



Universiteit
Leiden
The Netherlands

Visual similarity for socially interactive agents that support self-awareness

da Silva, C.A.; Hilpert, B.; Bhuvaneshwara, C.; Gebhard, P.; Nunnari, F.; Tsovaltzi, D.

Citation

Da Silva, C. A., Hilpert, B., Bhuvaneshwara, C., Gebhard, P., Nunnari, F., & Tsovaltzi, D. (2023). Visual similarity for socially interactive agents that support self-awareness. *Iva '23: Proceedings Of The 23Rd Acm International Conference On Intelligent Virtual Agents*, 52. doi:10.1145/3570945.3607329

Version: Publisher's Version

License: [Licensed under Article 25fa Copyright Act/Law \(Amendment Taverne\)](#)

Downloaded from: <https://hdl.handle.net/1887/3718816>

Note: To cite this publication please use the final published version (if applicable).

The Effects of Avatar Visual Similarity on Antecedents of Self-Awareness for Socially Interactive Agents

ABSTRACT

Self-Awareness is a critical factor in social interaction. In classroom interaction, being aware of their own emotions and thoughts may enable teachers' reflection and later adaption of behavior. While inducing self-awareness through mirrors or video is common in face-to-face trainings, it has been scarcely examined in digital trainings with virtual avatars. This paper examines the relationship between avatar visual similarity and inducing self-awareness in digital training environments. We developed a theory-based methodology to reliably manipulate specific perceptually important facial features of digital avatars based on human-human identification and emotional predisposition. We created personalized versions of digital avatars with varying degrees of visual similarity to the participants by manipulating these facial features (No, weak and strong facial features alteration). In a within-subject study ($N=33$) we tested effects of degree of similarity on antecedents of self-awareness: perceived similarity, explicit identification and implicit affective identification (affinity). Results show significant differences between the personalized avatars and both the highly manipulated and the random avatar for all three antecedents. An increasing degree of visual similarity influences inducing self-awareness in digital environments, even though this similarity does not reach the mirror-image. Thus, personalizing avatars may significantly improve self-awareness.

KEYWORDS

Avatar similarity, socially interactive agents, empathic agents, self-awareness, emotional affinity, explicit identification

ACM Reference Format:

. 2023. The Effects of Avatar Visual Similarity on Antecedents of Self-Awareness for Socially Interactive Agents. In *Proceedings of ACM Conference on Intelligent Virtual Agents (IVA '23)*. ACM, New York, NY, USA, 8 pages. <https://doi.org/XXXXXXX.XXXXXXX>

1 INTRODUCTION

Avatars are virtual representations of individuals that can be controlled by a human. As such, they can be used as personalized awareness tools to increase self-awareness. Avatars are often used in digital environments such as online games, social media, and, more recently, in virtual worlds [13]. The concept of virtual representation, or the use of avatars as a means of visual representation in digital environments, has gained significant attention in recent years. One area of the application is the use of avatars as a means

to increase self-awareness, and regulate emotions (e.g. [38]) and even in teacher professional development settings (e.g. [26, 31]). There exists conflicting evidence regarding the degree of similarity needed and how similarity should be defined. Some studies show, more similarity is good (e.g., [53]), while other studies and empirical findings (e.g., uncanny valley) show, too much similarity might have adversary effects ([43]). A strongly realistic (i.e., similar) avatar can, for example, be experienced as "rather heterogeneous or inharmonious to the surrounding virtual environment" [23]. In order to examine further the effects of the avatar and a user, we first need to understand which features influence perceived similarity and to be able to define how to manipulate specific facial features of digital avatars. This paper aims to develop a technical methodology to manipulate specific facial features of digital avatars by the degrees of visual similarity to the user. It also contributes to defining the preconditions of increasing self-awareness with avatars to guide further research on topics involving avatar visual similarity. The study evaluates the proposed methodology.

2 RELATED WORK

2.1 (Virtual) Emotion Regulation trainings

Social Interaction can be very emotionally challenging on a multitude of levels, especially when it comes to conflict of interests and different socio-emotional perspectives. This challenge increases in multi-party interactions, like modern classrooms. Teachers find it hard and are often insufficiently trained to deal with the integration of different cultural backgrounds and the socio-emotional conflicts that these may give rise to. They need to adequately manage both heterogeneous learning groups with regard to the taught content, and behavioral conflicts in class in order to secure a constructive learning environment and support student development [25, 46]. This can be very stressful and requires an effective capacity for conflict regulation [12], taking into account multiple student perspectives at once, without interrupting the ongoing lesson. Students are sharp in perceiving subtle emotions and underlying aggression in teacher behavior, and recursive teacher-student discussions disturb classroom conflict resolution [14]. Emotion regulation strategies that contribute to a positive classroom climate involve reappraisal, as opposed to suppression [22], and self-compassion, which can support understanding and coping with one's own and other's emotions in learning settings [31]. However, emotion regulation presupposes self-awareness[35]. Non-effortful implicit emotional awareness (IEA, e.g. self-awareness) and effortful explicit emotional awareness (EEA, e.g. self-compassion) jointly influence higher emotion regulation [18]. Training teachers' self-awareness and consequently emotion regulation can thus improve subtle (non-)verbal behavior and conflict regulation without superimposing additional unnecessary cognitive effort and stress. However, teachers' training on realistic conflict situations, and practicing in real classrooms as a unique possibility [25] holds ethical risks related, for instance, to

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for components of this work owned by others than ACM must be honored. Abstracting with credit is permitted. To copy otherwise, or republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee. Request permissions from permissions@acm.org.

IVA '23, September 19–22, 2023, Würzburg, Germany

© 2023 Association for Computing Machinery.

ACM ISBN 978-1-4503-XXXX-X/18/06...\$15.00

<https://doi.org/XXXXXXX.XXXXXXX>

undermining specific cultural groups. Mixed-reality trainings, implementing interactive simulation technology [15–17] and socially interactive agents (SIAs) with positive effects on human emotion regulation [39, 40] may offer a viable solution. They can provide a safe room to train situational awareness and self-awareness and resulting conflict behaviour through realistic virtual interactions. As they become more and more interactive and immersive, they allow users to interact as if they were in a real classroom, and practice the handling of conflict situations. Further, they offer options for playback and natural social interactive feedback, which can act as awareness tools to make users aware of their own behaviors and others' reactions and induce self-awareness by supporting reflection [45].

