Study information

**Title**:

The Uncanny Valley Hypothesis: Examining the Moderating Role of Motion and Appearance. A Replication of Piwek, McKay and Pollick (2014).

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**Description**:

The uncanny valley hypothesis refers to the idea that almost but not fully humanlike artificial characters will trigger a profound sense of unease in people. This hypothesis is widely claimed in the popular media and scientific research. Yet, despite its popularity, empirical evidence for this claim remains inconsistent. In this pre-registered replication effort, we set out to replicate the findings reported by Piwek et al. (2014).

Piwek et al. (2014) argued that improving the motion quality of characters systematically improved the perceived acceptability of those characters. Specifically, the character classified in the deepest location of the uncanny became more acceptable when it was animated. They claimed that although an uncanny valley effect was found for static characters, the deepening of the valley with motion, originally predicted by Mori (1970/2012), was not obtained.

**Analyses**:

**H1**: Ratings of human likeness (i.e., how similar to human a character is) will differ as a function of *Character Type*.

**H1a**. Follow-up comparison tests will examine if Piwek et al.’s (2014) findings replicate, such that robots will be rated lower in human likeness than a mannequin (but not each other), the mannequin lower than skeleton or zombie, and the skeleton and zombie will not differ from one another but both will be rated as lower in human likeness than the two human figures.

**H2**: Acceptability ratings will vary as a function of *Character Type.*

**H2a**. Follow-up comparison tests will examine if Piwek et al.’s findings replicate, such that characters close in likeness to humans but not themselves human (e.g., zombie, skeleton), will be liked least, characters that are most (e.g., humans) and least like humans (e.g., robots) will be liked relatively more.

**H3**: Acceptability ratings will vary as a function of *Motion Type.*

**H3a**. Follow-up comparison tests will examine if Piwek et al.’s findings replicate, such that the uncanny valley effect (see H2) will be larger for static characters than moving characters. Increasing movement distortion is predicted to lower acceptability ratings for all characters relative to those ratings obtained for characters in the natural motion condition.

**H4**: There will be an interaction effect between *Character Type* and *Motion Type* for acceptability ratings.

**H4a**. Follow-up comparison tests will examine if Piwek et al.’s findings replicate. Specifically we will examine if degrading motion has a generally negative effect on all characters, with the change in acceptability ratings from static to naturally moving differing as a function of character. Naturally moving zombies are predicted to be significantly more acceptable than the static zombie.

Design plan

**Study Type:**

This is an experimental study and will be carried out in an online setting. Participants will be recruited via the Prolific website (<https://prolific.co/>).

**Blinding**:

Participants will be blind to the purpose of the study when taking part. However, they will be informed about the purpose of the study after completing it (i.e., during the debriefing phase).

**Study Design:**

The Piwek et al. (2014) study contained one between participants factor (*Outcome Type*: human likeness ratings vs. acceptability ratings).

With respect to the human likeness ratings, all participants encountered a single factor (*Character Type*) with seven levels (i.e., battle robot vs. toy robot vs. mannequin vs. skeleton vs. zombie vs. low res man vs high res man).

With respect to acceptability ratings, a 7(*Character Type*) x 6 (*Motion Type*: static vs. natural motion vs. distorted A, vs. distorted B vs. distorted C vs. distorted D) within participants design was employed, such that all participants rated all character types across all motion types in terms of their acceptability.

**Randomization:**

Participants were randomly assigned to either the human likeness ratings condition or the acceptability rating condition. Presentation of the stimuli will also be randomly counterbalanced within each condition.

Sampling Plan

**Existing Data:**

In our study we will collect entirely new data. These data have not yet been collected, created, or realized.

**Explanation of existing data:**

Piwek et al. (2014) recruited forty students (M*age* = 25, *SD* = 4.7) from a Scottish university and paid them for their participation. They divided those participants into two different experimental groups: human likeness ratings and acceptability ratings.

**Data collection procedure:**

Participants will be recruited through the online data collection platform Prolific and provided with a monetary reward for their efforts.

**Sample size:**

We are interested in observing a large effect size regarding the interaction effect as found in Piwek et al. (2014) (*Partial Eta Squared ƞ²p = 0.171 > 0.140*). We used a formula to transform Partial Eta Squared to Effect Size f= 0.45 (*f=√ ƞ²p/1- ƞ²p*). Given a 90% power and an error probability of 5%, the sample size requires 147 participants.

**Stopping rule:**

Data collection will continue until we obtain complete and analysable data for 147 participants. In a first step, we will begin by collecting 177 participants (the required sample size plus an additional 30 participants to allow for attrition, incomplete, or unanalysable data). If at this point the required sample size is not met, then data collection will continue in batches of 10 participants until the required sample size is met.

Variables

**Manipulated variables:**

*Confirmatory Analyses*

**Outcome Type**: Two dependent variables will be assessed in the study in a between participants fashion: half of the participants will provide *human likeness ratings* for each character while the other half will provide *acceptability ratings* for each character completing each movement type.

* Human likeness ratings will be assessed using a 9 point Likert scale ranging from 1 (*Very Non-Humanlike*) to 9 (*Very Humanlike*).
* Acceptability ratings will be assessed using a 9 point Likert scale ranging from 1 (*Totally Unacceptable*) to 9 (*Totally Acceptable*). Participants will be encouraged to go with their first impressions when making their choice.

