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Self-identification with a Virtual Experience and Its Moderating Effect on Self-efficacy and Presence

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ABSTRACT

Effective psychological interventions for anxiety disorders often include exposure to fearful situations. However, individuals with low self-efficacy may find such exposure too overwhelming. We created a vicarious experience in virtual reality, which enables observation of one's experience from a first person perspective without actual performance and which might increase self-efficacy. With similarities to both traditional vicarious experiences and direct experiences, the level of self-identification with the experience was hypothesized to affect self-efficacy and its relationship with direct experiences. To test this, vicarious experiences with two distinct levels of self-identification were compared in a between-subjects experiment ($n = 60$). After being exposed to a vicarious experience of giving lectures on elementary arithmetic in front of a virtual audience with either a high or low level of self-identification with the public speaker, participants from both conditions actively gave another lecture. The results revealed that self-identification affected people's self-efficacy after vicarious experience. They further revealed that self-identification is a moderator of (1) the correlation between perceived performance and self-efficacy, (2) the correlation between self-efficacy measured after the vicarious and the follow-up direct experience; and (3) the correlation between the sense of presence reported in the vicarious and in the follow-up direct experience. We anticipate that the first-person-perspective experiences with high-level of self-identification have the potential to be beneficial for training where changing people's self-efficacy is desirable.

1. Introduction

Imagine that you are immersed in a virtual environment. You are standing behind a lectern and ready to give a presentation to a virtual audience. However, you do not need to speak. Instead, you hear a presentation you have never prepared. The voice sounds similar to your own as if it is coming from you. How would you feel about such an experience? Beforehand you felt not capable of giving the speech. Would you now feel more confident to give it because you feel as if you have already successfully delivered the speech? Such experiences may help individuals with social anxiety disorder to establish their confidence and overcome their anxiety. Social anxiety disorder is very prevalent. For example, 9.3% of the Dutch population has been estimated to suffer from social phobia during their lifetime (De Graaf et al., 2012), and the estimations were 12.1% for the US population (Kessler et al., 2005). As individuals with social phobia are afraid of being scrutinized and judged by others in social or performance situations, they often avoid social activities or endure extreme distress. According to Bandura's social cognitive theory (A. Bandura, 1997), low self-efficacy, one's perceived capability to execute a certain task or reach goals, related to coping with

potential threats is the main factor that gives rise to individuals' anxiety and avoidance behavior.

Self-efficacy can be enhanced by successful experiences, gained directly by individuals themselves, e.g., accomplishing tasks successfully (i.e., enactive mastery experience), or gained indirectly, i.e., by observing others' successful performance (i.e., vicarious experience) (A. Bandura, 1997). Thus, these methods are employed in psychotherapy, e.g., to help phobic individuals improve their self-efficacy in coping with potential threats, thereby eliminating their avoidant behavior. While enactive mastery experience is considered the most influential source to establish individuals' self-efficacy (A. Bandura & Locke, 2009), it can be problematic if individuals fail to accomplish the task, or they are even too afraid to be confronted with the situation in question in the first place. For vicarious experiences, the key to the effectiveness relies on the perceived similarity by individuals between themselves and the model in the experiences. Due to the moderating effects of the model, seeing themselves performing some sort of behavior might be more effective than observing another conducting the behavior in question. Video recordings can be used to observe one's own performance. However, making such recordings can be problematic because it requires the individuals to perform a certain task successfully or requires

considerable video editing work for therapists to make the impression that an individual can perform an anxiety task successfully when he or she in fact is not capable to perform the task in the first place. Virtual reality technology can provide a solution that enables an individual to experience a task from a first person perspective without actually performing it.

The introduction of a medium such as books, films, or virtual reality through which a person can experience an event, makes it sometimes less clear when to regard an event as a mastery or vicarious experience. Phenomena that in the natural world coincide can be decoupled by using a medium, such as: (1) the who – the person perceived acting in the event, e.g., yourself, or someone else; (2) the how – the point of view from which a person perceives a phenomenon, e.g., a first-person or a third-person perspective; (3) the what – the authenticity of the substance a person perceives, e.g., genuine, or artificial. Together this creates a three-dimensional who-how-what perception space, as shown in Figure 1a. To provide some intuition of this space, Table 1 gives eight examples about the experience of giving a talk. In the natural world, two everyday experiences can be identified. You give the talk, or you see someone else giving a talk. The first is an authentic, direct, first-person perspective about yourself and normally associated with a mastery experience. The second, although also genuine, is indirect, a third-person perspective about someone else and is normally associated with a vicarious experience. However, by using a physical camera connected to a head-mounted display (HMD) it is possible to shift perspective in realtime. The body-swapping illusion is an example of this. Here a person sees the world through a camera mounted on someone’s head looking at him or herself (Petkova & Ehrsson, 2008). Now the mastery versus vicarious experience or direct versus indirect distinction is less evident. Techniques such as video editing, deep fake videos, and virtual reality create artificial substances able to cause genuine experiences, i.e., processing of perceptions of the (artificial) world, that can lead to emotions, cognitions and beliefs. Authenticity, therefore, forms a third dimension in

Figure 1a. Several studies have already examined the effects of these artificial worlds when people see themselves from a third-person perspective. For example, to study self-modeling Marcus and Wilder (2009) showed children with autism an edited video where the child or another child performed a task. A task which the children had not done before in reality. Likewise, Fox and Bailenson (2009) let people see a virtual character jogging that looked either similar to themselves or not.

Less explored, however, is the scenario where individuals perceive themselves in a first-person perspective using artificial material. Virtual reality technology can provide this. It can give an individual a realtime, embodied first-person perspective of performing a task without actually performing it. This article examines this. We label this a first-person-perspective vicarious experience, and this experience mixes the features of a direct experience and an observed experience. On one side, the first-person-perspective vicarious experience relates to direct experiences. When a person experiences a scenario from a first-person perspective, the individual may relate himself or herself to such an experience, and perceive a sense of self-identification. Hence, the individual may have the impression of performance accomplishment, which in turn may influence self-efficacy. On the other side, as an observational experience, the experience is in some aspects similar to traditional vicarious experiences. For example, the moderating effect of the model’s identity may also exist on the experience’s influence in self-efficacy. Key, therefore, seems how much individuals identify with the model of the embodied experience. To study this, we compared an artificial situation where people would identify less (1B) or more (1A) with the model, and followed this up with a more genuine experience (2) to see changes in self-efficacy beliefs. Figure 1b summarizes the comparisons we set out to make in our study. It gives an insight into the influence of the first person-perspective vicarious experiences with a high-level of self-identification on people’s self-efficacy which might be beneficial for training or therapy.

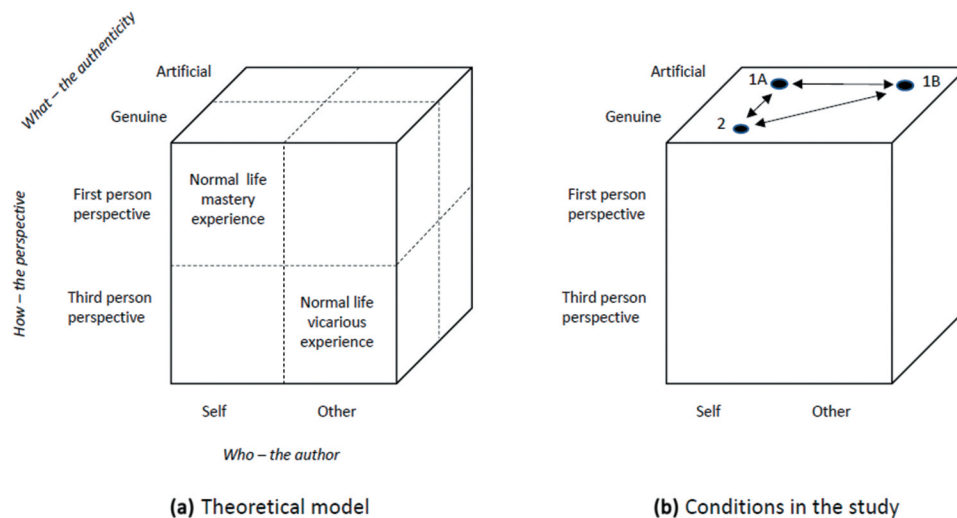


Figure 1. (a) left – theoretical who-how-what perception space model; (b) right – conditions explored in this study.

