

How does inner speech influence the Proteus effect?

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Abstract

In virtual reality (VR), the so-called avatars are the digital figures that a user requires in a virtual world and are primarily responsible for creating artificial reality. The experience of interacting as an avatar within VR environments creates a potential effect on the user called the Proteus effect. However, how an avatar influences user behavior is still an open scientific problem. The Proteus effect might be interfered by the inner speech where individuals are bound to create a constant self-awareness of their surroundings and own body within the virtual reality world. In order to find connections between the notions mentioned above, a lab-based experiment was conducted in Tilburg University to test the connection between inner speech, self-awareness, and the Proteus effect. 34 participants between the ages of 18-35+ were randomly assigned to two different conditions where one group's inner speech was interfered with an articulatory suppression. In contrast, the others rhythmically tapped their feet on the ground. Regarding the results of the experiment, it was concluded that there is no significance in any finding which refuses all the formulated hypotheses for the study. It was believed that the limitations were caused by the biases, the research design, the assets used to create the VR environment, and the prior knowledge and experience of the participants. However, this study establishes an unprecedented connection between inner speech and self-awareness and contributes on how and why the Proteus effect is influenced.

Keywords: Proteus Effect, Virtual Reality, Inner Speech, Self-Awareness

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Introduction

Worldwide, approximately more than 170 million people spend their time in virtual reality worlds for many different reasons, such as entertainment, medical and other purposes (Kolmar, 2022). The term VR describes 3D computer-generated immersive, interactive, multisensory worlds that are viewer-centered and made possible by a mix of technology (Cipresso et al., 2018). In VR, artificial reality is mainly created by so-called avatars, digital characters that a user needs in a virtual environment (Wu et al., 2021). In VR experiences, users can choose their avatar by specifically customizing it, or they are given a predetermined one to incorporate with the designed world or the overall concept. Research shows that avatars influence human behavior within and sometimes outside virtual environments. Cabiria (2008), for example, demonstrated that participating in communities in virtual worlds offers marginalized groups, such as gays and lesbians, therapeutic advantages that they may subsequently translate to their real lives (Cabiria, 2008). Such VR simulations can be used for good if they are mindfully designed and incorporate reasonable avatars. However, what allows avatars to influence human behavior or raises its effectiveness is an unsolved scientific issue with real-world application.

The experience of interacting as an avatar within VR environments creates a potential effect on the user called the Proteus effect. The Proteus effect is a term used to describe a situation where a virtual character’s (avatar) traits influence a person's behavior in virtual environments. (Yee & Bailenson, 2009). A study by Buisine et al. (2016), for example, shows how using an avatar that looks like an engineer prompts its users to think about the virtual environment in more technical terms than when using an avatar that does not look like an engineer (Buisine et al., 2016). The avatar serves as the primary identification cue in VR; as a result, it can be anticipated that how people behave digitally is significantly influenced by their avatars (Yee & Bailenson, 2009). In VR environments, the perception of presence can significantly affect the Proteus effect's outcome. In VR, a person's head, body, and finger movements can be transferred to the avatar, moving identically to the person. This helps people to identify with their

avatars, resulting in an increased Proteus effect and awareness. How an avatar influences user behavior, however, is still an open scientific problem.

One such influence might be inner speech and its relationship to self-awareness. In research about self-awareness, Morin (1993) mentions that inner speech and self-awareness are connected (Morin, 1993). Self-awareness refers to the ability to become the center of one's attention, in which case a person actively identifies, analyzes, and retains information about themselves (Wicklund, 1975). Cognitive processes, notably inner speech and imagery can reflect on the self, and inner speech can internally replicate the social processes that underlie self-awareness (Morin, 2005). In one of their research, Skipper (2022) mentions two mechanical reasons for inner speech enhancing self-awareness. One reason is that self-awareness results from "agency and ownership"; in other words, inner speech provides the phenomenological experience of producing, feeling, and listening (Skipper, 2022). The other reason is the "broadcast distance," which originates from the sense of distance, meaning that inner speech functions a bit like the announcer, calling attention to things directly to the self that may otherwise be missed (Skipper, 2022). The presence of inner speech when interacting in a virtual environment via an avatar might limit the efficiency of the Proteus effect, where the inner speech is constantly creating awareness about the real self.

In contrast, the VR environment provides cues, indicating that instead, the real self is the avatar. Users can evaluate themselves as an avatar through virtual mirrors and perceive the environment, other characters, and interactive objects by having information about their surroundings and their avatar. These indications are intended to persuade the user to behave in the virtual world as if they are the avatar and to suggest what behavior is appropriate for that avatar. However, self-awareness might be enhanced if inner speech is present, meaning that people may identify less with the avatar, and their inner speech might match their real self. To put it another way, inner speech may elicit self-awareness, which takes attention away from the avatar's appearance and other VR stimuli designed to induce the Proteus effect.

Therefore, inner speech can be researched within VR environments and possibly be found as a predictor for the Proteus effect and refocusing attention on the real self. This will be accomplished by responding to the following research question: "*How does inner speech influence the Proteus effect?"*.

Theoretical Framework

Virtual Reality & Proteus Effect

The word virtual reality refers to viewer-centered, 3D computer-generated, immersive, interactive, multimodal environments (Cipresso et al., 2018). In order to have a VR experience, individuals must obtain specific equipment called a VR headset, meaning that their connection with real-life surroundings will be severely diminished when the headset is worn. These virtual environments create high-quality artificial worlds for individuals to live and experience without distractions from the outside world. With such technology, with the help of 3D models, characters, lighting effects, and realistic sounds, VR experiences create realism, making people forget about the outside world. The immersion within a VR experience is highly dependent on the hardware capabilities of the headsets and their components, such as controllers or accessories (Radianti et al., 2020). Such high-end VR equipment is designed with the help of professionals such as military pilots, racing drivers, and many more to achieve the best results in realism. Realism is considered the most important element while designing such experiences that create simulator-like occurrences within VR. Simulators are considered to be used to replace and enrich real experiences, frequently "immersive" in style, which imitate or reproduce important features of the actual world in an entirely interactive way (Lateef, 2010).

Virtual reality is the representation of reality; meaning that everyday life elements and concepts can be replicated within a 3D space that is possible to provide high functionality where every improvement targets immersion and creates more realistic experiences for individuals (Cipresso et al., 2018). Within VR, individuals most often utilize human-like 3D characters to represent themselves in virtual environments called avatars (Wu et al., 2021). Avatars are identifiable digital representations

whose actions correspond to those taken by a particular human individual, usually in real-time (Yee & Bailenson, 2009). The avatars are a significant part of the VR experience, responsible for movement, expression, identity, and immersion. Depending on the quality of the hardware and the designed experience, individuals can become deeply involved in the experience that they think and behave like their avatars. This particular phenomenon is called the Proteus Effect. Yee & Bailenson (2009) define Proteus Effect as a situation where an avatar's traits influence a person's behavior in virtual environments. To be more specific, the psychological connection between the user's schema of self and the schema connected to the avatar is the basis for the Proteus effect (Ratan et al., 2019). The desirability or height of individuals' avatars had a tangible impact on how they interacted with a confederate, according to a set of two research done by Yee & Bailenson (2009). Participants in the first investigation received avatars with pretested physical beauty features. After witnessing their virtual self-representation in a virtual reflection, they engaged in conversation with an accomplice. Confederates always saw the participant with an average-rated face ruling out the probability that the subject's behavior influenced their interactions with them. Confederates were, therefore, unaware of their circumstances. Researchers discovered that individuals using appealing avatars approached closer and revealed more private information to the confederate than those using unappealing avatars (Yee & Bailenson, 2009).

This study builds on and extends the research done by Buisine et al. (2016) about the Proteus Effect. Within the laboratory-based experiment by Busisine et al., participants were randomly assigned to two avatars; a Persona (archetypal users of public transportation) and an Engineer. The participants took place in a metro traveling across Paris and started idea generation. The researchers formed an idea generation task and the participants’ goal was to identify uses for smart windows that will enhance consumers' privacy, well-being, security, and activity when using public transit (train, tramway, metro). According to the expectations of the researchers, the look of the avatars had an impact on the creative output: the Engineer condition produced an ideation profile that was more focused on technological solutions, whereas the Persona condition produced ideas that were more user- and need-centered (Buisine et al., 2016). According to Peña (2011), users' changes in behavior or attitudes inside a virtual

environment are the result of situational inputs priming and activating pre-existing schemata. For example, suppose a user becomes aware of their avatar's characteristics, such as being overweight. In that case, they tend to form a connection with their learned beliefs or schemata—sluggishness and low self-esteem—stimulating from their memory and influencing their following actions and attitudes (Peña, 2011).

Regarding the experimental and empirical studies, it is proven that the Proteus Effect can be achieved within VR environments; however, there are still some questions about how this phenomenon happens. The experience of Yee & Bailenson (2009), and Buisine et al. (2016), establishes a solid starting point for future researchers to learn from their limitations, propose different ideas, and discover distinct routes to uncover why Proteus Effect occurs and how avatars influence user behavior. For this study, it is valuable to follow the predecessors and take inspiration from how they created artificial environments to test out the Proteus Effect. Regarding that, the methodology part of the research made by Buisine et al. (2016) is taken as a framework and modified to fit into the circumstances of today's world.

Inner Speech & Self Awareness

The subjective perception of language without overt and audible articulation is known as inner speech. A careful examination of inner speech's phenomenological, developmental, and cognitive aspects demands some qualification of the term thinking, as the two concepts are frequently used interchangeably. However, it is preferable to refrain from discussing 'thinking' for the purposes of this study in favor of mental processes that can be more precisely described in different subsets. While investigating inner speech, a few well-proven theories were revealed and subsequently used within this study. One of the following theories was proposed by Vygotsky in the 1930s. He developed his notion of inner speech in opposition to John B. Watson's (1913). He recognized that inner speech and "thinking" were outcomes of a gradual reduction of self-directed speech. Instead, Vygotsky (1930) argued, internalization significantly transforms inner speech, and its growth entails processes more sophisticated than the simple reduction of speaking's behavioral components. Vygotsky (1930) found evidence to support his idea in the phenomena

now known as private speech, i.e. when children speak with themselves while executing a cognitive activity. According to Vygotsky's theory, private speech is a stage in internalization where interpersonal conversations are still partially converted into intrapersonal dialogues. Additionally, it is now understood that private speech may continue throughout adulthood as an adequate self-control and motivating tool rather than fading after internalization is complete.

Moreover, one of the main building blocks of this study is that inner speech happens within the working memory (WM). Retaining a very little quantity of information in an easily accessible shape is known as WM. The WM facilitates planning, comprehending, reasoning, and problem-solving (Cowan, 2013). According to Baddeley and Hitch (1974), WM consists of three parts: a *central executive*, which manages attentional resources; the *phonological loop*, often referred to as the articulatory loop; and the *slave system* for representing auditory, linguistic, or phonological information. Verbal and mental activity that requires the development of previous stages of private speech is challenged by the presence of a phonological loop (Alderson-Day & Fernyhough, 2015). Regarding that, the inner speech happens within the WM and can be interrupted by influencing the articulatory loop.

Another important name within the topic of inner speech is Skipper, who suggests that inner speech leads to a higher-order consciousness, specifically self-awareness. Awareness refers to being alert and conscious of surroundings, allowing individuals to comprehend what is going on in the world around them (Dretske, 1999). However, for this study, it is important to focus on self-awareness which refers to the capacity to not only be conscious and aware in a given environment but also to comprehend the *purpose* within it (Carver, 2012). Skipper (2022) highlights the notion of a fundamental connection between language, inner speech, and higher-order consciousness that approximately appears to be connected with the distinction of words (as felt and heard) from our other "thoughts" (as in primary consciousness) (Skipper, 2022). He identifies two mechanical arguments for inner speech strengthening self-awareness in one of their studies: *agency and ownership* and *broadcast distance*. One explanation is that agency and ownership, or the phenomenological experience of generating, experiencing, and listening, are the effects of self-awareness: *'I' am aware that 'I' developed this because 'I' created it, and*

'I' know that it is 'my' voice and 'I' recognize 'my' own experiences and 'my' ways during the speech. The second factor, the broadcast distance, comes from the perception of distance and refers to the inner speech's capacity to behave somewhat like an announcer by drawing attention to things immediately in front that could go unnoticed (Skipper, 2022): *'I' just heard 'do I really do this?' coming from 'my' head, more specifically in 'my' voice, and nobody was speaking nor answering, meaning that 'I' should alert 'myself' that doing this might result in a negative outcome.* These mechanical operations, suggested by Skipper (2022), often correspond to a "higher-order" mechanism that provides individuals with some awareness of the internal dynamics of their brains and ultimately creates focus on the self.

