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Psychology of Consciousness: Theory, Research, and Practice

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Out-of-Body Experience in Virtual Reality Induces Acute Dissociation

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An established challenge in studying dissociation is developing effective methodologies to induce dissociative symptomatology in the laboratory. The primary aim of this study was to pilot the efficacy of virtual reality (VR) in inducing dissociative states in healthy subjects by simulating out-of-body experiences. Healthy participants ($N = 25$) were asked to wear an Oculus Rift (Menlo Park, CA) VR head-mounted display, which was connected to a wide-angle GoPro (San Mateo, CA) video camera placed in front of participants so they could view themselves, the experimenter, and the surrounding environment. They were asked to partake in a number of exercises while wearing the Oculus Rift and completed a questionnaire on sleep quality (the Sleep Condition Indicator; Espie et al., 2014) and the Clinician-Administered Dissociative States Scale (CADSS; Bremner et al., 1998) both before and after the perceptual experience. Findings highlight a significant increase in acute dissociation after VR exposure, particularly with respect to the endorsement of depersonalization on the CADSS. This is—to the best of our knowledge—the first study to implement VR in inducing acute dissociation, and it offers preliminary support for the application of VR as a viable method to induce dissociative states in healthy participants. Our research paves the way for the investigation and use of these new technologies in the assessment and treatment of dissociative symptomatology, providing a valuable and fruitful path to understanding dissociation in the future.

Keywords: dissociation, out-of-body experience, perception, virtual reality, minimal phenomenal selfhood

Virtual reality (VR) creates novel computer-generated interactive environments that exchange actual real-life sensory perceptions with synthetic perceptions in a virtual world (Steuer, 1992). VR has been cited as "a technological revolution in mental health care" (Freeman et al., 2017, p. 1) because of its ability to create sensations or situations that are practically impossible to create in real life. Indeed, central to all mental health issues is an individual's struggle to engage or interact with the world (Freeman et al., 2017), which is why VR offers considerable promise.

Dissociative symptoms refer to disturbances in the integration of thoughts, feelings, and experiences in consciousness and memory (American Psychiatric Association, 2013) that can produce feelings of disembodiment and disconnectedness with the self and the environment, as in cases of dissociative identity disorder and depersonalization/derealization syndrome. Dissociative symptoms are notorious for their com-

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plex nature and encompass a wide variety of everyday experiences, including excessive daydreaming, absorption, and severe absentmindedness. Broadly speaking, dissociative experiences can be described as lapses in human consciousness, and are closely related to how we perceive ourselves and our surrounding environment. Indeed, part of a broad definition of dissociation refers to the phenomenon as "a sense of experiential disconnectedness that may include perceptual distortions about the self or the environment" (Cardeña & Carlson, 2011, p. 252), as well as an impairment in memory, as in the case of dissociative amnesia.

Although as mental disorders, dissociative disorders such as dissociative identity disorder are considered to be relatively rare, dissociative experiences are ubiquitous in both the general population and psychiatric samples (i.e., 4% and 29%, respectively, exhibit severe dissociative pathology; Foote, Smolin, Kaplan, Legatt, & Lipschitz, 2006). As many as 80% to 90% of individuals report at least mild dissociative experiences in their lifetimes (Gershuny & Thayer, 1999). Depersonalization refers to feeling detached one's mind or your body, and is often described as being a detached observer of one's self (Sierra & Berrios, 2001). It is the third most common psychological symptom, after feelings of depression and anxiety (Simeon, 2004), and can be a symptom of panic disorder, posttraumatic stress disorder (PTSD), and can accompany sleep deprivation, migraine, and temporal lobe epilepsy (Lambert, Sierra, Phillips, & David, 2002). Relatedly, derealization is about an alteration in the perception of experience of the external world so that it seems unreal, like seeing the world through a fog or feeling like living in a dream (APA, 2013). These symptoms are common, with a lifetime prevalence of around 5% and 31–66% during a traumatic event (Hunter, Sierra, & David, 2004). Depersonalization/derealization (co-)occurs with a variety of mental disorders (i.e., dissociative disorders, anxiety, bipolar disorder, borderline personality disorder, schizophrenia; Simeon, Knutelska, Nelson, & Guralnik, 2003), and patients suffering from both depersonalization/derealization symptoms and a mental disorder such as anxiety or depression predict a worse clinical picture with earlier age of onset, more functional impairment, and higher rates of current mental health-care utilization (Michal et al., 2016).

Moreover, dissociative symptoms in general are considered an important (and often negative) feature in several mental health diagnoses, including substance abuse (van Heugten-van der Kloet, Giesbrecht, van Wel, et al., 2015), PTSD (Stein et al., 2013), psychosis (Pilton, Varese, Berry, & Bucci, 2015), and anxiety and depression (Mula, Pini, & Cassano, 2007). Dissociative symptoms are also an important predictor of poorer treatment outcomes and prognoses in several disorders, including borderline personality disorder (Kleindienst et al., 2011), obsessive–compulsive disorder (Rufer et al., 2006), PTSD (Rufer et al., 2006), schizophrenia (Yu et al., 2010), and anxiety and depression (Prasko et al., 2016). Thus, developing a better understanding of causes and predictors of dissociative experiences is of great relevance to the field of psychopathology.