Table 1. Example experience of giving a talk.

No.	Author	Perspective	Authenticity	Example
1	self	first-person	genuine	Giving a talk.
2	self	first-person	artificial	Embodying a virtual lookalike and looking through its eyes, hearing yourself giving a talk, while in reality you say nothing.
3	self	third-person	genuine	Seeing a recording of yourself giving a talk.
4	self	third-person	artificial	Deep fake video where you see a deep fake representation of yourself giving a talk, while in reality you never gave this talk.
5	someone else	first-person	genuine	Looking through camera mounted on the head of a person that is giving a talk.
6	someone else	first-person	artificial	Embodying a virtual James Bond and looking through his eyes, hearing him giving a talk, while in reality you say nothing.
7	someone else	third-person	genuine	Seeing a person giving a talk.
8	someone else	third-person	artificial	A staged talk given by an actor.

2. Related work and hypotheses

2.1. Self-efficacy and its sources

Perceived self-efficacy is a person's subjective conviction of possessing the needed competence to cope with the demands for successfully completing a specific task. According to Bandura's social cognitive theory (A. Bandura, 2000), self-efficacy influences people's goals and accomplishments, including how people approach challenges and goals. For example, when confronted with a challenge, people with low self-efficacy tend to avoid the situation which they believe exceeds their capability, while people with high levels of self-efficacy believe that they are capable of performing well, thereby demonstrating more effort and persistence to achieve the goal. The concept of self-efficacy is also well-recognized in other theories, such as the goal-setting theory (Locke & Latham, 2002) and the theory of planned behavior (Ajzen, 1991). In the latter case, however, it is referred to as the perceived behavioral control.

To enhance one's self-efficacy beliefs, enactive mastery experiences (i.e., performance accomplishment) are regarded as the most influential source because experiences of success or failure provide direct evidence of one's capability (Garcia-Palacios et al., 2007; Robillard et al., 2010). Besides obtaining such direct experiences in the real world, individuals can also obtain the experiences by actively performing specific tasks in virtual environments. For example, they can deliver a speech in front of a virtual audience (Aymerich-Franch et al., 2014) or answer questions as candidate in a job interview (Hartanto et al., 2014). It also allows for enactive experiences with another virtual body, such as a body with another skin color (Peck et al., 2013), a body of a different age group (Banakou et al., 2013), or a body with three arms (Won et al., 2015). These experiences in virtual environments can affect people's self-efficacy belief as experiences in real world do. For example, people's self-efficacy can be affected by practicing a performance in virtual environments robillard2010using.

Research has further shown that effects of successful exposure to virtual environments in patients with anxiety disorders can be measured in real life (Morina et al., 2015b).

Vicarious experience is another powerful source to affect self-efficacy; a person can learn by observing others or a videotaped-self performing (A. Bandura, 1997). The observational learning can be affected by the modeled performance and social comparison between the observer and the model. According to the social cognitive theory, people judge their self-efficacy partly through social comparison (A. Bandura, 1997). This judgment can be based on the performance or self-efficacy information conveyed by the modeled events. For example, when seeing a model fail repeatedly to perform a cognitive task, observers showed deteriorated self-efficacy if they were alleged to be similarly capable to the model, whereas the self-efficacy maintained high when the observers were alleged to be superior in the capability to the model (Brown & Inouye, 1978). When learning from vicarious experiences, besides modeled performance, people may also evaluate their own capability by comparing themselves to the model on personal characteristics such as age and gender which are assumed to be predictive of performance capabilities. For example, children have been reported to derive a stronger self-efficacy from peer modeling than observing adult models exemplifying the same task (Schunk & Hanson, 1985). Thus, learning can be more effective, or the modeled performance is more relevant to a person, if the person perceives more similarity between oneself and the model (A. Bandura, 1997). A special case of similarity is when individuals can observe their own behavior indirectly. For example, children learn more quickly and master more letters by watching videos of themselves instead of watching videos of someone else (Marcus & Wilder, 2009).

When individuals obtain vicarious experiences in virtual reality by observing virtual characters performing, their beliefs can also be influenced. For example, the self-efficacy became lower when observing virtual classmates praising other virtual classmates but negatively criticizing the participant when answering questions in a classroom (Qu et al., 2015). Furthermore, like vicarious experiences obtained in real life, the experiences obtained in virtual reality tend to be more influential when the virtual model is more relevant to the observers (Fox & Bailenson, 2009; Segovia & Bailenson, 2009).

Although the effects of both direct experiences and traditional vicarious experiences on self-efficacy have been well studied, it is unclear how a first-person-perspective vicarious experience affects individuals. As an experience with mixed features of direct experiences and traditional experiences, it would provide people with an observational experience, and at the same time it might also create a sense of performance accomplishment without actual performance. Hence, the principles of how direct and vicarious experiences affect self-efficacy may be generalized to the new vicarious experience. Therefore, it has the potential to be an influential source that influences self-efficacy like direct experiences and traditional vicarious experiences.

2.2. Self-identification in virtual reality

As Jeannerod and Pacherie (2004) explain, the term self-identification can be perceived from two perspectives. It can be seen as a self-world comparison or as a self-other comparison. The first one is how Merriam-Webster dictionary defines self-identification: “identification with someone or something outside oneself.” This comparison helps to describe a person; for example, I am a teacher or a football fan. In virtual reality, this type of self-identification allows a person to relate to the experience of a virtual character. This can be seen in what Yee et al. (2009) referred to as the Proteus effect, which stipulates that individuals’ behavior conforms to how they are represented in the virtual world. They showed that the appearance of avatars in online communities, for example, length or the attractiveness of their avatar, affected how individuals interact with others online as well as in subsequent face-to-face interactions. Furthermore, instead of being used as self-representations, the characters can also be manipulated to be identified as a different person. For instance, people regarded the virtual characters as themselves when the characters behaved as what they had expected, whereas they identified the characters as others when the characters did not perform the expected behavior (Pavone et al., 2016).

The self-other comparison, on the other hand, focuses on whether this is you or someone else. Here the self can refer to both the person as an object, i.e., the physical body, and as a subject, i.e., an agent that can act and is the author of the intention to act (Jeannerod & Pacherie, 2004). In the context of full-body illusion, Blanke and Metzinger (2009) refer therefore to self-identification as “the degree to which an organism identifies with the content of a global body representation.” Several studies have examined the effect people experiencing a virtual-self or virtual-other. For example, Aymerich-Franch et al. (2014) found that self-identification could affect the level of anxiety. In their study, participants assigned to a self-avatar reported more anxiety in a public speaking situation than when assigned to a dissimilar avatar. Furthermore, when an illusion of body ownership was induced, light-skinned individuals showed a greater reduction in the level of racial bias after being embodied in a dark-skinned avatar than being embodied in a light-skinned avatar (Peck et al., 2013). Also, as mentioned before, people did more physical exercises after observing a virtual lookalike, i.e., a virtual-self, jogging than observing a dissimilar virtual character jogging (Fox & Bailenson, 2009). Also, in a study whereby elementary children observed a virtual-self or virtual-other character swimming with whales, they developed afterward more false memory of such swimming experience if they had observed a virtual-self (Segovia & Bailenson, 2009).

In addition, as discussed earlier, the sense of self-identification has a moderating effect on the effect of traditional vicarious experiences on efficacy beliefs. Hence, as the first-person-perspective vicarious experiences are related to traditional vicarious experiences where models can be perceived or observed, the experiences are expected to affect individuals differently when different levels of associations are perceived between the models and the individuals.

2.3. Presence

Presence is defined as “being in one place” regardless of whether the place is physical, mediated, or imagined. It has been identified as a critical enabler for the success of virtual reality experiences. For example, a higher level of the sense of presence can lead to a higher level of empathy with a virtual avatar (Schutte & Stilinovi, 2017). Furthermore, higher level of presence is associated with a higher level of experienced anxiety (Y. Ling et al., 2014), which is essential for the success of virtual reality exposure therapy. When considering presence, Witmer and Singer (1998) introduced two distinct components: involvement (i.e., attention side) and psychological immersion (i.e., perception of being enveloped in an environment). With an emphasis on the perception of self in a virtual environment, Biocca (1997) introduced the term self-presence which represents individuals’ mental model of themselves in virtual environments when it relates to their actual body. Lee (2004) also defined self-presence as a psychological state when virtual selves are experienced as the actual self in sensory and nonsensory ways. A question is, however, how presence, especially self-presence, would be experienced in a first-person-perspective.

