Virtual Reality-Enabled Treatment of Nightmares

Patrick McNamara
Center for Mind and Culture, Boston, Massachusetts, and Boston University School of Medicine

Kendra Holt Moore
Center for Mind and Culture, Boston, Massachusetts

Yiannis Papelis and Saikou Diallo
Old Dominion University

Wesley J. Wildman
Boston University School of Theology and Center for Mind and Culture, Boston, Massachusetts

We pilot tested the efficacy of a virtual reality-based imagery rehearsal and rescripting treatment (ReScript) for nightmares. Nineteen community volunteers (M_{age} = 49 years) who varied in terms of their nightmare distress levels participated in a 4-week-long trial of ReScript therapy. Participants used VR manual controls in an Oculus headset to manipulate 3 scary or threatening images per session with 2 sessions per week. The object was to manipulate these images into less scary or threatening images so as to gain cognitive control over intrusive imagery and to lessen overall anxiety or nightmare distress or nightmare daytime effects. Images were taken from the International Affective Picture System database and varied along 3 affective dimensions (valence, arousal, and dominance) important for nightmare imagery. Results demonstrated a significant reduction (from baseline to trial end) in anxiety levels, nightmare distress, and nightmare effects (all effect sizes .63 or above), as well as a significant decrease in anxiety words and a significant increase in cognitive process words in rescripted narratives. Nightmare frequency was also significantly reduced though effect size was small. No significant side or adverse effects were reported by participants during the 4-week trial. Indeed, Depersonalization and Posttraumatic Stress Disorder Symptom Checklist scores significantly declined and mood function tests improved over the 4-week trial. We conclude that ReScript may

Patrick McNamara, Center for Mind and Culture, Boston, Massachusetts, and Department of Neurology, Boston University School of Medicine; Kendra Holt Moore, Center for Mind and Culture; Yiannis Papelis and Saikou Diallo, Virginia Modeling and Simulation Center, Old Dominion University; Wesley J. Wildman, Boston University School of Theology and Center for Mind and Culture.

Correspondence concerning this article should be addressed to Patrick McNamara, Center for Mind and Culture, 566 Commonwealth Avenue, Suite M-2, Boston, MA 02215. E-mail: pmcnamar3@gmail.com

1053-0797/18/$12.00

2018, Vol. 28, No. 3, 205–224
http://dx.doi.org/10.1037/drm0000088

be a safe and effective short-term therapy for nightmare distress but should next be tested with a randomized, double-blind, placebo-controlled trial.

Keywords: nightmares, anxiety disorder, imagery rehearsal therapy, virtual reality

Epidemiological studies (Belicki & Belicki, 1982; Bixler, Kales, Soldatos, Kales, & Healey, 1979; Haynes & Mooney, 1975; Levin, 1994; Ohayon, Morselli, & Guilleminault, 1997) have indicated that 2–6% (about 6.4 to 15 million people) of the adult American population experience nightmares at least once a week. Between one half and two thirds of children experience frequent (weekly) nightmares. Frequent nightmares in children significantly predict later adolescent and adult psychosis. Indeed, experience of frequent nightmares in both children and adults is associated with generalized anxiety and a host of neuropsychiatric risk factors and disorders including anxiety, depression, stress, and suicidal ideation (Belicki, 1992; Fisher et al., 2014; Hublin, Kaprio, Partinen, & Koskenvuo, 1999; Ohayon et al., 1997; Spoormaker, Schredl, & van den Bout, 2006). Severely distressing and repetitive nightmares are a hallmark of posttraumatic stress disorder (PTSD), REM behavior disorder (Fantini, Corona, Clerici, & Ferine-Stambi, 2005), and several other chronic and disabling neuropsychiatric syndromes (Spoormaker et al., 2006). Despite the significant clinical dysfunction associated with nightmare distress, nightmare disorder itself remains underdiagnosed and understudied (Nadorff, Nadorff, & Germain, 2015), and there are no short-term, easy to use, and effective treatments for distress associated with nightmares or the anxiety associated with nightmares.

