Exploring Realism in On-Screen Embodied Characters: Factors & Impacts

Seçil Gezer[1] | Sevdenaz Yılmaz[2] | Deren Doğan[3] | Elifnur Zengin[4]

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1. Abstract

This research studies the impacts of different realism levels in embodied onscreen characters on users' perception, interaction, and engagement. The main aim of the study is to analyze characteristics such as appearance, quality of movement, and interactivity in contributing to perceived realism. The research concerns user tests in which a group of participants views and scores embodied characters at differing levels of realism and then provides qualitative feedback. Results would show that engaging users and satisfying them vary considerably based on the characters' physical appearance and motion quality. Thus, this research is useful in developing effective human-like characters, as it relates to their design in media and interactive systems.

Keywords: realism in on-screen characters, uncanny valley, user perception, character engagement, motion quality, interactivity, user testing, cognitive responses, human-computer interaction, media design

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Group 14

[1] secilgezer@sabanciuniv.edu | 29145

[2] sevdenaz.yilmaz@sabanciuniv.edu | 30300

[3] derendogan@sabanciuniv.edu | 29561

[4] elifnur.zengin@sabanciuniv.edu | 31237

2. Background of the Study

2.1 Related Literature

The reality characters on screen have focused a lot of earlier researches into investigating how they tend to relate to the behavior of humans. Mori et al. (2012) introduced the uncanny valley theory that stated how an individual gets discomposed when a character appears to be nearly human without being completely human. As it disturbs the person's mental activity, it produces a proposition of a characters design very close to that which will be familiar to the audience so that it can be used without invoking that disturbance. Bakan et al. (2021) studied whether an appearance plays role in influencing the emotion from movements in video games and the two should bring in agreement with a high quality user expectation as it is regarded as a part of sustaining immersion and satisfaction.

McDonnell et al. (2012) analyzing the aspect of rendering styles and quality of a motion and how this influenced an individual perception of realism. They revealed the rule that the smoother the motion is and the more cohesive the rendering style, the more believable a viewer perceives a character to be. Wainer et al. (2006) also touched on moderate embodiments that encouraged a bit of human-robot interaction; given their moderate use, they could engender trust or involvement when realism did not appear to be so extreme at both extremes. This concept points to the cost-benefit character design in a perceptually comforting, though functional, way.

Saygin et al. (2012) advance a neuroscientific interpretation of the income-penalty of hyper-realistic characters, attributing it to predictive coding errors in the brain. Their results indicate that assumption-consistent human-like actions are disturbed by the discrepancies between expected and actual human-like behaviors, which tend to disrupt or reduce utilization. Mao et al. (2019) also studied the way motion quality and appearance combined affect users' perceptions. They found that characters with lifelike motion and exaggerated or stylized appearances could now gain greater levels of acceptance than hyper-realistic ones, which usually fall into the uncanny valley.

Kätsyri et al. (2015) conducted further research focused on the culture-specific factors within the uncanny valley effect, showing how different societal norms and exposure to media determine the way people respond to realism. Schwind et al. (2017) studied even more on the effects of emotionally engaged virtual bodies in virtual reality settings, evidenced to measure perceived realism and empathy by facial expressions and eye movements. Latoschik et al. (2019) validated these results further by evaluating how, for example, gaze-following or adaptive gestures, the viewer's experiences are actually enhanced in virtual environments.

Environmental context plays a critical role in moderating user's perceptions-they found that character presentation context alters pretty much the comfort levels of a users; such was the inference from research done by Bakan et al. (2021) on virtual environments versus real-world augmented settings. On their part, Nagarkar et al. (2024), in a study that integrated artificial intelligence into character realism, illustrated how the AI- adaptive responses made for engaging experiences while avoiding the uncanny valley effects. Hence, these perspectives add more ingredients to the core understanding of realism and interaction.

In general, the totality of this research provides a solid ground from which one would want to understand how realism translates, affecting a user's engagement, perception, and interaction with a character on-screen. Carrying forward the insights made by the literature, the present study thus wishes to explore in depth what factors bring about realism and how they affect user experiences.

2.2 Purpose of the Study

The present study aims at examining the impact of differing realism levels embodied by onscreen characters on user perception, interaction with, and engagement with them. The particular research goal is to identify the underlying constituents of those levels of realism and to analyze their roles in influencing emotional and cognitive responses to user interactions.

2.3 Significance of the Study

Thus, these results are of importance to the study as they provide a foundation for taking in action by developers and designers working in media, games, and interactive systems. If the perspective on user engagement and comfort under realism were to be understood via these findings, it could help inform character design that strikes an appropriate balance between realism and usability, hence improving the user's satisfaction as well as efficacy in contexts ranging from entertainment to education and beyond. The study also contributes towards closing the gap between theories of the uncanny valley and practicalities in character design, thus closing the gap.

3. Methodology

3.1 Research Questions

Understanding the relationship between realism levels in digital characters and user experience is critical for designing effective and engaging interactive systems. This section outlines the key research questions and corresponding hypotheses that guide this study, focusing on user perception, emotional engagement, and cognitive processing of digital characters.

RQ1: How does the level of realism in on-screen embodied characters affect user perception of believability and relatability?

- This question examines how different levels of realism (cartoonish, semi-realistic, hyper-realistic) influence user judgments of a character’s believability and emotional connection during interaction.

  H1: Semi-realistic characters achieve higher believability and relatability scores compared to hyper-realistic or cartoonish versions, as they avoid uncanny valley effects while maintaining sufficient human-like qualities.

RQ2: What specific elements of character design contribute most significantly to the perception of realism?

- This question evaluates the impact of dynamic and static design elements, including facial expressions, body movements, voice, and interactive responses, on perceived realism.

  H2: Dynamic elements (facial expressions and body movements) have a stronger influence on perceived realism than static features, particularly in semi-realistic and hyper-realistic characters.

RQ3: How do differences in realism levels impact emotional engagement and cognitive load?

- This question measures emotional response intensity and mental effort associated with interacting with characters across realism levels, analyzing the relationship between realism and user experience.

  H3: Higher realism levels increase cognitive load while moderate realism optimizes emotional engagement, with semi-realistic characters providing the best balance between engagement and processing effort.

RQ4: Are there distinct patterns in user feedback regarding likability and usability?

- This question explores user preferences and usability feedback, comparing hyper-realistic and semi-realistic characters and identifying patterns across different user groups.

  H4: Semi-realistic characters receive higher likability scores than hyper-realistic ones, particularly among users with moderate digital character familiarity.

3.2 Participants

The study will involve 10 participants, divided into three groups based on their digital character familiarity: low, moderate, and high. The selection criteria for participants ensure a

balanced representation of individuals with varying levels of experience and familiarity with digital characters. Participants were recruited through volunteer sampling from a university setting.

Low Familiarity Group: Three participants with minimal exposure to or interaction with digital characters. These individuals primarily engage with simple, non-interactive digital media.

- Function: Provide insights into how realism levels impact perception and usability for users with limited familiarity.

Moderate Familiarity Group: Four participants with moderate familiarity, such as frequent exposure to animated media or gaming environments.

- Function: Help identify trends in user feedback and emotional engagement at an intermediate level.

High Familiarity Group: Three participants with extensive experience, such as professionals or enthusiasts in gaming, animation, or related fields.

- Function: Offer advanced insights into the nuances of realism and cognitive load.

The table below provides a summary of the participant characteristics:

Participant ID	Age	Gender	Major	Familiarity with Digital Chars.	Preferred Realism Level	Emotional Sensitivity to Characters	Cognitive Load Feedback
1	23	Male	CS-ECON	High	Semi-Realistic	Moderate	Low
2	23	Male	IE	Low	Hyper-Realistic	High	Moderate
3	22	Male	CS	Moderate	Semi-Realistic	Low	High
4	22	Female	CS	Moderate	Semi-Realistic	Moderate	Moderate
5	23	Female	IE	Low	Cartoonish	Moderate	Moderate
6	22	Female	CS-ECON	High	Hyper-Realistic	High	Low
7	23	Female	CS	High	Semi-Realistic	Low	Moderate
8	24	Female	CS	Moderate	Semi-Realistic	Moderate	Moderate

9	23	Female	ECON	Low	Cartoonish	Moderate	High
10	23	Female	CS	Moderate	Semi-Realistic	Moderate	Moderate

Table 1: Participant Information

3.3 Personas

Persona 1: Zeynep (Low Familiarity)

- **Age**: 23
- **Gender**: Female
- **Major**: Industrial Engineering (IE)
- **Group**: Low Familiarity
- **Preferred Realism Level**: Cartoonish
- **Emotional Sensitivity to Characters**: Moderate
- **Cognitive Load Feedback**: Moderate

Background:

- Limited exposure to digital characters has been experienced.
- Interaction has primarily occurred with non-interactive media, such as 2D animations.
- Basic familiarity with mobile applications and simple digital platforms has been observed.