Previous research has revealed that the first-person-perspective vicarious experiences (i.e., experiences observed in a first person perspective) are more related to one’s own experiences than traditional vicarious experiences (i.e., experiences observed in a third person perspective) when the models were identified as oneself. For example, stronger brain responses were elicited in individuals when observing an avatar committing an erroneous action in a first-person perspective than observing in a third-person perspective (Pavone et al., 2016). As the brain responses were also observed when individuals themselves committed errors in real life, this phenomenon suggested that the individuals regarded the errors observed in a first-person perspective as committed by themselves. In a study when an avatar was slapped by another virtual character (Slater et al., 2010), participants showed greater heart rate deceleration if they observed the scene from the avatar’s perspective than from a third person perspective, and the heart rate deceleration was positively correlated with the feeling of body ownership and the feeling of being attacked or hurt. Both examples showed people perceived the avatar’s experience as their own experience, suggesting that they have experienced a certain level of self-presence. Accordingly, when a weaker sense of self-association is perceived during such experiences, the experienced presence can be expected to be also weaker. For example, when delivering speeches in a virtual environment, individuals with self-representations which were similar to themselves experienced a stronger sense of presence than those with dissimilar self-representations (Aymerich-Franch et al., 2014). Therefore, the perceived self-association with the model is expected to have a moderating effect on the experienced presence in the first-person-perspective vicarious experiences.

As a result of the experienced presence, the vicarious experience may relate to direct experience regarding its effect

on individuals' efficacy beliefs. For example, individuals with specific phobias usually have a low sense of self-efficacy in coping with specific situations, and the first-person-perspective vicarious experiences have been successfully used as part of the treatment. Botella et al. (2007) simulated bodily sensations such as heart palpitations and shortness of breath for patients suffering from panic attacks by exposing them to virtual environments in a first-person perspective with the sound of heart palpitations or breathing. They compared the virtual experience treatment with another treatment, i.e., enactive mastery experience in vivo, and both treatments were found equally efficacious. Therefore, when regarded as one's own experiences, the vicarious experiences can be expected to evoke a similar effect on efficacy beliefs as direct experiences.

2.4. Hypotheses

When considering social anxiety treatment, patients with low levels of self-efficacy who find exposure to fearful social interactions too overwhelming might profit from exposure to some successful observational experience. Such an experience might increase their willingness to be exposed to direct experience and might even positively influence how they cope with the fearful situation. Against this background, four hypotheses were formulated (Figure 2), whereby the last two specifically focused on the relation between a vicarious experience and a follow-up direct experience. Note also that for brevity any experience discussed from now on in fact means a first-person-perspective experience. The four hypotheses are as follows:

H1: The level of self-identification affects self-efficacy after a vicarious experience.

H2: Self-identification has a moderating effect on the relationship between how people perceive the model's performance and their self-efficacy after a vicarious experience.

H3: Self-identification has a moderating effect on the correlation between presence in a vicarious and in a follow-up direct experience.

H4: Self-identification has a moderating effect on the correlation between people's self-efficacy measured after a vicarious and after a follow-up direct experience.

The first hypothesis puts forwards the idea that the level of self-identification with a vicarious experience affects people's self-efficacy beliefs after such an experience. The second hypothesis proposes the underlying mechanism for this effect. The observed performance becomes an indicator for one's self-efficacy beliefs; however, the strength of such indicator is determined by how strongly people identify with the observed model. In other words, self-identification with the model determines the relevance of this performance information to form or alter self-efficacy beliefs. Furthermore, vicarious experiences share more similarities with follow-up direct experiences when people identify with the model presented in the vicarious experience. Therefore self-identification was hypothesized as a moderator on the presence correlations (H3) and on the self-efficacy correlation (H4) between these two successive events. That is, when people regard an experience more as their own experience, the sense of presence experienced in the vicarious experience corresponds more to that in a direct experience, and self-efficacy after the vicarious experience correlates more to the efficacy after a direct experience.

3. Method

To test these hypotheses, an experiment was conducted in a public speaking context. Participants were to obtain the vicarious experience by observing a job interviewee's presentation performance from the interviewee's perspective. To examine moderating effects of self-identification on the vicarious experience, a between-subjects design was employed where participants experienced one of the two distinct levels of self-identification: an experience with a low and a high level of self-identification.

Self-identity is related to self-schema (Ratan & Hasler, 2010), which is based on any aspect of oneself as a person, including physical characteristics (e.g., appearance, voice), personality traits, interests, etc. Thus, the two experiences with different levels of self-identification were created by manipulating the virtual interviewee to be less or more like oneself in several aspects such as voice and body posture. The level of self-identification, or specifically, virtual-self similarity in this study, was manipulated by a holistic approach. Like the study on the relationship between virtual-self similarity and social anxiety (Aymerich-Franch et al., 2014), multiple factors (facial similarity, sex, skin color), instead of only one factor,

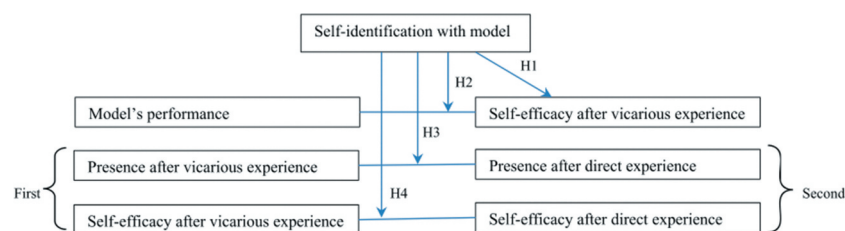


Figure 2. Conceptual model of the hypotheses. The solid lines represent correlational relationships between the connected constructs collected from sequential events, and the arrows stand for causal relationship. The curly brackets indicate the sequence of experiences, i.e., a vicarious experience was always followed by a direct experience.

were manipulated together to create conditions of different similarities to the virtual-self. For example, in the high-level condition, the virtual interviewee gave the presentations with the voice of the participant whereas the voice of the virtual interviewee sounded like another person in the low-level condition; Thus, from the concept of self-identity, the effects of the multiple manipulated factors are expected to be aligned.

To investigate how such a vicarious experience relates to a direct experience, a postmeasurement phase was included whereby people were also asked to give a real presentation in front of a virtual audience. Figure 3 shows the flow of the experiment. The study was approved by the university's human research ethics committee.

3.1. Virtual experience scenario and condition manipulation

A public speaking scenario was created in a virtual environment. University students and non-teaching staff were asked to give lectures on elementary arithmetic for school children as part of a job interview for a radio lecturer. This sample group had enough knowledge about the topic itself, yet only limited experience in giving such a lecture. In the vicarious experience, participants experienced the job interview scenario from the perspective of the interviewee. For this, they were exposed to a virtual audience (Kang et al., 2013). The interviewee was first asked by the chair of the interview committee to introduce himself or herself and then give two lectures: one was on fraction, and the other topic was randomly assigned as multiplication or division. The order of the two lectures was chosen at random. After each lecture, the interviewee needed to answer the questions asked by the committee. To avoid gender effect (Carli, 1989; Qu et al., 2015), the virtual chair and the participant had the same gender.

A participant was assigned to be exposed to an experience with either a high or a low level of self-identification. To

minimize the influence of the virtual interviewee's appearance on the participant's belief and behavior like the Proteus effect study (Yee et al., 2009), the virtual interviewee was not fully visible. Instead, this experiment manipulated several channels described in Table 2 to make the virtual interviewee less or more identifiable as the participant himself or herself. In the high-level condition, the virtual interviewee spoke with the participant's own voice and used the participant's name. To make the participant notice the name, the name was mentioned nine times by the virtual committee during the vicarious experience, e.g., "[participant's name], would you please give a lecture on multiplication?" To enhance the self-identification, when looking downwards, the participant saw a gender-matched virtual body wearing a black suit, and standing with the hands holding the side of a virtual lectern, which was the same as what he or she looked like in the real environment. In addition, the skin color of virtual interviewee's hands matched the skin color of the participants. In contrast, in the low-level condition, the virtual interviewee was different from the participant in all five aspects listed in Table 2. For example, in this condition, the arms and hands were positioned at the side of the virtual body although in the real world, participants' hands were holding the side of a lectern. The experimental setting and screenshots of the view in the two conditions are shown in Figure 4.