Feeling a sense of connectedness within ourselves and our bodies is fundamental to being conscious of the self, that is, the experience and behavior of *being someone*. An important term in this area is minimal phenomenal selfhood (MPS), which can be defined as the simplest form of self-consciousness and forms the basis of contemporary studies on body perception and self-consciousness (Blanke & Metzinger, 2009). There has been a recent flood of research on the topic of self-consciousness, with a particular interest in the body. The self can be conceptualized as the "experience of being a distinct, holistic entity capable of global self-control and attention, possessing a body and a location in time and space" (Blanke & Metzinger, 2009, p. 7). This sense of embodiment can be experimentally researched using illusory own-body perceptions. These can entail manipulations for parts of the body, such as the famous "rubber hand illusion" (Botvinick & Cohen, 1998), in which tactile sensations were referred to an alien limb. They can also include full-body illusions in which conflicting visual and somatosensory input in a virtual reality setting creates a disruption of the spatial unity between the self and the body (Lenggenhager, Tadi, Metzinger, & Blanke, 2007). These body-ownership illusions are important in understanding MPS because they manipulate our sense of having a body, which forms a core component of MPS.

One such method of a body-ownership illusion involves creating an out-of-body experience (OBE). An OBE can be defined as, while awake, seeing the body from a location outside of the physical body (Blanke, Landis, Spinelli, & Seeck, 2004). OBEs are associated with a sense of disembodiment; that is, the subject of conscious experience is located outside the person's bodily borders (Blanke & Metzinger, 2009). OBEs have been successfully experimentally induced in the laboratory. For example, Ehrsson (2007) manipulated participants to experience the location of their body to be at the location of a camera placed behind their back, which was connected to a head-mounted display. He simultaneously touched the participant's actual chest and the chest of the "illusory body"(a location just below the camera) with two plastic rods. The combination of the visual perspective and the multisensory information created the illusion that the participant was located behind his or her physical body.

An established challenge in studying dissociation is developing effective methodologies to induce dissociative symptomatology in the laboratory. Previous attempts to induce dissociative states include sleep deprivation, which is time-consuming, invasive, and expensive (van Heugten-van der Kloet, Giesbrecht, & Merckelbach, 2015) and by means of dot-staring or mirror-gazing (Dorahy, Peck, & Huntjens, 2016), which has been shown to be limited in its effect size (Leonard, Telch, & Harrington, 1999). Nash, Lynn, and Stanley (1984) and others (Cardeña, 2005; Tart, 1998; Tressoldi & Del Prete, 2007) have succeeded in either inducing OBEs with hypnotic suggestions or studying them during hypnosis, but the ability to experience such a realistic and complex perceptual hallucination has been examined only with highly suggestible individuals and may be very difficult to produce in less highly suggestible participants.

Thus, the primary aim of our study was to pilot the efficacy of VR to induce acute dissociative symptomatology in a group of healthy participants. Using VR equipment, participants experienced viewing themselves in the third person. Given that this perspective is closely aligned with the core dissociative experience of depersonalization, we hypothesized that this perceptual experience would induce dissociative experiences in healthy participants. Because of previous findings linking dissociation with sleep, that is, chronic poor sleep quality relates to higher levels of dissociation, and experimentally induced sleep loss leads to an acute increase in dissociative symptoms (van Heugten-van der Kloet, Cosgrave, et al., 2015), we also predicted that participants with poorer sleep quality would be more vulnerable to experiencing dissociation than participants who report good sleep quality.

Method

Participants

Twenty-five naïve volunteers (10 men, 15 women) took part in the study. Their mean age was 31 years (*SD* = 12.2; range = 18–60 years). Inclusion criteria included being 18 years or older and normal or corrected-to-normal vision, with the ability to give informed consent. Exclusion criteria included a history of severe motion sickness or epilepsy, or having experienced unpleasantness in a virtual reality scenario. The study was approved by the Medical Sciences Interdivisional Research Ethics Committee, University of Oxford (MS-IDREC–C1-2015–039).

Design

Given the primary aim of this study was to pilot the efficacy of VR in inducing a dissociative state, we employed a within-subjects design, with the baseline measurement of dissociative experiences for each participant acting as the comparison condition. Participants were seated at all times. They were asked to wear an Oculus Rift (Menlo Park, CA) head-mounted virtual reality display that filled the wearer's view up to 100 degrees. The Oculus Rift is padded and comfortable and was connected by a cable over the shoulder to a laptop computer. A camera stand was placed approximately three meters in front of the participant with a wide-angle GoPro (San Mateo, CA) video camera. The camera was positioned at standing eye level p (approx. 1.70 m) so that the participants were able to see themselves, the experimenter, and the surrounding environment (see Figure 1). Participants were asked to partake in a number of simple exercises that lasted for a maximum of 5 min while wearing the Oculus Rift (see

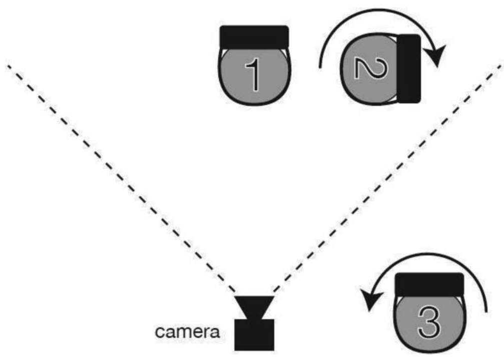

Figure 1. Oculus Rift and Go-Pro camera set-up.

Procedure section). Furthermore, participants completed a questionnaire on sleep quality (the Sleep Condition Indicator) and the Clinician-Administered Dissociative States Scale (CADSS) before and after the perceptual experience (see Measures).

Measures

SCI. The SCI (Espie et al., 2014) measures insomnia disorder with eight items. Scores range from 0–32, with lower scores indicating poorer sleep quality. The scale has good psychometric properties including good internal consistency, Cronbach's α = .86 (Espie et al., 2014). Internal consistency for the current sample was strong as well, with Cronbach's α = .87.

