The Hidden Face of the Proteus Effect: Deindividuation, Embodiment and Identification

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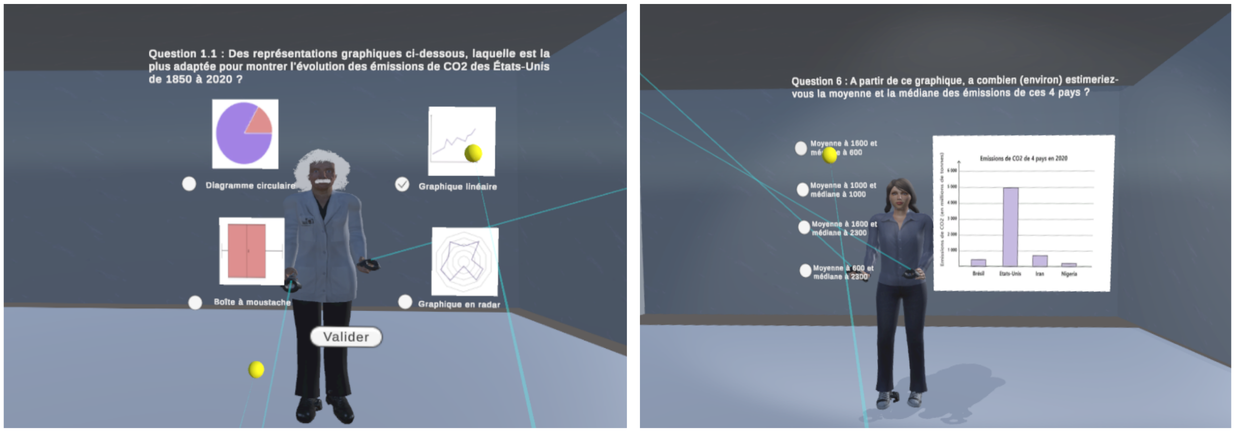

Fig. 1: Avatars engineering students embodied while completing a task testing their recollection of a statistics course they previously attended.

Abstract—The Proteus effect describes how users of virtual environments adjust their attitudes to match stereotypes associated with their avatar's appearance. While numerous studies have demonstrated this phenomenon's reliability, its underlying processes remain poorly understood. This work investigates deindividuation's hypothesized but unproven role within the Proteus effect. Deindividuated individuals tend to follow situational norms rather than personal ones. Therefore, together with high embodiment and identification processes, deindividuation may lead to a stronger Proteus effect. We present two experimental studies. First, we demonstrated the emergence of the Proteus effect in a real-world academic context: engineering students got better scores in a statistical task when embodying Albert Einstein's avatar compared to a control one. In the second study, we tested the role of deindividuation by manipulating participants' exposure to different identity cues during the task. While we could not find a significant effect of deindividuation on the participants' performance, our results highlight an unexpected pattern, with embodiment as a negative predictor and identification as a positive predictor of performance. These results open avenues for further research on the processes involved in the Proteus effect, particularly those focused on the relation between the avatar and the nature of the task to be performed. All supplemental materials are available at https://osf.io/au3wk/.

Index Terms—Proteus Effect, Avatar Embodiment, Deindividuation, Avatar Identification, Virtual Reality.

1 Introduction

Being able to visually embody someone else in a few seconds is an experience that seemed completely unimaginable until very recently. However, today, immersive virtual reality has made this feat possible and even relatively accessible for a large part of the population. As more people encounter these scenarios, it becomes essential to understand their impact on humans, given that our brains did not evolve to process such technology.

One way virtual reality (VR) impacts its users is through a phenomenon known as the *Proteus effect*. This effect describes how the behavior and the attitudes of users of virtual environments can be influenced by the avatars they embody. More specifically, the Proteus effect refers to users' tendency to adopt attitudes that are coherent with the stereotypes associated with their avatars' appearance [38]. For instance, participants embodying more attractive avatars have been found to display a more self-confident attitude [38]. In another study, participants embodying an avatar of Albert Einstein were found to have better scores on a cognitive task compared to participants using a control avatar [3]. This effect seemingly highlights an inherent drive to match behavior or attitude to external cues, such as avatar appearance.

If the reliability of this effect has been demonstrated through numerous replications and two meta-analyses [7, 29], the theoretical understanding of it is still weak (for a review, see [22]). Indeed, the currently most cited explanation of this phenomenon, Self-Perception Theory (SPT) [6], comes from the same publication that termed the effect [38]. Since this publication, very little research has sought to test this hypothesis or provide alternative explanations.