Although prazosin, an alpha adrenoceptor blocker, has demonstrated success in reducing distress associated with acute nightmares, it is not clear that it represents a viable long-term solution to frequent nightmares (Spoormaker et al., 2006). The drug is associated with significant side effects especially if taken over time. Imagery rehearsal therapy (IRT; Krakow et al., 2000) is a cognitive–behavioral therapy that effectively reduces distress associated with recurrent nightmares, but it may require up to 2 months of intervention with intensive staff monitoring of patient progress to be effective. In addition, because IRT depends on participants' self-generating new images to replace nightmare imagery, it may not be as effective for people who do not have effective visuospatial or imagery-generation skills. Nevertheless, because IRT has been demonstrated to be effective for treating nightmare distress, components of IRT may potentially be adapted into new delivery formats to increase options for people with recurrent nightmares.

Reviews of candidate mechanisms of action for IRT highlight the crucial importance of the imagery restructuring component (mentally transforming threatening imagery and rescripting the narrative action associated with the dream) for IRT success (Aurora et al., 2010; Germain et al., 2004; Krakow & Zadra, 2010). Indeed, distress due to nightmares may be related to lack of mastery over intrusive imagery. Lack of control over intrusive vivid imagery has been demonstrated in participants with PTSD and is positively correlated with PTSD severity (Bryant & Harvey, 1996; Laor et al., 1999). If imagery control and rescripting are the key ingredients for IRT success, it follows that an effective therapy for nightmares and associated anxiety could be developed that does not require participants to do the

work of generating images or to undergo the distress of working with nightmare imagery or traumatic imagery.

Consistent with the idea that control over vivid imagery may be key for amelioration of distress associated with nightmares is the work of Gackenbach and colleagues. They noticed that young males who engage in a lot of war video games tended to experience less violent or frightening imagery in their dreams. Gackenbach et al. (Flockhart & Gackenbach, 2017; Gackenbach, Darlington, Ferguson, & Boyes, 2013; Gackenbach, Ellerman, & Hall, 2011) proposed that these male gamers developed adaptive dream strategies for processing violent game play. The authors subsequently proposed a "nightmare protection hypothesis" (Boyes & Gackenbach, 2016), which suggests that exposure to threatening or scary images (as in combat-centric video game play or more benignly in IRT) may allow individuals to develop defensive control over violent/frightening imagery that can then act as a form of nightmare protection (Flockhart & Gackenbach, 2017; Gackenbach et al., 2011, 2013).

We developed a Virtual Reality app to treat anxiety and the distress associated with nightmares that we call ReScript. Consistent with Gackenbach et al.'s nightmare protection hypothesis, ReScript is an imagery rescripting therapy that focuses on boosting patients' defensive rehearsals and control over intrusive imagery processes. It does not require participants to generate mental images or to have high baseline mental imagery skills. It allows for individualized treatment regimens for participants and does not require participants to work with traumatic memories/images or recall their own nightmare imagery.

Virtual reality (VR) can be characterized as the use of interactive computer simulations that allow users to experience environments that appear and feel similar to real-world objects and events (Weiss, Keshner, & Levin, 2014). VR can enable simulated practice of functional tasks at a higher dosage than traditional therapies, and it therefore may facilitate deeper engagement with the imagistic and narrative rescripting process highlighted in IRT that has been demonstrated to reduce nightmare frequency and distress. VR is therefore an ideal vehicle with which to test our key hypothesis *that control over intrusive and frightening mental imagery can enable reduction in anxiety levels and in nightmare distress and daytime negative effects.* VR has previously been used effectively to treat phobias, PTSD, and body image disorders (Keizer, van Elburg, Helms, & Dijkerman, 2016; Maples-Keller, Bunnell, Kim, & Rothbaum, 2017; Rothbaum, Rizzo, & Difede, 2010; Schultheis & Rizzo, 2001) and to train motor skills for rehabilitation (Weiss et al., 2014), military skills in soldiers, surgical skills in surgeons (Patel & Joseph, 2012), and design skills in architects and engineers (Spiegel, 2016). VR provides an ideal learning environment for any task that can be simulated visually, in that it allows for high fidelity repetition of the target task and unlimited practice trials.