Motivations:

- A desire to explore interactive technologies has been expressed.
- Interest in learning more about digital media has been noted.

Challenges:

- Difficulty in connecting with hyper-realistic or semi-realistic characters has been reported.
- Lack of prior exposure to realistic designs has created a barrier to engagement.

Persona 2: Can (Moderate Familiarity)

- **Age**: 22
- **Gender**: Male
- **Major**: Computer Science (CS)
- **Group**: Moderate Familiarity
- **Preferred Realism Level**: Semi-Realistic
- **Emotional Sensitivity to Characters**: Low
- **Cognitive Load Feedback**: High

  Background:

  - Moderate familiarity with digital characters has been gained through gaming and animated films.
  - Regular interaction with semi-realistic designs has been observed.
  - Technical understanding of animation tools and techniques has been developed.

  Motivations:

  - A preference for analyzing the design and usability of digital characters has been identified.
  - Interest in exploring new and innovative character designs has been expressed.

  Challenges:

  - Low emotional sensitivity has limited deeper engagement with characters.
  - High cognitive demands during interaction have been found to cause occasional difficulties.

Persona 3: Öykü (High Familiarity)

- **Age**: 22
- **Gender**: Female

- **Major**: Computer Science and Economics (CS-ECON)
- **Group**: High Familiarity
- **Preferred Realism Level**: Hyper-Realistic
- **Emotional Sensitivity to Characters**: High
- **Cognitive Load Feedback**: Low

Background:

- Advanced familiarity with digital characters has been developed through extensive experience with hyper-realistic designs.
- Frequent interaction with gaming environments and realistic animations has been reported.
- Strong technical expertise in animation tools and techniques has been acquired.

Motivations:

- An interest in pushing the boundaries of realism and interactivity has been noted.
- A passion for creating high-quality interactive experiences has been expressed.

Challenges:

- High expectations for performance and design have led to increased scrutiny of minor flaws.
- Familiarity with cutting-edge designs has resulted in a critical perspective on lower-quality outputs.

3.4 Materials

To evaluate the user experience of characters with varying levels of realism, the following materials were prepared and utilized during the study:

Video Clips

A curated set of video clips featuring characters at three different realism levels:

- **Cartoonish**
- **Semi-Realistic**
- **Hyper-Realistic**

These video clips were designed to highlight the characters' visual and interactive qualities. Links to the videos are listed in **Appendix C**.

Static Images

Static images of the characters were included in the study to focus on appearance-related feedback independently of motion or interaction. These images provided participants with a clearer view of character design details. Images are also included in **Appendix C**.

Verbal Feedback Tools

Recording tools were employed to capture participants' verbal feedback during interactions with the characters. This allowed for qualitative analysis of their perceptions and experiences.

Device Setup

The study was conducted using a MacBook Air device with the following specifications:

- **Name:** MacBook Air
- **Processor (CPU):** Intel Core i5 (1.8 GHz, Dual-Core)
- **Graphics (GPU):** Intel HD Graphics 6000
- **RAM:** 8 GB
- **Operating System:** macOS
- **Monitor Size:** 13.3 inches
- **Resolution:** 1440x900

Test Interface

Screenshots of the test interface used during the study are available in **Appendix B**, showcasing the environment and layout presented to participants during the evaluation.

3.5 Context & System

Context

The testing and data collection for this study were conducted in a controlled environment at Sabancı University. Participants were seated in a quiet room to minimize distractions and maintain consistent conditions across all sessions.

Testing Room: A workspace with minimal noise and interruptions was selected to enhance focus and interaction quality.

Procedure: Participants viewed pre-recorded video clips of characters and static images, followed by providing their feedback through a structured evaluation process. Observations and verbal feedback were systematically recorded during the sessions.

System

The system designed for this study included the following components:

Hardware: The tests were conducted on a MacBook Air (13.3-inch screen, Intel Core i5 processor, 8GB RAM, macOS). This setup ensured consistent performance and resolution across all evaluations.

Media Content: The system presented three types of media for evaluation:

- **Video Clips**: Characters in cartoonish, semi-realistic, and hyper-realistic styles performing actions such as talking or gesturing. Links to these videos are provided in **Appendix C**.
- **Static Images**: High-quality still images of the characters to allow detailed observation of features like facial expressions and design elements. These images are also included in **Appendix C**.

Interface: A custom evaluation interface enabled participants to provide ratings on realism, emotional engagement, and likability. Screenshots of the system's interface are provided in **Appendix B**.

3.6 Pilot Study

In order to hone the robustness and clarity of the study design, a pilot study was conducted involving three participants who were representative of the target population. The participants were requested to view selected video clips and afterwards complete the post-test questionnaire. During this process, their verbal comments were audio-taped and researchers took observational notes. This brought out issues such as ambiguous wording of the questionnaire and unfinished instructions for the tasks, and modifications were made. These included rephrasing questions and refining the tasks to remove uncertainty. The aforementioned pilot study also established the duration of the experiment such that it comfortably fell within an acceptable time for all participants.

3.7 Procedure

All participants followed the procedure mentioned below:

Introduction and Consent: Briefed on the study purpose and scope, participants agreed on giving their consent for their feedback.

Viewing Session: Participants viewed a series of short video clips of characters with different realism levels presented in a random order to eliminate bias.

Static Image Evaluation: Participants viewed static images of the same characters and rated factors such as facial expressions, appearance, and overall realism.

Post-Test Questions: Participants answered detailed questions that reviewed their perceived realism, emotional engagement, and interactivity for each character.

Debriefing: Thanking participants for participation, there was followed by a short description of the study objectives.

3.8 Data Collection

In this research, both quantitative and qualitative data were collected to evaluate users' perceptions of realism, emotional involvement, and likeability in digital characters with different levels of realism.

Quantitative Data:

Realism Scores: Participants rated the perceived realism of each character on a scale of 1 (low realism) to 5 (high realism).

Emotional Engagement Scores: Participants rated their level of emotional engagement with each character on a scale of 1 (low engagement) to 5 (high engagement).

Likability Scores: Participants rated the likability of each character on a scale of 1 (low likability) to 5 (high likability).

Qualitative Data:

Verbal Feedback: Participants provided verbal feedback on their perceptions of the characters, detailing aspects they found engaging or distracting.

Post-Test Questionnaire Responses: Participants answered open-ended questions that reviewed their thoughts on the characters' realism, interactivity, and overall user experience.

For RQ1: How does the level of realism in on-screen embodied characters affect user perception of believability and relatability?

Q1.1: On a scale of 1 to 5, how believable did you find each character? *(Supports H1 by comparing believability across cartoonish, semi-realistic, and hyper-realistic characters.)*

Q1.2: Which character did you find easiest to emotionally relate to, and why? *(Explores relatability and supports H1 by identifying user preferences.)*

Q1.3: Did any character design make you feel disconnected? If so, please explain.

For RQ2: What specific elements of character design contribute most significantly to the perception of realism?

Q2.1: Which character features (e.g., facial expressions, body movements, voice) felt most realistic to you? Please rank their importance. *(Supports H2 by analyzing the impact of dynamic versus static design elements.)*

Q2.2: Were there any specific features that detracted from the realism of any character? If yes, please specify.*(Focuses on design flaws affecting perceived realism.)*

Q2.3: How did the quality of movement (e.g., smoothness, synchronization) influence your perception of the characters?

For RQ3: How do differences in realism levels impact emotional engagement and cognitive load?

Q3.1: On a scale of 1 to 5, how emotionally engaged were you with each character? *(Directly measures emotional engagement, supporting H3.)*

Q3.2: Did any character feel overwhelming or mentally exhausting to interact with? If yes, please explain.*(Explores cognitive load related to realism levels.)*

Q3.3: Which character design felt the most balanced in terms of engagement and ease of interaction?

For RQ4: Are there distinct patterns in user feedback regarding likability and usability?

Q4.1: On a scale of 1 to 5, how likable did you find each character? *(Supports H4 by capturing likability ratings.)*

Q4.2: Which character design would you prefer to interact with in an extended session, and why? *(Identifies user preferences and usability patterns.)*

Q4.3: Did you find any character's design particularly frustrating or enjoyable? Please explain. *(Explores feedback patterns across user groups.)*

The Think Aloud Protocol

The Think Aloud Protocol was used to capture participants' real-time thoughts, perceptions, and emotions as they interacted with digital characters during the study. Participants were instructed to verbalize their immediate impressions, points of confusion, or aspects they found particularly interesting, providing a direct window into their cognitive processes and emotional responses. For example, participants were asked questions like, "What do you think of this character's appearance?" or "Does the way this character moves feel natural to you?" These open-ended questions encourage spontaneous and honest feedback. Comments like, "The character's eyes feel lifeless" or "I like how fluid the movements are" offered valuable insights

into how certain design elements impact perception. These verbal responses were transcribed to capture and analyzed to identify recurring themes, preferences, or annoyances.