Thus, to deepen our understanding of the processes underlying the Proteus effect, this study aims to test another possible explanation of this phenomenon, one that relies on the concept of *deindividuation*. Deindividuation refers to a psychological state in which a person's actions are driven by situational norms instead of personal ones [27, 31, 35, 36]. Classically, in social psychology literature, this state is used to explain why people immersed in crowds may display extreme and sometimes violent behaviors they would otherwise never engage in [41]. However, more recently, deindividuation has also been theorized to play a role in how users of virtual spaces behave [26].

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In their first study on the Proteus effect, Yee and Bailenson [38] hypothesized that deindividuation could also explain avatar-induced attitude changes in users of virtual environments. More specifically, Yee et al. [40] theorized that a deindividuated state could be necessary for individuals to conform to their avatars' stereotypes through self-perception processes.

However, to our knowledge, no previous study has sought to test whether deindividuation does play a role in the Proteus effect. We thus aim to investigate the following research question:

[**RQ1**] *In which way does deindividuation play a role in the emergence of the Proteus effect?*

Investigating **RQ1** required to defining an experimental setting where the Proteus effect could be observed. Aside from a few notable exceptions [8, 9, 15], most Proteus effect studies are conducted in virtual environments with little to no connection with real-world applications. Therefore, to contrast with these publications, we aimed to test **RQ1** within an ecologically valid environment, which led us to also investigate a preliminary research question:

[**RQ0**] *Can the Proteus effect be applied to a real academic context?*

A few studies have successfully demonstrated the Proteus effect within a professional setting [9] and with engineering students [15]; however, the tasks used in these experiments were not directly based on employees' work or students' course materials respectively. Our study aims to test whether the Proteus effect can be demonstrated with real students using their course material within the task. More specifically, we aim to show that the Proteus effect could be used to increase engineering students' performance when testing their knowledge of a course they previously attended.

To address these research questions, the remainder of this publication will be structured as follows. In Sec. 2, we will present the current theoretical explanations of the Proteus effect and how deindividuation may be involved in this process. Then, Sec. 3 addresses **RQ0** by detailing the experiment aiming to test whether the Proteus effect could be shown in a real academic context. Having confirmed the emergence of the Proteus effect in this experimental context, Sec. 4 presents the protocol seeking to answer **RQ1** by testing the role of deindividuation within the Proteus effect. Finally, we discuss the overall findings of both experiments and their implications for the theoretical understanding of the Proteus effect in Sec. 5.

2 Theoretical Explanations of Proteus Effect

The main goal of this study is to deepen our current theoretical understanding of the Proteus effect. To do so, it is first important to understand the scope of this phenomenon. In the current literature, the Proteus effect refers to the way embodying certain avatars can affect its users. Among other processes, avatars have been found to impact users' emotions [23, 24], cognitive performances [3, 20], social interactions [38, 39], physiological reactions [13], motor behavior [11, 25, 32], creativity [9, 14, 15], or even implicit racial bias [2]. These examples highlight the broad range of processes that this effect can influence. If most articles on the subject broadly define the Proteus effect as behavioral change dependent on the avatar's appearance, it is important to note that this effect's impact is not only behavioral but also social, emotional, and cognitive.

To better understand this phenomenon, it is thus crucial to investigate the processes underlying it.

As mentioned earlier, most publications on the Proteus effect cite Self-Perception Theory (SPT) [6] to explain avatars' effects on their users [38]. SPT is defined as the way individuals might use their perception of their own behavior to deduce what their internal states (e.g., attitudes) may be when those happen to be unclear [6]. In Yee and Bailenson's [38] view, the perception of the avatar acts as an external sign (i.e., such as a behavior) from which users deduce their attitudes. However, this explanation was disputed by other researchers claiming the avatar's effect could be explained by simpler priming mechanisms instead of SPT [24]. In psychology, priming is broadly defined as the way in which exposure to a stimulus (i.e., the prime) can unconsciously shape an individual's response to another stimulus [4]. The authors proposing this alternative explanation hypothesized that, in Proteus effect studies, avatars actually act as primes that trigger a behavioral response matching the concepts associated with the prime. This explanation was rejected in a follow-up study [39] demonstrating that mere exposure to an avatar was not enough to induce the Proteus effect. Instead, the users needed to see themselves embody said avatar for the effect to be measured. Since these results could not be explained through priming mechanisms, SPT remains the most widely accepted explanation of the Proteus effect.

Beyond this debate between priming and SPT, very few studies have questioned or tested whether SPT is solely responsible for the Proteus effect. Interestingly, the initial publication defining the Proteus effect mentioned, along with SPT, deindividuation processes in their theoretical framework [38, 40]. Indeed, they hypothesized that virtual environments and avatar use triggered a deindividuated state, which then facilitated the effect of self-perception [40]. More specifically, the authors theorized that avatar embodiment leads users to be deindividuated as their attention is directed to the avatar's identity cues. Indeed, embodiment results in the avatar's identity cues visually covering the user's own body and the identity cues it normally conveys. This may, therefore, bring a sense of deindividuation. Through this process, users of virtual environments would thus tend to conform their behavior to the situational norms, in this case, the expectations evoked by their avatars' appearance.

