

A Systematic Review of the Predictors, Mediators, and Moderators of the Uncanny Valley Effect in Human-Embodied Conversational Agent Interaction

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Extended Abstract

1. Objectives

We addressed two primary concerns: why some people are more predisposed than others to Uncanny Valley effect (UVE) and what features determine embodied conversational agents (ECAs) to be perceived as uncanny. This systematic review aims to: **(1)** enrich the literature by reviewing the main predictors, mediators, and moderators of the UVE; **(2)** provide psychological recommendations regarding how the interaction with ECAs can be improved, and **(3)** provide methodological suggestions to help scientists improve experimental research of the UVE in interaction with ECAs.

2. Methods

A comprehensive search of the ACM Digital Library, IEEE Explore, Scopus, ProQuest, and Web of Science yielded potentially relevant papers. Eligible studies had to evaluate at least one of the UVE variables as outcomes (i.e., attractiveness, uncanniness, or anthropomorphism), using quantitative data collected from healthy children or adults exposed to an active interaction with an ECA (e.g., dialogue, game). We included papers that examined how humans perceive social interaction with an ECA, in which the ECA was represented graphically or physically with an anthropomorphic body. After the search procedure was completed, a total of 17,122 online records were examined. After removing duplicates, a total of 9,667 records remained, of which 9,511 were excluded after their individual title and abstract were examined. The full text of the remaining 156 articles was retrieved, in accordance with the PRISMA Statement [1]. The selection process led to the inclusion of 19 published studies that met our inclusion criteria. The Effective Public Health Practice Project (EPHPP) standards were used to examine the included studies' risk of bias and identify their general level of quality [2]. We also examined the quality of the predictors, mediators, and moderators included in the systematic review using another quality assessment tool [3].

3. Results

ECA friendliness is a possible mediator of the UVE in terms of agent features, indicating that as the ECA becomes more friendly, it is perceived as more attractive [4]. In addition, extraversion and emotional stability are personality features of the ECA that might increase their attractiveness [5]. Proximity is a moderator of the UVE, meaning that as ECA is displayed closer, it can be perceived as more uncanny, especially if the ECA is neurotic and less anthropomorphic [5]. Moving forward to human characteristics, gender was the most studied sociodemographic predictor of the UVE, showing that females view the ECA as typically more attractive compared to men [6]–[8]. Age is also a predictor of the UVE, suggesting that younger humans tend to perceive the ECA as more attractive [5]. Telepresence and flow experience are human characteristics that are predictive of higher anthropomorphism [9].

4. Discussion and conclusions

When trying to develop a potentially attractive ECA, the following *psychological recommendations* may improve interaction with it:

- *Verbal communication.* ECAs should display reflective listening, normalizing the experience that the humans are facing and increasing their self-efficacy [10].
- *Personality.* Future ECAs should be extroverted, emotionally stable, and agreeable, and should convey these characteristics via dialogue, voice, face, and body.
- *Positive attitude.* Future ECAs should be more humorous, and friendly. When communicating only via text messages, the ECA should use more words, less negative affect keywords, and more positive affect terms, as well as more punctuation and exclamation marks,

When performing experimental research that examines interactions between humans and ECAs, the following *methodological suggestions* may improve experimental investigations in this field:

- *Baseline characteristics.* Future studies should evaluate certain characteristics of the participants prior to randomization to confirm that variations between groups occur from the interaction with the ECA and not from baseline differences between groups.
- *Measurements.* Future studies need to avoid measuring the UVE with single item, and instead use validated questionnaires, because reliability indicator of a single-item measure can be lower.
- *Intervention.* To avoid drawing inflated conclusions from extreme comparisons, it is recommended to include a neutral condition wherever feasible.

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