The same scenario was employed in the postmeasurement phase except that this time participants needed to deliver a real lecture instead of just observing and this time they had no virtual body. Again the topics of the lecture was on elementary arithmetic, either multiplication or division. If participants were assigned to the multiplication topic in the vicarious experience phase, they gave a lecture on division in the postmeasurement phase, and the opposite was the case if they were signed to the division topic in the vicarious experience phase. While giving the lecture in this phase, participants were also requested to stand in front of the speech stand in the laboratory.

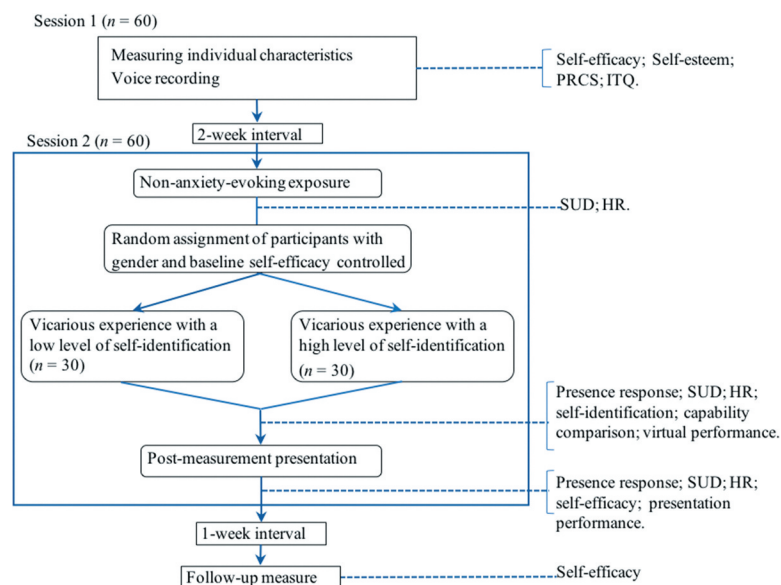


Figure 3. Experiment procedure and measures (listed on the right-hand side) obtained in corresponding phases. The measures are explained in Section 3.2.

Table 2. The condition manipulation in the vicarious experience.

Aspects	Virtual interviewee in the vicarious experience		Participant
	High-level of self-identification	Low-level of self-identification	
Speaking voice	Recorded participant's own voice	Recorded voice of another participant	*
Name mentioned by the virtual committee	Participant's name	Joey for male participants and Jane for female participants	*
Arm and hand position	The same as the posture of the participant: the hands are holding the side of the speech stand in the virtual environment.	The arms and hands were positioned at the side of the virtual body.	The hands were holding the side of a speech stand.
Skin color of hands	The same as the participant's skin.	The skin color was much lighter or darker than the participant's skin.	*
Suit color	Black	Light color	Dark

*No manipulation was employed.

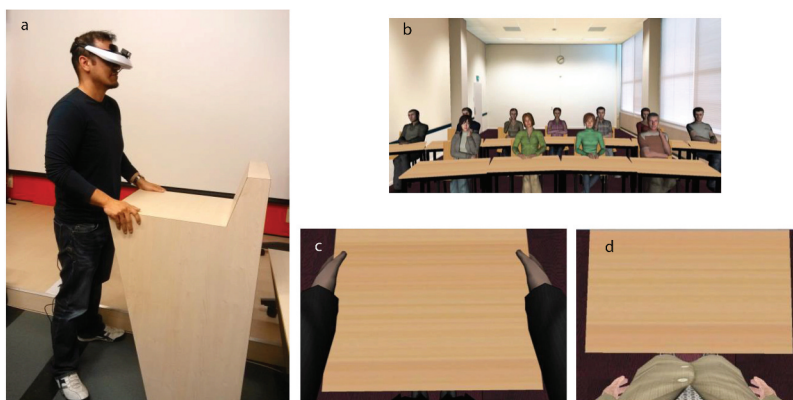


Figure 4. Experimental setting and screenshots of the virtual experience from the perspective of the virtual interviewee. (a) Experimental setting both in the vicarious experience and postmeasurement phase. (b) A female participant's front view of the virtual experience with a female chair sitting on the left in the front row. (c) A dark-skinned male participant's top view in high-level condition (high-level self-identification condition, matched skin color and position of virtual interviewee's hands). (d) A dark-skinned male participant's top view in low-level condition (low-level self-identification condition, mismatched skin color, and position of virtual interviewee's hands).

3.2. Measures

3.2.1. Outcome variables

3.2.1.1. Self-efficacy. Following Bandura's approach (A. Bandura, 2006), a one-item self-efficacy assessment was applied to measure self-efficacy for this specific task. As some (A. Bandura & Adams, 1977; Scopelliti et al., 2013) have observed, self-efficacy belief about one activity is often generalized to self-efficacy beliefs about other activities in the same domain. For example, when self-efficacy in one sport activity was strengthened, the belief in another sport activity was also enhanced, but no changes were found in the belief in for example, cooking skills. Hence, self-efficacy measured in this experiment was kept within the same scenario, i.e., giving lectures on elementary arithmetic. The question was formulated as: Please rate how certain you are that you can demonstrate to a panel of professionals that you are capable of giving radio lectures on elementary arithmetic such as subtraction and division to children aged around ten in an understandable way. As also suggested by A. Bandura (2006), the item was rated on a 11-point Likert scale from 0 (highly certain cannot do) to 10 (highly certain can do) with 5 (moderately can do) as the intermediate point.

3.2.1.2. Virtual performance (VP). Virtual performance (VP) was measured using a single scale (Kang, 2016) asking participants to rate the lecture performance of the virtual interviewee in the vicarious experience.

3.2.1.3. Presence response (PR). To assess how well realistic responses of people were elicited in the virtual experiences, a three-item questionnaire on presence response (Kang, 2016) was adapted from the one used in Pan et al. (2012). It reflects presence by comparing participants' responses to what these would have been in a similar real situation – with respect to their overall behavior, their emotional responses and their thoughts.

3.2.2. Explorative and descriptive measures

3.2.2.1. Rosenberg self-esteem scale (Rosenberg, 1965). This is a ten-item unidimensional scale that measures global self-worth by measuring both positive and negative feelings about the self. All items were answered on a 4-point Likert scale ranging from 1 (strongly disagree) to 4 (strongly agree). This measure was included because the experiment involved social

comparison which can influence self-esteem in a short term (Argyle, 2017; Bari, 2007).

3.2.2.2. Presentation performance (PP). This two-item questionnaire was designed for self-assessment of the presentation performance in the postmeasurement phase (Kang, 2016). This measure was taken as secondary outcome to examine the effects of vicarious experience on the performance in a direct experience.

3.2.2.3. Speech length. As behavioral assessment for social anxiety (Hofmann et al., 1995), the lengths of the presentation and answers to the questions was taken as a measure for confidence or avoidance behavior in the postmeasurement phase. This measure was also taken as the secondary outcome.

3.2.2.4. Heart rate (HR). Heart rate (HR) is a physiological measure of experienced anxiety of people (Wiederhold et al., 2002). Participants' heart rate was monitored continuously using a Bluetooth heart rate monitor (Zephyr HxM Smart), which participants wore around the chest.

3.2.2.5. Subjective unit of discomfort (SUD) (Wolpe, 1968). This item measures the levels of self-reported anxiety experienced by the participants. It was rated on an 11-point scale from 0 (no anxiety at all) to 10 (the highest level of anxiety that you can imagine).

3.2.2.6. Personal report of confidence as a speaker (PRCS). Personal report of confidence as a speaker (PRCS) (Paul, 1966) is a 30-item self-report scale, which assesses both behavioral and affective responses to public speaking situations. The questions are answered in a true-false format, and the questionnaire score ranges from 0 (i.e., no fear of public speaking) to 30 (i.e., highest level of fear).