2.2 Self-Awareness and Avatar Similarity

Mirrors [7] or cameras [42] are known as well-validated ways to induce self-awareness, considering that self-related stimuli (e.g. our own face) are more relevant to us than stimuli related to others [6], and that the sense of self seems to be inherently linked to one's own face [34]. In modern VR-training settings where the face is usually covered with the equipment, inducing self-awareness becomes more difficult [33]. Moreover, mixed-reality concepts involve the use of avatars that can cohabit a shared world with virtual agents [30]. To take this into consideration, recent research introduced the use of personalized avatars. When using visually similar avatars, users felt sufficiently self-represented [49] and emotionally attached [19] to the stimuli, so that these avatars could increase the levels of self-awareness in users.

Avatars can be defined as digital bodies or vehicles that users engage in order to interact with a digital environment [11]. They have further been conceptualized as symbolic representations of the face for computer-mediated communication [10].

The similarity of avatar and person can be achieved in a variety of ways. Some examples include matching visual characteristics such as hair and clothes [5, 23], and matching or mismatching weight [32]. The specific similarity between the user's and respectively avatar's face (subsequently called visual similarity) has been of special importance for the increase of self-presence [2], body ownership and even identification with the avatar [23, 44].

Similarity can be either subjective, referring to the perception of a dyad, or objective when considering, for example, degrees of observable similarities [36]. Perceived similarity was found to have a higher impact on predicting outcomes than observable similarity (i.e. similarity in measurable terms) in some studies (e.g. in [48]). However, there is scarce literature on visually detailed and humanoid avatars. Moreover, most studies (e.g. [2, 49]) examine the effects of comparing personalized versus an averaged control avatar. To the best of our knowledge, no study has tested varying degrees of visual facial similarity systematically. Therefore, this research's scope is concerned with visually detailed humanoid avatars and the systematic manipulation of their facial similarity. This paper investigates, which facial characteristics and what degree of their manipulation in personalized avatars yields higher perceived facial similarity (RQ1)?

Cohen [8] suggests that explicit identification is a two-stage process, with the first stage being the selection of relevant visual

features and the second stage being the comparison of those features to stored representations in memory. This process allows the recognition of familiar objects. Over a set of carefully constructed studies, [49] found a significant correlation between avatar-person similarity and self-awareness, attributed to triggering the same processes of self-representation as a mirror would. This type of identification occurs because of a perception that characteristics and values are shared and is "a process or state of seeing oneself as similar to, the same as, or fused with another object or person" [11]. Facial avatar-person similarity leads to a higher sense of self-presence [2] and self-identification [44]. Similarly, we understand the results of the relationship between an individual and their digital representation or online persona as a sense of identification. This research aims to consider measuring identification to validate if the proposed methodology for varying the appearance of the avatar will have an effect on self-identification, and which variation causes higher identification. This paper investigates, to what extent is explicit identification as an antecedent of self-awareness affected by the degree of facial manipulation (RQ2)?

Visual similarity is also a key aspect of implicit identification, as it involves the ability to recognize objects that are similar in appearance, even if they are not identical and influences the intention to use the avatar as well as emotional attachment [44]. People identify with their in-game avatars if they have a positive attitude towards them and find the avatar characteristics important to themselves [28]. Subsequently, visual similarity has been shown to increase avatar appreciation (enjoyment, comfort, helpfulness) in users [9]. They tend to develop a sense of affinity towards their avatar, which can lead to increased self-disclosure and more authentic interactions online [52]. Affinity can be described as natural liking "driven by subconscious processes that are beyond conscious control" [41]. Affinity can also be related to the degree of attraction or similarity between two or more entities. There is a significant effect of perceived visual similarity between an avatar and the user on self-awareness [19, 20]. This can be attributed to the personalized avatar triggering emotions, beliefs and attitudes like affinity that facilitated identification. This paper investigates, to what extent implicit affective identification (affinity) as an antecedent of self-awareness is affected by the degree of facial manipulation (RQ3)?

In conclusion, visual avatar-person similarity influences both explicit self-identification as well as implicit affective identification with the avatar and could be used to elicit self-awareness in human users in sophisticated interactive virtual training environments, a precondition of self-compassion.

2.3 Overview and Hypotheses

This study aims at investigating the effect of systematic manipulation of degrees of visual avatar-person similarity on the antecedents involved in eliciting self-awareness. In a first step, we developed a theory-based process (i.e. Section 3) of manipulating specific facial features of digital avatars by the degrees of visual similarity to a person, in view of using avatars as awareness tools to increase self-awareness in teacher professional development. In a second step, we aim to validate the use of the developed methodology in a study designed to investigate the effect of perceived similarity between the avatar and the user, as well as its influence on the

identification with the avatar and the affinity, which explores the following hypotheses:

H1: There will be a main effect of avatar-person similarity manipulation on perceived similarity. The avatar will be perceived as most similar in the not manipulated condition, and gradually less similar with increasing degree of manipulation.

H2: There will be a main effect of avatar-person similarity manipulation on explicit identification. There will be higher explicit identification with the avatar in the not manipulated condition, gradually declining with increasing degree of manipulation.

H3: There will be a main effect of avatar-person similarity manipulation on implicit affective identification, operationalized as affinity. There will be higher implicit affective identification in the not manipulated condition, gradually declining with increasing degree of manipulation.

3 A THEORY-BASED METHODOLOGY

In this section, the theory-based development of the methodology to systematically vary visual avatar-person similarity is described.

3.1 Perceptual Sensitivity and the Selection of Facial Features

A subset of critical facial features with high perceptual sensitivity (PS) has been identified, which is described as the sensitivity to detect feature differences across faces and are crucial for determining the identity of faces (i.e. face recognition across different images of the same face) [1]. In a set of studies, facial features were adjusted in a systematic and quantitative manner within a so-called "face-space", and perceptual effects of these adjustments were measured to determine a subset of critical features for which participants were found to show high perceptual sensitivity [1]. However, their research manipulated specifically static 2D images. In the present study, the following five critical facial features were selected, based on [1]: Chin shape, jaw width, eye shape, lip thickness, and nose shape. Beyond their importance for identification, the selection of these five features for the process of avatar-person similarity manipulation was based on their technical feasibility to manipulate them in the operationalization of the study discussed in Section 3.2.