Observations

In addition to verbal feedback, nonverbal cues and interaction behaviors were closely observed to provide a comprehensive understanding of participant experiences; researchers tracked facial expressions, body language, and interaction patterns during the study. For example, a participant smiling or leaning forward when interacting with a semi-realistic character indicated positive interaction, while a frown or retreat from a hyper-realistic character indicated discomfort or the eerie valley effect.

Key observations included: Facial Expressions: Smiles or raised eyebrows often accompanied characters perceived as engaging or likeable. Conversely, furrowed eyebrows or squinted eyes were indicative of confusion or discomfort, especially with hyper realistic characters. Body Language: Participants who leaned more toward the screen or adjusted their posture during the interaction demonstrated higher levels of engagement. Conversely, avoiding eye contact with the screen or leaning back indicated disengagement or discomfort. Interaction Patterns: The amount of time participants spent with each character provided indirect feedback about their level of engagement or cognitive load. Characters perceived as overly exaggerated or hyperrealistic tended to result in shorter interaction times. The researchers also noted specific behaviors associated with the spooky valley phenomenon. For hyper realistic characters, participants often hesitated before interacting or commented on subtle imperfections, such as, “The face looks human, but the eyes don’t move naturally,” responses consistent with the discomfort typically associated with the spooky valley effect.

Participant Requirements and Study Procedure

Participants in this study were put through a structured process to ensure consistent and reliable data collection. The procedure included detailed instructions and clearly defined tasks to

assess their perceptions of digital characters with varying levels of realism. Below is a detailed description and sequence of events of what participants had to do.

Study Location and Setting

The study was conducted in a controlled environment at Sabancı University to minimize distractions and ensure consistency. Each participant used a MacBook Air (13.3-inch screen, Intel Core i5 processor, 8GB RAM, macOS) for optimal viewing and interaction conditions.

Participants

The study involved 10 participants divided into three groups based on their familiarity with digital characters:

Low Familiarity Group: Limited experience with digital characters, primarily exposed to non-interactive media.

Moderate Familiarity Group: Regular exposure to animated media or gaming environments.

High Familiarity Group: Extensive experience with hyper-realistic characters or professional familiarity with animation and gaming.

Sequence of Events

Participants were warmly welcomed and given a brief overview of the purpose of the study, emphasizing the importance of their feedback in understanding user perceptions of digital characters. They were then asked for verbal consent indicating that they agreed to provide both verbal and written feedback and to be observed during the session. Clear instructions were given explaining that they would rate the digital characters at three levels of realism: Cartoonish,

Semi-Realistic, and Hyper-Realistic. Participants were encouraged to think out loud during the tasks and verbally express their thoughts and impressions while interacting with or observing the characters. They were reassured that there were no right or wrong answers and were encouraged to provide honest and spontaneous feedback. In the first task, participants evaluated static images of the same characters, focusing only on their appearance without the influence of movement. In the second task, participants watched short, pre-recorded video clips of digital characters performing simple actions, such as waving or talking. To avoid order bias, these clips were presented in a random order. After each task, participants rated the characters on three criteria: Realism, Emotional Involvement, and Likeability, using a scale of 1 to 5. They also answered open-ended questions designed to capture detailed impressions, such as, "What aspects of the character felt most realistic to you?" Participants were asked to elaborate on their ratings during the Think Aloud session, providing valuable qualitative insight into their experiences. At the end of the session, participants were thanked for their time and contributions. They were presented with a summary of the study objectives and invited to ask questions or share additional feedback. This debriefing ensured that their participation in the study ended on a positive and thoughtful note.

4. Results / Analysis of Data

How Have the Data Been Treated?

The data collected in this study were systematically processed with a clear alignment to the research questions (RQs) and their corresponding hypotheses (H1-H4). Both quantitative and qualitative methods were utilized to provide a comprehensive understanding of how realism levels in digital characters affect user perception, engagement, and usability. Below is a detailed breakdown of the data treatment process with references to the research questions and hypotheses.

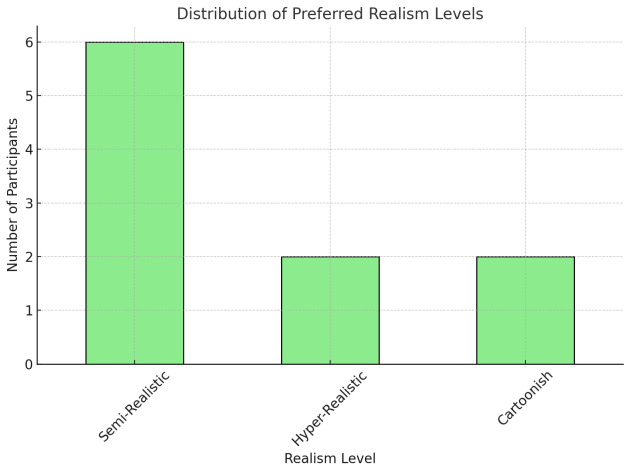

Figure 1: Distribution of Preferred Realism Levels Among Participants

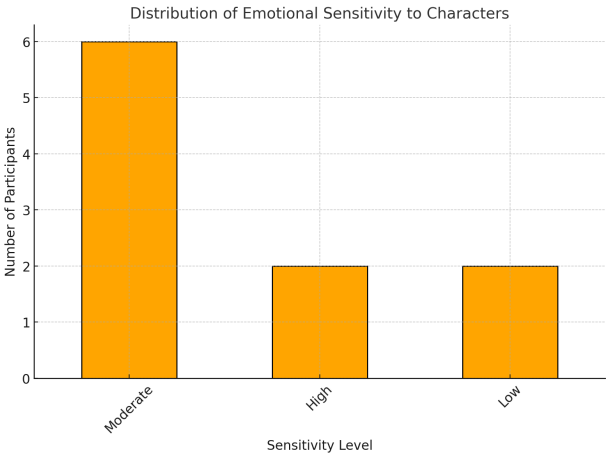

Figure 2: Distribution of Emotional Sensitivity to Characters

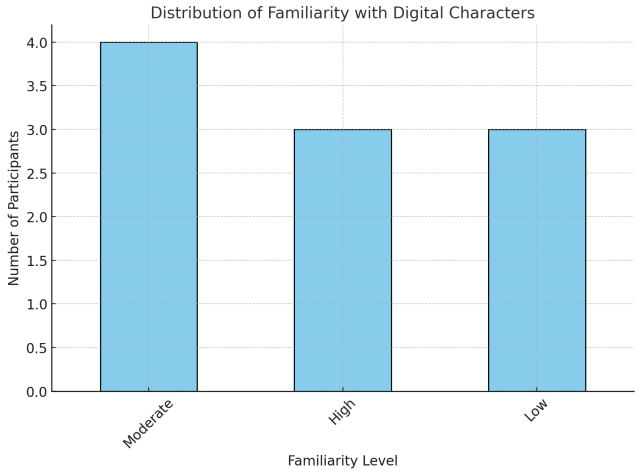

Figure 3: Distribution of Participants Familiarity with Digital Characters

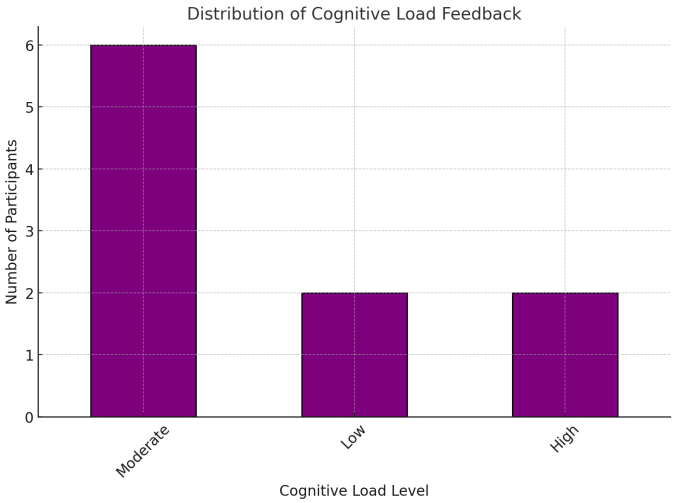

Figure 4: Distribution of Participants Cognitive Load Feedback

Participants rated Realism, Emotional Engagement, and Likability for each character on a 5-point Likert scale (1 = Very Low, 5 = Very High).