We propose that VR can be used to facilitate the learning of mental control over intrusive images and imagery processing and thus can be used to enhance imagery rescripting processes in IRT-related therapies to treat the distress associated with nightmares (see also Rose, 2013). By increasing the individual's sense of control over intrusive mental imagery, the individual's distress due to intrusive nightmare imagery may also be reduced. To test these ideas, we ran a pilot study of the ReScript therapy with a group of community volunteers who varied in their

self-reported anxiety levels and experience with nightmares. We tested the hypothesis that 4 weeks of ReScript therapy involving practice with morphing mildly threatening images into less threatening images would result in significant reductions in self-reported anxiety levels, nightmare distress, and nightmare effects.

Method

Participants

The study was approved and monitored by New England Institutional Review Board (Norwood, Massachusetts; www.neirb.com). We recruited a convenience sample of 30 community volunteers for a study on frequent nightmares. Two individuals were removed from the study on the first visit because they exceeded the age cutoff, one individual was removed after two sessions due to problems using the technology, and eight individuals were removed due to exceeding cutoff scores on one or more screening questionnaires (Depression, Anxiety and Stress Scale [DASS] mood function test and suicidal risk; see the following text). When initially so many people exceeded the screening cutoff scores, we obtained permission from the Institutional Review Board to adjust questionnaire cutoffs to admit more individuals with frequent nightmares. Nineteen was the final number of participants who completed the study. Seven of the 19 participants exceeded the 4-week time allotment for reasons either relating to schedule conflicts or exclusion from the study due to exceeding cutoff scores with a later re-introduction to the study after adjusting cutoff scores. All volunteers were informed of the purpose of the study and were paid 30 dollars per visit. At the first visit (baseline), participants were given a battery of questionnaires including the Nightmare Distress Questionnaire (NDQ; Belicki, 1992), the Nightmare Frequency Questionnaire (NFQ; Krakow et al., 2000), the Nightmare Effects Questionnaire (Krakow et al., 2000), the Suicide Risk Scale (Plutchik, Van Praag, Conte, & Picard, 1989), the DASS (Lovibond & Lovibond, 1995), the civilian version of the PTSD Checklist (PCL-C; Weathers, Litz, Herman, Huska, & Keane, 1993), and the Cambridge Depersonalization Disorder Questionnaire (Sierra & Berrios, 2000). The mood function test DASS measures depression, anxiety, and stress. Its psychometrics are excellent (Brown et al., 1997). The NFQ assesses "nights with nightmares" per unit of time (e.g., per week, per month) and actual "number of nightmares." Test–retest reliability produced weighted *r*s of .85 to .90. The NFQ (Krakow et al., 2000) retrospectively evaluates the frequency of nightmares and disturbing dreams as a continuous variable in two ways: nights with nightmares per unit of time (yearly, monthly, weekly, or nightly basis) and nightmares per unit of time (the same time intervals). Space is provided to estimate nightmare counts greater than once per night. The test–retest reliability of the NFQ, estimated by correlation coefficients and κs, is higher than .85 (Krakow et al., 2000). The NDQ (Belicki, 1992) includes 13 items rated on a 5-point scale from 0 (*never*) to 4 (*always*), except for three items for which the alternative responses vary. Items evaluate the degree of self-reported distress or emotional perturbation attributed to nightmares. The internal consistency of the NDQ has been shown to vary between .83 and .88 (Belicki, 1992). The Nightmare Daytime Effects Survey (Krakow et al., 2000) estimates, by means of 11

items rated on a 5-point scale from 0 (*nothing at all*) to 4 (*very much*), the self-reported degree of impairment that nightmares cause in different areas of a person's life (i.e., sleep, work, relationships, daytime energy, school, mood, sex life, diet, mental health, physical health, and leisure activities). The internal consistency of the effects survey is .90 (Krakow et al., 2000).