This idea does echo deindividuation literature that showed that elements such as costumes and disguises can trigger deindividuation among the people wearing them and thus alter their behavior. For example, in Johnson and Downing's study [16], when asked to administer electric shocks to a confederate, participants wearing Ku Klux Klan uniforms were more likely to increase the intensity of the shocks they gave while participants wearing a nurse's uniform were more likely to decrease them. Thus, it could be argued that avatar embodiment is a similar experience to wearing such costumes and could also evoke behaviors coherent with the avatar's appearance. Their hypothesis is also supported by recent work in which deindividuation is used to explain certain anti-normative behaviors, such as cheating in online games [10]. The idea is that virtual spaces also provide a certain level of anonymity and a greater perceived distance between the user and real-world consequences. These aspects are known triggers of deindividuation [37] and provide further support to the hypothesized role of deindividuation within the Proteus effect. Interestingly, this side of Yee and Bailenson's theoretical framework has not been cited as much as SPT in Proteus effect literature. Since this hypothesis was neglected in the current discussion about the Proteus effect and has never been tested before, the goal of our study is to investigate the role of deindividuation in the Proteus effect.

To the best of our knowledge, there is no existing subjective measure of deindividuation. In the social identity theory framework [31], the state of deindividuation decreases the salience of personal identity cues. In the context of the Proteus effect, this may occur when the avatar's identity cues are emphasized during embodiment. This attentional shift from one's identity cues to the avatar's identity cues may be reflected in the user's identification with their avatar. Identification is defined as the process in which the user incorporates certain characteristics of the avatar into their self-perception [19]. Previous research has suggested that avatar identification may be involved in the Proteus effect [12, 28, 33], but this link has been little studied. Thus, while we may not be able to directly measure deindividuation, it would be relevant to measure whether deindividuation subsequently increases identification with one's avatar.

Therefore, in this experiment, we wish to better understand how identification may be influenced by deindividuation and its link to the emergence of the Proteus effect.

We also decided to measure whether deindividuation influences the user's sense of embodiment (SoE). SoE corresponds to "the sense that emerges when [the avatar's] properties are processed as if they were the properties of one's own biological body" ([18], page 375). Many studies have investigated the link between SoE and the Proteus effect. However, their current results are conflicting. Indeed, if some research suggests that higher levels of embodiment are associated with a stronger Proteus effect [5, 13, 17], others do not seem to find such a link [12, 30, 32].

Both embodiment and identification are related to adopting one's avatar characteristics. Still, in the context of our experiment, we could consider that they address two complementary sides of this process. While embodiment may refer more closely to bodily characteristics, identification could refer to the assumed psychological characteristics of the avatar. Measuring both could, therefore, provide us with a well-rounded view of the processes at play during avatar use and how they may interact with deindividuation and the Proteus effect.

3 RQ0: Proteus Effect in an Academic Setting

Before investigating the role of deindividuation on the Proteus effect, we conducted an initial validation study to verify that we could provide a setting triggering the Proteus effect. As stated in **RQ0**, we chose to focus on a real academic setting, which provides an additional contribution to this publication.

To do so, we chose to replicate an existing Proteus effect paradigm: embodying an avatar of Albert Einstein, which was previously found to have a positive effect on participants' performance on a cognitive task [3, 20]. Einstein's avatar allows for a good application to an academic context in engineering, as the scientist relates to high intelligence and great scientific success. Contrary to previous work using the Einstein avatar with a standardized cognitive task (i.e., Tower of London task), the participants in this experiment were asked to assess their knowledge of a Statistics course they had previously attended. Since the Einstein avatar generally appeals to a certain level of intelligence, particularly in scientific domains, we hypothesized that it would have a similar impact on the Statistics task as those observed in previous publications using standardized tasks [3, 20].

3.1 Methods

3.1.1 Participants

The participants were recruited from a class of fourth-year engineering students in a French engineering school. A total of 30 students participated in this experiment, of whom two were excluded from the statistical analyses, leaving a final sample of n = 28. Those participants were excluded because they required assistance from the experimenter during the study, which could have influenced their feeling of immersion and performance. The remaining 28 participants had a mean age of 22.8 (SD = 2.1), with 25% reporting being women and 75% men, approximating the gender ratio of the class they were recruited from. They were randomly assigned to complete the task with either an avatar of Albert Einstein or a control avatar, with 14 students assigned to each of the two experimental conditions.