Regarding higher-order consciousness and self-awareness, Dr. Morin (1993) sheds more light on why inner speech can be related to self-awareness. He argues that inner speech can inwardly simulate the social processes that underpin self-awareness and that inner speech can reflect on the self, particularly inner speech and visuals (Morin, 2005). In his research, he gives examples that the connection between inner speech and self-awareness is valid and proven by various researchers. A few examples suggest that: inner speech is how one communicates with oneself (Kaufman & Raphael, 1984); a fundamental and common mechanism in human awareness and psychic activity is inner speech (Sokolov, 1972); the ability to have a meaningful discussion with oneself comes from the communicative origins of consciousness, which also results in self-awareness (Simonov, 1999); inner speech is used as the simplest (and, in a way, the most crucial) vehicle for maintaining self-awareness (Stamenov, 2003).

Synthesis

A necessity of this study is to find a valid link between Proteus Effect with self-awareness and inner speech. There have not been any studies regarding the direct connection between these notions. However, there is certain evidence that can be taken out from independent studies, ultimately helping the justification of a possible connection.

As mentioned, using an avatar within VR environments that are capable of presenting vital information can be a significant predictor of self-awareness. In one of his studies, Morin (2005) highlights

that the presence of self-reflective stimuli in the environment—such as mirrors, cameras, recordings of one's voice, and images of oneself—helps people learn essential details about themselves. For people to develop a clear self-image, these inputs are crucial. These details about oneself include facial characteristics and expressions, mannerisms (such as a person's walking, talking, or smiling style), voice pitch, body size and weight, skin color and texture, haircut, and many more. Morin's (2005) examples are from the physical world we live in; however, since virtual reality is a depiction of the real world, there is a convincing relationship between these two worlds (Zheng et al., 1998). In VR, users can easily inspect their avatars using virtual mirrors, and with knowledge of their surroundings and avatar, they can perceive the world, other characters, and interactive objects. Depending on the hardware and software capabilities of VR devices, users can have more detailed information about their virtual selves, such as the movement of eyelids, individual fingers, and facial expressions (Soler-Domínguez et al., 2020). If the technology can deliver such information precisely, an increase in self-awareness might be a potential outcome.

Morin (2005) links self-awareness with inner speech by mentioning that when people use or are exposed to self-reflective technology and focus on analyzing themselves, inner speech is likely to emerge—such as "I look really good at the moment," "My skin is very pale," "I might have gained some weight." Therefore, the production of inner speech within VR environments can certainly result in self-awareness which can contribute to the presence of the Proteus Effect. However, self-awareness might influence the Proteus effect negatively if there is no bonding between the avatar and the user. Instead of adopting the avatar's characteristics, individuals might focus on their real selves and constantly remind themselves about their physical and mental characteristics, resulting in a decreased Proteus effect. This study will assess whether there is a connection between self-awareness and the Proteus effect.

Moreover, for this study, it is valuable to analyze more theories that might connect with the Proteus effect and help explain why this phenomenon occurs and how it is influenced by self-awareness and inner speech. The *self-perception theory* proposed by psychologist Bem (1972) is relevant research that sheds light on the Proteus effect. This theory proposes that individuals analyze their past actions and environmental factors to develop identity cues and emotions, which happens when one is unsure about

their *own* emotions and attitudes (Bem, 1972). According to the self-perception theory, an assumption is that one's conscious observation of the avatar might have an impact on their thoughts and actions (Praetorius & Görlich, 2020). The question of whether wearing black uniforms makes athletes act more aggressively was the one that attracted Frank & Gilovich (1988). With the help of experimental studies, they concluded that individuals wearing black uniforms tended to be more aggressive overall. The statement: "Individuals in black uniforms are seen as aggressive." was taken as a general fact within their study. Under the self-perception theory, players wearing black uniforms assumed that they were aggressive and behaved as such. This led to a higher rate of penalties in the National Football and Hockey Leagues (Frank & Gilovich, 1988). Differently, this can be replicated within computer-mediated environments by giving background information on avatars and the environment. Possibly, participants might change or adjust their behavior regarding their avatars using the implanted background information.

Furthermore, a part of the proposed model by Looy et al. (2012) that connects avatar identification with three dimensions might be a competent beginning to identify connections. These dimensions are *wishful identification*, *similarity identification*, and *embodied presence*. Identification with an avatar may be viewed as a brief change in self-perception. One of the most frequent factors contributing to the Proteus Effect is the attractiveness of the avatars (Looy et al., 2012). According to Looy et al. (2012), wishful identification suggests whether the utilized avatar reflects a desirable feature, such as attractiveness, which a person believes they do or do not possess. Moreover, according to Looy et al. (2012), identification through self-similarity is based on the theory that if an individual invests more personally relevant information—adopting a self-relevant avatar figure—results in an increased Proteus effect. It enables individuals to adopt the avatar's personality for their representation in the virtual world (Praetorius & Görlich, 2020). During the identification process, self-awareness might be an element needed to judge the avatar's look, compare it with the self, and ultimately decide if the avatar's identity is a successful match. According to van Looy et al. (2012), within computer-mediated spaces, identification refers to *being aware* of the self as "I" and the virtual environment as "here." Another dimension of avatar identification is the embodied presence, which refers to an individual who has no awareness of the

virtuality of the experience. By that, the sensation of the embodiment is developed (Looy et al., 2012). According to McCain, Ahn & Campbell, the embodiment of an avatar in a virtual environment instantly builds bonding between the individual and the avatar. Regarding that, embodiment strengthens the bond between the avatar and the user, positively contributing to avatar identification and ultimately affecting the Proteus effect. Regarding the aforementioned information, the following hypotheses were formulated:

H1: *Participants whose inner speech is blocked by the articulatory suppression will have less self-awareness but more of a Proteus Effect than the participants whose inner speech is not blocked by the articulatory suppression.*

H2: *Participants whose inner speech is blocked by the articulatory suppression and has a Persona avatar will generate more User Needs ideas than the participants whose inner speech is not blocked by the articulatory suppression and has an Engineer avatar.*

H3: *Participants whose inner speech is blocked by the articulatory suppression and has an Engineer avatar will generate more Product Functions ideas than the participants whose inner speech is not blocked by the articulatory suppression and has a Persona avatar.*

H4: *Participants whose inner speech is blocked by the articulatory suppression and has an Engineer avatar will generate more Technical Solutions ideas than the participants whose inner speech is not blocked by the articulatory suppression and has a Persona avatar*.

Regarding the notions mentioned above, a conceptual model of this study was created with all the hypotheses formed to answer the research question (See Figure 1).

Figure 1

Visualized Conceptual Model

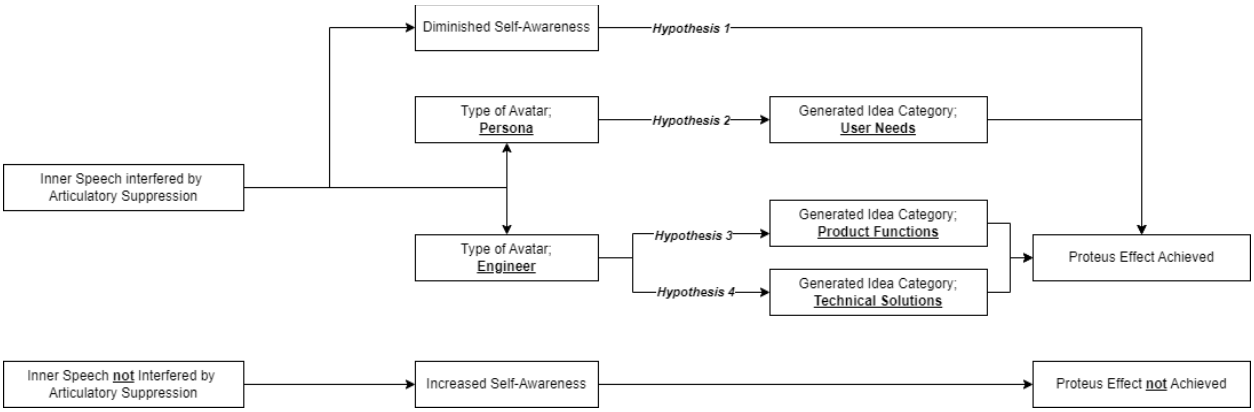


Figure 1: *Showcase of a conceptual model with all the variables and formulated hypotheses to answer the research question*.

Methodology

Research Design

A 2x2 experimental factorial design with one between-subjects independent variable (IV) and one within-subjects IV will be conducted to test the hypotheses about the effectiveness of the Proteus effect (see Figure 2). In order to gather more information from a smaller sample, the within-subjects design was selected whereas the between-subjects design was preferred to have less learning effects since the separation within the participants was evident. The dependent variable (DV) is the "Proteus effect," having three categories of measures (User Needs, Product Functions, Technical Solutions) and post-experiment surveys whereas the IVs are two levels of "suppression type" and two levels of "avatar." Specifically, suppression type levels are; 1) Inner speech is not being interfered with, and 2) Inner speech is interfered with by articulatory suppression. The avatar levels are; 1) an Engineer and 2) a Persona. Therefore, the same participants will experience two types of avatars during the same experiment. In

order to have sufficient data and be efficient throughout lab testing, a between-subjects design will be applied to the inner speech variable and a within-subjects design to the avatar variable.

Figure 2

Visualized 2x2 Research Design

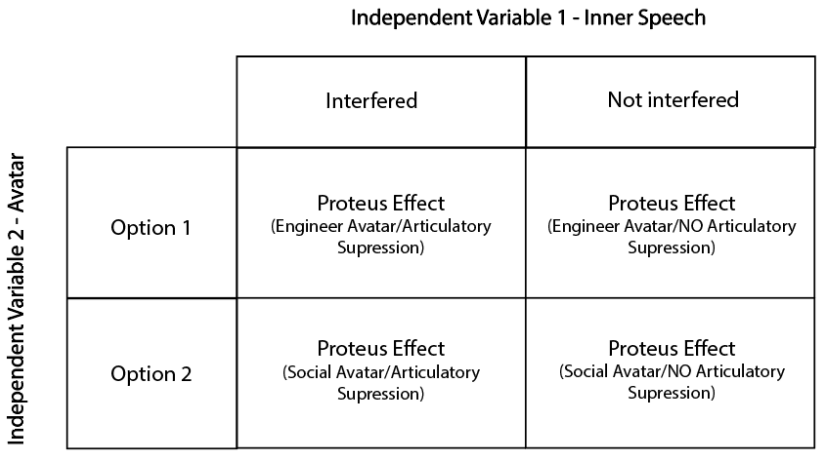


Figure 2: *Determining the 2x2 experimental factorial design, indicating the independent and dependent variables on a model.*

Participants and Sampling

In total, 34 people were recruited as participants from Tilburg University who registered for the experiment through the Human Subject Pool (HSP) or were directly contacted by the researcher. The HSP students received their course credits after their participation. The voluntary response sampling method was used for the experiment since the participants registered at their own will. The participants who registered through HSP received course credit by completing the experiment regarding experiencing the VR simulation and filling out the questionnaires.

Materials and Measurements

Testing the Proteus Effect with an Idea Generation Task

The participants did an idea generation task in a VR environment to test the effectiveness of the Proteus effect based on the approach developed by Buisine et al. (2016). Their findings suggest that the effectiveness of the Proteus effect can be assessed by the degree to which the content of the ideas people generate in VR relates to their avatars. In the study, participants were asked to "*generate ideas to improve the virtual environment they are in*" while they navigated the virtual environment with an assigned avatar. The participants were only able to present their ideas after the VR simulation, meaning that they used the VR to generate ideas, not to present them. The participants were provided with a blank canvas on a computer to write their ideas right after their interaction with VR.