To measure safety and side effects of the VR exercises, participants completed the Kennedy Simulator Sickness Questionnaire (SSQ; Kennedy, Lane, Berbaum, & Lilienthal, 1993), the PCL, the Suicide Risk and Behavior Scales, and the Cambridge Depersonalization Scale. We chose the civilian version of the PCL because it taps the major *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* (American Psychiatric Association, 2000), criteria for PTSD. The PCL is a 17-item self-report measure designed to assess the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition*, criteria of PTSD. Respondents typically rate the extent to which they have been bothered by symptoms over the past month on a 5-point Likert-like scale ranging from 1 (*not at all*) to 5 (*extremely*). The instrument has been shown to capture four major clinical dimensions of PTSD: reexperiencing, avoidance, emotional numbing, and arousal. The PCL has excellent concurrent validity with interview-based measures of PTSD (r = .79–.93—Blanchard et al., 1996; Keen et al., 2008) and test–retest reliability (r = .96; Keen et al., 2008; Weathers et al., 1993). The Cambridge Depersonalization Scale that was developed by Sierra and Berrios is a comprehensive instrument containing 29 items addressing the complaints classically associated with the depersonalization syndrome. Its items describe abnormal experiences affecting different sensory modalities like heightened self-observation, distortions in experience of space and time, and lack of agency. The global score of the scale is the arithmetical sum of all items (range, 0–290) and its items are rated on two Likert scales for frequency and duration of experience (range 0–10). The scale shows high internal consistency and good reliability (Cronbach's α and split-half reliability were 0.89 and 0.92, respectively; Sierra & Berrios, 2000). The Suicide Risk Scale (Plutchik et al., 1989) was developed to discriminate suicidal participants from controls. The scale successfully discriminates between participants who reported one or more past suicide attempts and those who reported none. Sensitivity and specificity estimates were also reported as adequate (Plutchik et al., 1989). The Suicide Behaviors Questionnaire places the emphasis on actual suicide-related behaviors and shows good internal consistency and reliability across multiple samples (Osman et al., 2001). If mood or suicidality scales showed clinically elevated scores at any session, the protocol was to discontinue the trial for that participant, debrief them before they left the lab, and refer them to a counselor or crisis intervention center before they left the lab. The Simulator Sickness Scale or SSQ assesses 16 symptoms and side effects of VR including oculomotor effects, disorientation, and nausea. The SSQ, the suicidality questionnaire, and the DASS mood scales were completed by all participants each week to monitor for adverse events of the therapy. With regard to the SSQ, if participants endorsed any single item as severe, they were interviewed by lab personnel to see if the symptoms could be ameliorated. If participants verbally complained of nausea or endorsed any four items as severe, the protocol was to cease the VR, give the participant a time-out, a glass of water, and a comfortable recliner chair to sit in for 20 min. If they wished to try the VR treatment again they could. If nausea persisted, their participation in

Table 1
Participant Characteristics (at Baseline Session 1)

Characteristics	Range	*M* (*SD*)
Age	19–65 (18+)	49.89 (13.11)
DASS Stress	0–7 (0–34+)	3.37 (2.63)
DASS Anxiety	0–5 (0–20+)	1.68 (1.80)
DASS Depression	0–8 (0–28+)	2.21 (2.49)
Cambridge Depersonalization Disorder Questionnaire–Frequency	0–21 (0–176)	6.28 (6.65)
Cambridge Depersonalization Disorder Questionnaire–Duration	0–35 (0–116)	10.00 (13.17)
PTSD Checklist–Civilian Version	17–38 (17–85)	26.53 (7.19)
Suicide Behaviors Questionnaire	3–9 (3–18)	4.06 (1.55)
Suicide Risk Scale	39–49 (24–72)	44.59 (3.22)
	n	
Sex		
Female	10	
Male	9	
Education		
No formal education	0	
High school diploma or GED	2	
Some college, no degree	4	
Associate's degree	2	
Bachelor's degree	6	
Master's degree	3	
Ethnicity		
Euro-American	11	
African American	5	
Hispanic or Latino	2	
American Indian or Alaska Native	1	
VR history		
None	12	
Read about it	1	
Used it some	0	
Used it a lot	1	
No answer	5	

Note. DASS = Depression, Anxiety and Stress Scale; GED = general equivalency diploma; VR = virtual reality.

the trial would end after a debriefing and wait period to ensure that the nausea had subsided.