Clinician-Administered Dissociative States Scale (CADSS). The CADSS (Bremner et al., 1998; Cronbach's α pre = .84; post = .93) is a 27-item scale with 19 participant-rated items, and eight observer-scored items, which are scored on a 5-point scale (0 = *not at all*, 4 = *extremely*). The CADSS has three subscales: Amnesia (Items 14, 15), Depersonalization (Items 3–7), and Derealization (Items 1, 2, 8–13, 16–19). The items are presented in Table 2. Bremner and colleagues (1998) found the CADSS to be a highly reliable and valid instrument for measuring present-state dissociative symptoms. We administered only the self-report items.

Procedure

Participants were asked to participate in the study during a science open day (during Brain Awareness Week) at the Museum of the History of Science, which was conducted by Dalena van Heugten–van der Kloet and Stephen Hicks. They were invited to experience virtual reality and were informed about completing questionnaires before and after the experience. They all provided written informed consent. Participants were placed on a swivel chair directly in front of the camera, making it possible for them to see themselves from the position of the GoPro camera, that is, in the third person (see Figure 1–1). We then carried out the following protocol. First, we swiveled the participant slowly from left to right while keeping the base of the chair stationary (see Figure 1–2), which allowed participants to adjust to the new visual perspective. Participants were then asked if this experience induced any experiences of nausea; all answered *no*.

Second, the experimenter moved the swivel chair, that is, the actual participant, to the side of the angle and then outside the angle of the camera, rendering the virtual participant no longer visible to the actual one (see Figure 1–3). Third, the experimenter began talking directly into the camera, which gave the participant the illusion that the experimenter was looking directly into the participant's eyes, which was designed to induce the experience of being present at the position of the camera (the virtual participant) rather than in his or her own physical body (depersonalization). Fourth, participants were instructed to conduct three exercises to strengthen the illusion of depersonalization. First, the experimenter asked if he could touch the shoulder of the virtual participant a number of times. During this exercise, one experimenter touched a point beneath the camera that corresponded to the location of the participant's shoulder, while a second experimenter standing behind and out of sight of the participant touched the actual participant's shoulder simultaneously. This methodology is based on a previous finding in VR research that, if a person's chest is stroked during a VR condition, this person would not feel the touch as strongly as if an area below the camera were stroked (Blanke & Metzinger, 2009). Second, participants were instructed to slowly raise their right arms while the second experimenter stood behind the camera and mimicked the exact movements to induce a feeling of control over the experimenter's arm, that is, the illusion that the experimenter's arm was their own. Third, the experimenter surprised the participant by throwing a ball to the camera and asking her or him to catch it. These exercises were considered an enjoyable experience, having provided no discomfort.

Results

Mean scores and Pearson product–moment correlations between sleep quality and acute dissociation before and after the OBE are displayed in Table 1. Given the skewed distribution of the CADSS (Bremner et al., 1998) and CADSS change scores, we performed a non-parametric Wilcoxon signed-ranks test with continuity correction. Acute dissociation was found to increase significantly following VR exposure, $W = 297.5$, $p < .001$ (see Figure 2a). No gender differences in dissociative states (pre- or post-VR) were observed in this sample (see Figure 2b). We examined the individual items of the CADSS (see Table 2) to determine which dissociative experiences were most influenced by VR. Items 1, 3–7, and 17 evidenced the greatest levels of change (see Figure 2c). These are the items that pertain to Depersonalization (3–7) and Derealization (1, 17). Finally, we explored which items were most frequently newly endorsed after VR exposure (see Figure 2d). We found that the greatest changes from pre- to postexposure were in Items 1 ("Do things seem to be moving in slow motion?"), 4 ("Do you feel as if you are looking at things from outside of your body?"), 6 ("Do you feel disconnected from your own body?"), and 7 ("Does your sense of your own body feel changed? For instance, does your own body feel unusually large or unusually small?"). Pertaining to the subscales of the CADSS, increases in acute dissociation therefore seemed specifically expressed in feelings of Depersonalization (Items 4, 6, 7) and Derealization (Item 1).

Table 1
Mean Scores and Pearson Product–Moment Correlations Between Subjective Sleep Quality and Acute Dissociation Before and After the Out-of-Body Experience (N = 25)

Measure	Mean (*SD*)	SCI	Pre-CADSS	Post-CADSS
SCI	22.20 (6.68)	—	—	—
Pre-CADSS	.19 (.27)	−.35	—	—
Post-CADSS	.65 (.61)	−.16	.70**	—
CADSS change	.47 (.46)	−.01	.33	.91**

Note. SCI = Sleep Condition Indicator total score; CADSS = Clinician-Administered Dissociative States Scale; pre-CADSS = mean score before out-of-body experience; post-CADSS = mean score after out-of-body experience; CADSS change = mean change computed as the difference between pre- and postscores.
** $p < .001$.

Table 2 also displays the exploratory partial correlations with the SCI (Espie et al., 2014) after controlling for gender and age. We found significant correlations between SCI and three items that assess Derealization on the CADSS (Bremner et al., 1998; Items 8, 17, and 18), revealing a tentative inverse relation between sleep quality and acute Derealization.

Discussion

The primary aim of our study was to pilot the efficacy of VR (via simulating out-of-body experiences in 25 participants) to induce dissociative states in healthy subjects. Our findings highlight a significant increase in acute dissociation after VR exposure, particularly with respect to the endorsement of depersonalization on the CADSS (Bremner et al., 1998). Our study is, to the best of our knowledge, the first to offer preliminary support that the application of VR offers a viable method to induce dissociative states in healthy participants.

Further applications of this work would include exploring three of the seven core uses of VR, as described by Freeman (2008). First, establishing causal factors, that is, manipulating the factor of interest (in this case, dissociation) and understanding the ramifications or short-term impact of inducing dissociative states in both healthy participants and psychiatric populations. A second, but related, application is establishing the correlates of the symptom of interest (i.e., dissociation). These could be state, or in the moment experiences (e.g., fatigue) or baseline traits/demographics (i.e., trait neuroticism or anxiety). Finally, following from this, is it then possible to identify what are referred to as "differential predictors" (Freeman, 2008, p. 607), that is, predictors that have alternate effects based on how they interact with different states or traits. For example, high trait anxiety may be more likely to induce paranoia in highly dissociative states, whereas low trait anxiety may be more related to nonpsychopathological outcomes, such as mind-wandering or amnesia.

