

Exploring the Uncanny Valley Effect of Motion Capture films through Anthropomorphism and Negative Emotions

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Abstract

This study was conducted with the aim of exploring whether watching a Motion capture (Mo-cap) movie can result in the Uncanny Valley (UV) effect amongst the young-adult population via the factors of Anthropomorphism and Negative Emotions (NE). Three objectives were brought forward; assess perceived anthropomorphism in Mo-cap films, examine NE induced by Mo-cap characters, and determine if both factors together elicit the UVE. The participants were divided into 3 groups, with each group having 15 participants. Each group viewed a different movie – animated, Mo-cap, and real. Afterwards, participants were instructed to fill the Godspeed questionnaire Series (GQS) and the Discreet Emotions Questionnaire (DEQ) to measure Anthropomorphism and NE respectively. The Mo-cap movie was not significantly different in anthropomorphism levels but did showcase higher levels of NE within the participants. The UVE was not observed due to high levels of anthropomorphism and NE was not of significant occurrence.

Keywords: Uncanny Valley effect, anthropomorphism, negative emotions, motion capture movies.

Introduction

Introduced in 1910s, the Motion Capture (Mo-cap) technology used visible markers to capture an individual's anthropomorphic features. With its evolution over the years, certain films were developed solely relying upon Mo-cap, which most audience have reported to cause Negative Emotions (NE) such as eeriness and repulsion. This effect, coined as the Uncanny Valley Effect (UVE) by Masahiro Mori in 1970, occurs when animated/robotic entities display anthropomorphic features over 70% of human likeness (Mori et al., 2012). While this may seem like a direct relationship, studies like that of Kätsyri et al. (2017) and Zlotowski et al. (2015) proposes a much more complex interaction.

As prior discussed, movies have been produced solely based on Mo-cap technology; however, this high realism has been found to affect the viewer's trust (Kätsyri et al., 2017). Zlotowski et al. (2015) however, has shown that despite being highly anthropomorphic, if the entities were polite in nature, the levels of repulsion were considerably lower; these findings are further supported by Ribino (2023). While Kätsyri et al. (2017) found Mo-cap movies to induce UVE, Yam et al.'s (2024) research showcases an exposure time of 50ms was enough to induce this effect.

Di Natale et al. (2023) showcases that the UVE is marked by NE and avoidance behaviors. Reuten et al. (2018) results indicate that despite being highly Anthropomorphic, if no expressions are marked on a robot, they will result in minimal empathy; contributing to this, Ratajczyk (2022) review of YouTube comments on anthropomorphic robots found viewers described these robots as “scary” and “creepy”. Miller et al. (2023) found age impacts UVE perception. Di Natale et al. (2023) also reported virtual faces appear eerier than real ones.

This study aimed to (1) assess perceived anthropomorphism in Mo-cap films, (2) examine NE induced by Mo-cap characters, and (3) determine if both factors together elicit the UVE. Based on these objectives, three hypotheses were generated: H₁ = There is a statistically significant difference in the perception of anthropomorphic features within each movie group; H₂ = There is a statistically significant difference in negative emotions within each movie group; H₃ = High levels of anthropomorphic features and negative emotions are observed only amongst the Mo-cap movie group.

Methodology

Design

Due to one group undergoing different experimental conditions, a quasi-experimental design was adopted. Participants were divided equally into three groups – Animated, Mo-cap, Real (control). The variables “Anthropomorphism”, and “Negative Emotions” were measured using questionnaires. H₁ and H₂ were measured using one-way ANOVAs while H₃ was measured using a Chi-Square analysis.

Participants

The research comprised of a convenient heterogeneous sample of ($n=45$) equally distributed across 3 groups. The number of participants for this research was research based (Kätsyri et al., 2017; Pütten et al., 2019). The participants had to be in the age range of 18-25 and watched movies at least on a monthly basis while the exclusion criteria were participants who had considerably low exposure to movies.

Materials

The Godspeed Questionnaire Scale (GQS) is mainly used to measure Human-Robot interactions. Its 5 subsets of Anthropomorphism, Animacy, Likeability, Perceived Intelligence, and Perceived Safety tallied with the requirements for our research (Bartneck, 2023). The scale consisted of a 1-5 Likert scale with 1 being robotic and 5 being humanistic.

The Discreet Emotions Questionnaire (DEQ) was used to measure self-reported NE of the participants as they observed the main characters of the movie (Harmon-Jones et al., 2016). The subsets considered for the experiment were that of disgust, fear, and anxiety. The scale consisted of a 1-7 Likert scale with 1 being “Not at all” and 7 being “An extreme amount”.