Recruitment efforts resulted in a total of 19 volunteers; nine males and 10 females. Their background characteristics and baseline scores on all questionnaires are displayed in Table 1. No participant scored within the DASS clinical diagnostic region for severe depression. Nine participants reported taking medications: One reported sertraline and viorele; one reported aspirin; one reported tramadol; one reported advair, spiriva, albuterol, aspirin, omeprisole, and simvistatin; one reported noixcare (B61B12); one reported linzess, senna, and amolodopine; one reported aptivus, norvir, vyriad, isentress, and triamcinolone; one reported "high blood pressure medication and bathroom medication"; and one reported vitamin D. Nine participants reported at least one nightmare per month. The mean score on the DASS Anxiety Scale was also relatively high, which is again consistent with recurrent nightmares. None of our participants had had any significant experience with VR applications before this trial.

Selection of Images

In the VR intervention, participants select an emotionally charged image from a library of images developed from the standardized and well-studied International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008) database and embedded in the VR application. The 956 images in the IAPS database are each associated with rankings that characterize the image along three dimensions: valence, dominance, and arousal. These ratings have been established as reliable (Lang, Bradley, & Cuthbert, 2005) and have been corroborated by a variety of assessment procedures (Ito, Cacioppo, & Lang, 1998), and by a range of psychophysiological measures (Smith, Löw, Bradley, & Lang, 2006), and functional MRI-measured brain activity patterns (Lang et al., 1998). In short, the IAPS provides a standardized pool of affect-inducing image stimuli that was the ideal tool to create a library of nightmare-like images that participants in ReScript could manipulate into less threatening images. We defined "nightmare-like images" in terms of the three IAPS dimensions as highly arousing, highly dominant, and highly negatively valenced images. These images would theoretically induce physiologic arousal (arousal), fear, negative emotion (negative valence), and a sense of disempowerment (dominance) in the viewer—all characteristics of intrusive nightmare imagery.

To check our intuitions on the dimensional aspects of nightmare imagery, we took a sample of nightmares and compared the imagery in them with the imagery in a sample of word-length-matched unpleasant dreams. The dream narratives (nightmares and unpleasant dreams) were gathered from a previous study of nightmares (McNamara et al., 2015). We randomly selected 50 nightmares and 50 unpleasant dreams from the pool of dreams gathered in the previous study until we had two samples that were equal in terms of word length. Mean word count for nightmares was 71.5 (48.5) and for unpleasant dreams 73.6 (35.2; $t < 1$, $p = ns$).

We deidentified the dream narratives (removed labels on the narratives) and then asked two graduate students to read each narrative, identify the "central or contextualizing image" (CI; using Hartmann's rules; see the following text), and then assign IAPS ratings (valence, arousal, and dominance) to the CI for that narrative. The CI of a dream or nightmare was defined and validated by Hartmann, Kunzendorf, Rosen, and Grace (2001; Hartmann, 2008). A contextualizing or central image is an image in the dream that seems to capture the main action and affect/mood in a dream or nightmare. It is the most memorable image from a dream or nightmare and may be a source for daytime intrusive images after nightmares. A CI appears to causally interrelate or encapsulate the actions or emotions and events in the dream. For example, an image of a frightening blue cresting tidal wave headed toward the dreamer and sweeping away one thing after another in a nightmare structures the narrative content in that dream. Hartmann argued that the CI captured or pictured the dreamer's main concern and emotion; in this example, the dreamer's terror and anxiousness concerning the tidal wave might picture some catastrophic event in the dreamer's life (a trauma or an economic crisis or a personal illness etc.). Hartmann's scoring rules for CIs entails that an image is scored as a CI if and only if it is detailed, vivid, and captures or causally interrelates events in a dream (Hartmann, 2008).