Table 2
Main Endorsement of CADSS Items and Partial Correlations With the SCI, Controlling for Age and Gender

Items	Pre-CADSS Mean (*SD*)	Post-CADSS Mean (*SD*)	Partial *r* SCI–Pre-CADSS
Depersonalization			
3. Do you have some experience that separates you from what is happening; for instance, do you feel as if you are in a movie or a play, or as if you are a robot?	.12 (.44)	.64 (.86)	−.05
4. Do you feel as if you are looking at things from outside of your body?	.08 (.29)	.84 (.94)	−.07
5. Do you feel as if you are watching the situation as an observer or spectator?	.20 (.50)	.76 (.93)	.03
6. Do you feel disconnected from your own body?	.12 (.44)	1.00 (.96)	.02
7. Does your sense of your own body feel changed; for instance, does your own body feel unusually large or unusually small?	.08 (.28)	1.16 (1.21)	.01
Derealization			
1. Do things seem to be moving in slow motion?	.04 (.20)	.88 (1.09)	−.18
2. Do things seem to be unreal to you, as if you are in a dream?	.20 (.50)	.68 (1.03)	−.17
8. Do people seem motionless, dead or mechanical?	.12 (.44)	.40 (.71)	−.45*
9. Do objects look different than you would expect?	.12 (.33)	.52 (.82)	−.11
10. Do colors seem to be diminished in intensity?	.16 (.47)	.44 (.92)	−.21
11. Do you see things as if you were in a tunnel, or looking through a wide-angle photographic lens?	.00 (.00)	.52 (.96)	—
12. Does this experience seem to take much longer than you would have expected?	.32 (.69)	.64 (.70)	−.06
13. Do things seem to be happening very quickly, as if there is a lifetime in a moment?	.32 (.63)	.56 (.92)	.05
16. Do sounds almost disappear or become much stronger than you would have expected?	.32 (.80)	.56 (.87)	−.33
17. Do things seem to be very real, as if there is a special sense of clarity?	.36 (.91)	1.00 (1.12)	−.44*
18. Does it seem as if you are looking at the world through a fog, so that people and objects appear far away or unclear?	.16 (.47)	.56 (.87)	−.53**
19. Do colors seem much brighter than you would have expected?	.12 (.44)	.44 (.77)	−.17
Amnesia			
14. Do things happen that you later cannot account for?	.36 (.81)	.20 (.58)	−.43
15. Do you space out, or in some other way lose track of what is going on?	.40 (.76)	.64 (.95)	−.12

Note. CADSS = Clinician-Administered Dissociative States Scale; SCI = Sleep Condition Indicator.
* $p < .05$. ** $p < .01$.

A number of applications for the treatment of psychiatric disorders using VR have already been established (for a review, see Freeman et al., 2017). Thus far, this research has been heavily dominated by treatment programs in anxiety disorders (particularly phobias), psychosis (specifically persecutory ideation), and eating and substance-abuse disorders to a lesser extent (Freeman et al., 2017). Further investigations of dissociative symptomatology in mental health disorders could be of real benefit to the field, given their prevalence on a transdiagnostic basis. Indeed, a long-term goal of research in this area may be the ability to work more effectively with patient groups for whom dissociative symptomatology is a known cause of significant impairment. More specifically, the induction of dissociation could facilitate the ability of patients to recognize the onset of the experience, and, in turn, learn to avoid or manage their symptoms (Leonard et al., 1999).

Another promising avenue for future research using VR is in the assessment of psychological symptoms in diagnosing mental health disorders. Recent studies point to the possibilities of inducing symptoms in an artificial setting to measure them more directly and objectively, instead of relying on patients' self-reports (Vel-