In order to understand if participants' ideas match their avatar identity, the written ideas were analyzed by following the method of Buisine et al. (2016). The qualitative content was transformed into a quantitative one and analyzed under three categories; *User needs* (ideas without any reference to a product or how to fulfill these needs), *Product functions* (desired features of products but with no reference to concrete solutions), and *Technical solutions* (a direct reference to the technologies or components). The participants created two different idea sheets (one for each avatar), meaning that there were 68 papers to analyze, and combining both avatars, there were in total 345 ideas/sentences (179 ideas for the Engineer, 166 ideas for the Persona avatar). In order to have understandable and reliable results, each sentence within these papers was individually analyzed. More specifically, categories were assigned to a color, and each sentence was highlighted with the corresponding color. For example, the idea suggests: "Put an *Artificial Intelligence* with a *3D printer* at the bar". According to the method of Buisine et al. (2016), "artificial intelligence" and "3D printer" are considered to be a fit for the *Technical solution* category regarding the participant making a direct reference to the technologies. After each sentence was highlighted with a corresponding color, the ideas were quantified and ready to be logged into the SPSS to conduct the appropriate tests.

These categories were able to justify whether the Proteus effect worked or didn't during VR simulation. More specifically, the assessment of the Proteus effect was possible depending on a successful match with the usage of words and the assigned avatar. For example, if the participants who completed the task with an Engineer avatar generated more technical-oriented ideas, then the Proteus effect might have worked successfully (Buisine et al., 2016).

Interfering with Inner Speech with the Articulatory Suppression Method

In order to interfere with the inner voice of participants, a method of articulatory suppression was used. Throughout the idea generation task, randomly selected participants were exposed to articulatory suppression in the form of repeating words out loud. The words suggest the days of the week; "Monday, Tuesday, Wednesday, etc.".

Inner speech has a role in executive function activities such as working memory, task switching, or planning. The articulatory suppression technique, in particular, disrupts the phonological loop, which is a part of working memory and is required for producing and experiencing inner speech (Alderson-Day & Fernyhough, 2015). Research about neuroimaging by Smith & Jonides (1998) indicates that repeating words constantly and trying to operate simultaneously on a task is difficult for working memory. Whenever a person maintains items and performs operations simultaneously, one essentially has two tasks: maintaining the items through rehearsal and carrying out the necessary operations. As a result, the person divides their attention between the two tasks, which means that their working memory is very engaged, and highly occupied (Smith & Jonides, 1998).

In contrast to the first condition, the control group tapped one of their feet on the ground in a rhythmic way. More specifically, their phonological loop was not interfered with; rather, their inner speech was evident throughout the idea generation task. By assigning the foot tapping task for the control group, possible confounding elements were avoided such as one group doing two tasks at the same time (idea generation, repeating the days of week) whereas the other group is only doing one task at a time

(idea generation). Rather, it was decided that each group would do two tasks at the same time and avoid confounding variables.

Avatar & Environment Selection

One of the IV was the avatar with two levels; 1) an Engineer and 2) a Persona. In order to be more inclusive, one male and one female avatar was picked for the Persona avatar. The selection for avatar types was made following the study by Buisine et al. (2016). Researchers used an engineer and a persona (a more regular/social look) as their playable 3D avatars (see Figure 3). This distinction made it possible to assess if the avatar affects the Proteus effect. Avatars were the digital representation of the participants within the VR environment, moving according to the participants. The employment of these 3D avatars was identical to each other, meaning that the participants experienced the VR simulation through both of the avatars, suggesting a within-subjects design. Regarding the employment of the avatars, it was determined that the best and most efficient way is to find existing 3D assets from the internet, where a large amount of content is readily available.

Figure 3

3D Avatar models



Figure 3: *Showcase of the utilized avatars taken from VRChat's free asset library.*

In order to present a relatable environment for the participants and make them feel confident, it was decided that the environment would be a virtual café, providing a more common day-to-day activity location. Moreover, the simplicity of the environment was an important factor during the selection to encourage and give room to the participants to create more ideas compared to an already occupied and well-designed environment. The virtual café was occupied with multiple tables and chairs and had a small bar downstairs and an upstairs space with an inner balcony (see Figure 4). The upstairs space provided the users with a large mirror where participants could see their avatar and be aware of their character and physical body. Regarding the Proteus effect being one of the main research elements, the mirror was one of the key factors while choosing the virtual environment. The same procedure was followed regarding the employment of the 3D assets, meaning that the environment was also found and chosen through the VRChat application.

Figure 4

3D Environment



Figure 4: *Showcase of the utilized environment called the Sky Café taken from VRChat's free asset library.*

Virtual Embodiment Questionnaire (VEQ)

In order to further assess the effectiveness of the Proteus effect, a seven-point Likert-scale questionnaire with 16 items, designed for VR simulations and the embodiment of an avatar was employed (see Appendix A). Human-computer interaction research by Roth & Latoschik (2019) provided a questionnaire to accurately, reliably, and fairly evaluate the components of virtual embodiment. The act of providing users with suitable bodily images to represent them to others (and themselves) is known as user embodiment (Roth & Latoschik, 2019). In VR research, the embodiment has been continuously studied, for instance, concerning the avatars' hand appearance and complete body representations.

Within the VEQ, there are three constructs under the embodiment, as Roth & Latoschik (2019) describes; 1) Ownership - the idea that one's own body is the source of personal, distinct bodily experiences that are felt in one's mental life. Such an example of "Ownership" suggests: "It felt like the virtual body was my body." 2) Agency - the perception of oneself as the agent of their acts, as opposed to the activities of others. Such an example of "Agency" suggests: "I felt as if I was controlling the

movement of the virtual body." 3) Change - the feeling of transforming into the avatar and carrying that impression to real life. Such an example of "Change" suggests: "I felt the need to check if my body really still looked like what I had in mind." (Roth & Latoschik, 2019).

Self-Awareness Questionnaire (SAQ)

In order to assess self-awareness within computer-mediated environments, a self-awareness questionnaire was used with five items, and seven-point Likert scale statements (see Appendix B). According to the research by Zao & Flanagin (2006), increased self-awareness makes people more aware of their inner feelings, attitudes, and beliefs. Such examples within the questionnaire suggest: "During the study, I was very aware of the way my mind works when I worked through the problem." Self-awareness has been demonstrated to increase individuals' awareness of and responsiveness to their emotions (Zao & Flanagin, 2006).

Control Questionnaire

In order to understand whether the participants followed the instructions correctly, three items with seven-Point Likert scale statements were integrated into the survey (see Appendix C), e.g., ‘’Throughout the experiment, I followed the given key instructions in a consistent manner.’’

Apparatus

Participants wore the "Meta Quest 2" head-mounted display featuring 1,920 horizontal by 1,832 vertical pixel resolution panels with a refresh rate of 120 Hz. The VR equipment also provided hand-held controllers to initiate more human-like interactions within the virtual environment.

Procedure

Participants registered for the published Lab experiment within the Human Subject Pool of Tilburg University or enrolled by contacting the researcher. The enrolled participants were invited to the

lab location at a designated time and date. Participants who arrived at the experiment were given a small introduction about the study and the equipment they would use throughout the experiment. Before the beginning of the experiment, participants filled out the informed consent (see Appendix D) and answered a questionnaire about their relevance and previous experiences with VR (see Appendix E). After the first survey, participants were given colored cards regarding the randomization of the conditions. These cards provided the participants with needed information about the avatar they were about to use and the instructions (see Appendix F) they had to follow during the experiment. The instructions were also given verbally to the participants to be more concrete. The instructions suggested the idea generation task, the condition (articulatory suppression yes/no), and the provided time within and outside the VR. When the participants acknowledged the information and were ready, the VR headset was presented to them. Certain technical checks were performed in order to understand if the system was working intendedly and if participants were comfortable with the VR headset. Then, participants were exposed to the environment and the chosen avatar in VR. During the first moments in VR, participants were asked to move around within the given environment and be sure that the system was functional. The experiment was initiated if the system was functional and the participants were comfortable.

Within the VR, participants did the idea generation task for three minutes, and then they were asked to take off the VR headset and write down their ideas on a blank canvas on a computer. While they were writing down their ideas, the researcher changed the avatar and made the next scene ready for the participants. After two minutes of writing, participants were asked to put on the headset again. The essential technical checks were conducted, as previously mentioned, and a question about comfort was asked to the participant. This time, participants experienced the VR simulation from the other predefined avatar's vision. Their task was precisely the same as before, generating ideas and writing them down on the blank canvas.

After the main testing, participants received two questionnaires in one survey. Firstly, through a computer, participants filled out the ''Self-Awareness Questionnaire''. Then, participants filled out the Proteus effect questionnaire, called the ''Virtual Embodiment Questionnaire'' (VEQ). To finalize the

experiment, participants received a debriefing at the end of the survey and were free to leave the experiment room, and were assured that their course credit was given.

Data Processing and Analysis

In order to find answers to the hypotheses, repeated measures ANOVA and a MANOVA test were conducted with all the necessary assumption checks, and the results from the created tasks and the questionnaires were analyzed and evaluated within the IBM SPSS. The questionnaires were created in Qualtrics, an online software tool to manage surveys (Qualtrics, 2022). Therefore, the data was easily logged and stored online for analysis and results. The results of the questionnaires were analyzed by the instructions of the previous researchers and those researchers who developed the chosen questionnaires. The experiment data was securely collected and stored in DataVerse, a Microsoft application that allows users to store and manage data safely (Microsoft, 2022).

Results

Descriptive Statistics

Participants were equally distributed across two conditions: one group received articulatory suppression (N = 17), whereas the others did not (N = 17). Moreover, all the participants experienced both types of the presented avatars (N = 34), meaning that they did the idea generation task twice with both of the avatars. Data analysis was based on 34 participants (20 female, 13 male, and one prefers not to say). The participants were aged 18-35+, and 58% of them were aged between 18-22. 73.5% of the participants declared they have experience with VR. 52% of the participants with VR experience indicated that they had interacted with VR within six months or less. 80% of the participants experienced VR very rarely. Regarding multiple answers possible, of the participants who have experience with VR, 44% of them used it for Gaming, 32% for Educational, 16% for Simulator (e.g., car, flight, bike, etc.)

purposes, whereas 12% only had a single experience with VR. 84% of the participants with VR experience did not own a personal VR device.

Reliability Checks

In order to trust the data and the utilized measurements, reliability checks were performed. Virtual Embodiment Questionnaire (VEQ) had good reliability $\alpha = .82$, and the mean score was 53.2 (*SD* = 11.04). Self-awareness questionnaire (SAQ) had adequate reliability $\alpha = .76$, and the mean score was 30.4 (*SD* = 8.96). Control variables had an acceptable reliability $\alpha = 71$, and the mean score was 18.3 (*SD* = 2.26). Regarding the reliability checks, each of the used measurements was proved to be trustworthy and the results were averaged for each participant which are then used within the main analysis.

Virtual Embodiment & Self-awareness on Proteus Effect

To test if the participants whose inner speech is blocked by the articulatory suppression will have less self-awareness but more of a Proteus Effect than the control group (H1), a one-way MANOVA was conducted to examine differences in the Proteus effect between the two interventions (out loud, tap). There were two dependent variables: virtual embodiment and self-awareness. Preliminary checks were performed to assess normality, outliers, linearity, homogeneity of variance-covariance matrices, and multicollinearity. Shapiro-Wilk tests indicated that not all dependent variables were normally distributed in both groups. For the dependent variable virtual embodiment under out loud intervention, a Shapiro-Wilk test showed a significant departure from normality, $W(17) = 0.87$, $p = .018$. For this, the null hypothesis was rejected. However, the rest of the groups (ps > .05) support the assumption of univariate normality. All Mahalanobis distance values were below 13.82, supporting the assumption of multivariate normality and suggesting that there were no multivariate outliers. Box plots indicated that there were five mild univariate outliers (Appendix G). Scatterplots indicated that the dependent variables were linearly related in both the out-loud and tap groups (Appendix H). Box's M test indicated that the assumption of

homogeneity of variance-covariance matrices was met, $p = .297$. A Pearson's correlation analysis suggested that the assumption of multicollinearity was met, $r = .52$, $n = 34$, $p < .001$.