Table 2
International Affective Picture System Ratings on Central Image by Dream Type

Variable	Dream type	*n*	*M*	*SD*	*t*	*p*
CI valence	Nightmare	50	1.86	1.28	−3.7699	<.001
	Unpleasant	50	2.92	1.52		
CI arousal	Nightmare	50	7.98	1.29	4.0540	<.001
	Unpleasant	50	6.86	1.47		
CI dominance	Nightmare	50	2.92	1.79	−4.6255	<.001
	Unpleasant	50	4.74	2.13		

Note. CI = central image. Valence describes the degree to which the central image caused the dreamer and rater to be pleasant/happy/satisfied/etc. (1 = *completely unpleasant/etc.* to 9 = *completely pleasant/etc.*). Arousal describes the degree to which the central image caused the dreamer and rater to be stimulated/frenzied/etc. (1 = *completely relaxed/calm/etc.* to 9 = *completely stimulated/excited/etc.*). Dominance describes the degree to which the central image caused the dreamer and rater to be disempowered/controlled/etc. (1 = *completely controlled/submissive/etc.* to 9 = *completely in control/dominant/etc.*).

Two scorers (research assistants in the McNamara Lab) were trained for 2 hr in scoring CIs and in the IAPS rating dimensions. They then individually read each dream narrative, identified the CI, and then rated that CI along the three IAPS dimensions. The scorers reached an interrater reliability score of at least 80% agreement for all four of the scored variables (CI, valence, dominance, and arousal rating). Results are displayed in Table 2. Central images of nightmare reports are significantly more negatively valenced, more highly arousing, and more disempowering for the dreamer and rater than are CIs found in unpleasant dreams.

Both our intuitions and these data supported the claim that nightmare images can be reliably distinguished from nonnightmare, unpleasant images in terms of the IAPS rating system. Nightmare images tend to be more negatively valenced, more highly arousing, and more disempowering for the viewer than are unpleasant images. The dominance dimension in particular seemed to pick out the disturbing aspects of nightmare imagery. There was a twofold difference in dominance scores between nightmare images and unpleasant dream images, whereas the difference scores for valence and arousal dimensions were far less pronounced. It may be then that this dimension will be most important for clinical reduction in nightmare distress. Given these results, we felt justified in using the IAPS images in the ReScript therapeutic regimen designed to control intrusive nightmare imagery.

After validating use of IAPS images for ReScript purposes, we next selected a group of images from IAPS to include in ReScript. As we have just seen, nightmare images are characterized as highly arousing, unpleasant, and disempowering images. We therefore selected IAPS images that reproduced these three dimensions *but at lower intensities* than actual nightmare images. We wanted to avoid exposing participants to highly disturbing or frightening images. For the 4-week intervention, we wanted to give participants two opportunities each week to work with images that varied along each of the three dimensions, thus allowing participants to gain a sense of control over all three aspects (valence, dominance, and arousal) of a nightmarish image. We selected three images to work with at each of the two sessions for each week of the 4-week intervention for a total of 24 images. Eight of those images loaded high on negative valence and neutrally on the other two dimensions, eight other images loaded high on dominance (disempow-

erment) and neutrally on the other two dimensions, and the last eight images loaded high on arousal and neutrally on the other two dimensions.

The Intervention

The content of the 4-week treatment program was as follows: Participants came to the lab twice each week for 4 weeks. Each week they were given the battery of questionnaires to ensure safety and to monitor for changes in the three clinical outcomes: anxiety, nightmare distress, and nightmare effects. After signing the consent form and filling out a packet of questionnaires, the patient was given instructions on how to wear the Oculus headset and to work the joystick controls with the headset. They sat in front of a desktop monitor that projected the image seen three-dimensionally in the headset. A research assistant sat with the patient in front of the monitor to provide further instructions and mitigate technological difficulties.

The ReScript device creates a virtual environment within which participants are initially placed in a room facing a wall that can display the selected images. Head movements yield realistic changes in the visual perspective, creating an immersive experience for the participant, who can use gestures and finger movements to manipulate the image. There are several ways in which the participant could choose to manipulate the image: (a) They could look away, something that will naturally remove the image from their view, (b) use gestures to change the size of the image, making it as small as they want, or resizing it back up to its initial full size, or (c) use gestures and finger movements to paint over any part of the image, or remove the paint and expose portions of the image again. When switching images, the system "remembers" the state at which an image was left, so should a participant return to that image, its rendering would reflect any sizing or painting performed by the participant up to that point.