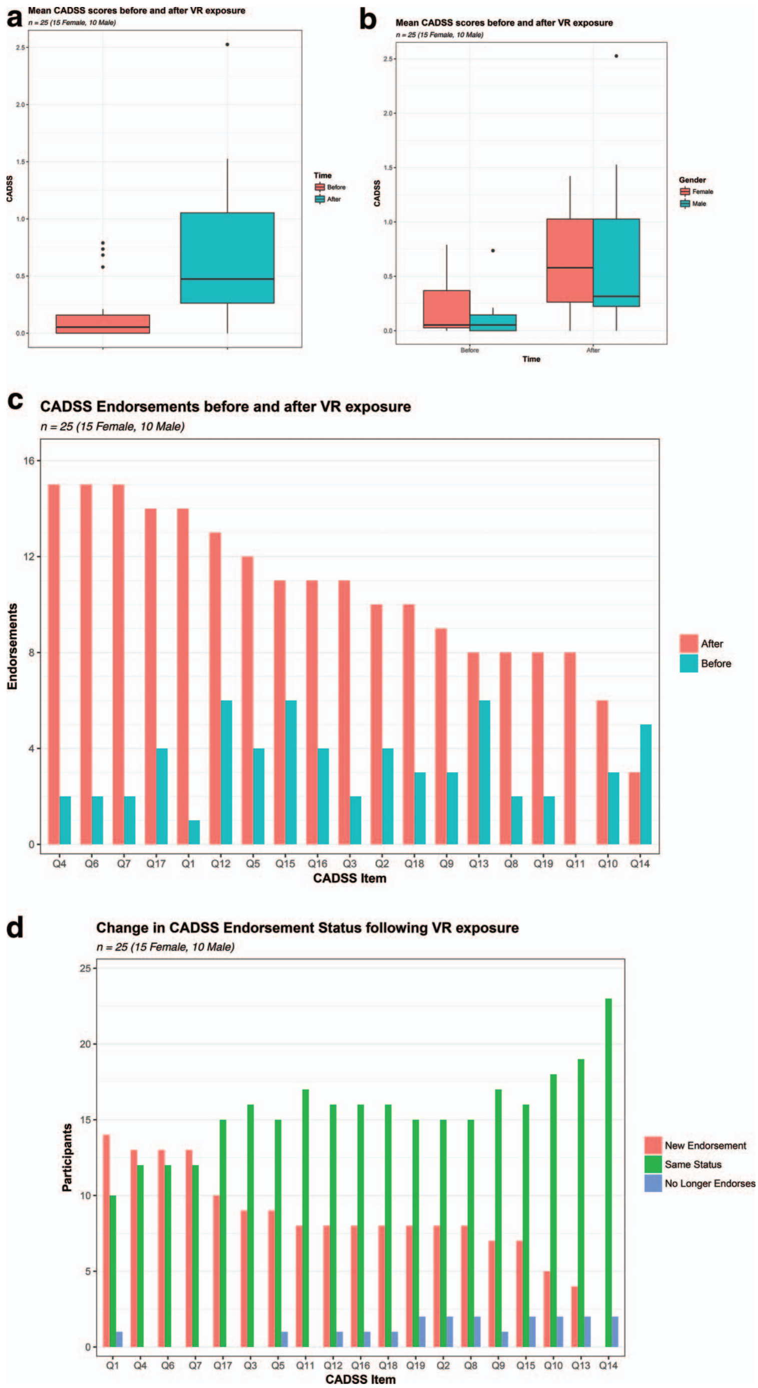

Figure 2. Endorsement of acute dissociation before and after virtual reality (VR) exposure. (1a) Mean Clinician-Administered Dissociative States Scale (CADSS) scores pre–post VR exposure; (1b) gender differences in CADSS scores pre–post VR exposure; (1c) CADSS items endorsement pre–post VR exposure; (1d) changes in endorsement of CADSS items pre–post VR exposure. See the online article for the color version of this figure.

ing, Moritz, & van der Gaag, 2014). The use of these techniques in diagnostic assessment still remains in its infancy, yet holds great potential for the field (Krijn, Emmelkamp, Olafsson, & Biemond, 2004; Veling et al., 2014). For example, it would be interesting to examine similarities and differences between "natural" OBEs and laboratory or induced OBEs and determine which stimuli and personality characteristics are conducive to or moderate OBEs in the laboratory, as well as in more naturalistic (i.e., not experimentally induced) situations.

Our study also yields interesting speculations with regard to the induction of dissociative experiences and their relation to self-consciousness. When studying these links, two important brain networks need to be considered: the default mode network (DMN) and the central executive network (CEN), which are continuously active during waking cognition and sleep (de la Salle et al., 2016). The DMN is active during passive rest and mind-wandering—a state in which we find ourselves most of the time. Accordingly, the constant presence of subpersonal and automatically generated mental activity might be the most functional core of human self-consciousness (Mantini & Vanduffel, 2013). DMN activity is negatively correlated with the CEN, which is geared toward externally oriented processes such as attention. Rather, the DMN reflects internal processes, such as self-reference and emotional states of one's self and others. When our minds are not wandering, spatial self-location, temporal self-location, and self-identification coincide; however, during mind-wandering, these aspects of consciousness become functionally dissociated (Blanke & Metzinger, 2009). One might speculate that an OBE via VR might thus be a suitable technique to interfere with or manipulate the DMN, and therefore serve as a method to study self-consciousness and dissociation.

Imbalance between these networks may underlie clinical and cognitive features of various psychiatric disorders (Menon, 2011). Specifically, a reduced negative correlation between DMN and CEN is thought to confuse internal and external mental contents, producing "self-environment blurring" (Vollenweider et al., 1997). Experiencing less clear distinctions between the self and the environment, because the DMN and CEN are not acting as separate agents, potentially provides a mechanistic pathway to explain dissociative symptoms.

Relatedly, Simeon (2004) provided preliminary physiological evidence linking dissociation to dysfunction in brain areas connected to the DMN, including alterations in metabolic activity in the sensory association cortex and prefrontal hyperactivation and limbic inhibition in response to aversive stimuli. Furthermore, a recent study using fMRI in 21 patients with PTSD (Tursich et al., 2015) showed that dissociation was associated with reduced DMN connectivity and altered synchrony between DMN and CEN. Accordingly, the dynamic relationship between the DMN and the CEN is worthy of study in terms of shifts in the sense of self and the environment generally, and in particular, as it relates to depersonalization/derealization.

A secondary goal of this experiment was to understand whether poor sleep quality was a symptom correlate of the level of dissociation induced, which is why we had each participant rate his or her sleep quality before the experiment. We found that poorer sleep quality was related to qualitatively higher initial scores of acute dissociation before the VR. This correlation is consistent with earlier studies, although not statistically significant because of weak power (Aviram & Soffer-Dudek, 2018; Giesbrecht, Smeets, Leppink, Jelicic, & Merckelbach, 2007; Soffer-Dudek et al., 2017; van Heugten-van der Kloet, Cosgrave, et al., 2015). This association demonstrated remarkable specificity to Items 7, 17 and 18 on the CADSS, that is, the three items responsible for assessing derealization. This finding fits well with research by Picchioni, Duyn, and Horovitz, (2013), who studied sleep as a modulator of DMN and identified how sleep stages are linked to various connectivity levels between DMN and CEN. Specifically, sleep loss results in both a decreased connectivity within the DMN and between the DMN and the CEN. However, these results should be interpreted with caution, as we found no association between the overall scores on either measure, nor did we find a relation between sleep quality and the change in dissociation pre- to postexperiment, most likely because of power issues.