3.2 Avatar Creation and Modification

In order to ensure the replicability of this work, we aimed to use exclusively openly accessible software tools to create the different degrees of avatar-person similarity manipulation.

Previous studies applied different techniques to achieve different levels of avatar-person similarity. [23] created avatars comprising a 3D mesh (a structural construction of a polygon-based 3D model), reconstructed from real imagery of participants, towards a cartoon-like virtual character-based avatar created by a 3D artist. Other studies used a 3D scan of the participant's faces to create highly similar avatar faces [44], avatars with a face that was modeled by a 3D artist after photographs [2], and online construction tools embedded in applications or games such as Yahoo! [49] and Second-Life [19]. The present study was concerned with a way to manipulate the avatar-self similarity by applying different degrees of avatar-person similarity variation on a continuous scale based on PS. Thus,

a technical set-up that allowed for continuous manipulation of each of the 5 selected high-PS facial features was selected.

To comply with the research goal of creating visually detailed humanoid avatars, we selected existing software that allowed us to generate a realistic (i.e. high visual fidelity) 3D avatar from participant's photos, and then vary the appearance systematically according to differing degrees of similarity. Our selection criteria included a) the possibility to manipulate specific facial features on a continuous scale, b) the possibility to animate the created avatars (e.g. create short videos of facial movements) and c) a pragmatic approach to only use tools, that require minimal technical knowledge and a reasonable amount of time and effort to create multiple avatars for each participant. After considering a range of available software tools, *FaceGen Modeller Demo* (facegen.com/modeller.htm) and *MetaHuman Creator* (metahuman.unrealengine.com) were selected to be used in this study.

FaceGen Modeller Demo (subsequently called *FaceGen*) is a desktop software to generate 3D heads from one or more pictures. The ideal results are obtained from inputting three images (front, left, and right of the face). *FaceGen* allows modifying 150+ parameters such as demographics (age, gender, racial group), shapes, colours, textures and individual facial features based on slide menus. Some of the limitations in regard to this study include that it only generates a 3D model of a face (not including hair) and does not include animation capabilities.

To compensate, we also used *MetaHuman Creator*, which is a free cloud base app to create 3D high-fidelity digital avatars (including hair). The creation of avatars does not require artistic modeling skills, since its 3D creation capabilities are also based on slide menus and interface controls. Another advantage of *MetaHuman* for the scenario of the research is that it allows exporting the 3D avatar to animation tools, which can be used to personalize facial animations including eye tracking.

3.3 Manipulation of Avatar-Person Similarity

Besides the challenge of creating a manipulable avatar most similar to a person, this research faced the challenge of defining a methodology to vary the degree of similarity between the avatar and the user. As elaborated in (Section 2.2), avatar-person similarity has usually been manipulated in the model of low similarity being a generic avatar that might simply match gender, race and ethnicity, to high similarity by matching clothes, or even the participant's faces (e.g. [51]). However, with fast advancements in animation technology [3] and the rise of platforms for their use like e.g. the *Metaverse* (e.g., [24, 37]), creating "realistic" personalized avatars and subsequently their similarity becomes relative to the technological progress. Even more importantly, as this research aims to better understand on a process level how visual similarity affects self-awareness and its antecedents in interactive virtual trainings, we aimed for a more fine-grained analysis of visual similarity manipulation beyond a simple distinction between personalized vs. non-personalized. To implement this, a scale was designed to guide the definition of the conditions for creating degrees of similarity variations (i.e. a visual similarity scale, inspired by approaches taken by [29]) for this research study that served as the baseline for avatar-person similarity manipulation (see Table 1).

Table 1: Degrees of Similarity Manipulation

S	M	Description
High	0%	Avatar face modeled from participants' pictures (i.e. highly similar with 0% of manipulation of facial features)
Medium	50%	Avatar face modeled from participant's pictures, then applied a percentage of manipulation (50%) on selected facial features (chin shape, jaw width, eye shape, lip thickness, nose shape).
Low	100%	Avatar face modeled from participant's pictures then applied a percentage of manipulation (100%) on selected facial features (see above).

S = Degree of Similarity, M = Degree of Manipulation

To generate the most similar facial avatar stimuli (0%-condition), we used MetaHuman Creator. For the facial manipulation of the 50%- and 100%-conditions, we used FaceGen first, which generates 3D faces from photos and offers modifiers in the form of sliders. FaceGen allows for the distinct manipulation of the facial features on a scale from -10 to +10, with the tool automatically determining the participant's facial features scale value based on their pictures. The direction of the similarity degree manipulation in FaceGen (towards -10 or +10) was defined as the direction of the longest distance from the scale value automatically determined by FaceGen. For instance, if a face analyzed by FaceGen (0% condition) points to a chin shape feature having the value of 0.58 in its scale (from -10 to +10), the variations would be towards -10, which is the longest distance from 0.58. Using this example, the manipulation of the chin shape for the 50% condition would result in updating the chin shape scale value from 0.58 to -4.71 (absolute distance from 0.58 to -10 divided by two minus 0.58), and for the 100% condition to -10, which is the longest possible distance from the original value, 0.58. The exception was for the lip thickness feature, which was defined to always move in the positive direction (+10) to avoid deformations on the face that would be impossible to reproduce on MetaHuman (i.e. unrealistic thinner lips sizes). Each facial feature was manipulated individually on FaceGen, and each resulting image was exported. This represented a FaceGen export of 10 images per participant. As a next step, the first MetaHuman condition made from the participant's pictures (0%) was triplicated and each facial feature manipulation in MetaHuman for the 50% and 100% conditions reproduced, by using the exported FaceGen images. Figure 1 illustrates the output of the different conditions from MetaHuman.



Figure 1: Original photo and the 0%-, 50%- and 100%- variations

4 EVALUATION STUDY

In a first evaluation study, the effects of the varying degrees of visual similarity manipulation on the antecedents of self-awareness were examined.

Following the recommendations for open research practices [50], all materials (coding plan, experimenter instruction, data and analysis code) can be found on OSF¹. (Note: Due to anonymization, the data and analysis will be made public after the review process, as it contains information that would reveal the authors' nationality.)