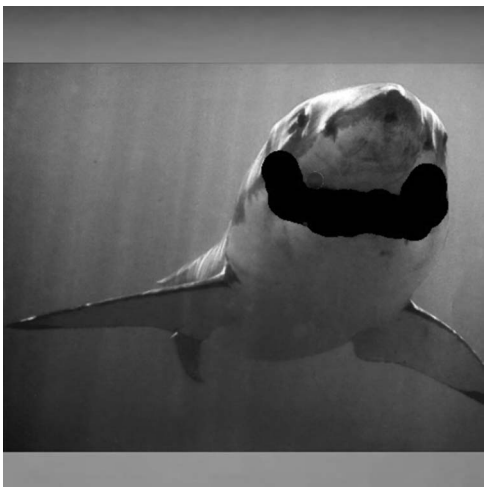
During each treatment session, the participant was told they would see up to five images or scenes in the virtual world. The initial two images served as sample photos to ensure participants understood and remembered how to use the controls before beginning the actual treatment, which began with a patient's transition to the third image in a five-image set.

Including sample photos helped decrease the official recorded morphing times for sessions because sample image morphing times were not included in the data set, which meant participants could spend more time in the sample images if they were confused by the technology without compromising the times for the treatment images. As participants became more proficient with the technology, they were given the choice to skip over the sample images and begin the treatment, which started with the third image and finished with the fifth image.

During the sample images, participants were given instructions on how to use the controls: They used hand controls to change the images. Each hand's controller served different functions: *Right hand*: swipe to next or previous photo with the thumbstick, paint over the image with index trigger, unpaint with middle finger trigger, and click record, stop, and play with index trigger. *Left hand*: use index trigger to resize photos larger or smaller by holding down

button with simultaneous movement of the left hand from side to side. Participants practiced using these controls on the sample images, working through each function until they felt ready to advance to the treatment images.

Participants were told the idea behind the functions was to take a mildly disturbing image and change it in whatever way they preferred to make it less threatening to them for the purpose of improving mental control over the image. They could paint over more disturbing parts of the image, draw something else to enhance the image, or they could shrink an image to make it appear less threatening (see Pictures 1 and 2).



When they finished editing, participants were asked to record short oral narratives of two to three sentences for the newly edited, less threatening image. Although participants could choose the order of painting, unpainting, and resizing, the recorded narratives were created only after other edits were finished for each image to ensure the narrative centered on the newly edited image and not the original, more threatening image.

Participants repeated the process of editing and recording for all three treatment images in the set. To analyze these rescripted narratives, we used the

computer program Linguistic Inquiry and Word Count (LIWC 2001; Pennebaker, Francis, & Booth, 2001; www.liwc.net). The output from this program consists of a spreadsheet with total number of words in each sample, as well as percentages of words in each of 74 categories. We focused on the following word categories: cognitive mechanisms, I (personal pronoun), anxiety, verbs, social words, positive emotion words, negative emotion words, and words indicating anxiety. We also computed total number of words per rescript (known as dictionary words in LIWC). LIWC is a simple word-counting software tool that classifies words into superordinate categories. LIWC reports the percentage of words in each of these categories, thereby controlling for word-length differences across narratives. LIWC categories were validated against a wide array of texts and text types during LIWC development (see technical manual liwc.net). LIWC reports norms in each of these categories as well, which makes comparison with norms possible.