**Character Type**: The type of characters will be manipulated within participants. Seven 3D computer characters will be used: a battle robot, toy robot, mannequin, skeleton, zombie, low resolution man, and a high resolution man. Each image will be located in the middle of the screen and presented in the frontal orientation, facing the viewer.

**Motion Type**: The manner in which a character moves will also be manipulated within participants (for those in the acceptability condition). Specifically, participants will encounter each character statically as well as engaging in five different movements: natural movement, distorted movement A, B, C, and D. The movement will always involve a knocking motion (e.g., knocking on a door) with the character’s right hand. Whereas the natural movement is generally smooth and accomplished by moving multiple joints simultaneously to create an end-effector (e.g., wrist) trajectory with a bell-shaped speed profile (Flash & Hogan, 1985; Rosenbaum, 2009).

The distorted movements were designed to make the motion less natural by disrupting simultaneous movement of the joints of the arm. This was achieved by locking the shoulder joint angle constant whilst allowing the elbow to move, and then switching to locking the elbow joint angle constant whilst letting the shoulder joint move, and continuing this alternation for the duration of the movement.

*Exploratory Analyses:*

In addition to the confirmatory analyses we will also carry out a series of exploratory analyses:

* We decided to examine if participants were familiar with the uncanny valley hypothesis. Specifically, at the end of the study, we will ask the following question: “Have you ever encountered an idea known as the ‘uncanny valley’?” Response options (Yes/No) and then we will ask the following: “if yes please indicate what the uncanny valley idea refers to.” Response option: open-ended textbox.
  + - We will then examine if the author’s original effects still emerge when individuals who are aware of the uncanny valley are removed from the sample.
* We will recruit a separate group of participants and have them rate the characters in terms of *Perceived* *Humanness,* *Eeriness, Warmth* and *Attractiveness,* using items from Ho and McDorman (2010). These variables, except for warmth, found to be nonoverlapping indices. They have respectively six, eight, five and five items. *Pleasure* will not be assessed while it is not applicable for Piwek et al. (2014) characters.

**Outcome Type:**

Two dependent variables, *Perceived Humanness* and *Eeriness*, will be added in a within-participants design. These variables will be assessed by rating 8 items for the *Eeriness* index and 6 items for the *Perceived Humanness* index by all participants.

The *Eeriness* index will be assessed by using following items on a continuum:

* Reassuring – Eerie

*Eerie*

* Numbering – Freaky
* Ordinary – Supernatural
* Uninspiring-Spine-tingling
* Unemotional – Hair-raising

*Spine-tingling*

* Boring-Shocking
* Predicable – Thrilling
* Bland – Uncanny

The *Perceived Humanness* index will be assessed by using following items on a continuum:

* Artificial- natural
* Human-made-humanlike
* Without definite lifespan – mortal
* Inanimate – living
* Mechanical movement – biological movement
* Synthetic-real

The *Attractive* index will be assessed by using following items on a continuum:

* Ugly – beautiful
* Repulsive – agreeable
* Crude – stylish
* Messy – sleek
* Unattractive – attractive

The *Warmth* index will be assessed by using following items on a continuum:

* Cold-hearted–warm-hearted
* hostile–friendly
* spiteful–wellintentioned,
* ill-tempered–good-natured
* grumpy–cheerful

**Measured variables:**

*Confirmatory Analyses:*

Human likeness and acceptability ratings will be measured.

*Exploratory Analyses:*

Eeriness will be measured.

**Indices**:

NA

Analysis Plan

**Statistical models:**

*Confirmatory Analyses*

We will use the following models (and corrections as in Piwek et al. [2014]):

* Human likeness ratings will be subject to a one-way ANOVA with Character Type as a within participant factor. If a main effect of Character Type emerges follow-up testing will be carried out to interpret that effect.
* Acceptability ratings will be subject to a 7(*Character Type*) x 6 (*Motion Type*) within participants ANOVA. If the main effects of Character Type or Motion Type, or the interaction between the two emerge, then follow-up tests will be carried out to interpret the findings.

*Exploratory Analyses*

* *Eeriness* will be subject to a 7 (*Character Type*) x 6 (*Motion Type*) within participants ANOVA. If the main effects of Character Type or Motion Type, or the interaction between the two emerge, then follow-up tests will be carried out to interpret the findings.

Note: Greenhouse–Geisser corrections will be used for all tests in cases where violations of the sphericity assumption occur.

**Transformations:**

No transformations will be required.

**Inference criteria:**

For this replication we will use the original authors criteria (*p*-value < 0.05) for the confirmatory analyses. We will also compute Bayesian factors in accordance with procedures outlined by Rouder, Speckman, Sun, Morey, and Iverson (2009) to estimate the amount of evidence for the hypothesis that likeness and acceptability ratings differ as a function of Character Type or Motion Type (alternative hypothesis) or that there is no such difference (null hypothesis).

**Data exclusions:**

*Confirmatory Analyses*

As the static images shown before the dynamic characters could influence participants ratings, we will conduct an control experiment, as suggested and executed in original study. If the results show an interference for certain participants, the data cannot be used to make assumptions regarding the hypothesis.

*Exploratory Analyses*

Participants will be excluded from analyses if they fail to provide complete data for all measures, or if they fail the attention or suspicion checks.

**Missing data:**

Participants will be excluded from analyses in any case where they fail to provide complete data for all measures. Therefore missing data treatment will not be necessary.