The movies chosen were based on similar research (Kätsyri et al., 2017). The animated movie was “The Incredibles (2004)”, Mo-cap movie was “Beowulf (2007)”, and the real was “The Bridge to Terabithia (2007)”. Family-friendly movies were chosen to prevent any attraction bias. While the “Beowulf” movie did contain scenes with suggestive themes, they were extremely minimal in play time, resulting in a negligible level of possible attraction bias.

Procedure

Participants were recruited via a WhatsApp text outlining the study and eligibility criteria. Afterwards, the participants were divided such that each group had a number of ($n=15$). A timeslot and venue were assigned to each group based upon their availability. On the day of the experiment, the participants were instructed to watch the movie and focus on the anthropomorphic features and NE they felt when observing the main character. Distractions were restricted, and after screening, a projected QR code led them to a questionnaire consisting of the consent form, demographic details, GQS, DEQ, and a debriefing sheet. Due to issues in scheduling, the control group were told to watch their respective movies at home; they were provided with the same instructions prior to screening and the same questionnaire after screening. All procedures were followed ethically as per the conditions of Sri Lanka Institute of Information Technology Ethics Committee as well as those of Liverpool John Moores university.

Data analysis

After cleaning the gathered data, the GQS total and DEQ total were calculated. Data was then imported to SPSS, where the descriptive statistics of Shapiro-Wilk, Skewness-Kurtosis, and Levene's test were conducted to meet all the assumptions of ANOVAs and Chi-square analysis. The one-way ANOVAs tested the GQS and DEQ scores across the three movie groups. Based on expected data from literature, the cut-off scores for the Chi-square analysis were calculated. The GQS scores between 84-117 (70-95%) were indicated high anthropomorphism while DEQ scores between 42-84 indicated high levels of NE. Participants with scores tallying to both these ranges were considered to have experienced the UVE.

Results

Descriptive statistics

Table 1: Descriptive statistics for variables

	Movie Frequency	Movie group	AM_Total	NE_Total
Mean	2.11	2.00	83.29	32.22
Std. Deviation	.832	.826	15.323	14.762
Skewness	.529	.000	.188	.555
Kurtosis	-.003	-.1535	-.710	-.736

Table 1 showcases the descriptive statistics for the main variables necessary for the experiment. AM_Total indicates the data for GQS calculating anthropomorphism while NE_Total indicates data for the DEQ calculating NE. Interpreting the data, all variables can be seen to showcase a normal distribution as per the Skewness-Kurtosis values being between +2 and -2. Further analysis through Shapiro-Wilk test also indicated all variables to have a normal distribution with ($p>0.05$). The Shapiro-Wilk test was considered due to the sample size ($N<50$).

Table 2: Levene's test for homogeneity of variances of anthropomorphism and negative emotions

		Levene statistic	df1	df2	Sig.
AM_Total	Based on Mean	1.356	2	42	.269
NE_Total	Based on Mean	1.913	2	42	.160

Table 2 showcases the Levene's test scores for the Anthropomorphism and NE variables and helped determine the homogeneity of variances. With the results for Anthropomorphism and NE being, $F = (2, 42) = 1.356$, $p = .269$, and $F = (2, 42) = 1.356$, $p = .269$ respectively, they are shown to be non-significant, indicating a homogeneity among variances. With both normality and homogeneity being met, the parametric inferential stats for one-way ANOVA and Chi-square will be conducted.

Inferential statistics

Table 3: One-way ANOVA for anthropomorphism and negative emotions

		Sum of squares	df	Mean square	F	Sig
AM_Total	Between groups	3505.044	2	1752.022	10.778	.000
	Within Groups	6827.2	42	162.552		
	Total	10331.244	44			
NE_Total	Between groups	2125.644	2	1062.822	5.982	.005
	Within groups	7462.133	42	177.670		
	Total	9587.778	44			

Table 3 displays the one-way ANOVA conducted to test for anthropomorphic scores and NE scores between the groups. The anthropomorphic scores indicate there to be a significant difference between the groups, $F(2, 42) = 10.778$, $p = .000$; the NE scores also indicate a significant difference between the groups $F(2, 42) = 5.982$, $p = .005$. To test whether all groups are significantly different from one another, Tukey's HSD post-hoc was conducted. The post-hoc for anthropomorphism revealed the Mo-cap movie group were not significantly different from the Animated movie group ($p = .205$); as per these results, while H_1 can be accepted, the desired change in the Mo-cap group was not observed through the post-hoc. The post-hoc for NE also revealed there was no significant difference between the control group and animated group ($p = .827$), resulting in H_2 being accepted despite the desired outcome not being observed.