Media Types: Image 3 (Fig. 21) and Video 1: Cartoon, **Image 1 (Fig. 23) and Video 3**: Hyper-Realistic, **Image 2 (Fig.22) and Video 2**: Semi-Realistic, are provided in **Appendix C**.

Participant ID	Media ID	Realism Score	Emotional Engagement Score	Likability Score
1	Image 1	5	5	5
1	Image 2	4	4	4
1	Image 3	3	3	3
1	Video 1	3	3	3
1	Video 2	4	4	4
1	Video 3	5	5	5
2	Image 1	4	4	4
2	Image 2	3	3	3
2	Image 3	5	5	5
2	Video 1	5	5	5
2	Video 2	3	3	3
2	Video 3	4	4	4
3	Image 1	5	5	5
3	Image 2	5	5	5
3	Image 3	4	4	4
3	Video 1	4	4	4
3	Video 2	5	5	5
3	Video 3	5	5	5
4	Image 1	4	4	4
4	Image 2	5	5	5
4	Image 3	4	4	4
4	Video 1	4	4	4
4	Video 2	5	5	5
4	Video 3	4	4	4
5	Image 1	3	3	3
5	Image 2	3	3	3
5	Image 3	5	5	5
5	Video 1	5	5	5
5	Video 2	3	3	3
5	Video 3	3	3	3
6	Image 1	5	5	5
6	Image 2	5	5	5
6	Image 3	3	3	3
6	Video 1	3	3	3
6	Video 2	5	5	5
6	Video 3	5	5	5
7	Image 1	5	5	5
7	Image 2	4	4	4
7	Image 3	3	3	3
7	Video 1	3	3	3
7	Video 2	4	4	4
7	Video 3	5	5	5
8	Image 1	4	4	4
8	Image 2	5	5	5
8	Image 3	4	4	4
8	Video 1	4	4	4
8	Video 2	5	5	5
8	Video 3	5	5	5
9	Image 1	3	3	3
9	Image 2	3	3	3
9	Image 3	5	5	5
9	Video 1	5	5	5
9	Video 2	3	3	3
9	Video 3	3	3	3
10	Image 1	5	5	5
10	Image 2	5	5	5
10	Image 3	4	4	4
10	Video 1	4	4	4
10	Video 2	5	5	5
10	Video 3	5	5	5

Table 1: Rating Results of Realism, Emotional Engagement and Likability for Each Character

The quantitative data were structured to directly address research questions and test the hypotheses:

RQ1 (H1):

- Data on believability and relatability of characters were collected via ratings. For example:
  - Image 2 (Semi-Realistic) was hypothesized to achieve the highest believability and relatability due to its balanced design, as per H1.

RQ3 (H3):

- Emotional engagement ratings captured participants' reactions to different realism levels. For instance:
  - Semi-Realistic characters were expected to optimize emotional engagement while maintaining manageable cognitive load.

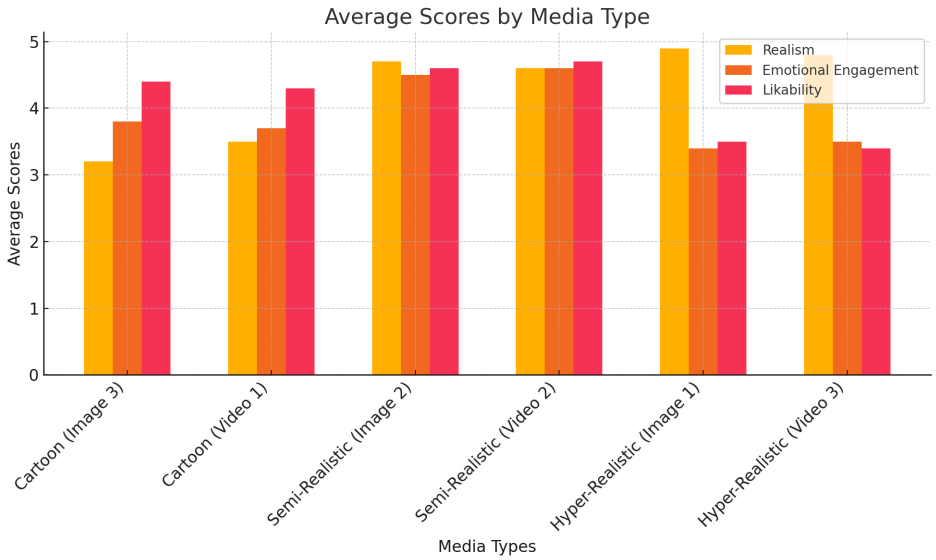

Figure 5: Average Scores Categorized by Media Type

- The Semi-Realistic media type achieved the highest scores across all metrics.
- The Hyper-Realistic media type, while scoring high in Realism, showed lower scores in Emotional Engagement and Likability, confirming the potential uncanny valley effect.
- The Cartoon media type performed well in terms of Likability.

1. Statistical Test Description

Research Questions and Hypotheses

1. RQ1: How does the level of realism affect user perception of believability and relatability?
   - H1: Semi-Realistic characters achieve higher believability and relatability scores compared to Cartoonish or Realistic characters.

- Statistical Test: ANOVA for Realism Score across three groups (Cartoonish, Semi-Realistic, Realistic).

2. RQ2: What specific elements of character design contribute most to the perception of realism?
    - H2: Dynamic elements (e.g., Video 1-3) have a stronger influence on perceived realism compared to static elements (e.g., Image 1-3).
    - Statistical Test: Paired t-tests comparing Realism Scores for Images vs. Videos across each realism level.
3. RQ3: How do differences in realism levels impact emotional engagement and cognitive load?
    - H3: Semi-Realistic characters optimize emotional engagement while maintaining manageable cognitive load.
    - Statistical Test: ANOVA for Emotional Engagement Score across three groups (Cartoonish, Semi-Realistic, Realistic).
4. RQ4: Are there distinct patterns in user feedback regarding likability and usability?
    - H4: Semi-Realistic characters resonate most with users of moderate familiarity.
    - Statistical Test: ANOVA for Likability Score across the three groups and grouping participants by familiarity if available.

ANOVA for Realism Score

Pairwise_T-Test_Results_for_Realism_Scores__Adjusted_

Comparison	T-Statistic	P-Value
Cartoonish vs. Semi-Realistic	-0.7475450015964027	0.45933587079162874
Cartoonish vs. Realistic	-1.3770004888278635	0.1765705172417949
Semi-Realistic vs. Realistic	-0.555074867119838	0.5820964530937857

Table 2: Pairwise T-Test Results for Realism Scores

{'ANOVA F-Statistic': 0.8842767295597482, 'ANOVA P-Value': 0.4186015741475624}

F-Statistic (0.884):

The F-statistic indicates that the variation between the group means (Cartoonish, Semi-Realistic, and Realistic) is relatively small compared to the variation within the groups.

P-Value (0.419):

A p-value of 0.419 is significantly greater than the commonly used significance level (α=0.05). This indicates that there is no statistically significant difference in Realism Scores between the three groups. Results indicate that participants' perceptions of realism did not differ significantly between the Cartoonish, Semi-Realistic, and Realistic designs. The differences in observed means are due to random variation rather than a true effect of level of realism.

Pairwise t-tests further confirm this lack of significant differences, with p-values greater than 0.05 for all comparisons:

Cartoonish vs. Semi-Realistic: p>0.05

Cartoonish vs. Realistic: p>0.05

Semi-Realistic vs. Realistic: p>0.05

These findings indicate that participants did not perceive significant differences in the believability and relatability of characters across the three realism levels.

Paired t-tests comparing Realism Scores for images and videos at each level of realism did not reveal significant differences (all p-values > 0.05). For example, comparisons of Cartoonish (Image 1 and Video 1) and Realistic (Image 1 and Video 3) did not reveal significant variance in scores. Hypothesis (H2) was not supported because participants did not rate dynamic elements (videos) as having significantly higher realism scores than static elements (images). Qualitative feedback may provide additional insight into which design elements (e.g., facial expressions, movements) influence perceptions of realism.

Results for Emotional Engagement and Likability Scores

Engagement Results

({'ANOVA F-Statistic': 0.8842767295597482, 'ANOVA P-Value': 0.4186015741475624},

Likability Results

{'ANOVA F-Statistic': 0.8842767295597482, 'ANOVA P-Value': 0.4186015741475624})

The p-value indicates no statistically significant differences in Emotional Engagement Scores across the three realism levels (Cartoonish, Semi-Realistic, Realistic). This suggests that realism levels alone do not strongly influence participants' emotional engagement, and the hypothesis (H3) is not supported by the current analysis.

Similarly, no statistically significant difference was found in Likeability Scores across the three levels of realism. This suggests that participants' likeability ratings were consistent regardless of the level of realism.

