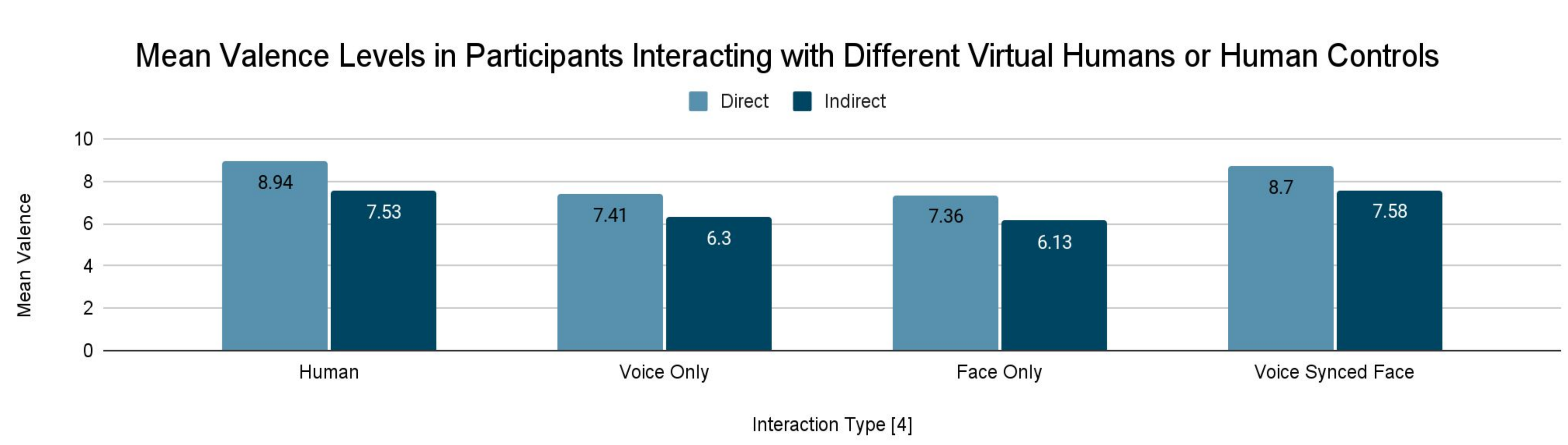
This study investigates the interaction between users and VH based interfaces and attempts to quantify the effect of this interaction analyzing electroencephalographic (EEG) data. User emotional responses to such advanced UIs may provide insights for the development of empathetic and responsive VH technologies in diverse professional and personal contexts.

The expected results of this analysis are that the EEG data for a user will be furthest from their baseline EEG data when the user is interacting with the VH with the least human-like characteristics. Additionally, it is expected that similar patterns of change will be observed in the EEG data of users overall as they interact with each VH instance.

Preliminary Work

VH's may be driven by various AI algorithms and they may be trained for content-specific conversations [1]. They listen, respond, and engage in dialogue with learners. In a phenomenon known as "algorithm avoidance," people are inclined to trust human judgment over the judgment of an algorithm, which can lead to incorrect results as algorithms often perform better than humans [2]. Several factors can influence the trust a human holds towards VHs. Increasing ease of use, usefulness, anthropomorphism, perceived intelligence, and perceived animacy can improve a human's attitude toward a VHs [3]. Prior research shows that interactions between a human and a VH are more positive when the VH has an expressive facial embodiment than when the VH has no facial embodiment [4]. Research shows that an increase in human-like characteristics in a VH elicit stronger social responses in humans.

During a study conducted on student participants, statistically, the participants described the text–to–speech voice as boring, eerie, and supernatural [5]. The participants believed the recorded voice was easier to understand. Human emotions are created by the brain and can be analyzed using EEG data, however due to differences in individuals, emotions are complex to decode. Brainwaves are classified into five groups [6]: delta waves range from approximately 1-3 Hz, theta waves range from approximately 4-7 Hz, alpha waves range from approximately 8-12 Hz, beta waves range from approximately 13-30 Hz, and gamma waves range from approximately 30-50 Hz. One common approach to classifying brain waves into emotions attempts to correlate each emotion with a specific brainwave pattern. Another common approach is to classify emotions using the valence-arousal-dominance model [7].