The sample size of this experiment was based on a previous study that found a significant improvement in performance on a standard cognitive task for users embodying an Einstein avatar compared to those embodying a control avatar [3]. While using a task different from that of Banakou et al. [3], our experimental task also relied on cognitive skills. We therefore chose to use a similar sample size for this experiment.

3.1.2 Virtual Environment

The virtual environment used in this study consisted of an empty room in which one of the walls was covered by a mirror that allowed participants to observe the avatar they embodied. The environment was developed using the software Unity 3D and displayed using the head-mounted display (HMD) HTC Vive. The HMD's controllers tracked participants' hand movements and allowed for interactions with the environment, such as selecting and submitting answers during the task. Participants' leg movements were tracked using two HTC trackers placed around their ankles. This setup allowed for seamless real-time tracking of the participants' gestures during the task, providing a base for an adequate sense of agency [18].

3.1.3 Task

The task developed for this experiment consisted of 10 multiple-choice questions displayed within the virtual environment. The questions were based on a Statistics course that all participants had attended six months before the experiment. The questions were developed with the help of a professor involved in the course. The multiple-choice questions addressed basic statistical logic (e.g., choosing the appropriate statistical test for a given dataset or correctly interpreting a spurious correlation).

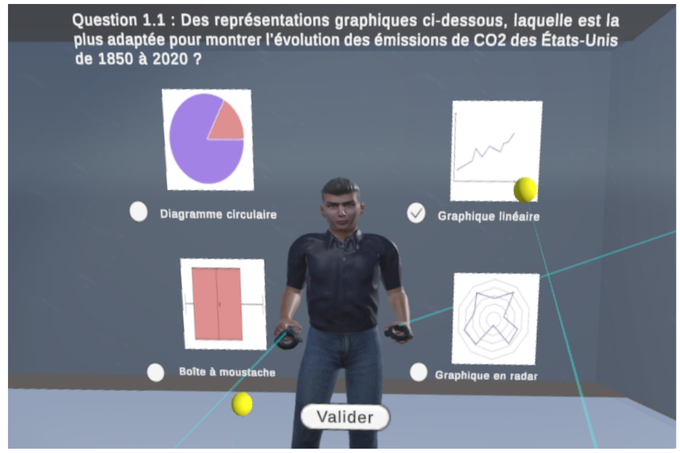

Fig. 2: A screenshot of a multiple-choice question from the statistical task participants completed. The questions were displayed on the virtual mirror such that the participants could always see their avatar (control avatar in this example, see Sec. 3.1.4).

Fig. 3: The Einstein (a) and Control (b) avatars embodied by the participants displayed on the mirror during the experiment.

A paper version of the task was pretested on a small group of engineering students who had taken the statistics course the year before. The pretest results revealed scores ranging from 3.5 to 7.5 correct answers out of 10 and a median score of 6 out of 10, indicating a satisfactory level of difficulty (i.e., no ceiling or floor effect). The questions and all relevant components (e.g., graphs or illustrations) were displayed on top of the virtual mirror during the task. This was done so the participants could always visualize their avatar throughout the task and reinforce the Proteus effect associated with the Einstein avatar. An example of a question in the virtual environment is shown in Fig. 2.

3.1.4 Independent Variable

In this experiment, we manipulated the appearance of the **avatar** participants embodied during the task. Similarly to previous work [3], the participants embodied either an *Einstein* avatar or a *Control* avatar (see Fig. 3). The conditions were randomly assigned between the participants at the start of the experiment.

3.1.5 Dependent Variables

Task Score. Performance on the statistics task was measured by summing each participant's total correct answers. Based on this, we formulate the following hypothesis :

H0: *the scores of the participants embodying the Einstein avatar will be significantly higher than those using the control avatar*.

Validating **H0** would successfully demonstrate the Proteus effect within an applied academic context.

Embodiment scale. After completing the statistical task, we assessed students' *Embodiment* level during the task using the French version of Roth and Latoschik's [34] post-VR self-assessment Virtual Embodiment Questionnaire (VEQ). This scale was chosen as it adheres closely to the definition of embodiment of Kilteni et al. [18], which is the one we rely on for this experiment.

This scale comprises 12 items divided into three four-item-subscales: *Body Ownership*, *Agency*, and *Perceived Change* in body schema. Body ownership refers to perceiving the avatar's body as one's own. The sense of agency describes the feeling of having control over the avatar's movements. Finally, perceived change refers to the perceived difference between one's body schema and the avatar's.

The questionnaire was filled out post-VR. Participants were instructed to read each item and indicate whether the presented statement applied to them using a 7-point Likert scale ranging from "strongly disagree" to "strongly agree".