Recent studies have focused on the link between sleep quality and dissociation, in an attempt to explore the possibilities of normalizing sleep and reducing dissociation as a consequence (van der Kloet, Lynn, Giesbrecht, Merckelbach, & de

Zutter, 2012). These findings therefore warrant further study, as they might point in a direction of specifying outcome measures for future studies (i.e., focusing more specifically on connecting derealization to sleep-quality measures). A treatment focused on sleep normalization might specifically target and reduce derealization experiences.

Several caveats merit mention. The exploratory design, small sample size, absence of psychopathology measures, and lack of a comparison group direct us to interpret our findings with caution. All participants were recruited during a public engagement event in Oxford, England, which inevitably would have influenced the sampling of the study and the demographics of the participants. Because of the location, we were not able to reduce ambient noise. Potentially, participants might have had better insight into their bodies' location as a result of directional hearing.

Another limitation relates to exploring the induction of depersonalization by way of an OBE, which is a core feature of dissociation. The mere fact that these illusions isolate specific components of dissociation, focusing on depersonalization rather than studying dissociation as a whole, is a fundamental caveat in itself. Earlier studies have already identified the paradox of how we perceive our bodies both as objective "things" that are part of the world, and as subjective forms that comprise our means of interacting with the world. It is the *absence* of experiencing the objective body that gives us the feeling of interacting with the world (Gallagher, 1986; Metzinger, 2004). Thus, it is through ignoring the objective sense of our bodies that we create the mental space to function within our environment. To illustrate, consider the common feeling of nervousness about giving a presentation to an audience. Acute awareness of our bodies, for instance, raised heart rate, blushing, or sweating might prevent us from connecting with the audience and delivering the speech.

However, in body-illusion experiments, when we manipulate such perceptual features as body location, we might only target this one objective part of our experience, thus making links with dissociation and MPS difficult (Limanowski, 2014). Admittedly, to feel as if we are interacting with our environment, we need to disconnect from our objective sense of body, rather than focus on it, as in body-illusion experiments. As dissociation causes us to feel disconnected from ourselves and our environment, it would be preferable to study both subjective and objective senses of ourselves as a whole. Conversely, Metzinger (2013) proposed that the "currently active conscious content that generates the subjective experience of 'I am this'" may change during mind-wandering and out-of-body experiences, and thus potentially also when experiencing acute dissociative symptoms. Therefore, the claim that we need an objective body representation for MPS may be incorrect. For example, when we sleep and we are disconnected from exteroceptive sensory input, we still experience the presence of a core self. Therefore, the study of self-consciousness and its relations with acute dissociation and sleep quality should be considered important.

A final caveat entails the possible influence of demand characteristics, as the hypotheses of the study were quite transparent: Participants may well have expected an increase in dissociative experiences as a consequence of the procedures implemented.

These caveats notwithstanding, we believe that our study represents an important contribution and paves the way for investigating and using VR in the induction, assessment, and treatment of dissociative symptomatology. Dissociative experiences and symptoms are very common in both general and patient populations, and dissociative disorders remain recalcitrant to treatment. Thus, recent technological developments in VR could provide a valuable and fruitful path to understanding dissociative symptomatology in the future.

References

American Psychiatric Association (APA). (2013). *DSM–5: Diagnostic and statistical manual of mental disorders* (5th ed.). Arlington, VA: Author.

Aviram, L., & Soffer-Dudek, N. (2018, March). Lucid dreaming: Intensity, but not frequency, is inversely related to psychopathology. *Frontiers in Psychology*. Advance online publication. http://dx.doi.org/10.3389/fpsyg.2018.00384

Blanke, O., Landis, T., Spinelli, L., & Seeck, M. (2004). Out-of-body experience and autoscopy of neurological origin. *Brain: A Journal of Neurology, 127,* 243–258. http://dx.doi.org/10.1093/brain/awh040

Blanke, O., & Metzinger, T. (2009). Full-body illusions and minimal phenomenal selfhood. *Trends in Cognitive Sciences, 13,* 7–13. http://dx.doi.org/10.1016/j.tics.2008.10.003

Botvinick, M., & Cohen, J. (1998). Rubber hands 'feel' touch that eyes see. *Nature, 391,* 756. http://dx.doi.org/10.1038/35784

Bremner, J. D., Krystal, J. H., Putnam, F. W., Southwick, S. M., Marmar, C., Charney, D. S., & Mazure, C. M. (1998). Measurement of dissociative states with the Clinician-Administered Dissociative States Scale (CADSS). *Journal of Traumatic Stress, 11,* 125–136. http://dx.doi.org/10.1023/A:1024465317902

Cardeña, E. (2005). The phenomenology of deep hypnosis: Quiescent and physically active. *International Journal of Clinical and Experimental Hypnosis, 53,* 37–59. http://dx.doi.org/10.1080/00207140490914234

Cardeña, E., & Carlson, E. (2011). Acute stress disorder revisited. *Annual Review of Clinical Psychology, 7,* 245–267. http://dx.doi.org/10.1146/annurev-clinpsy-032210-104502

de la Salle, S., Choueiry, J., Shah, D., Bowers, H., McIntosh, J., Ilivitsky, V., & Knott, V. (2016). Effects of ketamine on resting-state EEG activity and their relationship to perceptual/dissociative symptoms in healthy humans. *Frontiers in Pharmacology, 7,* 348. http://dx.doi.org/10.3389/fphar.2016.00348

Dorahy, M. J., Peck, R. K., & Huntjens, R. J. C. (2016). The impact of dissociation on perceptual priming and intrusions after listening to auditory narratives. *Journal of Trauma & Dissociation, 17,* 410–425. http://dx.doi.org/10.1080/15299732.2015.1134746