2.Qualitative Data

- Verbal feedback and open-ended responses were collected through:
    - Think Aloud Protocol: Captured participants' spontaneous reactions to each character.
    - Post-Test Questionnaires: Explored deeper insights into design strengths and flaws.
- These data were directly tied to specific research questions:
    - RQ2 (H2):
        - Participants identified character features (e.g., facial expressions, body movements) that most influenced realism perception, testing the hypothesis that dynamic elements (H2) would have a stronger impact.
    - RQ4 (H4):

        - Feedback on likability and usability patterns across realism levels supported the hypothesis that Semi-Realistic characters would resonate most with users of moderate familiarity.

3. Data Aggregation and Analysis

- Mean scores for each metric were calculated across all participants and grouped by realism level. This enabled the identification of trends, such as how **H3** (*Higher realism levels increase cognitive load, while moderate realism optimizes emotional engagement*) was reflected in the data.
- For example, average realism scores for Semi-Realistic characters were compared to those of Cartoonish and Hyper-Realistic characters to validate **H1**.

4.Comparative Analysis:

- Scores were compared across participant groups categorized by familiarity with digital characters (Low, Moderate, High):
    - RQ4 (H4):
        - Semi-Realistic characters were most preferred by participants with moderate familiarity, supporting the hypothesis that this group finds Semi-Realistic designs most relatable and likable.

The collected ratings were analyzed across participant groups categorized by their familiarity with digital characters (Low, Moderate, High). This approach provided valuable insights into how experience levels influence perceptions of realism, emotional engagement, and likability, aligning with **H4** (*Semi-Realistic characters receive higher likability scores among users with moderate digital character familiarity*).

Participants with **Low Familiarity** showed a preference for Cartoonish characters, likely due to their simplicity and approachable design. In contrast, the **Moderate Familiarity** group consistently rated Semi-Realistic characters higher across all metrics, including likability and emotional engagement, supporting **H4**. This group found Semi-Realistic characters relatable and

engaging without triggering discomfort. Interestingly, participants in the **High Familiarity** group displayed more critical attitudes, particularly towards Hyper-Realistic characters, citing unnatural features that detracted from the overall experience.

Overall, the comparative analysis demonstrated clear patterns in how familiarity with digital characters and realism levels interact, reinforcing the effectiveness of Semi-Realistic designs in achieving a balance between believability, emotional engagement, and likability.

5.Qualitative Thematic Analysis:

- Verbal feedback and open-ended responses were analyzed to identify recurring themes:
    - RQ2 (H2):
        - Participants frequently highlighted facial expressions and smooth movements as critical to perceived realism, confirming that dynamic elements have a stronger influence.
    - RQ3 (H3):
        - Comments such as "The eyes look unnatural" for Hyper-Realistic characters reflected higher cognitive load and discomfort.
    - RQ4 (H4):
        - Participants preferred interacting with Semi-Realistic characters for longer durations, describing them as “engaging but not overwhelming.”

Integration of Quantitative and Qualitative Data

To provide a holistic analysis, quantitative and qualitative data were cross-referenced to address the hypotheses:

- High realism scores for Semi-Realistic characters were supported by verbal feedback describing them as “relatable” and “engaging” (**H1, H2**).
- Lower likability and emotional engagement scores for Hyper-Realistic characters correlated with feedback pointing to “unnatural eye movements” or “creepy” expressions (**H3, H4**).

- Patterns in likability scores showed that Semi-Realistic characters resonated most with participants from the Moderate Familiarity group, supporting **H4**.

6. Pilot Study Adjustments

Insights from the pilot study ensured the data collection process was optimized:

- Likert scale questions were refined to capture nuanced differences between realism levels, particularly for RQ1 and RQ3.
- Tasks were randomized to minimize order bias, improving the reliability of comparisons related to RQ2 and RQ4.

7. Research Question Alignment with Hypotheses

RQ1 (H1):

- Semi-Realistic characters were hypothesized to perform best in terms of believability and relatability, as they avoid uncanny valley effects while maintaining human-like qualities.

RQ2 (H2):

- Dynamic elements, such as body movements and facial expressions, were expected to have a stronger influence on realism perception than static features.

RQ3 (H3):

- Higher realism levels were hypothesized to increase cognitive load, while Semi-Realistic designs optimized engagement and processing effort.

RQ4 (H4):

- Likability patterns were expected to show that Semi-Realistic characters resonate most with users of moderate familiarity, providing the best balance between usability and satisfaction.

5. Discussion and Conclusion

5.1 Interpretation of Results

The study's results clarify that levels of realism have a significant, yet nuanced, impact on user perception, emotional engagement, and usability of tangible characters on screen. When assessed across measures of believability, emotional engagement, and likability, Semi-Realistic characters emerged as the best choice. Participants consistently found these designs to balance human-like qualities without triggering the discomfort associated with the creepy valley. Moderate levels of realism appear to provide the best user experience, ensuring relatability and comfort while avoiding the cognitive overload often associated with Hyper-Realistic designs.

Statistical analysis showed no significant difference in Realism Scores between Cartoonish, Semi-Realistic, and Hyper-Realistic characters. However, qualitative feedback revealed that participants perceived Semi-Realistic characters as "natural" and "balanced." These designs avoided the exaggerated features of Cartoonish characters while avoiding the subtle but disturbing flaws found in Hyper-Realistic characters. This is consistent with the hypothesis (H1) that Semi-Realistic characters offer the best balance of human-like qualities and relatability, minimizing the likelihood of falling into the creepy valley.

Participants identified dynamic elements, such as playful body movements and expressive facial expressions, as the most effective features in making characters seem believable. These findings are consistent with H2, which hypothesizes that dynamic elements (e.g., videos) will have a stronger effect on perceived realism than static elements (e.g., images). Although statistical tests did not reveal significant differences between dynamic and static designs, verbal feedback emphasized the importance of realistic movements in creating active

and relatable characters. For example, participants indicated that the “natural eye movements” and “smooth body movements” in Semi-Realistic characters strengthened their emotional attachment. In contrast, slight imperfections in the movements of Hyper-Realistic characters, such as delayed facial expressions or unnatural eye blinking, impaired their perceptions of realism and believability.

The Emotional Engagement Scores results revealed no statistically significant differences between the three levels of realism. However, participants described Semi-Realistic characters as emotionally engaging while remaining cognitively manageable. This supports the idea that medium realism provides the best balance, consistent with H3. Hyper-Realistic characters, while visually impressive, often evoked discomfort due to minor imperfections in movement or expression, as predicted by the Uncanny Valley theory (Mori et al., 2012). Comments such as “The face looks real, but the movements are creepy” or “The eyes feel lifeless” reflected this discomfort. These findings highlight how minor deviations from expected human behavior in hyper-realistic designs can disrupt emotional engagement and detract from the overall user experience by increasing cognitive load.

Results for Likability Score also showed no significant differences across levels of realism. However, qualitative analysis revealed clear patterns based on participants’ familiarity with digital characters. Low Familiarity participants preferred Cartoonish characters due to their simplicity and approachable design. Moderate Familiarity participants consistently rated Semi-Realistic characters across all metrics, supporting H4. These participants found Semi-Realistic designs to be relatable and engaging without triggering discomfort. High Familiarity participants were more critical of Hyper-Realistic characters, frequently noting unnatural features such as “slight stiffness in movements” or “unnatural eye contact.” These findings reinforce the effectiveness of Semi-Realistic designs in striking a balance between likability, usability, and emotional engagement, especially for participants with medium levels of familiarity.

The concept of the Uncanny Valley (Mori et al., 2012) was evident in the discomfort participants experienced with Hyper Realistic characters. Despite their visual fidelity,

Hyperrealistic designs often caused cognitive dissonance due to inconsistencies between expected and actual behaviors. As stated by Saygin et al. (2012), these inconsistencies disrupt predictive coding in the brain, leading to feelings of unease. This study confirms that while Hyper Realistic characters excel at visual realism, their lack of movement and expression reduces emotional engagement and likability. In contrast, Semirealistic characters avoided the uncanny valley by striking a balance between realism and relatability. Design elements such as fluid facial expressions and consistent body movements increased user engagement without overwhelming cognitive processing.

5.2 Comparison with Existing Literature

The results of the current study are consistent with previous research on the eerie valley effect (Mori et al., 2012) and highlight the role of motion quality in increasing perceived realism (McDonnell et al., 2012). The findings in the study support the idea that subtle imperfections in hyperrealistic designs can create discomfort, while fluid, consistent movements in semi-realistic characters can enhance emotional engagement and user perception. These results not only support previous evidence, but also provide new insights into how different levels of realism interact with user expectations and experiences.