Identification scale. We also measured participants' *Identification* levels toward their avatar using the Player Identification (PI) scale created by Looy et al. [21]. This scale was chosen as, to our knowledge, it is the only scale aimed at measuring avatar identification in virtual environments that has already been used in the context of the Proteus effect [33]. Since this scale was initially designed to measure identification in the context of video games, we chose to include only the three sub-scales that defined the notion of avatar identification. These included *Embodied Presence*, which refers to experiencing the virtual environment through the avatar; *Wishful Identification*, which describes the desire to be more like the avatar; and *Similarity Identification*, which defines the feeling of resembling one's avatar [21].

Unlike the embodiment scale, we did not find a French translation of this questionnaire. Therefore, with the help of two native English-speaking teachers, we translated this questionnaire to French for our experiment. The reliability of this translated questionnaire was found to be acceptable with a Cronbach's alpha of 0.76. Similarly to the embodiment questionnaire, participants used a 7-point Likert scale to evaluate the degree to which the statements applied to them.

3.2 Procedure

Before starting the experimental procedure, participants were randomly assigned to either of the two avatar conditions (i.e., *Einstein* or *Control*). For those assigned to the latter condition, their avatar was matched to their reported gender (either a man or a woman).

After giving informed consent, the participants read the task instructions. To conceal the true goal of this experiment, they were told that the purpose of the study was to test the prototype of a virtual environment developed for educational purposes and gather feedback from real students. To justify the use of the Einstein avatar, they were told they might be using avatars of famous scientific figures because upcoming versions of the virtual environment will include teachings of scientific history. Students were then informed that their task within the virtual environment would be to answer a series of 10 multiple-choice questions based on knowledge they had learned in prior courses.

Afterward, all participants were equipped with ankle trackers, the HMD, and its controllers. They had a few minutes to get acquainted with the virtual environment and their avatar through the virtual mirror. Before starting the task, all participants were asked by the examiner to stand in front of the virtual mirror and raise their arms and legs one by one. This was done, similarly to previous Proteus effect studies [3, 32], to reinforce the image of the avatar and the feeling of embodiment through witnessing the visuomotor synchronicity between the participant's movements and the avatar's. After that, the students could start the statistics task by selecting the start button within the environment. During the entire task, the participants could, at least partly, see their avatar in the mirror on which the questions appeared.

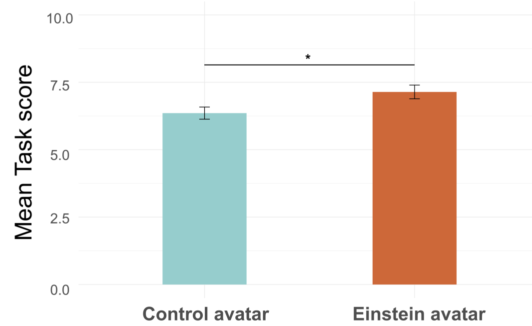

Fig. 4: Mean and SE of *Task score* for each of the **avatar** conditions. * = $p < 0.05$.

Table 1: Mean ± Standard Deviation of *Embodiment* and *Identification* scores, for each of the **avatar** conditions. No statistical differences were found between the conditions.

Measure	Einstein	Control
Embodiment	4.98 ± 0.89	4.92± 0.37
Body Ownership	5.14 ± 1.04	4.73 ± 1.06
Agency	6.43 ± 0.48	6.21 ± 0.68
Perceived Change	3.36± 1.68	3.82 ± 1.06
Identification	3.46 ± 0.83	3.12 ± 0.86
Embodied Presence	4.68 ± 0.83	4.27 ± 1.17
Wishful Identification	2.73 ± 1.61	1.96 ± 0.92
Similarity Identification	2.85 ± 0.91	2.93 ± 1.12

At the end, participants were asked to complete a quick online questionnaire comprising demographic information (age and gender), the *Embodiment* scale, and the *Identification* scale. Before they left, each participant was told not to share any details of this experiment with their peers to prevent following students from having any potential biases. All participants received a collective debriefing explaining the motivation behind this study after all data was collected.

3.3 Results

3.3.1 Task Score

The mean score across all participants was 6.75 out of 10 ($SD = 0.97$), with a minimum score of 5 and a maximum score of 9. As shown in Fig. 4, an independent samples t-test using **avatar** as the independent variable revealed that participants' mean *Task score* in the *Einstein* condition ($M = 7.14$; $SD = 0.95$) were found to be significantly higher compared to scores of participants in the *Control* condition ($M = 6.36$; $SD = 0.84$; $t(25.6) = -2.317$, $p < 0.05$, $d = 0.8$). These results indicate that the Proteus effect was successfully demonstrated within a real educational context, using course material, thus validating **H0**.

3.3.2 Embodiment and Identification Scores

We further tested whether *Identification* and *Embodiment* levels differed between **avatar** conditions, but no significant difference was found (all $p > 0.05$). Descriptive statistics for each sub-scale are provided in Tab. 1.