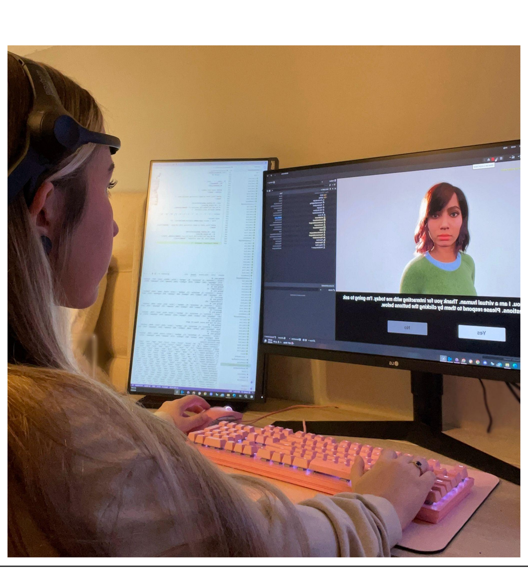
Methodology or Approach

Participants are given pre-experiment survey and time wearing the BCI to get baselines.

a) Participants are assisted with the BCI headset placement.
b) Participants are in a quiet setting without visual distractions during the collection of baseline data.

Each participant goes through twelve trials featuring varying trait qualities in the virtual human.

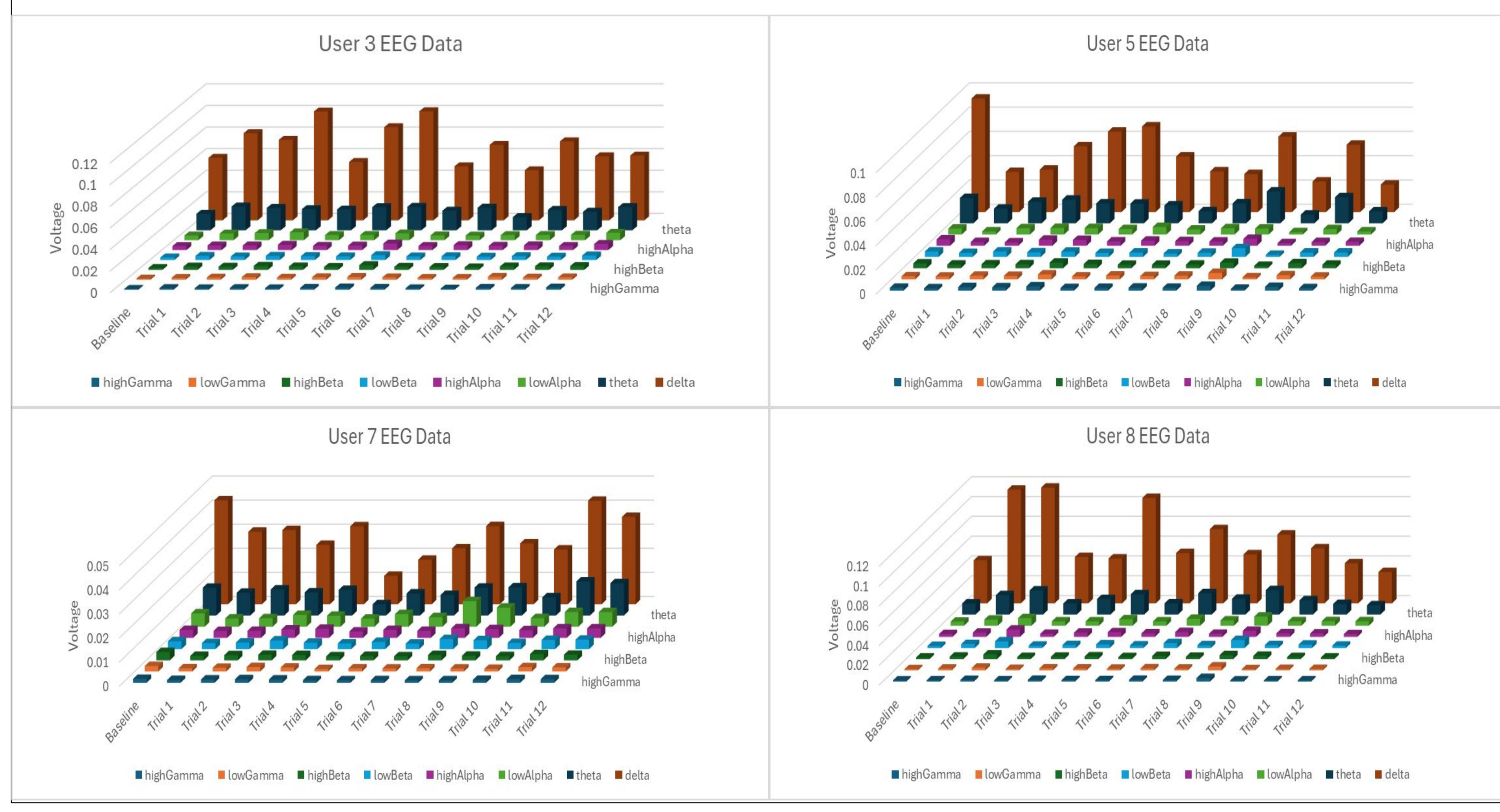
a) Participants answer some questions from the virtual human as BCI records brainwave data.
b) Participants given post-trial survey.