There was a non-significant main effect of the intervention on the Proteus effect, $F(2, 31) = 1.50$, $p = .240$, Wilks' $\lambda = .91$, $\eta 2 = .09$. There was a non-significant effect of the intervention on the virtual embodiment, $F(1, 32) = .19$, $p = .668$, $\eta 2 = .01$, and there was a non-significant effect of the intervention on self-awareness too, $F(1, 32) = 4.52$, $p = .241$, $\eta 2 = .04$ (see Figure 5). Therefore, H1 is not supported, meaning that self-awareness and virtual embodiment does not have a significant effect on Proteus effect.

Figure 5

Bar Chart of MANOVA

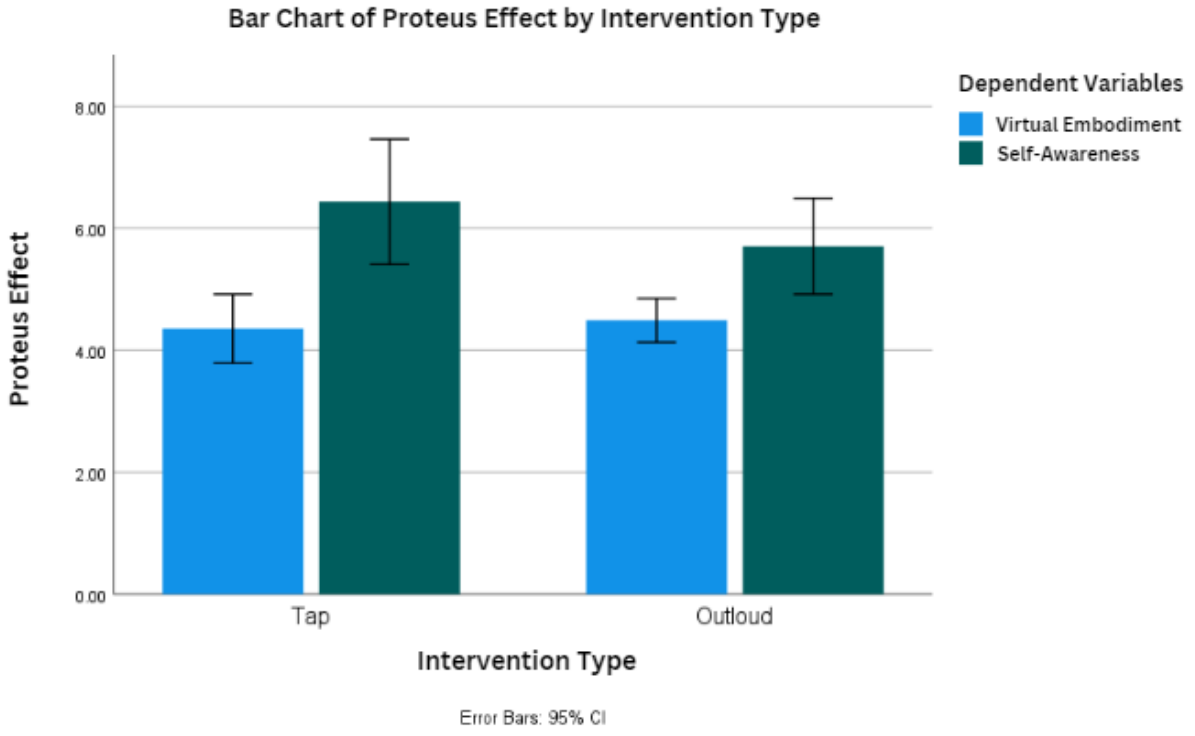


Figure 5: *Proteus Effect measured with mean scores of Virtual Embodiment and Self-Awareness Questionnaires by Intervention Type (tap, out loud)*

Idea Generation on Proteus Effect

To test how the outcome of ideas generated under three categories *(User Need, Product Functions, Technical solutions*) with two interventions (*tap, out loud*) influenced the Proteus Effect, a repeated measure ANOVA was performed for each of the three idea generation categories (H2, H3, and H4).

For Hypothesis 2, the *User Need* scores were normally distributed for all the conditions; Tap/Engineer (z-score skewness = 1.85, z-score kurtosis = 1.43), tap/persona (z-score skewness = 0.17, z-score kurtosis = 0.85), Out loud/Engineer (z-score skewness = 1.01, z-score kurtosis = 0.84), Out loud/Persona (z-score skewness= .06, z-score kurtosis = 0.63). However, the homogeneity of variances was not met (VR = 2.42). Because the ANOVA is less resistant against violations of the assumption of variance homogeneity, the p-value may be somewhat skewed. The ANOVA showed a non-significant main effect of the type of avatar, $F(1, 16) = .19$, $p = .747$, $\eta 2 = .01$. The number of generated ideas under *User Needs* for the Persona condition was higher than the Engineer condition, but the difference was not significant. The ANOVA showed a non-significant main effect of the type of suppression, $F(1, 16) = .01$, $p = .918$, $\eta 2 = .001$. The number of generated ideas under *User Needs* for the tap condition was higher than the Out loud condition, but the difference was not significant. The ANOVA showed a non-significant interaction effect, $F(1, 16) = .01$, $p = .925$, $\eta 2 = .001$ (see Figure 6). Despite avatar having a higher impact on *Technical Solutions* idea scores than suppression type, the difference was not significant. Therefore, the H2 is not supported, meaning that the participants whose inner speech was blocked and had a Persona avatar didn't generate more *User Need* ideas than the participants whose inner speech was not blocked and had an Engineer avatar.

Figure 6

Bar Chart of ANOVA on User Needs category

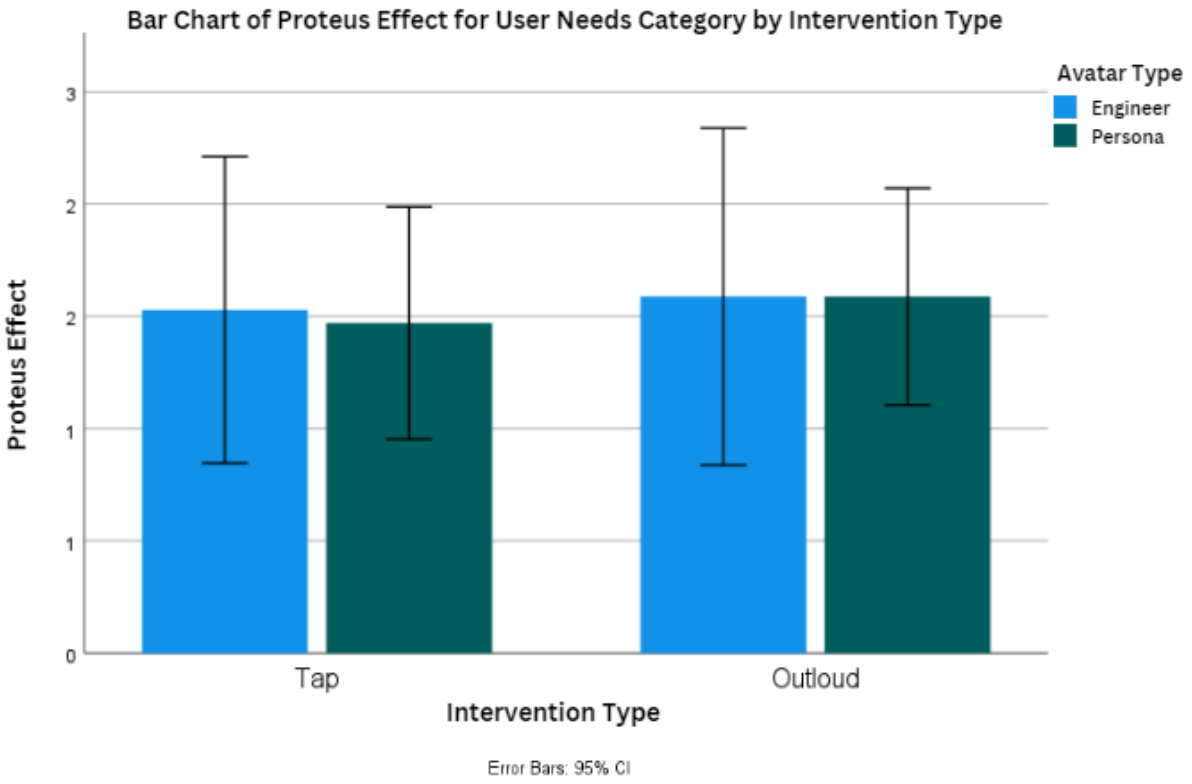


Figure 6: *Proteus Effect measured with mean scores of generated ideas under User Needs category by Intervention Type (tap, out loud)*

For Hypothesis 3, the *Product Functions* scores were normally distributed for all the conditions; Tap/Engineer (z-score skewness = 1.92, z-score kurtosis = 0.82), tap/persona (z-score skewness = 1.11, z-score kurtosis = 0.35), Out loud/Engineer (z-score skewness = 0.23, z-score kurtosis = 0.47), Out loud/Persona (z-score skewness = .69, z-score kurtosis = 0.67). However, the homogeneity of variances was not met (VR = 2.40). Because the ANOVA is less resistant against violations of the assumption of variance homogeneity, the p-value may be somewhat skewed. The ANOVA showed a non-significant main effect of the type of avatar, $F(1, 16) = .51$, $p = .484$, $\eta 2 = .03$. The number of generated ideas under *Product Functions* for the Engineer condition was higher than the Persona condition, but the difference

was not significant. The ANOVA showed a non-significant main effect of the type of suppression, $F(1, 16) = .12$, $p = .730$, $\eta 2 = .01$. The number of generated ideas under *Product Functions* for the Out loud condition was higher than the Tap condition, but the difference was not significant. The ANOVA showed a non-significant interaction effect, $F(1, 16) = 1.5$, $p = .232$, $\eta 2 = .09$ (see Figure 7). Despite avatar having a higher impact on *Technical Solutions* idea scores than suppression type; the difference was not significant. Therefore, the H3 is not supported, meaning that the participants whose inner speech was blocked and had an Engineer avatar didn't generate more *Product Functions* ideas than the participants whose inner speech was not blocked and had a Persona avatar.

Figure 7

Bar Chart of ANOVA on Product Functions category

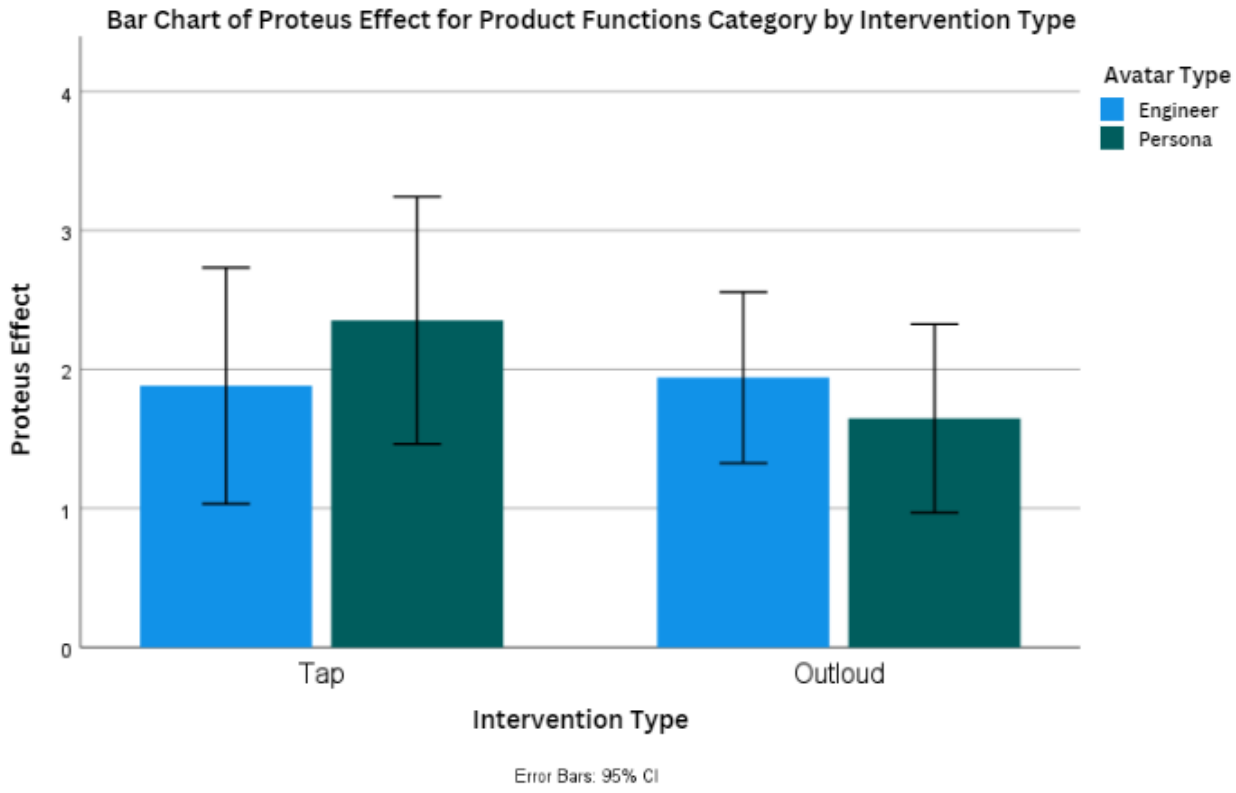


Figure 7: *Proteus Effect measured with mean scores of generated ideas under Product Functions category by Intervention Type (tap, out loud)*