In addition, we also tested whether avatar condition, embodiment, and identification could predict *Task score*, using multiple regression analysis. For that, the **avatar** variable was processed as a dummy variable (0 = *Control* avatar, 1 = *Einstein* avatar). No other factor was found to be a significant predictor of students' scores besides the **avatar** condition (*Identification*: $\beta = 0.11$, $t = 0.4$, $p = 0.68$; *Embodiment*: $\beta = -0.15$, $t = -0.46$, $p = 0.65$; **avatar**: $\beta = 0.76$, $t = 2.1$, $p < 0.05$; $F(3,24) = 1.75$, $p = 0.18$, $R^2 = 0.18$ (adj $= 0.08$)).

3.4 Discussion

This first experiment allowed us to test our preliminary research question (**RQ0**) and validate our hypothesis (**H0**). Indeed, we were able

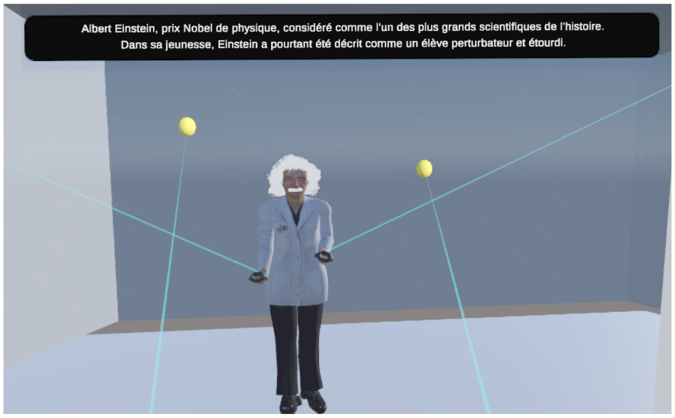

Fig. 5: View within the virtual environment for participant in the *backstory* condition.

to show that students embodying the Einstein avatar had higher scores when tested on their recollection of study material compared to those embodying a control avatar. This result demonstrates that the Proteus effect can be applied to a real educational setting, adding to the ecological validity of this phenomenon.

These results, therefore, allowed us to use this experimental setting to test our second research question (**RQ1**) that aimed at determining the role of deindividuation within the Proteus effect.

4 RQ1: Deindividuation

The main goal of this experiment was to investigate the role of deindividuation as an underlying process of the Proteus effect. To do so, we aimed to manipulate the state of deindividuation of the participants in a Proteus effect experimental protocol. Based on previous work on the subject [16], deindividuation was manipulated by exposing participants to identity cues referring to themselves or their avatars. Our goal was to test whether the Proteus effect would still be measured when deindividuation was low.

For that, we used the experimental protocol validated in the preliminary study (see Sec. 3), but in this case, all the participants embodied Einstein's avatar. In addition, the statistical task was slightly updated to increase its difficulty level. This was done to increase the range of Task scores and make any potential differences between groups more detectable. These changes, however, did not alter the nature of the task.

4.1 Methods

4.1.1 Participants

The participants were recruited from the same class as the ones in the first study, assuming they had not participated in the first experiment. A total of 59 students completed the experiment, but three were excluded from further analysis, leaving a final sample of 56. Two were due to vision issues that made it too difficult for the participants to complete the task correctly, and one was due to an apparent pattern of random replies during the task. This final sample comprised 27% women and 73% men, with an average age of 22.2. In this sample, 28 were randomly assigned to a condition aimed at reinforcing deindividuation, and the remaining 28 were assigned to a condition aimed at decreasing deindividuation.

4.1.2 Experimental Design

To test **RQ1**, we aimed to manipulate the state of deindividuation of the participants. This was done either by bringing their attention toward cues relating to their identity to decrease deindividuation (*biography* condition) or by bringing their attention toward identity cues pertaining to Albert Einstein to increase deindividuation (*backstory* condition). More specifically, the goal of the biography condition was to potentially break the avatar's effect on the user by reinforcing the participant's identity. On the other hand, the backstory condition aimed to provide more identity cues of the avatar than simply its appearance and, therefore, increase the avatar's effects.

This setup resulted in the between-subjects variable **deindividuation** having two groups: high deindividuation (*backstory*) and low deindividuation (*biography*).

Therefore, if deindividuation does facilitate the Proteus effect, we hypothesize that:

H1.1: *Participants in the backstory condition would have significantly higher scores compared to those in the biography condition*.

This result would show that the beneficial effects of the Einstein avatar on *Task scores* demonstrated in **RQ0** weaken when participants' deindividuation decreases. This would therefore mean that a certain level of deindividuation is needed for the Proteus effect to occur.