4.1 Participants

The study was conducted with voluntary participants recruited via online platforms. Participants were required to be at least 18 years old, have access to a computer/mobile device with a camera, and have a minimum English proficiency level of B2 according to the Common European Framework of Reference for Languages (CEFR; Council of Europe 2001). Of the total of $N = 88$ participants, $n = 54$ were excluded due to incomplete responses ($n = 35$). The final sample of $n = 33$ consisted of $n = 13$ males and $n = 20$ females between 18 and 40 years ($M = 27.6$ years, $SD = 4.74$ years). We offered the participants who completed the study the option to receive a short video of their personalized avatar and to participate in a contest to win Amazon vouchers.

4.2 Study Design and Procedure

A within-subjects study was conducted fully online and used self-administered questionnaires delivered via an online survey platform (limesurvey.org). The Study consisted of four conditions: high, medium and low similarity (see Table 1) plus one Control group (CG). The study was divided into two sessions, with a 24h to 72h interval between them that corresponds to the time considered for generating the personalized avatars. The main dependent variables were perceived avatar-person similarity, explicit cognitive identification as well as implicit-emotional identification with the avatar.

In the first session, participants were asked to review introductory information about the study and sign the consent form and data protection. Participants confirmed their eligibility by self-reporting their English proficiency level. The participants with the required proficiency level preceded the survey by filling out a questionnaire including data collection such as e-mail address², three facial pictures (as required by FaceGen) and demographic data.

Once participants' data were received from the first survey, the pictures were used to create personalized avatars in varying degrees of similarity to the participants' faces as described in Section 3.3. Once the avatars were created in MetaHuman, a 12 seconds GIF was created recording the pre-defined idle facial animation from each of the three conditions (0%, 50% and 100%).

As the next step, we set up the second survey by adding the recordings of each personalized avatar condition in the form of animated images (GIF). The conditions and instruments were presented to participants in random order. The previous same-gender

¹https://osf.io/zfbjx/?view_only=cbec58b6ab38428aba43c778b511d97c

²E-mail addresses were saved in a separate dataset. Merging was done through a unique alphanumeric token. All data that could be used to identify participants was deleted after the merging was completed

participant's 0% avatars were used as a control condition. The first two participants were presented with control-condition a male and female avatar was created ahead from two volunteers' pictures.

4.3 Measurements and Instruments

The instruments to collect the data described in the study design section were the following³:

Demographics: Participants were asked for their age and gender.

Perceived facial similarity between avatar and user: The subscale "physical similarity" from the Polythetic model of identification was used [11], containing five items to measure physical similarity.

Explicit cognitive Identification with the Avatar: No existing scale was found. Self-created items were used, which includes a question based on the definition of identification by [11], "If I look at the GIF, it feels as if I am this Avatar", and two questions from [47], "I identify with this Avatar" and "I feel represented by this avatar".

Implicit-emotional Identification with the Avatar: Implicit-emotional Identification was operationalized as the affinity towards the Avatar. We used the affinity scale from [41] which contains five items.

Perceived Realism of the Avatar (Manipulation Check): We used a single item based on [23]: "How realistic is the avatar?"

5 RESULTS

Data analyses were conducted with R version 4.2.3.

Prior to conducting the analysis, we assessed the presence of potential outliers, identifying values exceeding $Q3 + 1.5 \times IQR$ or falling below $Q1 - 1.5 \times IQR$ as outliers. A total of $n=5$ outliers were detected. Upon examination, the scores of these outliers were found to be within the range of plausible data, with no indication of measurement errors or inattentive ratings by participants. Furthermore, analyses conducted using both the raw data and data excluding outliers yielded similar results. Consequently, we opted to retain the outliers and present findings based on the complete data set.

Shapiro Test for normality and Mauchly's Test for sphericity both indicated violations. However, ANOVAs are rather robust against normality and sphericity violations, see [21]. Moreover, the reported results were corrected using the Greenhouse-Geisser method.

As a manipulation check, we tested the perceived realism of the avatars with one item. While the avatar in the 0%, 50% and the CG was perceived as rather realistic, there was a significant difference between each of these 3 and the 100%-condition, indicating, that the avatar was seen as significantly less realistic.

We hypothesized that for all three tested constructs, there would be a significant main effect for condition, with the most similar (0% condition) scoring highest for perceived similarity, explicit identification and affinity. A repeated measures ANOVA's was used to examine the effect of condition (0%, 50%, 100%-Manipulation, CG) on each of the dependent variables individually.

Further, we performed post-hoc t-tests to examine the differences between each condition more closely. Bonferroni-Holm corrections were applied. Results are reported individually per construct.

5.1 Perceived Similarity

Hypothesis 1 examined the effect of the degree of avatar-person similarity manipulation (condition) on perceived similarity. The ANOVA revealed a significant main effect for condition, $F(1.87, 59.72) = 10.13, p < .001, \eta^2 = .11$. Subsequent comparisons did not show a significant effect between the 0%- ($M = 3.34, SD = 1.26$) and the 50%-condition ($M = 3.18, SD = 1.21$), $t(32) = 1.36, p = .18$. All other comparisons showed a significant difference, showing a steady decline in similarity with increasing similarity manipulation (0% = highest - CG = lowest). This included significant effects between the 0%- and the 100%-condition ($M = 2.75, SD = 0.85$), $t(32) = 3.17, p < .01$, as well as the CG ($M = 2.44, SD = 0.73$), $t(32) = 3.83, p < .01$. Further, between the 50%- and 100%-condition, $t(32) = 2.54, p = .02$, as well as the CG, $t(32) = 3.46, p < .01$ and between the 100%-condition and the CG, $t(32) = 2.14, p = .04$. Thus, H1 was partially confirmed: Manipulation of avatar-person similarity influences the perceived similarity, except for the first two degrees of manipulation (see Fig. 2).