For Hypothesis 4, the *Technical solutions* scores were normally distributed for all the conditions; Tap/Engineer (z-score skewness = 0.64, z-score kurtosis = 0.86), Tap/Persona (z-score skewness= 0.42, z-score kurtosis = 1.48), Out loud/Engineer (z-score skewness = 1.24, z-score kurtosis = 0.14), Out loud/Persona (z-score skewness = 1.84, z-score kurtosis = 1.80). However, the homogeneity of variances was not met (VR = 2.17). Because the ANOVA is less resistant against violations of the assumption of variance homogeneity, the p-value may be somewhat skewed. The ANOVA showed a non-significant main effect of the type of avatar, $F(1, 16) = .16$, $p = .693$, $\eta 2 = .01$. The number of generated ideas under *Technical solutions* for the Engineer condition was higher than the Persona condition, but the difference was not significant. The ANOVA showed a significant main effect of the type of suppression, $F(1, 16) = 7.40$, $p = .015$, $\eta 2 = .32$. The mean score for Tap condition ($M = 1.88$, $SD = .22$) was higher than Out loud condition ($M = 1.32$, $SD = .21$). The ANOVA showed a non-significant interaction effect, $F(1, 16) = .20$, $p = .889$, $\eta 2 = .001$ (see Figure 8). Despite suppression type having a higher impact on *Technical Solutions* idea scores than avatar type, the difference was insignificant. Therefore, the H4 is not supported, meaning that the participants whose inner speech was blocked and had an Engineer avatar did not generate more *Technical solutions* ideas than the participants whose inner speech was not blocked and had a Persona avatar.

Figure 8

Bar Chart of ANOVA on Technical Solutions category

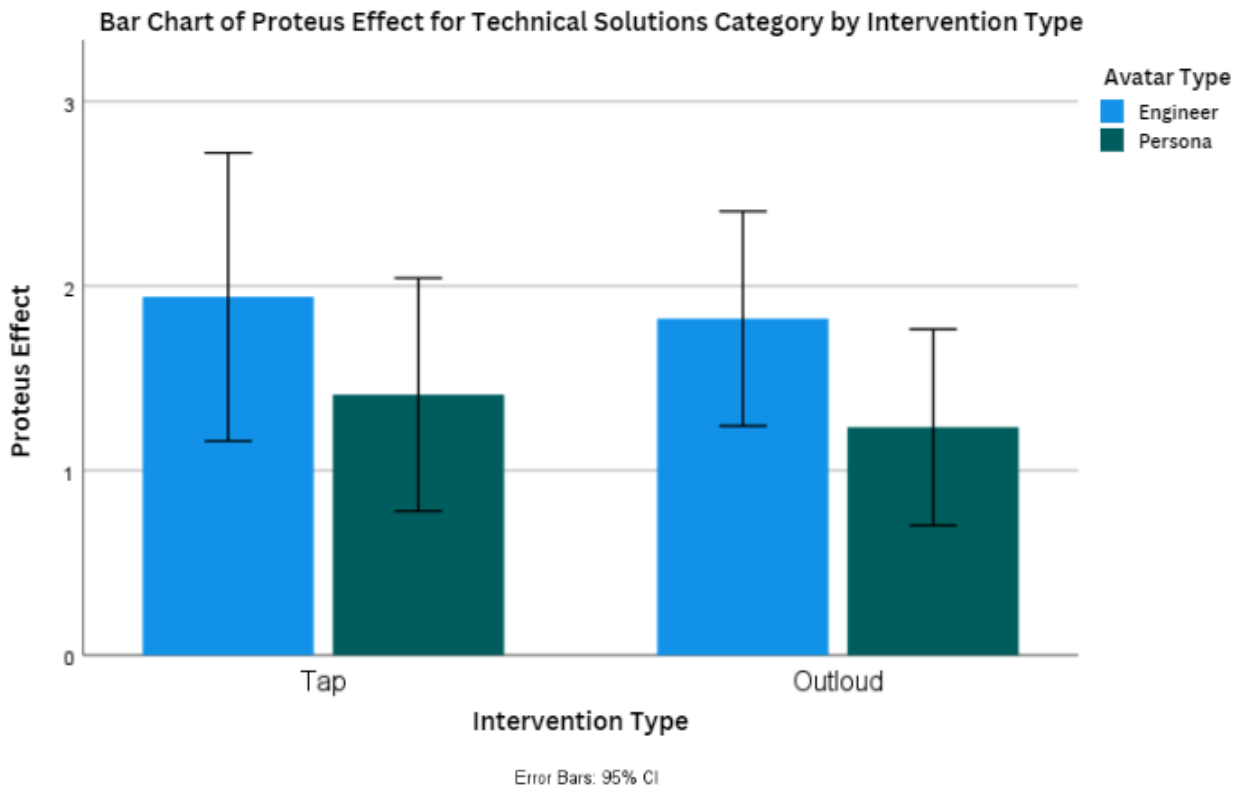


Figure 8: *Proteus Effect measured with mean scores of generated ideas under Technical Solutions category by Intervention Type (tap, out loud)*

Discussion

The study's main purpose was to find how inner speech influences the Proteus effect. In order to make scientific connections, self-awareness was taken into account as a strong element that might influence the Proteus effect. Self-awareness happens when individuals are exposed to VR environments where inner speech is likely to arise since they tend to concentrate on examining and evaluating themselves (Morin, 2005). It was hypothesized that participants whose inner speech was interfered with would have more of a match between their avatar types and generated ideas. Moreover, it was expected

that participants whose inner speech is interfered with would have less self-awareness resulting in an increased Proteus Effect. However, no evidence was found to support the hypotheses mentioned earlier.

Proteus Effect on Idea Generation

Regarding the idea generation categories (*User Need, Product Functions, Technical solutions*), three possible hypotheses were developed. It was hypothesized that participants who utilized the Engineer avatar would generate ideas that are categorized under the *Product Functions* and *Technical Solutions.* In contrast, it was hypothesized that participants who utilized Persona avatars would generate ideas that are categorized under *User Need.* However, in the end, all three hypotheses were not supported.

It was predicted that participants whose inner speech was interfered with and who used an Engineer avatar would create more technical-oriented ideas, and the participants whose avatar is a Persona would create more user-oriented ideas. For all three predictions, there was no significant effect on avatar type or the condition of inner speech. A possible explanation for the non-significant Proteus effect might be the types of avatars used within the study. Regarding the utilized avatars, pre-designed assets taken from the VRChat application (out of -/+100 avatars) did not provide any control over the looks and the types of avatars. Rather, the avatars were selected depending on the proximity of the match, meaning that the closest Persona/Engineer looking avatar was selected for the study. For example, there was no close proximity match on the Engineer avatar; rather, a non-human-looking avatar was used to depict a scientist from the outer world and supported with written background information (see Appendix I) to teach the avatar to the participants. Burkholder (2021) divides the avatar types into two groups: broad and narrow avatar characteristics; where he mentions if an avatar has more relatable values over a substantial segment of the population would be referred to as broad avatar characteristics, whereas the opposite can be said to the narrow avatar characteristics. In this case, the Engineer avatar is considered to have very narrow characteristics regarding relatable values. Broad avatar characteristics are more likely to provoke the Proteus Effect than narrow avatar characteristics, whereas the narrow avatar characteristics either do not activate the Proteus Effect or do so insufficiently to identify it (Burkholder, 2021).

Moreover, a possible reason for a non-significant match between the avatar type and the generated ideas might be that a learning effect was evident due to the within-subjects design. Certainly, some participants ended up generating ideas in the second run that were very similar to the ones they had already generated during the utilization of the first avatar. If the number of repetitions increases, then the overall score might no longer be affected and achieves a state of stabilization (Tao et al., 2019). Another possible reason for a non-significant effect might be that the participants wrote down their ideas after their experience with VR. It is possible that some of the participants generated ideas while they had the time to transfer the ideas they had during the VR experience. Regarding that, the Proteus effect would be challenging to achieve since there is a point where the individual is out of the VR experience.

Finally, a possible reason for the insignificant results can be the sample itself. The Buisine et al. (2016) study used a sample of engineering students who were most likely suitable for the Engineer avatar. This might have created a significant congruency effect leading to the 'Engineer' ideas being more engineer-like compared to this study, where the ideas were generated by random students of Tilburg University who did not study engineering. Overall, such differences in the sample could have additional effects on the study regarding the ideas generated by the participants.

Self-Awareness & Proteus Effect

The first hypothesis suggested that the results of virtual embodiment and self-awareness questionnaires would predict the Proteus effect. However, the results of the experiment showed no significance. Regarding that, no existing research directly connects inner speech, self-awareness, and the Proteus effect, and the number of research papers that can be used to justify the reasons is considered to be very low.

However, a possible reason for a non-significant effect might be that the embodiment of the avatar did not build any bond with the participants. According to McCain, Ahn & Campbell, if there is a non-existent bond between the avatar and the users, then there is a negative influence on the Proteus effect. As mentioned before, the attractiveness of the avatars is one of the most prominent factors

contributing to the Proteus effect (Looy et al., 2012). Each individual who utilizes an avatar in VR will be judging their own look, trying to fit into a virtual body that is not them but rather much different from their own looks. According to the self-perception theory, one's conscious observation of the avatar may influence their ideas and behaviors (Praetorius & Görlich, 2020). Regarding the non-significant results, it might be explained that the participants were alienated from their avatars, meaning that they did not create a bond (not adopting the characteristics and the look of the avatar) and might be aware of their real body and their personal values. Regarding that, throughout the experiment, the participants might not feel like the avatar, rather keeping their own identity forward and most likely influenced the Proteus effect negatively.

Another possible reason for a non-significant effect might be that the participants were solely experiencing VR rather than focusing on the given tasks/instructions. Regarding the demographics, out of 34 participants, 28 of them used VR very rarely. This indicates that a significant part of the test group had very little experience with VR. Most of the participants did not know the controllers, had a difficult time adjusting to the computer-mediated environment and had issues with motion sickness. It can be possible that within the given three minutes of VR, participants might have been adjusting themselves to the environment, being aware of their surroundings, figuring out the movements, and maybe appreciating or disliking the whole experience of VR. Regarding the possibilities, participants could have spent valuable VR time for their adjustment and experimental needs, which might seriously affect the outcome of the Proteus effect and might result in falsely reported self-awareness and virtual embodiment questionnaires.

Limitations & Future Work

Sampling Bias

There have been visible threats to external validity, such as the sampling bias. Regarding the participants, the sample consisted of random students aged between 15 to 35+ with no distinct similarities, meaning they had a wide range of characteristics and capabilities. Most participants had

experience with VR; however, most did not use VR for the past six months or only had a single experience, meaning that the sample population was not highly experienced with the digital system.

In the future, it will be better to focus on the individuals who had prior experience with VR and have experienced it regularly for the past months so that the sample would be more likely to be representative of the VR user population.

Observer Bias

Moreover, an observer bias might have limited the potential of the study. During the experiment, the researcher was always present in the laboratory, interacting with the participants and usually giving and repeating the instructions. However, the presence of the research led certain participants to ask direct questions about the experiment, sometimes unintentionally speaking during the idea generation task and even commenting on how fascinating the study was, making the participants distract themselves from the actions within the experiment.