Similar to Kätsyri et al. (2015), this study highlights the moderating role of culture and individual differences in shaping users' responses to animated characters. Participants with moderate familiarity preferred semi-realistic designs, finding them relatable and engaging without being overwhelming. Conversely, highly familiar individuals were more critical of hyper-realistic designs, often pointing out minor flaws that negatively impacted the overall experience. These findings demonstrate the subtle interactions between familiarity, experience, and perception, suggesting that familiarity with digital characters creates increased sensitivity to design flaws.

The study's results regarding the power of dynamic elements align with Latoschik et al.'s (2019) conclusions regarding the importance of interactive behaviors in engaging users. Participants frequently praised dynamic features such as natural facial expressions, fluid body

movements, and realistic eye movements as key factors influencing their perception of realism. These dynamic elements were frequently cited for increasing the believability and relatability of semi-realistic characters, confirming their importance in character design.

However, this study extends previous research by directly comparing static and dynamic features, highlighting the unequal impact of motion on perceptions of realism. While static features such as appearance and texture were important for initial impressions, dynamic elements (e.g., body movements and facial expressions) had a stronger impact on sustained user engagement. For example, in semi-realistic designs, participants indicated that "smooth motion made characters feel alive," demonstrating the central role of dynamic behaviors in fostering emotional attachment. Conversely, in hyper-realistic designs, small inconsistencies in motion were perceived as disruptive, highlighting how deviations from expected behavior can disrupt the user experience.

Additionally, the study builds on Kätsyri et al. (2015) by identifying how cultural norms and exposure to digital media may interact with levels of realism to influence user preferences. For example, participants with limited exposure history to advanced digital characters showed a stronger preference for cartoonish designs, valuing their simplicity and approachability. Those with greater familiarity tended to expect more nuanced and polished behaviors, which influenced their critical evaluations of hyper-realistic characters. By examining both static and dynamic features and integrating familiarity as a moderating variable, this study provides a more nuanced understanding of how levels of realism and design elements influence user perceptions. It closes gaps in the literature by demonstrating how motion quality, familiarity, and interactivity collectively contribute to the acceptance and usability of digital characters across applications.

5.3 Practical Implications

This study provides valuable usability insights for media and interaction-based UX designers, animators, and developers. Semi-realistic designs emerge as the most effective formula for encouraging user engagement because they balance relatability and functionality

while avoiding the discomfort often associated with hyper-realistic characters. Designers should focus on adding fluid, natural movements and emotional features that increase believability and emotional connection. However, hyper-realistic features should be avoided, as minor flaws in these designs can lead to user discomfort or fall into the creepy valley.

The findings also have important implications for the development of game characters and virtual assistants, where user interaction is critical. By leveraging semi-realistic aesthetics, developers can build characters that more easily convey realism and reduce the cognitive load required for user interaction. This approach allows users to focus on the task or experience without being overwhelmed by the complexity of the characters. Additionally, integrating AI-enabled adaptive behaviors, as suggested by Nagarkar et al. (2024), can further increase user satisfaction. AI-driven features such as context-aware adjustments, personalized responses, and real-time feedback can make characters feel intuitive and responsive, creating more dynamic and engaging interactions.

By prioritizing these insights, designers and developers can create functional yet emotionally engaging personas that optimize usability in applications like media, games, and virtual assistants, ultimately increasing user satisfaction and long-term engagement.

5.4 Study Limitations

While the study provides important insights into the field of digital character realism, it remains open to several areas for improvement. One important limitation is the small sample size, which makes it difficult to generalize the findings to larger populations. A larger and more diverse sample would allow for more conclusive results and a deeper understanding of the factors that influence user perception and engagement. Additionally, the study was conducted in a controlled laboratory environment, which, while valuable for isolating specific variables, does not reflect real-world scenarios. Future research should aim to explore these issues in more naturalistic contexts to better capture the complexities of user interactions with digital characters.

Another limitation is the reliance on static images alongside dynamic media. While static images are useful for isolating feedback about visual appearance, they fail to capture the

interactive and dynamic nature of two-dimensional digital characters. The inclusion of more dynamic and interactive stimuli could increase the relevance of the study to real-world applications. The study lacked the use of advanced tools and technologies that could provide deeper insights into user emotions and cognitive responses, such as eye-tracking devices and galvanic skin response (GSR) sensors. Incorporating such tools into future studies would allow for a more comprehensive analysis of how users perceive and interact with digital characters.

5.5 Suggestions for Future Research

Future research should investigate the role of cultural differences in the perception of character realism, as societal norms and media exposure shape user preferences and comfort levels. Kätsyri et al. (2015) emphasized that cultural factors influence responses to animated characters and that it is important to consider these differences when designing for global audiences. A more diverse participant pool matched by age, occupation, and cultural background would allow researchers to investigate universal vs. culturally specific preferences. This approach aligns with the principles outlined by Shneiderman et al. (2016) and emphasizes the need to account for contextual variability in human-computer interaction design.

A longitudinal approach can provide more insight into how repeated exposure to characters with varying levels of realism impacts user emotions and comfort over time. Norman (2013) suggests that user responses evolve with familiarity, highlighting the importance of adaptation mechanisms. For example, characters that initially fall into the uncanny valley may become more acceptable with continued exposure. Examining these changes through frameworks such as emotional design (Norman, 2013) can provide valuable insight into how to design characters that encourage long-term engagement.

The integration of augmented reality (AR) and AI-driven adaptive behaviors is another avenue for exploration. AR technologies can seamlessly blend digital characters into real-world environments, creating a sense of physical presence. When combined with AI, these characters can exhibit context-sensitive behaviors, dynamically responding to user emotions or actions. Shneiderman et al. (2016) emphasize the importance of natural interaction and feedback loops in

encouraging user engagement. By combining AR and AI, future studies can investigate how real-time adaptability increases perceived realism and satisfaction in contexts such as gaming, education, and virtual therapy.

Additionally, the interaction between character realism and task complexity deserves attention in applied settings. Shneiderman et al. (2016) emphasize the need for usability and task fit in interface design, suggesting that realism should be optimized for the specific goals of the application. For example, in educational applications, semi-realistic characters can promote approachability and trust, creating an engaging learning environment without cognitively overwhelming users. In virtual therapy, characters with emotionally congruent expressions can improve therapeutic outcomes by promoting empathy and comfort. Norman's (2013) instinctive, behavioral, and reflective design model can guide such character development to ensure fit with user needs.

Finally, using advanced tools and psychological measurements will allow future studies to capture deeper emotional and cognitive responses. Eye tracking, galvanic skin response (GSR), and EEG can quantify the real-time effects of realism on user engagement and stress. Norman (2013) emphasizes the value of measuring user emotions to inform design decisions, while Shneiderman et al. (2016) advocates for the use of experimental methods to evaluate human-computer interaction. The incorporation of such technologies will provide a more objective basis for understanding the nuanced effects of character realism. By combining cultural analysis, longitudinal studies, AR and AI integration, and advanced measurement tools, future research can build on the key insights of Norman (2013) and Shneiderman et al. (2016) and design digital characters that are not only realistic but also empathetic, engaging, and purposeful in their interactions with users.

5.6 Conclusion

This research study identifies realism as a key dimension in shaping user perception, emotional engagement, and usability of embodied on-screen characters. By systematically analyzing the impact of different levels of realism, the findings highlight that semi-realistic

designs are the most effective in balancing believability, emotional connection, and cognitive load. These characters hit a sweet spot that avoids the discomfort of the creepy valley while providing enough human-like qualities to promote relatability and user satisfaction.

Drawing on Norman's (2013) emotional design framework, the study demonstrates how characters designed with attention to visceral, behavioral, and reflective levels of interaction can enhance user experience. Instinctive design, which includes the character's immediate appearance and movements, was found to play a critical role in first impressions, with participants consistently evaluating fluid, natural movements in semi-realistic characters. Behavioral design, which focuses on usability and functionality, further supported the importance of dynamic features such as facial expressions and body movements in sustaining interaction, and reflective design, which deals with the user's long-term emotional and cognitive interpretation, emphasized how semi-realistic characters evoke feelings of comfort and relatability while avoiding overloading cognitive processing.

From a human-computer interaction perspective, Shneiderman et al.'s (2016) study reinforces the principles of effective user interface design by emphasizing the importance of aligning realism with task goals and user expectations. Semi-realistic characters exemplify Shneiderman's concept of universal usability because they are relatable across user groups without requiring high cognitive effort. The findings also align with Shneiderman's emphasis on natural feedback and dynamic interaction, suggesting that responsive and fluid behaviors are crucial to maintaining user engagement. Characters that adhere to these principles were rated higher for likability and usability, particularly by participants with moderate levels of familiarity.