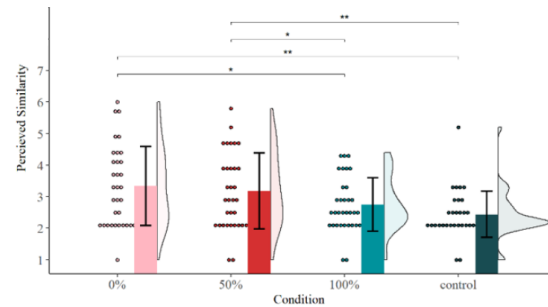


Figure 2: Effects of similarity manipulation on perceived similarity. Dots (left) represent data points of individual participants, violins (right) distribution within conditions

5.2 Explicit Identification

Hypothesis 2 examined the effect of the degree of avatar-person similarity manipulation (condition) on explicit identification. The ANOVA revealed a significant main effect for condition, $F(2.03, 65.01) = 13.11, p < .001, \eta^2 = .13$. Subsequent comparisons did not show a significant effect between the 0%- ($M = 2.76, SD = 1.84$) and the 50%-condition ($M = 2.64, SD = 1.72$), $t(32) = 0.64, p = .53$, or between the 100%- ($M = 1.82, SD = 1.05$) and the CG ($M = 1.53, SD = 0.67$), $t(32) = 1.68, p = .1$. All other comparisons showed a significant difference, showing a decline in explicit identification with increasing similarity manipulation. This included significant effects between the 0%- and the 100%, $t(32) = 3.71, p < .01$, as well as the CG, $t(32) = 4.05, p < .01$. Further, between the 50%- and 100%, $t(32) = 4.03, p < .01$, as well as the CG, $t(32) = 4.16, p < .01$. Thus, H2 was also partially confirmed: Manipulation of avatar-person similarity influences also explicit identification, except for the first and last two degrees of manipulation (see Fig. 3).

³All items (except for demographics) contained a seven-point Likert scale

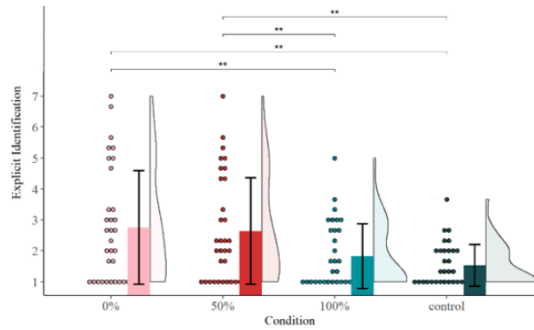


Figure 3: Effects of similarity manipulation on explicit identification. Dots (left) represent data points of individual participants, violins (right) distribution within conditions

5.3 Implicit Identification (Affinity)

Hypothesis 3 examined the effect of the degree of avatar-person similarity manipulation (condition) on affinity. The ANOVA revealed a significant main effect for condition, $F(2.2,70.44) = 7.66$, $p < .001$, $\eta^2 = .05$. Subsequent comparisons again did neither find a significant effect between the 0%- ($M = 3.22$, $SD = 1.77$) and the 50%-group ($M = 3.08$, $SD = 1.72$), $t(32) = 0.95$, $p = .35$, nor between the 100%- ($M = 2.52$, $SD = 1.51$) and the CG ($M = 2.37$, $SD = 1.3$), $t(32) = 0.74$, $p = .46$. However, all of the other group comparisons showed a significant difference, showing a decline in explicit identification with increasing similarity manipulation. This included significant effects between the 0%- and the 100%, $t(32) = 3.30$, $p < .01$, as well as the CG, $t(32) = 3.32$, $p < .01$. Further, between the 50%- and 100%, $t(32) = 3.17$, $p < .01$, as well as the CG, $t(32) = 2.77$, $p = .01$. Thus, H2 was again partially confirmed: Manipulation of avatar-person similarity influences also explicit identification, except for the first and last two degrees of manipulation (see Fig. 4).

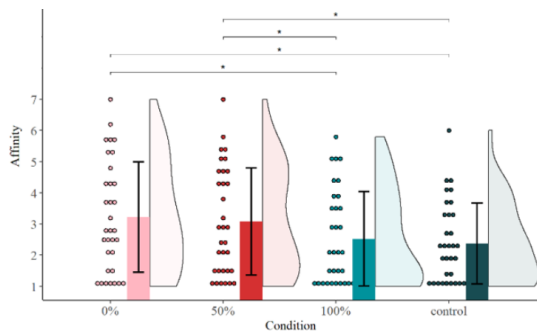


Figure 4: Effects of similarity manipulation on affinity. Dots (left) represent data points of individual participants, violins (right) distribution within conditions

6 DISCUSSION

This paper investigated the effect of manipulating specific facial features of digital avatars by degrees of visual similarity to the

participants on perceived similarity of the avatar, as well as two antecedents of self-awareness: explicit and implicit identification. A similarity scale was defined formalizing three degrees of variations (high similarity - 0%, medium similarity-50%, low similarity-100%).

All degrees except the 100%-manipulation were perceived as realistic. This lets us assume that all effects, especially the ones between the 0%-, 50%- and CG, can be attributed to the manipulation rather than an unnatural distortion of the participants' faces.

Manipulating visual avatar-person similarity using the developed methodology indeed showed an effect on the similarity perceived by the user in the expected direction (confirming H1). This also serves as a manipulation check for the following analyses. Single comparisons revealed, that there was a steady decline in perceived similarity between degrees of manipulation, indicating that the approach, adjusting specific facial features to manipulate the degree of similarity, is suitable. This is especially underlined by the fact that the avatar in the CG was perceived as more realistic than the one in the 100%-condition but seen as less similar. The difference between 0%- and 50%-manipulation, although objectively different, was not perceived as dissimilar. This gives future researchers and practitioners a bit of an error margin to work with, in terms of manipulating visual similarity.

Further, avatar-person similarity also showed an effect on the explicit identification by the user in the expected direction (confirming H2). Thus, the participants tended to identify more with an avatar, the more it was objectively similar to them. While not particularly surprising, this result has important implications, given that identification is one of the key antecedents in eliciting self-awareness. None of the conditions showed a normal distribution of answers. Examining the distributions of answers between the four conditions closely, however, in the 0% and 50%-condition, a wide range of answers was observable, compared to the other two conditions, where answers largely concentrated on the lower end of the scale. Single comparisons revealed that there was a steady decline in explicit identification with decreasing similarity. Taken together, these detailed analyses deliver a strong argument against generic, non-personalized avatars whenever explicit identification with the avatar and self-awareness elicitation are goals in the study. Here too, the difference between 0%- and 50%-manipulation did not have an effect on explicit identification by the user, and neither did the difference between 100%-manipulation and the CG. This effect could be explained assuming, that for a difference in identification, a small change in the avatar seems not enough, while in the 100%-condition, the participants apparently did not recognize themselves anymore (as further indicated by the significant effect between 50%- and 100%-, but not 100%-manipulation and CG). An interaction with the missing realism can be claimed here. However, the missing effect in the CG, which was perceived as realistic, speaks against that. We can conclude that, in terms of explicit identification, the right amount of similarity manipulation is important.