Furthermore, if deindividuation decreases the salience of personal identity cues, we hypothesize that:

H1.2: *Participants in the backstory condition would have significantly higher scores of Identification and Embodiment compared to those in the biography condition*.

This, in turn, would demonstrate that deindividuation impacts both identification and embodiment processes.

Identification and Embodiment scores were collected using the same questionnaires as in the first study (see Sec. 4.2.2).

4.1.3 Procedure

The procedure of this second protocol was identical to that of the first study (see Sec. 3.2), except for how deindividuation manipulations were implemented within the virtual environment. For the *biography* group, the participants were asked to type their name, age, and a few interests or hobbies on a computer before they entered the virtual environment. This was not the case for students in the *backstory* condition. Then, when immersed in the virtual environment, students in the *biography* group could see a short description of themselves (using the data they had just provided) displayed on the virtual mirror (e.g., "Charlie, 22 years old, 3rd year in CESI engineering school. Hobbies include: cooking, cinema, running.") On the other hand, students in the *backstory* condition saw in the same place a short description of Albert Einstein (see Fig. 5), which translated to: "Albert Einstein, a Nobel prize winner in physics, is considered one of the greatest scientists in history. In his youth, however, Einstein was described as a disruptive and distracted student." All participants were presented with these statements when they entered the virtual environment and looked at the mirror. They remained present during the entire task above the questions to reinforce the exposure to either personal identity cues or Einstein's identity cues.

4.2 Results

4.2.1 Task Score

The mean score across all participants was 6.14 out of 10 ($SD = 1.33$), with a minimum score of 3 and a maximum score of 9. An independent samples t-test, with **deindividuation** as the independent variable, showed no statistical difference in task scores between the *Backstory* ($M = 6.07$, $SD = 1.36$) and *Biography* conditions ($M = 6.21$, $SD = 1.32$, $t(54) = -0.69$, $p = 0.69$). It seems that the deindividuation manipulation did not affect the avatar's effect. Therefore, **H1.1** is rejected.

4.2.2 Identification and Embodiment Scores

We did not find any significant difference in the overall score of *Embodiment* nor *Identification* between the deindividuation conditions (embodiment test result: t(49.5) = -1.58, p = 0.12; identification test results: t(52.9) = -0.31, p = 0.75), which invalidates **H1.2**. All descriptive statistics regarding both scales are provided in Tab. 2.

Through further exploratory analyses, we also sought to investigate the relationship between task score, embodiment, and identification levels. For that, we used a multiple linear regression that took task score as the dependent variable and embodiment and identification scores as predictors. Through this regression, both embodiment and identification were found to be significant predictors of task score among participants, regardless of their deindividuation condition (F(1.3, 53) = 3.23, p =

Table 2: Mean ± Standard Deviation of *Embodiment* and *Identification* scores, for each of the **deindividuation** conditions. No significant differences were found between deindividuation conditions.

Measure	Backstory	Biography
Embodiment	4.56 ± 0.89	4.89 ± 0.65
Body Ownership	4.13 ± 1.28	4.68 ± 1.33
Agency	5.96 ± 0.85	6.29 ± 0.62
Change	3.58 ± 1.36	3.69 ± 1.18
Identification	3.11 ± 0.98	3.15 ± 0.88
Embodied Presence	4.37 ± 1.51	4.41 ± 1.28
Wishful Identification	2.50 ± 1.19	2.61 ± 1.14
Similarity Identification	2.33 ± 0.87	2.35 ± 0.92

0.04, $R^2 = 0.11$ (adj = 0.08)). Interestingly however, embodiment was found to be a negative predictor of task score (β = -0.574, t = -2.121, $p < 0.05$), whereas identification was found to be a positive predictor of task score (β = 0.556, t = 2.4, $p < 0.05$). These results indicate that higher embodiment is associated with lower task scores, whereas higher identification is associated with higher task scores.

4.3 Discussion

Overall, this second experiment was not able to demonstrate the hypothesized role of deindividuation within the Proteus effect. The most likely explanation for this result is that our attempt at experimentally manipulating deindividuation within our participants failed. Exposure to the short descriptions of Albert Einstein or of participants may not have been enough to trigger significant changes in deindividuation levels. This could be because the statistical task demanded participants' full attention, which did not allow them to be mindful of the identity cues. These cues might have been more effective if they had been introduced in a more immersive way. This could have been done by embedding them into the statistics task and having, for example, questions mentioning the participant's name directly (e.g., "[Albert] / [Charlie], which of these options...").

Another explanation for our results could be that deindividuation does not play any part in the Proteus effect. Therefore, alternative theoretical explanations, such as self-perception theory or priming, may be favored. Further experimental attempts should obviously be conducted before discarding the deindividuation theoretical hypothesis, and other methods for inducing deindividuation should be implemented (e.g., using immersive identity cues or introducing social dynamics between several avatars within the virtual environment).