Table 4: Chi-Square test between movie groups and uncanny valley effect

	Value	df	Asymptotic significance (2-sided)
Pearson Chi-Square	1.800	2	.407
Likelihood Ratio	1.687	2	.430
Linear-by-Linear Association	.000	1	1.000

Table 4 consists of the Chi-Square test of independence conducted to examine which movie groups displayed the UVE. The relationship between the variables, however, was found not to be significant, $X^2(2, N = 45) = 1.800$, $p = .407$. Crosstabulation revealed 20% of the Mo-cap movie group, 6% of the control movie group, and 6% of the animated movie group to have experienced the UVE. While the Mo-cap movie group may have a higher percentage, H_3 has to be rejected due to the non-significant results obtained via the analysis.

Discussion

This study was conducted to examine the UVE proposed by Mori in 1970, by including NE as a variable alongside his proposed Anthropomorphism variable. Based on the literature analyzed, this is the first

experiment to utilize full-length films to test the UVE. Questionnaires GQS and DEQ were used to measure the variables. H_1 and H_2 were tested using one-way ANOVAs while H_3 was tested using a Chi-square analysis.

The analysis of the anthropomorphism related data, despite showing to be inferential did not showcase significant differences between the three groups. A factor contributing to these results could be the GQS itself as this is the first time it was used on a scenario beyond Robot-human interactions. Secondly, the Animacy subset within the questionnaire may have skewed the scores due to animated movies appearing considerably more anthropomorphic over the Mo-cap movies due to their exaggerated movements (Bhokare, 2024). Furthermore, the gender of the participants being mostly female may have also contributed in this results as Anica-Popa's (2022) research indicates that men are more sensitive to physical anthropomorphism over females. Another factor that may have contributed is the participants acclimatizing to the content presented (Zlotowski et al., 2015).

The analysis of NE once again, despite being significant and inferential, showcased no significant difference between groups; however, the Mo-cap movie group experienced significantly higher levels of NE compared to the other two. This outcome can be linked to Di Natale et al.'s (2023) findings which also showcased virtual faces trigger NE. However, similar to the caveat encountered analyzing anthropomorphism, gender may have played a role on emotions as females are considered to be more prone to NE (Chaplin, 2015).

With the anthropomorphic data not aligning with our expectations, the assumption of high NE and high anthropomorphism causing UVE remains inconclusive. A contributing factor for these results could be due to children and young-adults having frequent exposure to highly anthropomorphic entities resulting in acclimatization with those features (Miller et al., 2023). Further, the extended exposure may also have resulted in a loss of NE intensity (Ratajczyk, 2022). These findings reflect that the UVE is not driven by NE and anthropomorphism alone, but also by a complex interplay of age, gender, and levels of exposure as well.

Theoretical contributions

This study offers two main theoretical implications. The first being that via the use of full-length movies, the data on anthropomorphism levels reflects that acclimatization and gender may play a significant role in how anthropomorphism itself is perceived. Secondly, the findings on NE showcases that Mo-cap movies can induce higher levels of NE compared to other types of exposure which indicates that usage of Mo-cap technology-based media/AI models/deepfakes may need revisiting prior to being used in mass-media.

Limitations and future research

This study faced several limitations. The first of which was the control group having to undergo the experiment in a different environment due to unforeseen circumstances. Secondly, the GQS while being versatile was also noted to be vague on certain objects it measured. Thirdly, the gender distribution of the participants may also have played a significant role in the resultant data (Anica-Popa, 2022).

Future studies are recommended to use more recent movies due to the rapid development in Mo-cap technology. If self-report tools such as GQS is being used, providing thorough instructions on what each object within the instrument might result in far more accurate readings. Furthermore, a Gender-balanced sampling is encouraged to be used in replication along with gender being considered as a main variable in an alternative approach to examine the UVE.

Conclusion

This study was conducted with the aim of exploring the UV effect proposed by Masahiro Mori in 1970, using films that utilized the Mo-cap technology. While the results obtained indicated Mo-cap movies to not have any perceptual prominence in anthropomorphic features, they were found to induce notably high NEs within an individual, resulting in the lack of an UV effect; whether this is due to improper methodological limitations or flaws of the theory remains unclear. Therefore, future research exploring this theory by applying it to anthropomorphic entities beyond robots might help us to have a glimpse of this uncanny valley.

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