3.2.2.7. Immersive tendencies questionnaire (ITQ). Immersive tendencies questionnaire (ITQ) (Witmer & Singer, 1998). This 18-item questionnaire measures the capability or tendency of individuals to be involved or immersed in virtual environments. Each item was rated on a 7-point semantic differential scale. ITQ rating has been associated with the level of experienced presence in a virtual environment (Y. Ling et al., 2013).

3.2.3. Manipulation check

3.2.3.1. Self-identification. Self-identification measured the felt ownership of the experience and identification with the virtual interviewee (Kang, 2016). The measure included eight items which were inspired by the four self-presence items from the Behm-morawitz questionnaire (Behm-Morawitz, 2013). The self-presence items seemed more suitable for third-person perspective, i.e., observing your avatar in Second Life environment. The eight new items were, therefore, written to be suitable for first-person perspective experience, focusing not only whether participants felt presence in the virtual world, but also experienced it as an experience of their own and not of someone else.

3.2.3.2. Capability comparison. A two-item questionnaire was designed to investigate how people compared their capabilities with the observed performance of the virtual interviewee in the vicarious experience phase.

3.3. Participants

Sixty participants (24 females and 36 males) were recruited throughout the university campus. Their ages ranged from 19 to 42 years. Based on visual inspection, fifty-two participants from Europe, East Asia, Southeast Asia, West Asia, and Latin America were classified to have light skin, and eight participants from South Asia, Southeast Asia, and Latin America were classified to have dark skin.

3.4. Procedure and apparatus

The experiment included two sessions. In the first session, participants were first asked to fill in the measurements of self-efficacy, self-esteem, PRCS, and ITQ. Afterward the speaking voices of the virtual interviewee used later in the vicarious experience were recorded. This was done for all participants. To prepare the speaking voice of the virtual interviewee, each participant was asked to read aloud a piece of text provided by the experimenter, and the reading was audio recorded with a pair of binaural microphones (Roland CS-10EM) worn by the participant. The binaural recording included spatial information of the sound sources, thereby creating a three-dimensional sound sensation for the listener. Thus, the recorded audio was supposed to sound similar to what the participant hears when he or she gives a presentation. They were instructed to read the text at a moderate speed as if they were explaining something to children in a primary school. The text included three topics on elementary arithmetic: fraction, multiplication, and division. However, the sentences from the three topics were mixed together and disarranged so that it became difficult for people to figure out the storyline, thereby minimizing the chance that the participants memorized the content. The participants were also requested to introduce themselves such as by name, occupation, and age. This audio introduction was used when the virtual interviewee introduce itself in the high-level condition.

To reduce the impact of individual difference between the two experience conditions, a matched pairs design was employed to assign the participants to either the high-level condition or low-level condition of a vicarious experience based on their gender and their self-efficacy values acquired in the first session. Hence, each condition involved 30 participants (12 females and 18 males). When assigned to the high-level condition, the recorded reading was edited to be used as the speech of the virtual interviewee. In addition to rearrangement of the audio, noticeable flaws were edited out, such as mistakes, long pauses, and hesitations, so as to make consistent and successful presentations. For the speech of the virtual interviewee in the low-level condition, a set of pre-edited readings by four other male participants and four other female participants was prepared. The noticeable flaws were also edited out. The reading records for each gender included reading by a non-native English-speaking European with

a little Dutch accent, a non-native English-speaking European with a clear German accent, a native speaker with an Indian accent, and an Asian speaker with an Asian accent. The experimenter selected a gender-matched reading from the recordings of the other participants. To control for potential difference in the quality in the presentations in the vicarious experience phase and consequently the feeling of superiority, the experimenter selected recordings that matched the participant's own recording in terms of accent and pace so that the reading was perceived as comparable to the participant's own reading. Additionally, for the self-introduction in the low-level condition, the name of the virtual interviewee was edited to be Jane for female participants and Joey for males.

To ensure that the participants did not remember much about the content read, the second session was arranged to take place at least two weeks after the first session. In this session, each participant was exposed to three virtual experiences sequentially using a Sony HMZ-T2 head-mounted display (HMD) with a rotation tracker to track the participant's head orientation in three rotational degrees of freedom. The diagonal field of view of this HMD was 45 degrees. The resolution of the right and left display was 1280×720 (horizontal \times vertical) pixels with a refresh rate of 60 Hz. All virtual environments were displayed with stereoscopic rendering. Participants' heart rate (HR) was continuously monitored in all three exposures.

In the first exposure, a nonanxiety-evoking environment was used to obtain the baseline of the anxiety level. The participant was requested to sit and watch a short video in a virtual neutral room for five minutes (Busscher et al., 2011). SUD score during this neutral exposure was asked afterward. Next, the participants were exposed to the vicarious experience. Before it started, they were asked to put on a black suit and stand at the speech stand in the laboratory. Their hands held the side of the speech stand in the laboratory. When ready, the vicarious experience unfolded automatically. The experience included two presentations on arithmetic of around four minutes each with a question and answer round after each presentation. The vicarious experience lasted on average 15 min. After the virtual experience, the participant was asked to rate the SUD, presence response, self-identification, capability comparison, virtual performance, self-efficacy, and self-esteem. Afterward, the participants were exposed to a postmeasurement phase where they needed to give a real lecture and answer the questions asked by the virtual audience in the same job interview scenario as the one in the vicarious experience. This took on average eight minutes. Afterward, they rated the SUD, presence response, self-efficacy, and presentation performance. To check whether the vicarious experience had a long-term impact on people's self-efficacy, the participants were asked again to rate self-efficacy one week after the second session.

4. Data preparation and statistical analysis

Cronbach's α was calculated for the questionnaires containing multiple items, ranging from 0.77 to 0.88 (Table 3). Because of these acceptable levels of reliability, the mean value of the included items within each questionnaire was taken as a single measure. The data were statistically analyzed in R version 3.4.2. To examine whether the two experience conditions

Table 3. Reliability between items within the questionnaires.

Questionnaire and measuring phase	Removed item	Cronbach's α
Self-identification	Q6	0.83
Presence response		
Passive virtual experience	None	0.85
Postmeasurement presentation	None	0.88
Capability comparison	None	0.80
Presentation performance	None	0.77

differ in their effects on self-efficacy (H1), a priori *t*-test, repeated measures ANOVAs were performed on the outcome variables. To examine self-identification's moderating effects on the vicarious experiences (H2, H3, and H4), regression analyses with self-identification as the dichotomous moderator were firstly considered to test the hypotheses. As only linear relationships were found in the high-level self-identification condition, this violated assumptions for the dichotomous moderator variable (Aguinis, 2004). Hence, instead, the relationships hypothesized in H2, H3, and H4 were first examined by correlation analyses for each self-identification condition. The moderating effects were then investigated by comparing correlations between the two experience conditions. For *t*-tests, bootstrap procedures were used. For repeated measure analyses, a Greenhouse-Geisser correction was used when sphericity assumption was not met. To compare data collected during the different phases, Bonferroni correction was applied to adjust the *p* value for post-hoc testing. No correction was made for H1 *t*-test comparison on the data collected after vicarious experience, as this was a priori test (H1). Correlation analyses between data collected across various phases were calculated using a procedure for repeated observation data (Bland & Altman, 1995).

As skin color has been reported as a predictor for self-efficacy (Thompson & Keith, 2001), additional analysis was conducted on skin color homogeneous sample to rule out social stigma as an alternative explanation for self-efficacy differences found between low and high-level self-identification conditions.

All the experiment data, the R markdown files can be found online.¹

5. Results

Each condition involved 30 participants (12 females and 18 males). To check whether pre-experimental differences existed between the conditions, independent *t*-tests were performed. The results (Table 4) showed no significant differences between participants in high-level and low-level condition in self-efficacy before vicarious experience, self-esteem before vicarious experience, PRCS, and age. However, a significant difference was found in the total scale of ITQ, $t(58) = 2.51, p = 0.01$.

5.1. Explorative analysis

Correlation between the explorative measures and self-efficacy collected in the same phase were calculated. Table 4 shows that the SUD score and HR have significant negative correlation with self-efficacy rating. However, no significant correlation with self-efficacy was found in either speech length or self-esteem.

Table 4. Descriptive statistics of the measures, mean (SD), and results of independent post-hoc *t*-tests between conditions and correlation with the self-efficacy.