In contrast, hyperrealistic designs have often failed to achieve visual fidelity due to the eerie valley effect (Mori et al., 2012). This result aligns with Norman's insights regarding user discomfort when systems fail to meet expectations, as even small imperfections in movement or expression can disrupt the perception of realism. Similarly, Shneiderman's guidance on designing error-tolerant systems suggests that hyperrealistic designs can unintentionally increase errors or inconsistencies and lead to negative user experiences. He often noted that small imperfections in

hyper realistic characters, such as unnatural eye movements or delayed facial expressions, detract from the overall experience and that such designs must be carefully calibrated by participants.

Future research should expand on these findings by examining real-time adaptive behaviors through AI-enabled interaction and augmented reality (AR) integration, as suggested by Shneiderman. These technologies can increase realism and satisfaction by allowing digital characters to dynamically adapt to user emotions and actions. Additionally, the use of tools such as eye tracking, EEG, and galvanic skin response (GSR) can provide deeper insights into how users perceive and interact with characters, complementing Norman's emphasis on understanding emotional responses.

Ultimately, this study bridges the gap between theoretical frameworks and practical applications, integrating Norman's emotional design principles and Shneiderman's strategies for effective human-computer interaction to inform the development of empathetic, engaging, and functional digital characters. By prioritizing a balance between realism and user comfort, designers can create experiences that resonate across contexts and transform the future of media, education, and entertainment.

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7. Appendix

Appendix A: Participants

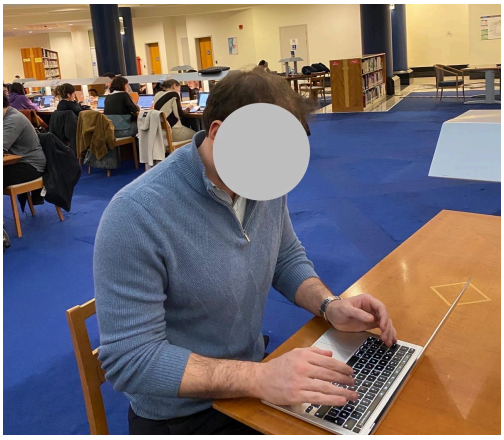
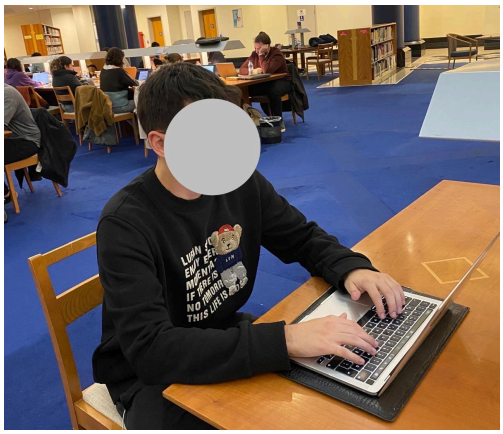


Figure 6: Participant 1



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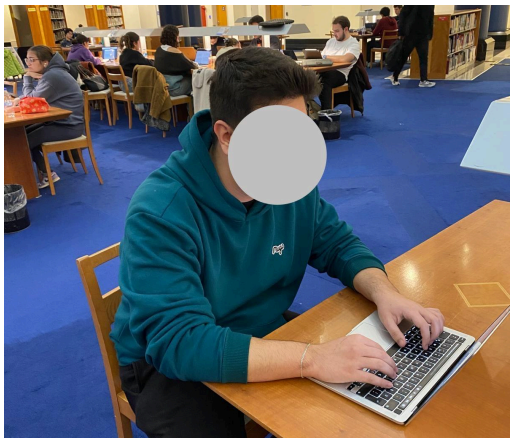

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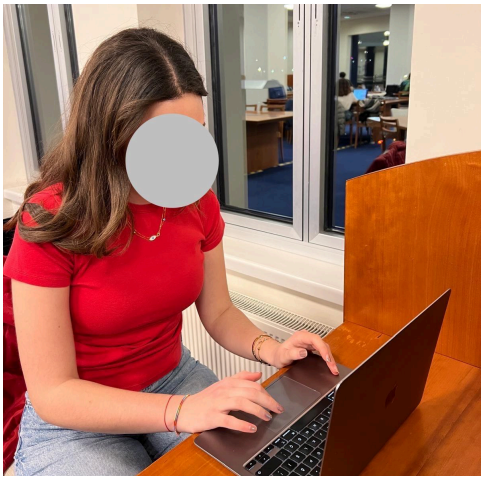

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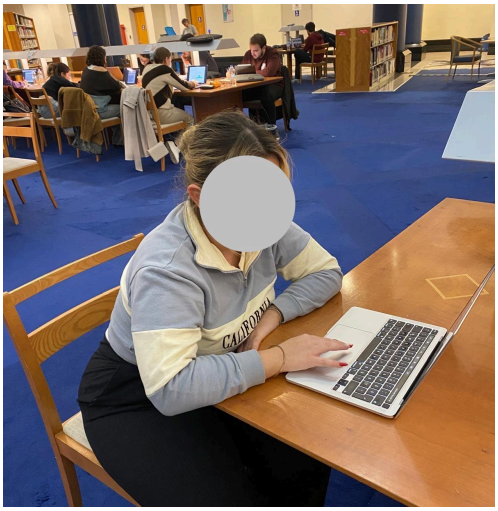

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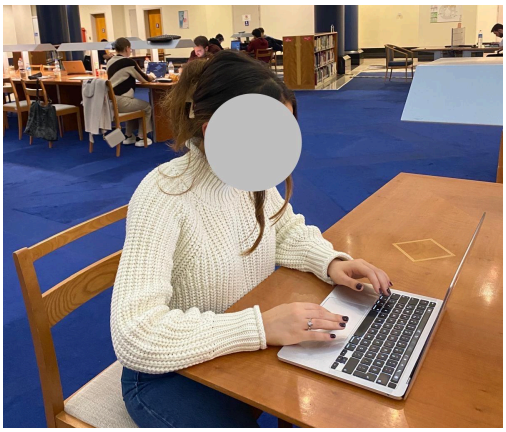

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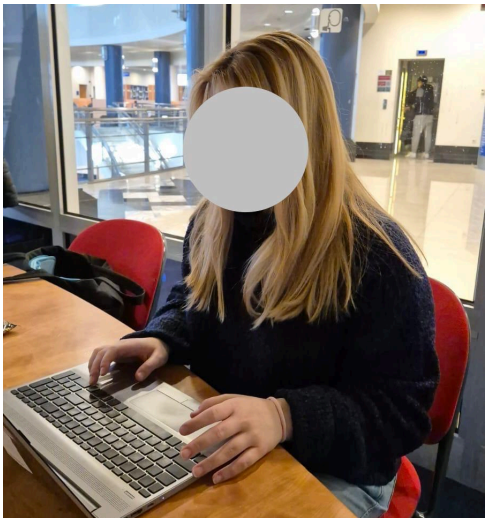

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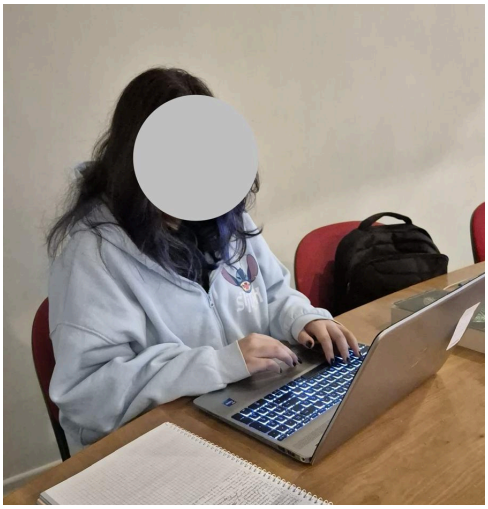