Lastly, manipulating visual avatar-person similarity indeed showed an effect on implicit affective identification (affinity) in the expected direction. Apart from merely identifying with the avatar, participants also rather created an emotional bond - an affinity - towards avatars that are more similar to them. Single comparisons revealed the same pattern of effects between the conditions as in explicit identification, again indicating, that, whenever affinity or self-awareness

are to be elicited, using a generic avatar could be counterproductive. Similarly, the difference between 0%- and 50%-manipulation did not produce an effect in affinity, neither did the difference between 100%-condition and the CG. Again, a small change in avatar-person similarity did not seem to affect the affection towards the avatar, while in the 100%-condition, the participants apparently did not feel an emotional affinity anymore.

6.1 General Discussion

Compared to previous studies, this paper examined in closer detail how avatar-person similarity is processed by users and the effects it produces. The results of the research suggest that the proposed methodology including the definition of the manipulation of relevant facial features can be applied to vary visual avatar-person similarity. One of the major advantages of the approach chosen in this work, is that it was all based on openly accessible tools, so it could be easily adapted for future research. Introducing this custom methodology revealed that perceived similarity as well as explicit and implicit affective identification with virtual avatars are both dependent on the degree of visual avatar-person similarity, and highlighted that generic avatars are insufficient for manipulations that depend on them, like self-awareness. As visual avatar-person similarity is correlated with explicit identification [49] and Homophily (i.e., liking persons perceived as similar), which both were found to predict self-awareness [19, 20], next steps in future research might involve the identification and testing of other aspects of similarity, such as behavioural contingency, to increase support self-awareness. Given that self-awareness and consequently, self-compassion are key ingredients in reflection and emotion regulation [18], the effects of interactive virtual trainings such as [4], where teachers interact with interactive virtual agents (students), could be amplified significantly by personalizing teacher avatars to increase their self-awareness. These findings also have important implications for the design of digital environments in the area of interactive virtual training environments in general, such as online educational games, simulations and virtual worlds, where the use of avatars may be beneficial for training situations. This is especially important for scenarios where constructs related to perceptions of the self, like self-awareness, self-compassion (and mindfulness), but also presence and immersion are aimed at.

On the practical side, these research findings are significant in light of the fact that many applications from computer games to educational tools allow players to create and customize avatars. With technology evermore advancing, virtual representation is already starting to become a key ingredient online platforms such as e.g. the Metaverse [24, 27]. The present study shows, how much of a difference for self-representation and immersion personalized avatars could have. Future work is needed to examine this further.

6.2 Limitations and Future Work

The technical methodology for creating avatar variations was applied to a study that used animated facial images (GIF) of avatars, and it is possible that the results may differ from studies that require the use of dynamic avatars containing the whole body. Equivalently, further research with dynamic avatars is needed to validate the findings and explore the full potential of avatars as a means of

increasing self-awareness. Regarding the avatar generation, the sample size of the study was relatively small, and further research is needed to replicate the results of the methodology. Another limitation is in regard to the limitations of the solutions that were used to create avatars and their variations. Some of the visual characteristics (e.g. hair, beard, eyebrows format) have a limited amount of pre-defined choices that might not match some participants' features. We consider that the 100%-condition (low similarity), might impact the participant's perception of the other avatar's conditions (0% and 50%) in terms of realism and similarity. It could have happened that when the low similarity condition was presented first in the study survey, it caused the participant to consider the next avatars very different from them. Further data needs to be collected to validate that limitation. Finally, future research should consider applied research scenarios to validate the methodology for other effects measurements when considering avatar-person similarity.

7 CONCLUSION

This paper has successfully presented a theory-based methodology to manipulate the facial features of digital avatars, with the aim of achieving varying degrees of visual similarity to the user. A subsequent evaluative study has evaluated this methodology and demonstrated the effect of this manipulation of visual avatar-person similarity the preconditions necessary for increasing self-awareness with avatars, which can guide further research in the field of avatar visual similarity. In conclusion, this paper aimed to provide a detailed analysis of the manipulation of visual similarity beyond the binary distinction of personalized versus non-personalized avatars. The results suggest that in situations where constructs related to self-perception, such as self-awareness, self-compassion, mindfulness, presence, and immersion are targeted, generic avatars may not be sufficient. Therefore, it is crucial for future research to consider more nuanced approaches to visual similarity manipulation in these scenarios to achieve better outcomes.

ACKNOWLEDGMENTS

We thank ANONYMIZED for their help with this study.

REFERENCES

- [1] Naphtali Abudarham and Galit Yovel. 2016. Reverse engineering the face space: Discovering the critical features for face identification. *Journal of Vision* 16, 3 (2016), 40–40.
- [2] Laura Aymerich-Franch, René F Kizilcec, and Jeremy N Bailenson. 2014. The relationship between virtual self similarity and social anxiety. *Frontiers in human neuroscience* 8 (2014), 944.
- [3] Shubhajit Basak, Peter Corcoran, Rachel McDonnell, and Michael Schukat. 2022. 3D face-model reconstruction from a single image: A feature aggregation approach using hierarchical transformer with weak supervision. *Neural Networks* 156 (2022), 108–122.
- [4] Chirag Bhuvaneshwara, Manuel Anglet, Bernhard Hilpert, Lara Chehayeb, Ann-Kristin Meyer, Daksitha Withanage Don, Dimitra Tsovaltzi, Patrick Gebhard, Antje Biermann, Sinah Aucht, Nils Lauinger, Andreas Kaiser, Fabian Kersting, and Gregor Mehlmann. 2023. MITHOS-Mixed Reality Interactive Teacher Training System for Conflict Situations at School. In *Proceedings of the International Society of the Learning Sciences*.
- [5] Max V Birk, Cheralyn Atkins, Jason T Bowey, and Regan L Mandryk. 2016. Fostering intrinsic motivation through avatar identification in digital games. In *Proceedings of the 2016 CHI conference on human factors in computing systems*. 2982–2995.
- [6] Serge Brédart, Marie Delchambre, and Steven Laureys. 2006. Short article: One's own face is hard to ignore. *Quarterly journal of experimental psychology* 59, 1 (2006), 46–52.