Ehrsson, H. H. (2007). The experimental induction of out-of-body experiences. *Science, 317,* 1048. http://dx.doi.org/10.1126/science.1142175

Espie, C. A., Kyle, S. D., Hames, P., Gardani, M., Fleming, L., & Cape, J. (2014). The Sleep Condition Indicator: A clinical screening tool to evaluate insomnia disorder. *British Medical Journal Open, 4,* e004183. http://dx.doi.org/10.1136/bmjopen-2013-004183

Foote, B., Smolin, Y., Kaplan, M., Legatt, M. E., & Lipschitz, D. (2006). Prevalence of dissociative disorders in psychiatric outpatients. *The American Journal of Psychiatry, 163,* 623–629. http://dx.doi.org/10.1176/ajp.2006.163.4.623

Freeman, D. (2008). Studying and treating schizophrenia using virtual reality: A new paradigm. *Schizophrenia Bulletin, 34,* 605–610. http://dx.doi.org/10.1093/schbul/sbn020

Freeman, D., Reeve, S., Robinson, A., Ehlers, A., Clark, D., Spanlang, B., & Slater, M. (2017). Virtual reality in the assessment, understanding, and treatment of mental health disorders. *Psychological Medicine, 47,* 2393–2400. http://dx.doi.org/10.1017/S003329171700040X

Gallagher, S. (1986). Lived body and environment. *Research in Phenomenology, 16,* 139–170. http://dx.doi.org/10.1163/156916486X00103

Gershuny, B. S., & Thayer, J. F. (1999). Relations among psychological trauma, dissociative phenomena, and trauma-related distress: A review and integration. *Clinical Psychology Review, 19,* 631–657. http://dx.doi.org/10.1016/S0272-7358(98)00103-2

Giesbrecht, T., Smeets, T., Leppink, J., Jelicic, M., & Merckelbach, H. (2007). Acute dissociation after 1 night of sleep loss. *Journal of Abnormal Psychology, 116,* 599–606. http://dx.doi.org/10.1037/0021-843X.116.3.599

Hunter, E. C. M., Sierra, M., & David, A. S. (2004). The epidemiology of depersonalisation and derealisation. A systematic review. *Social Psychiatry and Psychiatric Epidemiology, 39,* 9–18. http://dx.doi.org/10.1007/s00127-004-0701-4

Kleindienst, N., Limberger, M. F., Ebner-Priemer, U. W., Keibel-Mauchnik, J., Dyer, A., Berger, M., . . . Bohus, M. (2011). Dissociation predicts poor response to dialectical behavioral therapy in female patients with borderline personality disorder. *Journal of Personality Disorders, 25,* 432–447. http://dx.doi.org/10.1521/pedi.2011.25.4.432

Krijn, M., Emmelkamp, P. M. G., Olafsson, R. P., & Biemond, R. (2004). Virtual reality exposure therapy of anxiety disorders: A review. *Clinical Psychology Review, 24,* 259–281. http://dx.doi.org/10.1016/j.cpr.2004.04.001

Lambert, M. V., Sierra, M., Phillips, M. L., & David, A. S. (2002). The spectrum of organic depersonalization: A review plus four new cases. *The Journal of Neuropsychiatry and Clinical Neurosciences, 14,* 141–154. http://dx.doi.org/10.1176/jnp.14.2.141

Lenggenhager, B., Tadi, T., Metzinger, T., & Blanke, O. (2007). Video ergo sum: Manipulating bodily self-consciousness. *Science, 317,* 1096–1099. http://dx.doi.org/10.1126/science.1143439

Leonard, K. N., Telch, M. J., & Harrington, P. J. (1999). Dissociation in the laboratory: a comparison of strategies. *Behaviour Research and Therapy, 37,* 49–61.

Limanowski, J. (2014). What can body ownership illusions tell us about minimal phenomenal selfhood? *Frontiers in Human Neuroscience*. Advance online publication. http://dx.doi.org/10.3389/fnhum.2014.00946

Mantini, D., & Vanduffel, W. (2013). Emerging roles of the brain's default network. *The Neuroscientist, 19,* 76–87. http://dx.doi.org/10.1177/1073858412446202

Menon, V. (2011). Large-scale brain networks and psychopathology: A unifying triple network model. *Trends in Cognitive Sciences, 15,* 483–506. http://dx.doi.org/10.1016/j.tics.2011.08.003

Metzinger, T. (2004). *Being no one: The self-model theory of subjectivity*. Cambridge, MA: MIT Press.

Metzinger, T. (2013). The myth of cognitive agency: Subpersonal thinking as a cyclically recurring loss of mental autonomy. *Frontiers in Psychology*. Ad-