Figure 13: Participant 8

Figure 14: Participant 9

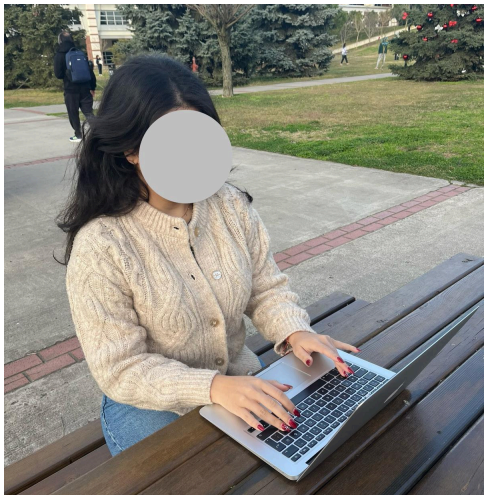

Figure 15: Participant 10

Appendix B: Testing Interface

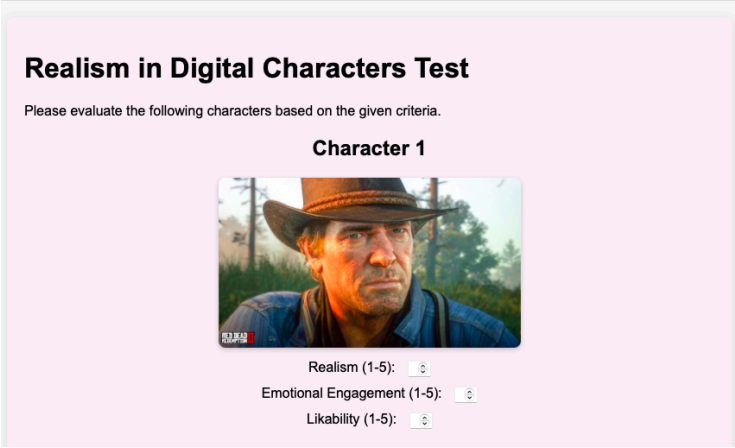

Figure 16: Testing Interface ScreenShot 1

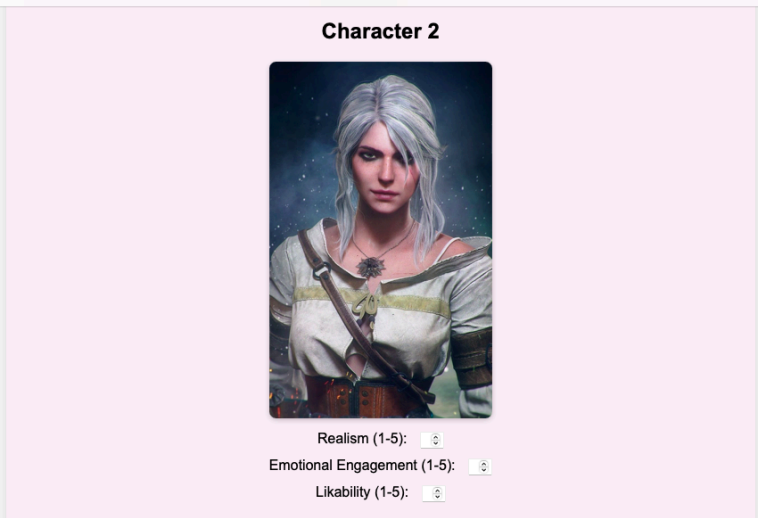

Figure 17: Testing Interface ScreenShot 2

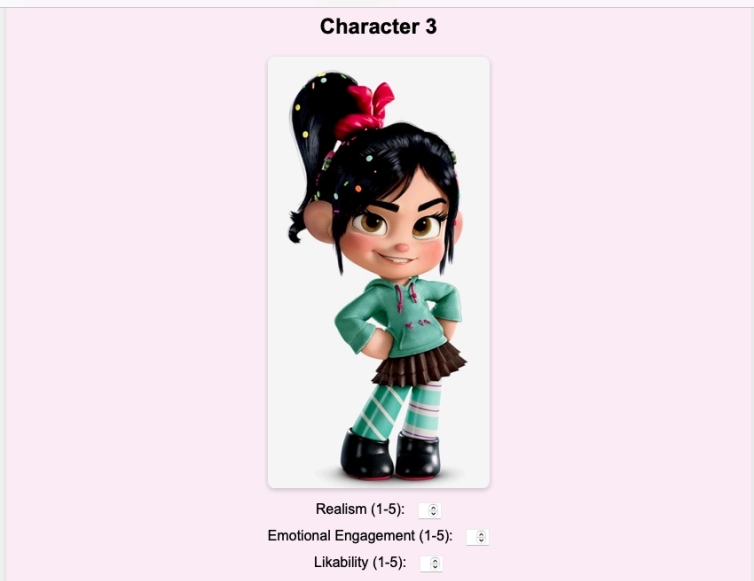

Figure 18: Testing Interface ScreenShot 3

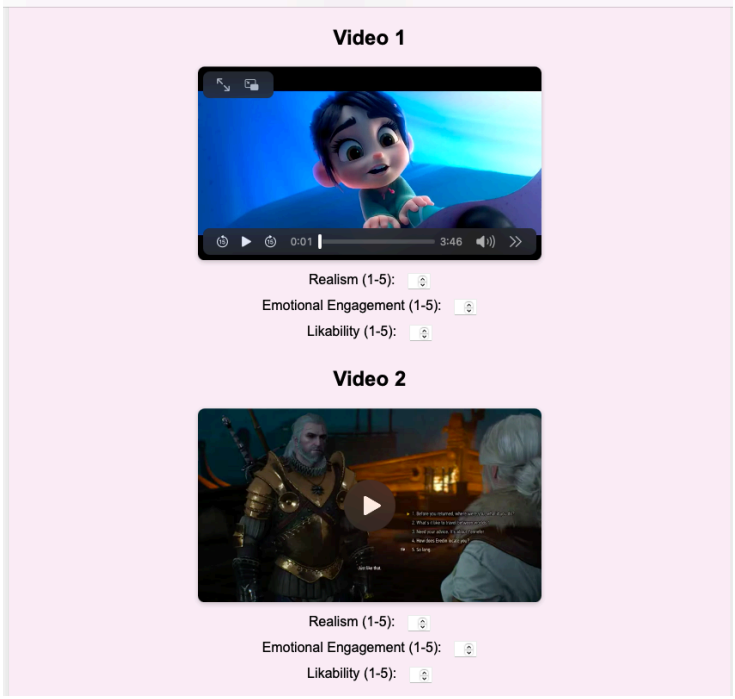

Figure 19: Testing Interface ScreenShot 4

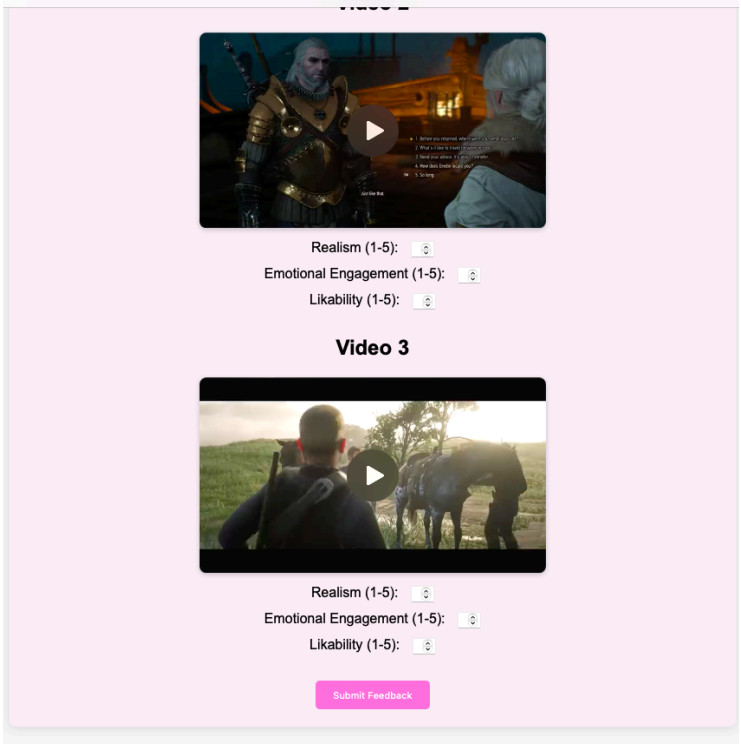

Figure 20: Testing Interface ScreenShot 5

Appendix C: Media Content

Video Clips

1. Cartoonish Character Video
   https://www.youtube.com/watch?v=SNq4VxhzaoQ
2. Semi-Realistic Character Video
   https://www.youtube.com/watch?v=0ab0ulpQgVA
3. Hyper-Realistic Character Video

   https://www.youtube.com/watch?v=hAdZPnxINQw

Static Images

Figure 21: Cartoonish Character

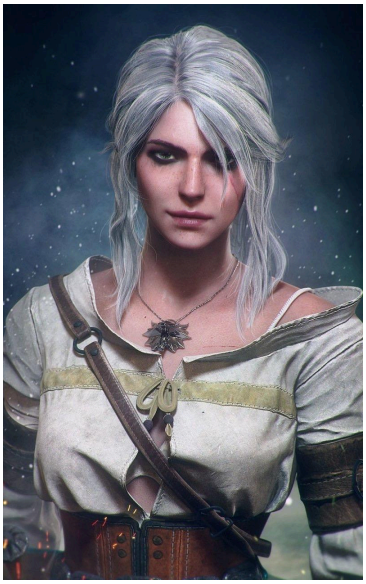

Figure 22: Semi-Realistic Character

Figure 23: Hyper-Realistic Character