- [7] Charles S Carver and Michael F Scheier. 1978. Self-focusing effects of dispositional self-consciousness, mirror presence, and audience presence. *Journal of personality and social psychology* 36, 3 (1978), 324.
- [8] Jonathan Cohen. 2001. Defining identification: A theoretical look at the identification of audiences with media characters. *Mass communication & society* 4, 3 (2001), 245–264.
- [9] Jingyu Cui, Yasmin Aghajan, Joyca Lacroix, Aart van Halteren, and Hamid Aghajan. 2009. Exercising at home: Real-time interaction and experience sharing using avatars. *Entertainment Computing* 1, 2 (2009), 63–73.
- [10] Judith Donath. 2001. Mediated faces. In *Cognitive Technology*. 373–390.
- [11] Edward Downs, Nicholas D Bowman, and Jaime Banks. 2019. A polythetic model of player-avatar identification: Synthesizing multiple mechanisms. *Psychology of popular media culture* 8, 3 (2019), 269.
- [12] Joana Duarte and José Pinto-Gouveia. 2017. Empathy and feelings of guilt experienced by nurses: A cross-sectional study of their role in burnout and compassion fatigue symptoms. *Applied Nursing Research* 35 (2017), 42–47.
- [13] Jesse Fox and Sun Joo Ahn. 2013. Avatars: portraying, exploring, and changing online and offline identities. In *Handbook of research on technoself: identity in a technological society*. IGI Global, 255–271.
- [14] Anne C Frenzel, Lia Daniels, and Irena Burić. 2021. Teacher emotions in the classroom and their implications for students. *Educational Psychologist* 56, 4 (2021), 250–264.
- [15] Patrick Gebhard. 2005. ALMA: a layered model of affect. In *Proceedings of the fourth international joint conference on Autonomous agents and multiagent systems*. 29–36.
- [16] Patrick Gebhard, Tanja Schneeberger, Tobias Baur, and Elisabeth André. 2018. MARSSI: Model of Appraisal, Regulation, and Social Signal Interpretation. In *Proceedings of the 17th International Conference on Autonomous Agents and Multi-Agent Systems*. International Foundation for Autonomous Agents and Multiagent Systems, 497–506.
- [17] Scott W Greenwald, Alexander Kulik, André Kunert, Stephan Beck, Bernd Fröhlich, Sue Cobb, Sarah Parsons, Nigel Newbutt, Christine Gouveia, Claire Cook, et al. 2017. Technology and applications for collaborative learning in virtual reality. Philadelphia, PA: International Society of the Learning Sciences.
- [18] Anett Gyurak, James J Gross, and Amit Etkin. 2011. Explicit and implicit emotion regulation: A dual-process framework. *Cognition and emotion* 25, 3 (2011), 400–412.
- [19] Rosalie Hooi and Hichang Cho. 2012. Being immersed: avatar similarity and self-awareness. In *Proceedings of the 24th Australian Computer-Human Interaction Conference*. 232–240.
- [20] Rosalie Hooi and Hichang Cho. 2014. Avatar-driven self-disclosure: The virtual me is the actual me. *Computers in Human Behavior* 39 (2014), 20–28.
- [21] PK Ito. 1980. 7 Robustness of ANOVA and MANOVA test procedures. *Handbook of statistics* 1 (1980), 199–236.
- [22] Jingwen Jiang, Marja Vauras, Simone Volet, and Yili Wang. 2016. Teachers' emotions and emotion regulation strategies: Self- and students' perceptions. *Teaching and Teacher Education* 54 (2016), 22–31. <https://doi.org/10.1016/j.tate.2015.11.008>
- [23] Dongsik Jo, Kangsoo Kim, Gregory F Welch, Woojin Jeon, Yongwan Kim, Ki-Hong Kim, and Gerard Joungyun Kim. 2017. The impact of avatar-owner visual similarity on body ownership in immersive virtual reality. In *Proceedings of the 23rd ACM Symposium on Virtual Reality Software and Technology*. 1–2.
- [24] Do Yuen Kim, Ha Kyung Lee, and Kyunghwa Chung. 2023. Avatar-mediated experience in the metaverse: The impact of avatar realism on user-avatar relationship. *Journal of Retailing and Consumer Services* 73 (2023), 103382.
- [25] Andreas Krause, Cosima Dorsemagen, and Sophie Baeriswyl. 2013. *Zur Arbeitssituation von Lehrerinnen und Lehrern: Ein Einstieg in die Lehrerbelaugungs- und gesundheitsforschung*. Springer.
- [26] Mareike Kunter, Jürgen Baumert, and Werner Blum. 2011. *Professionelle Kompetenz von Lehrkräften: Ergebnisse des Forschungsprogramms COACTIV*. Waxmann Verlag.
- [27] Jason Lawrence, Ye Pan, Dan B Goldman, Rachel McDonnell, Julie Robillard, Carol O'Sullivan, Yaser Sheikh, Michael Zollhoefer, and Jason Saragih. 2022. State of the art in telepresence. In *ACM SIGGRAPH 2022 Courses*. 1–74.
- [28] Melissa G Mayhew, John Gardner, and Neal M Ashkanasy. 2010. Measuring individuals' need for identification: Scale development and validation. *Personality and Individual Differences* 49, 5 (2010), 356–361.
- [29] Hannah Park, Sarah Brown, and Sharon Lynn Chu. 2019. Understanding Avatar Identification Through Visual Similarity for Richer Story Creation. In *HCI International 2019-Posters: 21st International Conference, HCI 2019, Orlando, FL, USA, July 26–31, 2019, Proceedings, Part II 21*. Springer, 423–431.
- [30] Juyeon Park and Jennifer Paff Ogle. 2021. How virtual avatar experience interplays with self-concepts: the use of anthropometric 3D body models in the visual stimulation process. *Fashion and Textiles* 8, 1 (2021). <https://doi.org/10.1186/s40691-021-00257-6>
- [31] Sheenyong Park and Dimitra Tsovaltzi. 2022. Implicit and Explicit Emotion Regulation for Conflict Resolution: Narrative and Self-Compassion as Anti-Bullying Training. In *Proceedings of the 16th International Conference of the Learning Sciences-ICLS 2022*, pp. 187–194. International Society of the Learning Sciences.