vance online publication. http://dx.doi.org/10.3389/fpsyg.2013.00931
Michal, M., Adler, J., Wiltink, J., Reiner, I., Tschan, R., Wölfling, K., . . . Zwerenz, R. (2016, June 27). A case series of 223 patients with depersonalization-derealization syndrome. *BMC Psychiatry, 16,* 203. http://dx.doi.org/10.1186/s12888-016-0908-4
Mula, M., Pini, S., & Cassano, G. B. (2007). The neurobiology and clinical significance of depersonalization in mood and anxiety disorders: A critical reappraisal. *Journal of Affective Disorders, 99,* 91–99. http://dx.doi.org/10.1016/j.jad.2006.08.025
Nash, M. R., Lynn, S. J., & Stanley, S. M. (1984). The direct hypnotic suggestion of altered mind/body perception. *American Journal of Clinical Hypnosis, 27,* 95–102. http://dx.doi.org/10.1080/00029157.1984.10402863
Picchioni, D., Duyn, J. H., & Horovitz, S. G. (2013). Sleep and the functional connectome. *NeuroImage, 80,* 387–396. http://dx.doi.org/10.1016/j.neuroimage.2013.05.067
Pilton, M., Varese, F., Berry, K., & Bucci, S. (2015). The relationship between dissociation and voices: A systematic literature review and meta-analysis. *Clinical Psychology Review, 40,* 138–155. http://dx.doi.org/10.1016/j.cpr.2015.06.004
Prasko, J., Grambal, A., Kasalova, P., Kamaradova, D., Ociskova, M., Holubova, M., . . . Zatkova, M. (2016). Impact of dissociation on treatment of depressive and anxiety spectrum disorders with and without personality disorders. *Neuropsychiatric Disease and Treatment, 12,* 2659–2676. http://dx.doi.org/10.2147/NDT.S118058
Rufer, M., Held, D., Cremer, J., Fricke, S., Moritz, S., Peter, H., & Hand, I. (2006). Dissociation as a predictor of cognitive behavior therapy outcome in patients with obsessive–compulsive disorder. *Psychotherapy and Psychosomatics, 75,* 40–46. http://dx.doi.org/10.1159/000089225
Sierra, M., & Berrios, G. E. (2001). The phenomenological stability of depersonalization: Comparing the old with the new. *Journal of Nervous and Mental Disease, 189,* 629–636. http://dx.doi.org/10.1097/00005053-200109000-00010
Simeon, D. (2004). Depersonalisation disorder: A contemporary overview. *CNS Drugs, 18,* 343–354. http://dx.doi.org/10.2165/00023210-200418060-00002
Simeon, D., Knutelska, M., Nelson, D., & Guralnik, O. (2003). Feeling unreal: A depersonalization disorder update of 117 cases. *The Journal of Clinical Psychiatry, 64,* 990–997. http://dx.doi.org/10.4088/JCP.v64n0903
Soffer-Dudek, N., Shelef, L., Oz, I., Levkovsky, A., Erlich, I., & Gordon, S. (2017). Absorbed in sleep: Dissociative absorption as a predictor of sleepiness following sleep deprivation in two high-functioning samples. *Consciousness and Cognition, 48,* 161–170. http://dx.doi.org/10.1016/j.concog.2016.11.009
Stein, D. J., Koenen, K. C., Friedman, M. J., Hill, E., McLaughlin, K. A., Petukhova, M., . . . Kessler, R. C. (2013). Dissociation in posttraumatic stress disorder: Evidence from the world mental health surveys. *Biological Psychiatry, 73,* 302–312. http://dx.doi.org/10.1016/j.biopsych.2012.08.022
Steuer, J. (1992). Defining virtual reality: Dimensions determining telepresence. *Journal of Communication, 42,* 73–93. http://dx.doi.org/10.1111/j.1460-2466.1992.tb00812.x
Tart, C. T. (1998). Six studies of out-of-body experiences. *Journal of Near-Death Studies, 17,* 73–99. http://dx.doi.org/10.1023/A:1022932505993
Tressoldi, P., & Del Prete, G. (2007). ESP under hypnosis: The role of induction instructions and personality characteristics. *Journal of Parapsychology, 71,* 125–137.
Tursich, M., Ros, T., Frewen, P. A., Kluetsch, R. C., Calhoun, V. D., & Lanius, R. A. (2015). Distinct intrinsic network connectivity patterns of posttraumatic stress disorder symptom clusters. *Acta Psychiatrica Scandinavica, 132,* 29–38. http://dx.doi.org/10.1111/acps.12387
van der Kloet, D., Giesbrecht, T., Lynn, S. J., Merckelbach, H., & de Zutter, A. (2012). Sleep normalization and decrease in dissociative experiences: Evaluation in an inpatient sample. *Journal of Abnormal Psychology, 121,* 140–150. http://dx.doi.org/10.1037/a0024781
van Heugten-van der Kloet, D., Cosgrave, J., Merckelbach, H., Haines, R., Golodetz, S., & Lynn, S. J. (2015). Imagining the impossible before breakfast: The relation between creativity, dissociation, and sleep. *Frontiers in Psychology*. Advance online publication. http://dx.doi.org/10.3389/fpsyg.2015.00324
van Heugten-van der Kloet, D., Giesbrecht, T., & Merckelbach, H. (2015). Sleep loss increases dissociation and affects memory for emotional stimuli. *Journal of Behavior Therapy and Experimental Psychiatry, 47,* 9–17. http://dx.doi.org/10.1016/j.jbtep.2014.11.002
van Heugten-van der Kloet, D., Giesbrecht, T., van Wel, J., Bosker, W. M., Kuypers, K. P., Theunissen, E. L., . . . Ramaekers, J. G. (2015). MDMA, cannabis, and cocaine produce acute dissociative symptoms. *Psychiatry Research, 228,* 907–912. http://dx.doi.org/10.1016/j.psychres.2015.04.028
Veling, W., Moritz, S., & van der Gaag, M. (2014). Brave new worlds: Review and update on virtual reality assessment and treatment in psychosis. *Schizophrenia Bulletin, 40,* 1194–1197. http://dx.doi.org/10.1093/schbul/sbu125
Vollenweider, F. X., Leenders, K. L., Scharfetter, C., Antonini, A., Maguire, P., Missimer, J., & Angst, J. (1997). Metabolic hyperfrontality and psycho-

pathology in the ketamine model of psychosis using positron emission tomography (PET) and [^{18}F]fluorodeoxyglucose (FDG). *European Neuropsychopharmacology, 7,* 9–24. http://dx.doi.org/10.1016/S0924-977X(96)00039-9

Yu, J., Ross, C. A., Keyes, B. B., Li, Y., Dai, Y., Zhang, T., . . . Xiao, Z. (2010). Dissociative disorders among Chinese inpatients diagnosed with schizophrenia. *Journal of Trauma & Dissociation, 11,* 358–372. http://dx.doi.org/10.1080/15299731003793468

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