Measure and phase	Condition		Correlation self-efficacy ¹
	High	Low	Pearson's <i>r</i>
PRCS	12.03(6.53)	12.47(6.39)	-0.50***
Age	26.27(4.07)	26.33(5.13)	0.16
ITQ	70.10(11.63)	62.73(11.08)*	0.13
Capability	5.02(1.58)	5.02(1.75)	0.43***
VP	6.90(2.35)	7.67(1.81)	0.33*
Self-identification	6.62(1.52)	4.31(1.80)***	-0.06
SUD	Neutral room	1.03(1.19)	0.53(0.68)
	Vicarious experience	2.47(1.48)	1.77(1.43)
	Postmeasurement presentation	5.03(2.33)	4.13(2.33)
	Total	2.84(2.39)	2.14(2.20)*
HR	Neutral room	75.63(14.28)	74.24(10.14)
	Vicarious experience	84.57(14.65)	87.39(10.54)
	Postmeasurement presentation	87.85(12.80)	86.46(10.54)
	Total	82.62(14.72)	82.56(11.94)
PR	Vicarious experience	4.58(2.10)	3.83(2.54)
	Postmeasurement presentation	6.68(2.04)	6.37(2.05)
	Total	5.63(2.31)	5.10(2.62)
	Self-efficacy	6.87(2.47)	7.07(2.50)
Self-identification	Two weeks beforehand	5.10(2.66)	6.80(2.17)*
	After vicarious experience ²	4.43(2.66)	5.90(2.32)
	After postmeasurement presentation	6.37(1.61)	6.77(1.72)
	One week afterward	5.69(2.55)	6.63(2.22)**
	Total	20.87(5.49)	22.50(4.08)
Self-esteem	Two weeks beforehand	21.03(5.89)	22.90(4.66)
	After vicarious experience	20.95(5.65)	22.70(4.35)
	Total	4.38(2.41)	5.07(2.01)
PP	4.38(2.41)	5.07(2.01)	0.73***
Speech length	374.00(94.12)	348.00(71.17)	-0.13

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note 1. Correlation with self-efficacy measured at the same phase. If a measure item was measured multiple times, the correlation was calculated within individuals between the multiple observations of the item and self-efficacy beliefs at corresponding phases.

Note 2. At this phase, a priori *t*-test was conducted on self-efficacy.

5.2. Manipulation check

To check whether the condition manipulation of the vicarious experience was successful, a comparison was conducted between the conditions on people's self-identification. People identified the virtual interviewee significantly more ($t(58) = 5.37$, $p < 0.001$) as themselves in the high-level condition than in the low-level condition. Thus, people identified themselves with the high-level experience other than the low-level experience. It is important to notice that no significant difference was found between the two experience conditions in the perceived performance of the virtual interviewee (i.e., virtual performance) and how the participants compared their own capabilities with the capability of the virtual interviewee (i.e., capability comparison). This rules out an alternative explanation for affecting self-efficacy differently due to an unplanned difference in the perceived quality of the presentation by the virtual interviewee. The potential alternative explanation caused by the unplanned ITQ difference between the high-level condition and the low-level condition was also not probable because no significant correlation in either the high-level condition ($r = 0.11$, $n = 30$, $p = 0.58$) or the low-level condition ($r = 0.28$, $n = 30$, $p = 0.13$) was found between ITQ and the self-identification.

5.3. Overall analyses on self-efficacy across the phases

To study how self-efficacy changed after the different experiences, a two-way mixed ANOVA was conducted on the self-efficacy measured in the recording session two weeks beforehand, after

vicarious experience, after postmeasurement presentation, and one week afterward, with time of measurement as the within-subjects factor and the self-identification condition (high versus low) was included as the between-subjects factor. Significant main effects for condition ($F(1, 58) = 4.30$, $p = 0.04$) and time of measurement ($F(2.71, 156.94) = 12.70$, $p < 0.001$) were found. Furthermore, a significant interaction effect was observed between condition and time of measurement ($F(2.71, 156.94) = 2.91$, $p = 0.04$). The mean scores are shown in Figure 5. A priori test² found a significant ($t(58) = -2.71$, $p = 0.009$) difference in self-efficacy beliefs after the vicarious experience between the two experience conditions (Table 4), while additional post-hoc tests showed that beliefs after the postmeasurement presentation did not differ significantly between the experience conditions. Overall self-efficacy beliefs after the vicarious experience and beliefs after the postmeasurement presentation changed significantly compared with the belief measured two weeks beforehand (i.e., beforehand versus after vicarious experience, $t(59) = 2.98$, $p = 0.03$; beforehand versus after postmeasurement presentation, $t(59) = 5.07$, $p < 0.001$). However, no significant difference between the conditions was found either in self-efficacy measured two weeks beforehand or one week afterward. Hence, there was no indication that the vicarious experience and postmeasurement presentation had a long-term effect on self-efficacy. Furthermore, *t*-tests were conducted on self-efficacy in the high-level condition and low-level condition separately. Results show that self-efficacy decreased significantly ($t(29) = 3.98$, $p = 0.003$) in the high-level condition, while no significant change was found in the low-level condition when comparing data collected two

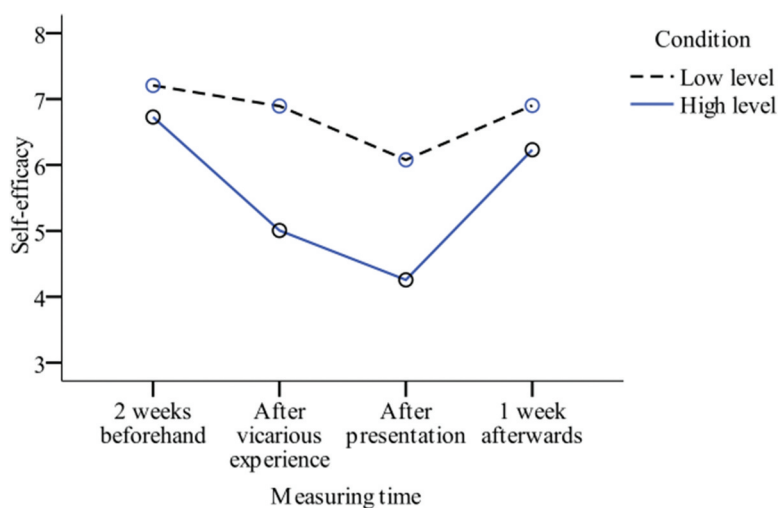


Figure 5. Self-efficacy measured at different times in high and low-level self-identification condition.

weeks beforehand and after the vicarious experience. Thus, H1 was supported.

5.4. Moderating effect of self-identification

5.4.1. Performance in the vicarious experience and self-efficacy afterward

The next step was to analyze the moderating effect of self-identification on how self-efficacy was affected in the vicarious experience (H2). As shown in Table 4, the overall correlation was significant ($r = 0.33$, $n = 60$, $p = 0.01$) between self-efficacy after the vicarious experience and the interviewee's performance (i.e., virtual performance). Comparing the correlations between the two conditions, the correlation in the high-level condition ($r = 0.54$, $n = 30$, $p = 0.002$) was significantly higher ($z = 2.68$, $p = 0.01$) than the correlation in the low-level condition ($r = -0.12$, $n = 30$, $p = 0.52$). Figure 6 illustrates the correlations for both conditions between virtual performance and self-efficacy after the vicarious experience. Thus, participants' efficacy belief was more associated with the performance perception in the high-level condition than in the low-level condition (H2 supported).

5.4.2. Self-efficacy

The correlation between self-efficacy after vicarious experience and the one after postmeasurement presentation in the high-level condition ($r = 0.71$, $n = 30$, $p < 0.001$) was significantly higher ($z = 3.28$, $p = 0.001$) than the correlation in the other condition ($r = -0.004$, $n = 30$, $p = 0.98$). Figure 7 shows the different correlations in the high-level condition and the low-level condition. The high correlation suggests that vicarious experience has a similar effect as a direct experience has on self-efficacy when the sense of self-identification is high. Thus, the level of self-identification has a moderating effect on the relationship between self-efficacy after a vicarious experience and the self-efficacy after a direct experience (H4 supported).