In the future, depending on the possibilities of the testing location or the methodological approach of the researcher, there has to be a layer between the participants and the researcher. By having such a layer of separation, participants can solely focus on the instructions and efficiently partake in the experiment, creating less threat to the external validity.

VR Environment & Avatars

One of the most prominent limitations of this study is that the VR environment and the avatars were developed by someone else, meaning that all the assets for the experiment were taken from VRChat's free library. Within the pre-made environment, certain elements can distract participants, steer them away from the idea generation task, and ultimately deviate from a proper result. For example, the VR café had a bedroom significantly different from the concept of a café. Moreover, on the bottom floor, participants were able to use colored pencils, which were hanging on a wall. All these actions were announced as forbidden when individuals were given instructions; however, this did not change the fact

that these elements were evident within the experience. One example of this was a participant mentioning a room with a TV and a bed, even though he was clear with the instructions. Another example is that one of the participants started drawing in the air with colored pencils. All these situations were handled right after their occurrence, meaning that the participants were re-instructed to only an observer rather than an interactor. Regarding the situation with avatars, the Engineer avatar did not look like a typical engineer; rather, the avatar looked like a semi-robotic alien, and their 3D model was much more complex than the Persona avatar. To handle this avatar identity situation, participants received written backstories of the avatars in order to understand and identify themselves a little bit with the avatar rather than being confused and assuming things about themselves.

In the future, both the environment and avatars must be designed solely for the purpose of the experiment. The researcher must design the environment so that nearly zero unwanted elements can negatively affect the results of the study. This can be done with the help of 3D modelers and programmers who are capable of developing a working environment and animated avatars. Recruitment of such talented individuals could levitate the power of the research and create results that are much more valid than the usage of premade assets.

Locomotion

Another crucial part of the limitations was the locomotion within the VR experience, which might have caused performance issues within the idea generation task. Since the experiment was done within VR Chat, there are only two locomotion methods: Holoport and First-Person locomotion. Holoport is the locomotion type where the player points a laser beam to a location and watches their avatar moving towards that location in a third-person view, and when their avatar successfully arrives, the actual body of the player would teleport to that location. VRChat suggested this particular option for inexperienced individuals; however, after a pilot test, this option was discarded since it would affect Proteus Effect negatively where the players can see themselves from a third-person perspective. Therefore, the First-Person locomotion was selected because it would enable the participants to move around with the hand-

held controller and experience everything from a first-person perspective. However, this type of locomotion type caused inexperienced and even semi-experienced people to experience motion sickness, which might have affected their overall idea generation performance. All the participants had to be moving around within the VR environment since there was no accurate imitation of walking (participants mostly stood in a small circular location), the experience of walking felt disorienting and unpleasant for some participants. Regarding the post-experiment comments about disorientation effects caused by movement, the instructions for movement were prioritized. The participants received more detailed instructions, such as how to move safely and how to not get dizzy, during the first three minutes of the VR experience.

In the future, full-fetched instructions must be prepared about the movement in VR and the safety of individuals regarding motion sickness. One of the possible approaches to this is to consider all the participants as the same and as in-experienced; by this, there will not be any participants with a lack of information. Another solution would be to own a device that can imitate the movement in VR as in real life. This can be possible by acquiring an omnidirectional walking pad where the participants are tied into a single place, and the surface of this device is dynamic, meaning that the participants can imitate walking by literally moving their legs and feet like in real life.

No prior connections between Inner Speech and the Proteus Effect

During the first stages of the study, research was a critical setback in the whole process. Regarding that there were no connections made between the main notions, it took much work to find sources that were truly relevant to the study. Also, the small number of sources led to more comprehensive information. The connections of the notions must have been made by discovering small elements of more general sources about the topics and creating connections from these small parts that might make sense as a whole.

In the future, the planning can be done better, and even though the research process is taking longer, the resources can still be used for the other parts of the study and balance the overall focus. Since

this research created the roots of such a connection, in the future, more distinct connections can be made and contribute to this study and ultimately help justify the connection between inner speech and the Proteus Effect.

Conclusion

The study contributes to a better understanding of the elements that influence the Proteus effect. After an arduous process of preparations, lab tests, and analyzing both qualitative and quantitative data, the study was finalized. The results showed no significant connection between self-awareness and the Proteus effect. Also, the type of avatar and the type of generated ideas did not have an interaction effect, resulting in a non-significance. However, since no research papers directly connect the aforementioned notions, this study can be an interesting starting point for future researchers. Also, regarding the limitations of this study, it can be helpful for those willing to assess further and analyze the notions and create a testing ground that is highly specified and primarily designed for the study. Technology rapidly and constantly brings innovative and life-changing products and experiences. Regarding VR becoming much more accessible by more general audiences, it is possible to find more researchers testing why the Proteus effect occurs and how it is influenced.

References

Alderson-Day, B., & Fernyhough, C. (2015). *Inner speech: Development, cognitive functions, phenomenology, and neurobiology*. Psychological Bulletin. *141*(5), 931–965. https://doi.org/10.1037/bul0000021

Baddeley, A. D., & Hitch, G. (1974). *Working Memory*. Psychology of Learning and Motivation, 47–89. https://doi.org/10.1016/s0079-7421(08)60452-1

Bem, D. J. (1972). *Self-Perception Theory. Advances in Experimental Social Psychology Volume 6*, 1–62. https://doi.org/10.1016/s0065-2601(08)60024-6

Buisine, S., Guegan, J., Barre, J., Segonds, F., & Aoussat, A. (2016). *Using avatars to tailor ideation process to innovation strategy - Cognition, Technology & Work*. SpringerLink. https://link.springer.com/article/10.1007/s10111-016-0378-y

Burkholder, R. (2021). *The Proteus Effect in Context: Evidence From a Gaming Community*. ProQuest. https://www.proquest.com/openview/5b900dd043b47582dd95d1c6e5fe953d/1?pq-origsite=gscholar&cbl=18750&diss=y

Cabiria, J. (2008). *Virtual World and real world permeability: Transference of positive benefits for marginalized gay and lesbian populations*. Journal For Virtual Worlds Research. https://jvwr-ojs-utexas.tdl.org/jvwr/index.php/jvwr/article/view/284/0

Carver, C. S. (2012). Self-awareness. In M. R. Leary & J. P. Tangney (Eds.), *Handbook of self and identity* (pp. 50–68). The Guilford Press.

Cipresso, P., Giglioli, I. A. C., Raya, M. A., & Riva, G. (2018). *The past, present, and future of virtual and Augmented Reality Research: A network and cluster analysis of the literature*. Frontiers in psychology. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6232426/

Cowan, N. (2013). *Working Memory Underpins Cognitive Development, Learning, and Education*. PubMed. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4207727/

Dretske, F. (1999). *The Mind's Awareness of Itself. Philosophical Studies: An International Journal for Philosophy in the Analytic Tradition, 95*(1/2), 103–124. http://www.jstor.org/stable/4320951

Frank, M., & Gilovich, T. (1988). *The dark side of self and social perception: Black uniforms and aggression in professional sports.* Journal of Personality and Social Psychology, 54, 74-85

Hackshaw, A. (2008). *Small studies: strengths and limitations*. ERS Publications. https://erj.ersjournals.com/content/32/5/1141

Inoue, Y., & Kitazaki, M. (2021). *Virtual Mirror and beyond: The psychological basis for avatar embodiment via a mirror*. Journal of Robotics and Mechatronics. https://www.fujipress.jp/jrm/rb/robot003300051004/

Kaufman, G. and Raphael, L. (1984). *Relating to the self: Changing inner dialogue*. Psychological Reports, 54, pp. 239–50.

Kolmar, C. (2022). *25 amazing virtual reality statistics [2022]: The future of VR + AR*. Zippia 25 Amazing Virtual Reality Statistics 2022 The Future Of VR + AR Comments. https://www.zippia.com/advice/virtual-reality-statistics/

Lateef, F. (2010). *Simulation-based learning: Just like the real thing*. PubMed. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2966567/

Morin, A. (1993). *Self-talk and self-awareness: On the nature of the relation*. Journal of Mind and Behavior, *14*(3), 223–234.

Morin, A. (2005). *Possible Links Between Self-Awareness and Inner Speech: Theoretical Background, Underlying Mechanism, and Empirical Evidence*. Journal of Consciousness Studies, *12*(4-5), 115–134.

Microsoft. (2022). *What is Microsoft Dataverse? - power apps*. Power Apps | Microsoft Learn. https://learn.microsoft.com/en-us/power-apps/maker/data-platform/data-platform-intro

Qualtrics. (2022). *Online survey software - digital survey management tool*. Qualtrics. https://www.qualtrics.com/uk/core-xm/survey-software/?rid=ip&prevsite=en&newsite=uk&geo=NL&geomatch=uk

Peña, J. F. (2011). Integrating the influence of perceiving and operating avatars under the automaticity model of priming effects. Communication Theory, 21(2), 150–168.

Radianti, J., Majchrzak, T. A., Fromm, J., & Wohlgenannt, I. (2020). *A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda.* Computers &Amp; Education, *147*, 103778. https://doi.org/10.1016/j.compedu.2019.103778

Ratan, R., Beyea, D., Li, B. J., & Graciano, L. (2019). *Avatar characteristics induce users' behavioral conformity with small-to-medium effect sizes: a meta-analysis of the proteus effect.* Media Psychology, *23*(5), 651–675. https://doi.org/10.1080/15213269.2019.1623698

Roth, D., & Latoschik, M. E. (2019). *Construction of a Validated Virtual Embodiment Questionnaire*. Semantic Scholar. https://www.semanticscholar.org/paper/Construction-of-a-Validated-Virtual-Embodiment-Roth-Latoschik/0ec7ec8a13fcb3d059c2d7378d5db62bd2b851c5

Simonov, P.V. (1999). *The bright spot of consciousness*. Herald of the Russian Academy of Sciences, 69(5), pp. 378–85.

Skipper, J. I. (2022). *A voice without a mouth no more: The neurobiology of language and consciousness* . ScienceDirect. https://doi.org/10.1016/j.neubiorev.2022.104772

Smith, E. E., & Jonides, J. (1998). *Neuroimaging analyses of human working memory*. PNAS. https://doi.org/10.1073/pnas.95.20.12061

Sokolov, A.N. (1972). *Inner Speech and Thought.* New York: Plenum Press.

Soler-Domínguez, J. L., de Juan, C., Contero, M., & Alcañiz, M. (2020). *I walk, therefore I am: a multidimensional study on the influence of the locomotion method upon presence in virtual reality*. Journal of Computational Design and Engineering, *7*(5), 577–590. https://doi.org/10.1093/jcde/qwaa040

Stamenov, M. (2003). *Language and self-consciousness: Modes of self-presentation in language structure*. Cambridge, UK: Cambridge University Press.