This second experiment, however, did reveal interesting results regarding the influence of embodiment and identification on the Proteus effect. Our analyses indicated that both notions were predictors of participants' scores on the statistics task, but each in an opposing way. Embodiment was found to negatively predict task scores and identification to positively predict them. These findings are stimulating because they describe an uncommon relationship between the variables.

Firstly, most studies have either found a positive influence of embodiment levels on the Proteus effect [1,5], or no effect at all [30,32] (for a review see Dupraz et al. [12]), but we are not aware of published results highlighting the negative impact of embodiment on the Proteus effect.

Secondly, avatar identification being a driver of performance in the academic task provides a new framework to understand the Proteus effect. A few previous studies have hypothesized the role of identification in this phenomenon [12, 22, 28, 29], but this study presents an example in which avatar identification is positively associated with avatar-induced effects.

Taken together, these opposite effects of embodiment and identification draw our attention to which side of the avatar was relevant to adopt in the current experiment. For the specific task we implemented (involving statistic knowledge and skills), the bodily dimension of Einstein's avatar (an old man with white hair) may have been counterproductive, as old age evokes cognitive decline. In contrast, his psychological characteristics (outstanding intelligence) were highly relevant for excelling at the task. This may explain why embodiment (emphasizing bodily features) was negatively associated with performance while identification (emphasizing psychological features) was positively associated with performance.

This pattern of results was not observed in the first experiment because the dataset gathered data from two avatar conditions and not only from the Einstein avatar. Furthermore, data from the Einstein condition alone would represent too small a sample to find significant differences.

The effects observed in the second study may be specific to the task at hand and may not generalize to all applications of the Proteus effect. In particular, a task involving physical skills and performance [5, 11, 25] may exhibit the opposite pattern, in which embodiment would yield positive effects and identification no or negative effects. In sum, the unexpected results obtained in the present study open avenues for designing new and more accurate experiments to deepen our understanding of the Proteus effect and how it operates in different kinds of tasks and applications.

5 General discussion

The aim of our research was to shed light on the processes underlying the Proteus effect. In this respect, our results do not provide a definite answer but contribute to inform the discussion and revive the theoretical debate.

The generalizability of our findings may, however, be limited due to the composition of our sample. For both experiments, young and mostly male university-level engineering students were recruited. While the gender ratio of our sample matched the one of the school they were recruited from, it might not have shown potential disparities between men and women. Future studies may want to explore potential gender differences regarding the Proteus effect, embodiment, or identification processes. Furthermore, it is important to note that our findings are limited to adult students and may not apply to children in an educational context. The use of avatars and virtual environments for children's education involves different considerations that this study did not address.

All in all, although our second experiment failed to implement or demonstrate the effect of deindividuation, it provided new insights and future research questions about the role of embodiment and identification in the Proteus effect as a function of the target task to perform.

Finally, our first study constitutes a successful application of the Proteus effect within an academic context, which is a contribution in itself and further demonstrates how powerful the effect is. Can you imagine that after attending a class, changing your appearance may change your score on a test and your knowledge transfer?

More than ever, the Proteus effect holds a strong potential for applications in educational contexts. However, such applications should still be approached with caution regarding ethical criteria. Indeed, this research does not constitute a recommendation to use Einstein or similar avatars simply to try to improve students' grades. While it is possible to use the Proteus effect ethically, having students or pupils play at being Einstein may actually reinforce negative stereotypes regarding marginalized groups' scientific abilities. For instance, having women embody Einstein, an older man, to do mathematics may, consciously or not, reinforce the idea that science is a masculine field. Furthermore, it is currently unknown whether the positive effects of these avatars persist over prolonged use of the avatar in an academic virtual environment, for instance. Thus, with the current trend in digitization of education, the Proteus effect should be applied positively and mindfully.

Ethical statement

The experiments followed the requirements of the Office Français de l'Intégrité Scientifique to which the authors' institution has adhered. As it had no ethical review board in place at that time, the experiments were not submitted for ethics approval. The research complies with GDPR procedures as all data was anonymized using random participant numbers, and no sensitive data was collected. In addition, participants signed an informed consent form and could stop participating at any moment without any consequences.

Supplemental Materials

All supplemental materials are available on OSF at https://osf.io/au3wk/, released under a CC BY 4.0 license. These include (1) data collected in both experiments; (2) the French translation of the VEQ [34] provided by authors at https://sites.google.com/view/virtualembodimentquestionnaire/; (3) our French translation of the Avatar Identification Scale [21] and the results of the reliability analysis conducted on the results collected in this study. Finally, these also include (4) a video of a user embodying the Einstein avatar within the virtual environment answering statistics questions.

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