5.4.3. Presence response

A two-way mixed ANOVA was conducted on the presence responses after vicarious experience and after the postmeasurement presentation, with the experience phase (vicarious experience or the postmeasurement presentation) as the within-subjects factor, and self-identification condition as the between-subjects factor. Whereas no significant effect was found for self-identification condition, a significant main effect of experience phase ($F(1, 58) = 49.04$, $p < 0.001$) was found. As Figure 8a reveals, the presence response in the postmeasurement presentation was significantly higher than that in vicarious experience both in the high-level condition ($t(29) = -7.04$, $p < 0.001$) and in the low-level condition ($t(29) = -4.29$, $p < 0.001$). Correlations between presence response in vicarious experience and the one in the postmeasurement presentation were also examined, respectively for the high-level condition and the low-level condition. As hypothesized, correlation of the high-level condition ($r = 0.69$, $n = 30$, $p < 0.001$) was significantly higher ($z = 3.04$, $p = 0.002$) than the correlation in the other condition ($r = 0.02$, $n = 30$, $p = 0.92$). Figure 8b,c illustrate the different correlations in high-level condition and low-level condition. The high correlation in high-level condition indicates that the self-identification induced a similar but weaker presence experience compared with the experience induced in the postmeasurement presentation. Thus, the presence response in the vicarious experience predicted better the presence response in the postmeasurement presentation in the high-level condition than in the low-level condition. The association between ITQ and presence response was also checked respectively for the high and low-level self-identification condition. No significant correlation was observed, making it therefore unlikely that the unplanned ITQ difference between the self-identification conditions affected the reported presence response.

5.4.4. Potential effect of skin color on self-efficacy

As a darker skin complexion was found to be associated with lower self-efficacy (Thompson & Keith, 2001), additional

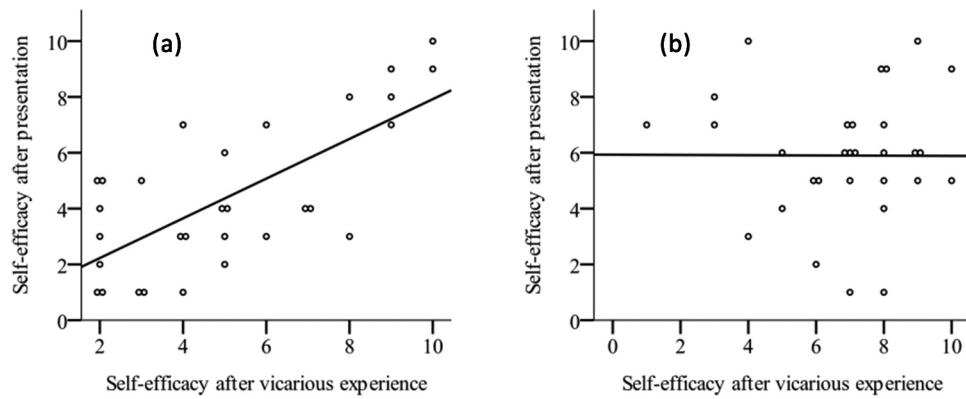


Figure 6. Scatter plot of self-efficacy after vicarious experience and perceived performance of the virtual interviewee in (A) high and (B) low-level self-identification condition.

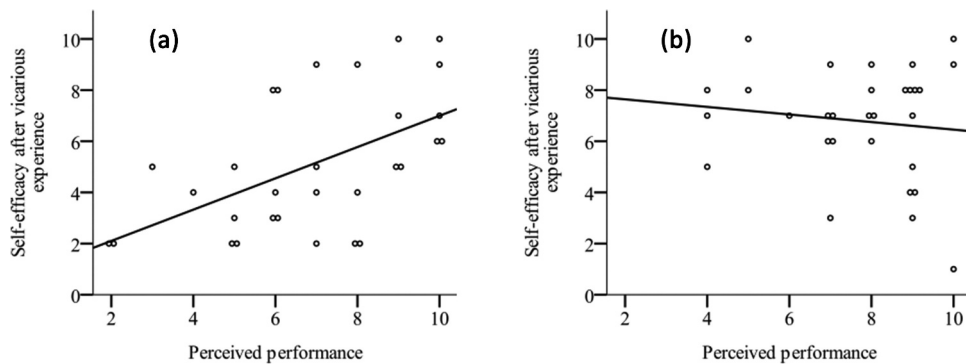


Figure 7. Relationship of self-efficacy before and after the postmeasurement presentation in (A) high and (B) low-level self-identification condition.

analyses were conducted to rule out social stigma or racial bias as a confounding variable for the self-efficacy findings. In our study, the majority (52 out of 60) of the participants had a light-color skin. Thus, in the low self-identification condition, most participants had an avatar with a dark-color skin, and following the idea of a negative racial bias toward darker skin would suggest even a lowering of the self-efficacy. In other words, a difference between the low and high self-identification conditions, would have been caused not by a change in the high condition, but by one in the low condition. To explicitly examine this, we did an additional analysis by filtering out the data from eight dark-skinned participants from both conditions and ran the analysis again on a homogeneous sample ($n = 52$, 26 participants in each condition). As shown in the results (Table 5), the same conclusion can still be drawn that the participants' self-efficacy was significantly affected only in the high self-identification condition when the avatars' skin color was also light, whereas self-efficacy remained unchanged in the condition when the avatars' skin color was darker than the participants' skin color and therefore a racial bias as an alternative explanation is unlikely.

6. Discussion and conclusions

Based on the results, a number of conclusions can be drawn. First, participants in the high-level condition identified with the

virtual interviewee more than participants in the low-level condition, and participants' self-efficacy changed more after the vicarious experience in the high-level condition than in the low-level condition. Thus, the results suggest that vicarious experiences with a higher level of self-identification were more able to alter self-efficacy beliefs than experiences with a lower level of self-identification, thereby supporting H1. The analyses on self-efficacy reported after the vicarious experience also revealed a significant moderator effect of self-identification on the relationship between the perceived performance and self-efficacy (H2 supported). In other words, participants who experienced a higher level of self-identification seem to have related more the performance of the virtual interviewee with their own self-efficacy. When individuals experienced a weaker sense of self-identification, this performance was not regarded as exemplar for their own ability. Thus, the learning process of a traditional vicarious experience seems to be the underlying mechanism explaining the observed change in self-efficacy. Another finding was the moderating effect on the relationship between the vicarious experience and the direct experience (i.e., the postmeasurement presentation) regarding the experienced presence and the effect on self-efficacy (H3 and H4). Only for participants who experienced a high level of self-identification, their beliefs established during the vicarious experience strongly correlated with their beliefs after the direct experience, and the correlation was also significant between the senses of presence in the two experience phases. However, no effect of the vicarious experience on