- [32] Jorge Peña, Subuhi Khan, and Cassandra Alexopoulos. 2016. I am what I see: How avatar and opponent agent body size affects physical activity among men playing exergames. *Journal of Computer-Mediated Communication* 21, 3 (2016), 195–209.
- [33] Nicola Petrocchi, Cristina Ottaviani, and Alessandro Couyoumdjian. 2017. Compassion at the mirror: Exposure to a mirror increases the efficacy of a self-compassion manipulation in enhancing soothing positive affect and heart rate variability. *The Journal of Positive Psychology* 12, 6 (2017), 525–536.
- [34] Giuseppina Porciello, Brittany Serra Holmes, Marco Tullio Liuzza, Filippo Crostella, Salvatore Maria Aglioti, and Ilaria Bufalari. 2014. Interpersonal Multi-sensory Stimulation reduces the overwhelming distracting power of self-gaze: psychophysical evidence for 'engagement'. *Scientific Reports* 4, 1 (2014), 6669.
- [35] Cynthia J. Price and Carole Hooven. 2018. Interceptive awareness skills for emotion regulation: Theory and approach of mindful awareness in body-oriented therapy (MABT). *Frontiers in Psychology* 9, MAY (2018), 1–12. <https://doi.org/10.3389/fpsyg.2018.00798>
- [36] Everett M Rogers and Dilip K Bhowmik. 1970. Homophily-heterophily: Relational concepts for communication research. *Public opinion quarterly* 34, 4 (1970), 523–538.
- [37] Anca Salagean, Eleanor Crellin, Martin Parsons, Darren Cosker, and Danaë Stanton Fraser. 2023. Meeting Your Virtual Twin: Effects of Photorealism and Personalization on Embodiment, Self-Identification and Perception of Self-Avatars in Virtual Reality. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems*. 1–16.
- [38] Tanja Schneeberger, Patrick Gebhard, and Dimitra Tsovaltzi. [n. d.]. ExHAIL: Explicit and Implicit Emotion Regulation Training with a Social Agent. ([n. d.]).
- [39] Tanja Schneeberger, Naomi Sauerwein, Manuel S. Anglet, and Patrick Gebhard. 2021. Stress Management Training Using Biofeedback Guided by Social Agents. In *26th International Conference on Intelligent User Interfaces* (College Station, TX, USA) (IUI '21). Association for Computing Machinery, New York, NY, USA, 564–574. <https://doi.org/10.1145/3397481.3450683>
- [40] Tanja Schneeberger, Mirella Scholtes, Bernhard Hilpert, Markus Langer, and Patrick Gebhard. 2019. Can Social Agents elicit Shame as Humans do?. In *Int. Conf. on Affective Computing and Intelligent Interaction*. IEEE, 164–170.
- [41] Mike Seymour, Lingyao Ivy Yuan, Alan Dennis, Kai Riemer, et al. 2021. Have we crossed the uncanny valley? Understanding affinity, trustworthiness, and preference for realistic digital humans in immersive environments. *Journal of the Association for Information Systems* 22, 3 (2021), 9.
- [42] Paul J Silvia and Ann G Phillips. 2004. Self-awareness, self-evaluation, and creativity. *Personality and Social Psychology Bulletin* 30, 8 (2004), 1009–1017.
- [43] Jan Philipp Stein and Peter Ohler. 2017. Venturing into the uncanny valley of mind—The influence of mind attribution on the acceptance of human-like characters in a virtual reality setting. *Cognition* 160, May 2018 (2017), 43–50. <https://doi.org/10.1016/j.cognition.2016.12.010>
- [44] Kil-Soo Suh, Hongki Kim, and Eung Kyo Suh. 2011. What if your avatar looks like you? Dual-congruity perspectives for avatar use. *Mis Quarterly* (2011), 711–729.
- [45] Dimitra Tsovaltzi, Nikita Dutta, Thomas Puhl, and Armin Weinberger. 2017. Group and individual level effects of supporting socio-cognitive conflict awareness and its resolution in large sns discussion groups: A social network analysis. In *Computer-Supported Collaborative Learning Conference, CSCL*, Vol. 1. 247–254.
- [46] Dimitra Tsovaltzi and Alina Makhkamova. 2020. The influence of Compassion and Self-Compassion on Perspective-Taking and Conflict Resolution in learning contexts. (2020).
- [47] Jan Van Looy, Cédric Courtois, and Melanie De Vocht. 2010. Player identification in online games: Validation of a scale for measuring identification in MMORPGs. In *Proceedings of the 3rd International Conference on Fun and Games*. 126–134.
- [48] Asimina Vasalou and Adam N Joinson. 2009. Me, myself and I: The role of interactional context on self-presentation through avatars. *Computers in human behavior* 25, 2 (2009), 510–520.
- [49] Asimina Vasalou, Adam N Joinson, and Jeremy Pitt. 2007. Constructing my online self: avatars that increase self-focused attention. In *Proceedings of the SIGCHI conference on Human factors in computing systems*. 445–448.
- [50] Janet Wessler, Tanja Schneeberger, Bernhard Hilpert, Alexandra Alles, and Patrick Gebhard. 2021. Empirical research in affective computing: an analysis of research practices and recommendations. In *2021 9th International Conference on Affective Computing and Intelligent Interaction (ACII)*. IEEE, 1–8.
- [51] Elizabeth Chenhui Yee. 2021. Facial similarity and player-avatar identification. (2021).
- [52] Nick Yee. 2006. The psychology of massively multi-user online role-playing games: Motivations, emotional investment, relationships and problematic usage. *Avatars at work and play: Collaboration and interaction in shared virtual environments* (2006), 187–207.
- [53] Nick Yee and Jeremy Bailenson. 2007. The Proteus effect: The effect of transformed self-representation on behavior. *Human communication research* 33, 3 (2007), 271–290.