BCI data and survey answers are analyzed.

a) For each user, the mean of each frequency band is calculated for each trial.
b) These averages are compared across all users and trials.

Results and Findings



Discussion

Our methodology employs a unique amalgamation of characteristics across different levels, with each trial incorporating a combination of these traits. These trials were carefully constructed to investigate the impact of human-like attributes on the likability of virtual humans. Specifically, we examined the influence of voice type (Robot, Artificial, and Human), eye contact (Yes or No), and animation (Yes or No) on participants' perceptions. Notably these characteristics were integrated simultaneously in each trial, allowing for a comprehensive exploration of their combined effect. Despite the robustness of our study design, wherein each trial represented an incremental increase in complexity, the EEG analysis results did not consistently demonstrate discernible patterns in brainwave data across various levels of virtual human interaction.

In addition to our EEG analysis, we conducted pre-experiment and post-trial questionnaires to gather qualitative data on participants' perceptions following each interaction level. These questionnaires provided valuable insights into users' subjective experiences and allowed us to complement the EEG findings with rich qualitative data. Analyzing the responses across the 12 trials and considering the different configurations of the virtual human (varying voice type, eye contact, and animation presence), a trend can be observed relating to the perception of the virtual human by users before and after the interaction.

Conclusion

- Based on variations in eye contact, voice quality, and facial animation, there appears to have been no uniform trend in EEG data changes across all users.
- Additional research with a larger sample size is required to confirm or negate these findings.
- The responses across the 12 trials and considering the different configurations of the virtual human (varying voice type, eye contact, and animation presence), a trend can be observed relating to the perception of the VH by users before and after the interaction.
- Voice Type: Trials with a human voice (Trials 3, 6, 9, and 12) tend to have more positive responses compared to those with robot or artificial voices, especially when combined with eye contact and animation.
- Eye Contact: Introducing eye contact (Trials 4-6, 10-12) generally leads to more positive or very positive responses compared to trials without eye contact (Trials 1-3, 7-9), suggesting that eye contact significantly influences user perception positively.
- Animation: The presence of animation (Trials 7-12) tends to improve the user's response, moving from neutral or negative to more positive responses, especially when combined with human voice and eye contact (Trial 12), indicating that animation enhances the perceived warmth or liveliness of the VH.
- The most notable positive shift in responses is observed in trials where all features (human voice, eye contact, animation) are combined (Trial 12), indicating that users respond more positively to the most human-like interactions.
- In summary, the trend indicates that features making the VH more human-like (human voice, eye contact, animation) lead to more positive responses. The most favorable responses come from the combination of all three features, underscoring the importance of designing VHs with human-like characteristics for positive user interaction.

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