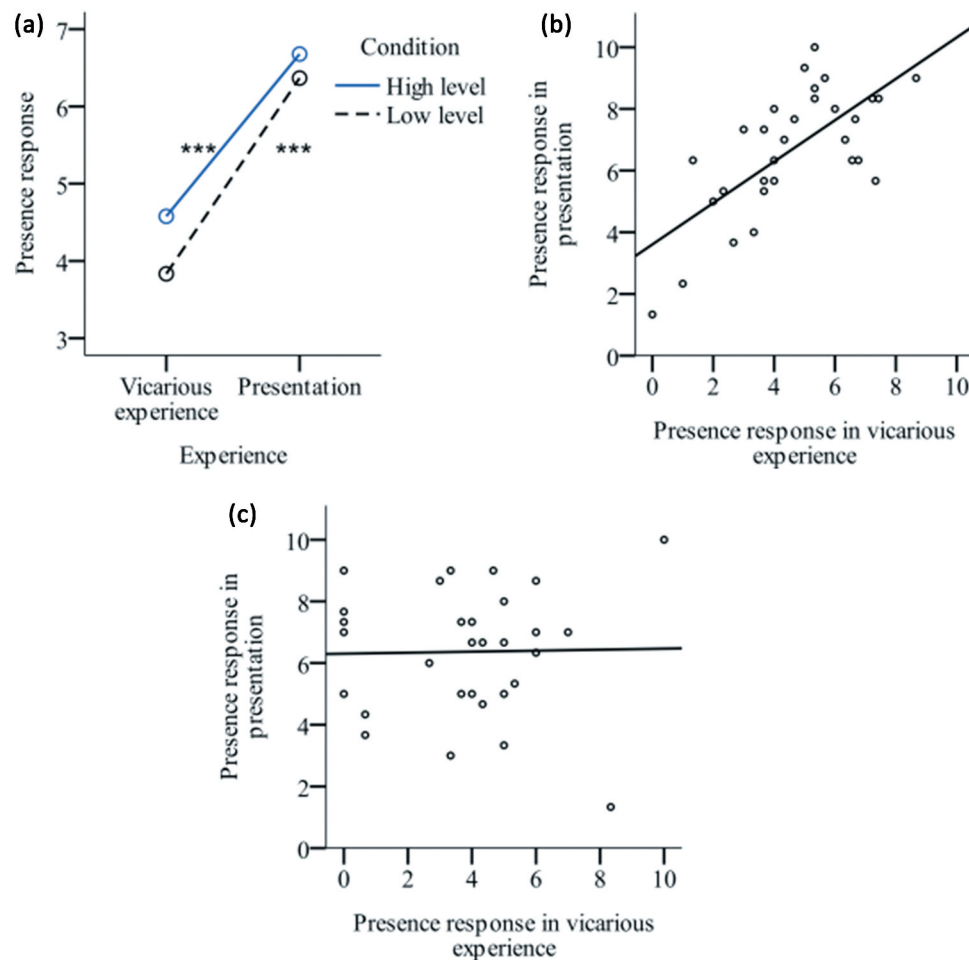


Figure 8. Relationship of presence responses in vicarious experience and the postmeasurement presentation. (a) Presence responses during the vicarious experience and the postmeasurement presentation. (b) Correlation between presence responses in vicarious experience and the postmeasurement presentation in the high-level condition. (c) Correlation between presence responses in the vicarious experience and the postmeasurement presentation in the low-level condition.

either self-efficacy or presence was observed when the level of self-identification was low.

The study has a number of limitations. One limitation is the short duration and frequency of exposure to vicarious experience. Increasing its frequency might result in more lasting belief change. For example, the study by Morina et al. (2015a) included two exposure sessions of around one hour each and found an increase in self-efficacy at a three-month follow-up measurement. Besides, the learning effect of video self-modeling or peer-modeling can usually be observed after a few weeks of video-watching sessions (Marcus & Wilder, 2009; Montgomerie et al., 2014). The limited exposure in this study might explain the observed return of the self-efficacy score after a week to pre-experimental values. Another limitation of this study is that

the identity of the virtual interviewee was manipulated by controlling multiple factors (e.g., voice, skin color, and name) at the same time. Thus, it cannot be established how each factor contributed to the overall sense of self-identification. Besides these limitations, there existed an unplanned ITQ difference between the participants of the high-level condition and the low-level condition. Although previous studies (Y. Ling et al., 2012; Witmer & Singer, 1998) found a significant correlation between ITQ and presence as measured by Igroup Presence Questionnaire (Schubert et al., 2001), no correlation was found in this study between on one hand ITQ and on the other hand presence response, the self-identification of the virtual interviewee, and self-efficacy. Therefore, this unplanned ITQ difference can be ruled out as an alternative explanation for the observed effect. Another factor worth discussing is the manipulation of skin color in the vicarious experience. One underlying concern is whether the manipulation of skin color led to an unplanned social stigma effect that caused participants assigned to an avatar with a darker skin complexion to lower their self-efficacy. Reanalysis with homogeneous skin complexion sample, however, found no support for such an unplanned effect.

Table 5. Descriptive statistics of self-efficacy, mean (SD), and results of *t*-tests between different measuring times.

Self-identification Condition	Measuring time		<i>p</i>
	2 weeks beforehand	After vicarious experience	
High	6.93 (2.46)	4.96 (2.62)	< 0.001
Low	7.48 (2.22)	7.12 (1.83)	0.48

Although the study succeeded in influencing people's self-efficacy belief, self-efficacy decreased after the vicarious experience instead of going up which would be desirable when building someone's confidence in performing a certain task. As students and nonteaching staff from a university of technology, the participants likely lacked the actual experience of giving a lecture on elementary arithmetic to ground their self-efficacy beliefs. When appraising their capability, the participants might therefore have suffered from a cognitive bias, known as the Dunning–Kruger effect (Kruger & Dunning, 1999) or overconfidence effect (Moore & Healy, 2008), causing the initial high self-efficacy rating (A. Bandura, 1997). After their experience in virtual reality, they might have realized that giving such lecture is more difficult than what they initially anticipated. This explanation was supported by a recent study conducted by Ding et al. (2020) where a passive virtual reality negotiation training with simulated thoughts in first-person perspective successfully enhanced people's self-efficacy. In that experiment, participants started out with a relative low level of self-efficacy, which increased throughout the training and remained high even after multiple weeks after the training. Further research therefore might look at the effect of vicarious experiences when people unnecessarily underestimate their ability.

Another issue is people's interpretations of the success of the experienced presentation. During the vicarious experience, the chair of the panel always ended the session by stating that the lecture was excellent. Participants might not have noticed, believed, or conformed to this judgment as this might have been too contradicting with their own belief as the social judgment theory (Sherif & Hovland, 1961) would predict. Especially when a communication message is perceived as being very different from one's own viewpoint, people might simply reject the message. In such case is unlikely that people are persuaded, due to a contrast effect (Griffin, 2006). A similar effect might also occur when the performance that people experienced in virtual reality or through video recordings is very different from their own ability or performance. For example, Wood et al. (2009) indicates that hearing positive self-statements can even backfire if they do not match the person's current belief. Additionally, although only an association between capability comparison and self-efficacy can be argued for in this study, the relationship may be causal, as it was found in other vicarious experience studies (Brown & Inouye, 1978). If that is the case, future work might investigate whether self-efficacy can be improved by persuading participants to believe that they are more capable than a model that already successfully accomplished a task.

This study can be extended in many directions. First, instead of manipulating multiple factors in this study, the effectiveness of each single factor could be examined separately to achieve identification with the virtual person. As suggested by Ratan and Hasler (2010), the identity of an avatar is more related to fleeting and malleable aspects such as name and appearance but less to the stable characteristics such as race and gender. Therefore, identifiable channels such as voice might be of interest in manipulating the avatar or model identity. Second, besides creating an illusion of one's own virtual body through the similar physical appearance or static posture, future work can also focus on creating the body illusion through the consistency between participants' motor

behavior and the sensory feedback in virtual reality (auditory stimuli), for example, vibrotactile stimulation of the body. For example, Banakou and Slater (2014) administered this stimulation on the thyroid cartilage when participants heard a prerecorded voice to create the illusion of speaking by the participant. Third, future research could examine the extent to which the vicarious experience can be used effectively to assist psychological interventions for individuals with mental disorders. For example, individuals with anxiety disorders might profit from this approach by applying the vicarious experience as a first step to increase motivation to participate in exposure sessions of direct experience in virtual reality and further in real life. Moreover, it would be worthwhile to investigate the possibility of using our approach to support people suffering from traumatic experience, e.g., car crash, to rebuild their self-efficacy in driving a car, once this task has been disassociated from severe anxiety. Fourth, the use of vicarious experience in skills training could also be of value, such as in helping people to visualize their future performance and master a task in a short time. Of course, attention should be paid to the application of this approach, as increasing self-efficacy is not always desirable if it leads, for example, to overconfidence which is not followed up by training that actually enhances the person's actual capabilities. Finally, this study only compared three situations in the theoretical who-how-what perception space model. Still, the model can help in formulating new research questions. For example, how would an artificial virtual lookalike experience differ between a first and a third-person perspective? More understanding of the model could benefit designers in creating appropriate experiences as part of training or therapy.

In conclusion, our method succeeded in influencing people's self-efficacy belief by a vicarious experience obtained in virtual reality. Another main contribution of the study is the insight of the underlying mechanism that might govern people's self-efficacy. When the virtual model in the vicarious experience is more strongly identified with the observers themselves, the performance of the virtual model becomes a better predictor of the observers' self-efficacy. The mechanism seems closely related to how traditional vicarious experiences affect self-efficacy. Future research needs to investigate the extent to which this new virtual vicarious experience has the potential to benefit psychological interventions where the belief in one's own ability is essential.

Notes

1. These files are stored for public access on a national database for research data with the 4TU Center for Research Data in the Netherlands. The DOI to this storage is <https://doi.org/10.4121/12826307.v2>.
2. Even with a posthoc correction for four phases, the result remained significant ($t(58) = -2.71, p = 0.03$).

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