Tao, M., Yang, D., & Liu, W. (2019). *Learning effect and its prediction for cognitive tests used in studies on indoor environmental quality*. Energy and Buildings, *197*, 87–98. https://doi.org/10.1016/j.enbuild.2019.05.044

Van Looy, J., Courtois, C., De Vocht, M., & De Marez, L. (2012). *Player Identification in Online Games: Validation of a Scale for Measuring Identification in MMOGs*. Media Psychology, *15*(2), 197–221. https://doi.org/10.1080/15213269.2012.674917

Yao, M. Z., & Flanagin, A. J. (2006). *A self-awareness approach to computer-mediated communication*. ScienceDirect. https://doi.org/10.1016/j.chb.2004.10.008

Yee, N., & Bailenson, J. N. (2009). *The proteus effect: Implications of transformed Digital Self on Online and Offline Behavior.* Sage Journal. https://journals.sagepub.com/doi/10.1177/0093650208330254

Watson, J. B. (1913). *Psychology as the behaviorist views it*. Psychological Review, *20*(2), 158–177. https://doi.org/10.1037/h0074428

Wicklund, R. A. (1975). *Objective self-awareness*. Advances in Experimental Social Psychology. https://www.sciencedirect.com/science/article/pii/S006526010860252X

Wu, Y., Wang, Y., Jung, S., Hoermann, S., & Lindeman, R. W. (2021). *Using a fully expressive avatar to collaborate in virtual reality: Evaluation of task performance, presence, and Attraction*. Frontiers. https://www.frontiersin.org/articles/10.3389/frvir.2021.641296/full

Zheng, J., Chan, K., & Gibson, I. (1998). *Virtual reality*. IEEE Potentials, *17*(2), 20–23. https://doi.org/10.1109/45.666641

Appendices

Appendix A

The Virtual Embodiment Questionnaire (VEQ):

Virtual Embodiment Questionnaire

	1 Strongly disagree	2	3	4	5	6	7 Strongly agree
It felt like the virtual body was my body.	○	○	○	○	○	○	○
It felt like the virtual body parts were my body parts.	○	○	○	○	○	○	○
The virtual body felt like a human body.	○	○	○	○	○	○	○
It felt like the virtual body belonged to me.	○	○	○	○	○	○	○
The movements of the virtual body felt like they were my movements.	○	○	○	○	○	○	○
I felt like I was controlling the movements of the virtual body.	○	○	○	○	○	○	○
I felt like I was causing the movements of the virtual body.	○	○	○	○	○	○	○
The movements of the virtual body were in sync with my own movements.	○	○	○	○	○	○	○
I felt like the form or appearance of my own body had changed.	○	○	○	○	○	○	○
I felt like the weight of my own body had changed.	○	○	○	○	○	○	○
I felt like the size (height) of my own body had changed.	○	○	○	○	○	○	○
I felt like the width of my own body had changed.	○	○	○	○	○	○	○

Appendix B

The Self-Awareness Questionnaire (SAQ):

Self-Awareness Questionnaire

	0 Disagree	1	2	3	4	5	6	7	8	9	10 Agree
During the study I was very aware of the way my mind works when I worked through the problem.	○	○	○	○	○	○	○	○	○	○	○
During the study I found myself paying attention to changes in my mood	○	○	○	○	○	○	○	○	○	○	○
During the study, I found myself attending to my inner feelings	○	○	○	○	○	○	○	○	○	○	○
During the study I felt that I was trying to figure myself out	○	○	○	○	○	○	○	○	○	○	○
During the study, I felt that I was watching myself	○	○	○	○	○	○	○	○	○	○	○

Appendix C

The control check questionnaire:

Control Checks

	1 Strongly disagree	2	3	4	5	6	7 Strongly agree
Throughout the experiment, I followed the given key instructions in a consistent manner.	○	○	○	○	○	○	○
I did my very best to come up with ideas to improve the virtual environment.	○	○	○	○	○	○	○
I did my very best to visualize the ideas instead of verbalizing them in my head.	○	○	○	○	○	○	○

Appendix D

Informed Consent (deceptive):

Welcome,

Thank you for considering participating in this study by Tilburg University! Below you can find the information you need to know before you can start, so please read it carefully.

The purpose of this study is to learn how a type of avatar within virtual reality affects the creativity of the person playing as that avatar. The type of avatar within VR might affect the solution to a possible real life problem. Being in VR, might help people to act differently regarding the situation, motivating them to come up with solutions that are unique and valuable for society.

The procedure, suggests:

1. Informed Consent & Demographics
2. Small Questionnaire about VR relevancy
3. Wearing the VR Headset
4. Final checks (if the system is working accordingly)
5. The initialization of the creative task
6. Redoing the task with a different avatar
7. Final Questionnaire
8. Debriefing

There are no risks associated with participating in this study. All data collection is in accordance with the AVG (General Data Protection Regulation) law. The Research Ethics and Data Management Committee of Tilburg School of Humanities and Digital Sciences has reviewed and given permission to conduct this study. Data will be processed completely anonymously and treated with the utmost confidentiality. Under no circumstance will your name be linked to the results. The anonymized data from this study will be kept for 10 years, and data can only be shared with other researchers upon request. Eligible students receive 1.0 HSP credit for their participation.

Participation is entirely voluntary and during this study you have the right to withdraw at any time, for any reason, and without any adverse consequences. If you have questions about this study you may contact Ali Erentok (a.erentok@tilburguniversity.edu). If you have any remarks or complaints regarding this research, you may also contact the "Research Ethics and Data Management Committee" of Tilburg School of Humanities and Digital Sciences via tshd.redc@tilburguniversity.edu

When you agree to participate in this study, you confirm that you:

-have carefully read the information given above;
-are older than 18 years; know that you can withdraw at any time and without giving any reason;
-agree that your anonymized data will be stored for ten years;
-agree that the anonymized data can be used for possible follow-up research or scientific publications;
-agree that the anonymized data can be shared with other researchers;

- ○ I agree and want to start with this study.
- ○ I do not agree to participate in this study.

Appendix E

VR relevancy questions:

Do you have any experience with VR?

- ○ No
- ○ Yes

How long have you been interacting with VR systems?

- ○ 6 months or less
- ○ More than 6 months but no more than a year
- ○ More than 1 year but no more than 2 years
- ○ More than 2 years but no more than 5 years
- ○ More than 5 years

How often do you experience VR?

- ○ Several times a week
- ○ Once or twice a week
- ○ A few times a month
- ○ Very rarely

What purpose do you use VR for?

- ○ Gaming
- ○ Educational
- ○ Simulator (e.g., car, flight, bike, etc.)
- ○ Design (e.g., architecture, product design, etc.)
- ○ Viewing (e.g., watching movies, animations, etc.)
- ○ Not in the list? Please specify it here

Do you own a personal VR device? (if yes, please select the brand)

- ○ HP Reverb G2
- ○ Valve Index
- ○ Sony Playstation VR
- ○ HTC Vive Pro 1/2
- ○ HTC Vive Cosmos
- ○ Meta Quest 2
- ○ Meta Quest Pro
- ○ Oculus GO
- ○ VR kit for mobile devices
- ○ Not in the list? Please specify it here
- ○ I don't own a personal VR device

Appendix F

The instructions for the 'foot tapping' group:

1. **Visualize as many ways as possible to improve the virtual environment.** You will have 3 minutes for this task.
2. In a consistent manner, please **rhythmically tap one of your feet** throughout the time you are in the VR simulation.
3. The start will be given when you are ready and comfortable with the VR glasses.
4. After 3 minutes in the VR, you will take out the glasses and **will have 2 minutes to write down your ideas** on a blank canvas.
5. Try **visualizing the ideas** rather than verbalizing them!

The instructions for the 'out loud' group:

1. **Visualize as many ways as possible to improve the virtual environment.** You will have 3 minutes for this task.
2. In a consistent manner, please **repeat the days of the week out loud (e.g., Monday, Tuesday, Wednesday, etc.)** throughout the time you are in the VR simulation.
3. The start will be given when you are ready and comfortable with the VR glasses.
4. After 3 minutes in the VR, you will take out the glasses and **will have 2 minutes to write down your ideas** on a blank canvas.
5. Try **visualizing the ideas** rather than verbalizing them!

General instructions of the VR device:



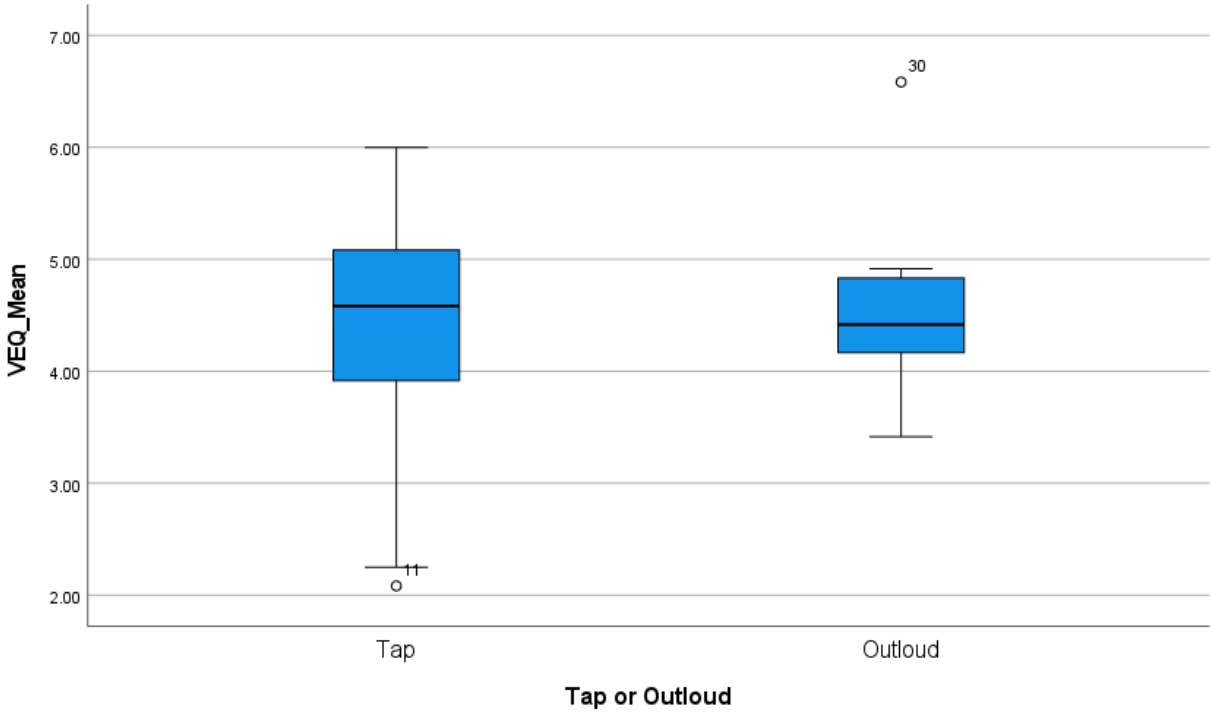
Left Controller

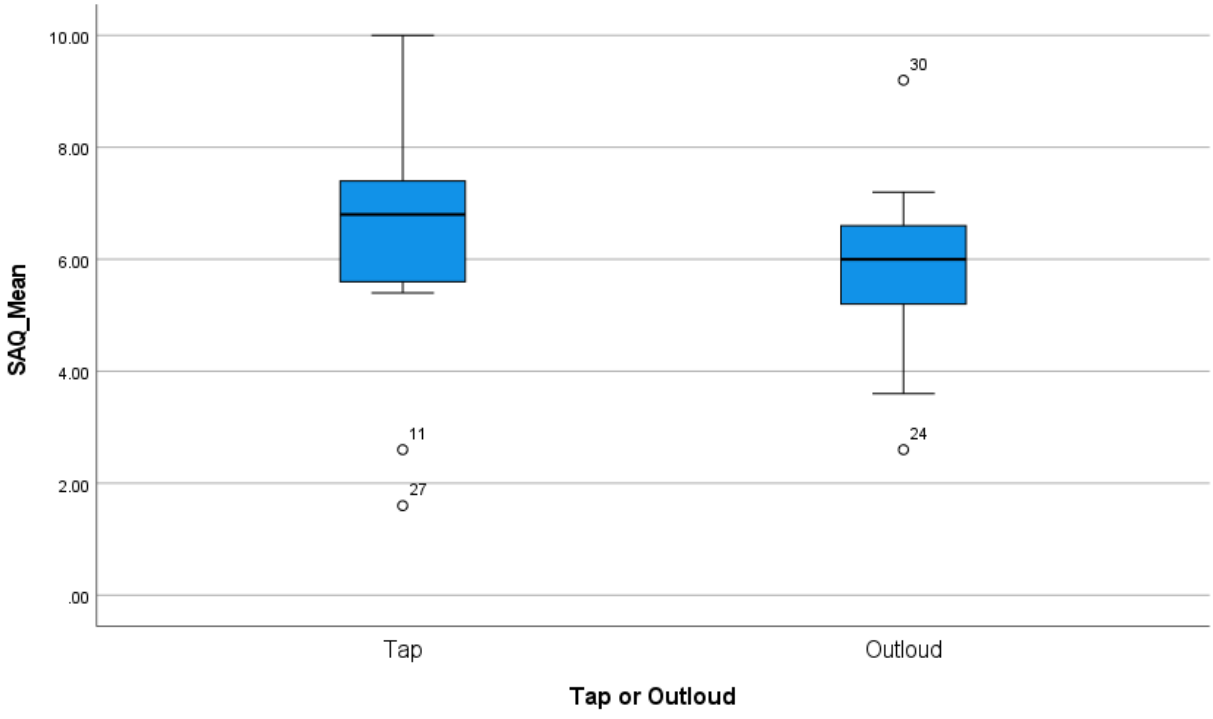


Right Controller

Appendix G

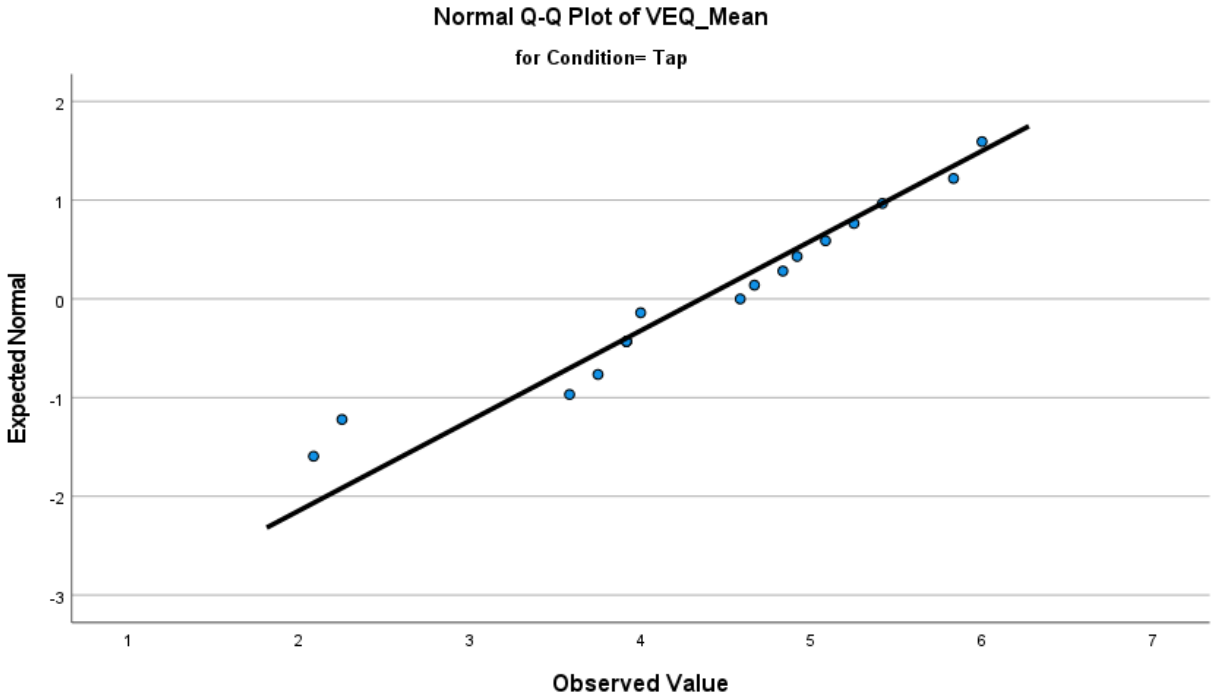
The box plots that indicate the five mild univariate outliers.

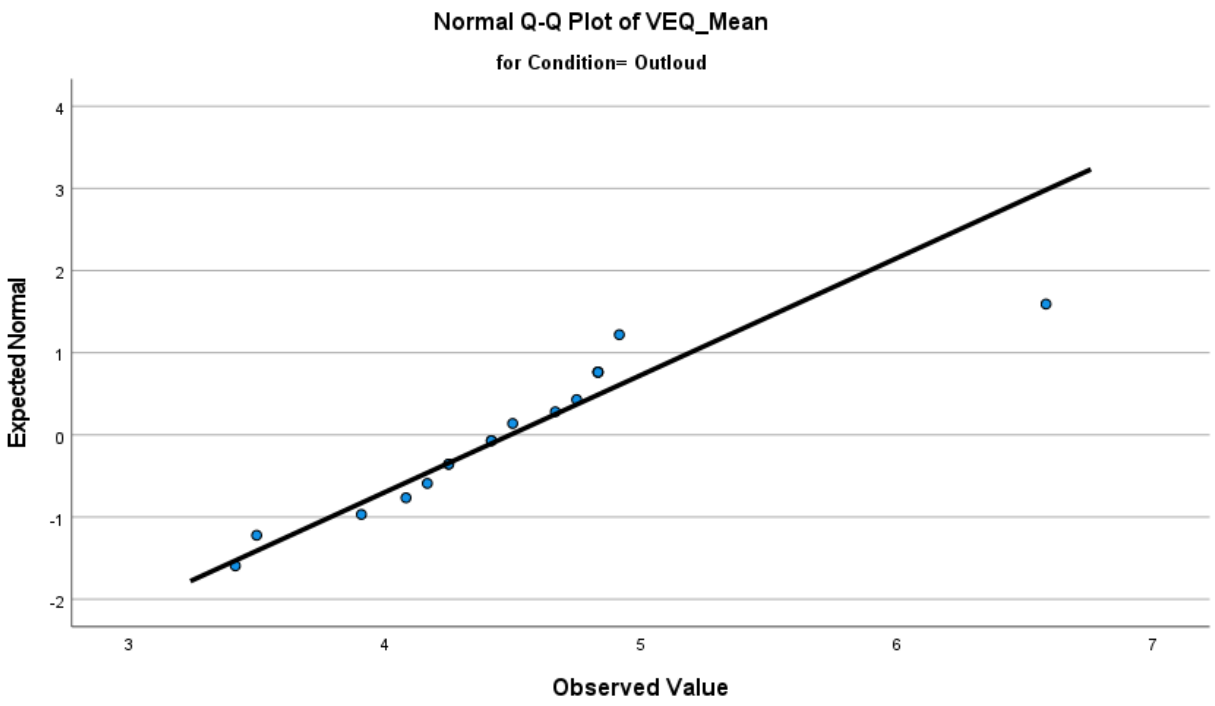


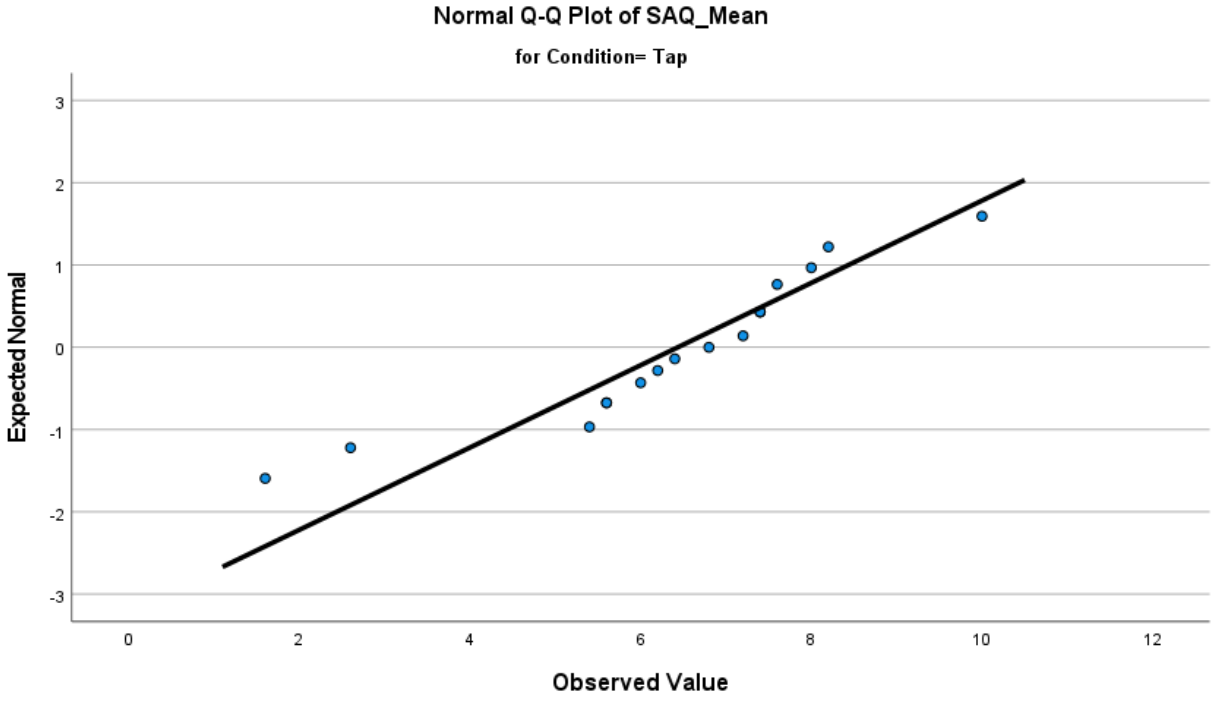


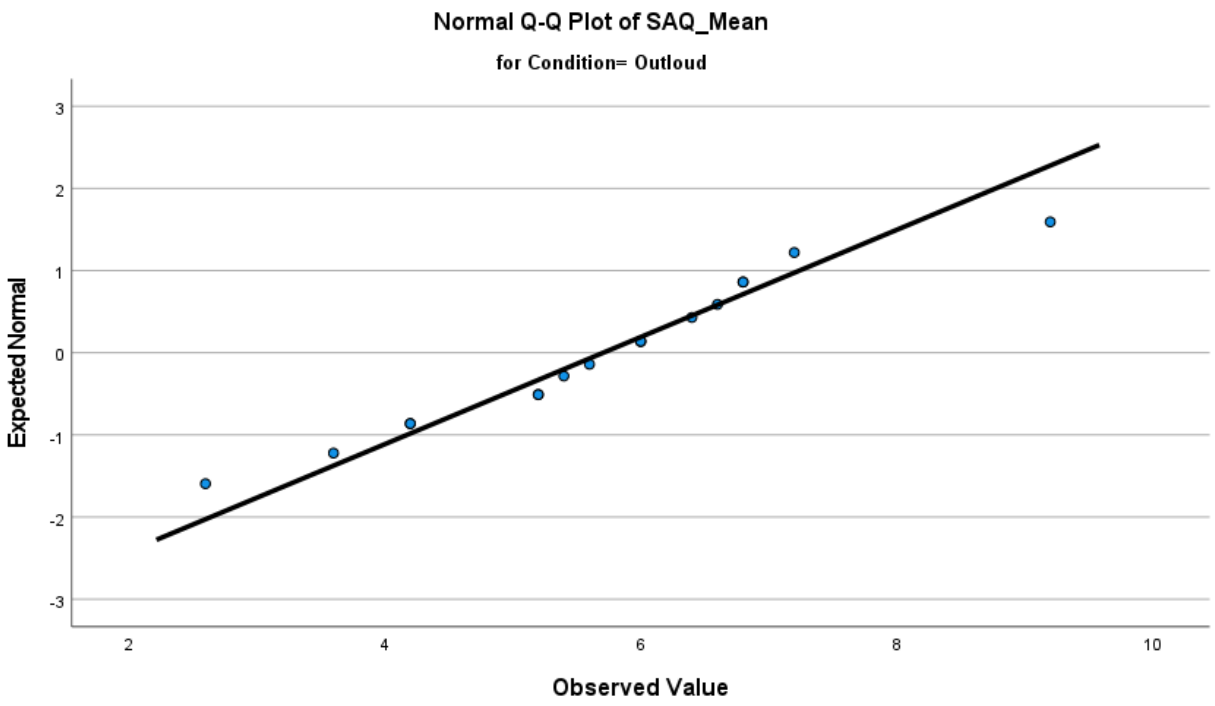
Appendix H

Scatterplots that indicate that the dependent variables were linearly related in both the out-loud and tap groups.




Normal Q-Q Plot of VEQ_Mean
for Condition= Outloud
Expected Normal
Observed Value
4
3
2
1
0
-1
-2
3
4
5
6
7


Normal Q-Q Plot of SAQ_Mean
for Condition= Tap
Expected Normal
Observed Value
3
2
1
0
-1
-2
-3
0
2
4
6
8
10
12



Appendix I

Background information of Engineer avatar:

Character Card – Who Am I?

You are born into the cosmos to find meaning and improve people's quality of life. Your specialty is being an inventor; you are a highly respected engineer. People know you as highly creative and effective in solving problems and creating unique ideas.

Background information of Persona avatar:

Character Card – Who Am I?

You are born as a regular human, a mid-class citizen. You endeavor to find the best suitable profession and work towards it. Your dreams are made for this world where you get along well with your kind. People know you as a socially intelligent human being and envy you for your small-scaled achievements like a certificate from a drawing class.