The *cognitive processes* category picks up words indicating insight, causation, discrepancy, tentativeness, certainty, inhibition, inclusion, and exclusion. If ReScript promotes cognitive control over intrusive imagery then we should see an increase of cognitive processes due to ReScript (Session 8 vs. Baseline Session 1). The *verb* category refers to "common" verbs such as walk, went, see, and includes verbs in all tenses, that is, past tense (went, ran, had), present tense (is, does, hear), and future tense (will, gonna). Not included under the verb category are auxiliary verbs (am, will, have). The verb variable would, of course, capture changes in frequency of actions in a dream. If ReScript is increasing agency and executive control in participants then increased verbs should appear in the rescripted narratives. Instead of being passive victims in nightmares, participants would become more active in their dreams thanks to ReScript, and this would manifest as increased verbs. The target category, *personal pronouns*, is made up of social pronouns (e.g., I, me, he, she, it, etc. first person plural, second and third person pronouns), communication verbs (e.g., "talk," "share"), and references to family, friends, and other humans. The personal pronouns category would capture changes in sense of self and interactions with others. Although we expected a change in sense of self and interaction with others due to ReScript, we had no a priori prediction with regard to direction of change. On the one hand, a decrease in references to self versus others may result as patients feel less threatened and greater control over intrusive imagery and their environment. On the other hand, an increased in self reference might result if patients felt a greater sense of self-efficacy. The *social* category refers to social interactions (e.g., friends, talk, work, they, child), and is an overarching category for family, friends, and humans. These include words such as daughter, husband, aunt (family), buddy, friend, neighbor (friends), collaborate and so forth. Also included in the social category are words that imply human interaction (e.g., sharing, talking) as well as all non–first-person-singular pronouns. The social category would capture ReScript's ability to enhance frequency of social interactions. The *emotion* category is a subset of the affect category of LIWC. The affect category contains 615 words drawn from two subcategories called positive emotions and negative emotions. Examples of negative emotion words include "hate" and "worthless," and positive emotion contained words such as "joy," "happy," and so forth. We expected ReScript to increase positive emotions and decrease negative emotions. Within the negative emotion category, we picked out "anxiety"-related words, as we felt that ReScript would be

especially effective in reducing anxiety-related words like "fear," "terror," and so forth.

Statistical Analyses

The primary outcome measures were change (relative to baseline) in anxiety levels, nightmare distress, and nightmare effects after the intervention. Paired sample *t* tests, along with Cohen's effect sizes, were computed to assess significance of the change from baseline to trial's end. Although our hypothesis was directional, we used the Bonferroni correction factor to correct for tests. We also assessed effects of the verbal rescripting by calculating the change from baseline in number of words within each of seven word categories (personal pronouns, verbs, positive and negative emotions, anxiety total words [dictionary words], and cognitive processes) in the verbal ReScript narratives (which participants produced after morphing the images). An estimate concerning "dose–response" effects was calculated by computing the means on each clinical outcome score for each of the eight sessions. Safety and side effects were computed by taking the means on the DASS total score, the SSQ, the Depersonalization Scale, and the Suicidal Ideation Scale for each session of the intervention. We ran repeated-measures analysis of variance (ANOVA) on the changes in session means to detect differences in these mean scores by week.

Results

There were significant effects for all three of the clinical outcome variables (anxiety levels, nightmare distress, and nightmare effects; see Table 3). Anxiety levels declined from Session 1 (mean DASS Anxiety subscale score = 1.68 [*SD* = 1.7]) to Session 8 (Week 4; 0.84 [1.2], $t = 2.73$, $p = .014$; two-tailed; Cohen's $d = 0.63$). Similarly, nightmare distress declined from Session 1 (0.60 [.52]) to Session 8 (0.40 [.50], $t = 3.29$, $p = .004$, two-tailed; Cohen's $d = 0.76$). Nightmare effects declined from Session 1 (0.59 [.55]) to Session 8 (0.28 [.35], $t = 3.93$, $p = .001$, two-tailed; Cohen's $d = 0.90$). Interestingly, though not a focus for ReScript, we also noted that nightmare frequency (nights per year) declined from Session 1 (30.74 [55.62]) to Session 8 (25.47 [40.25], $t = 0.902$, $p = .037$, two-tailed; Cohen's $d = 0.21$).

Table 3
Results for Clinical Outcome Variables

Outcome	*M* (*SD*) Session 1 (baseline)	*M* (*SD*) Session 8 (end trial)	*t* value	*p* value; two tailed	Cohen's *d* effect size
DASS–Anxiety	1.68 (1.80)	0.84 (1.17)	2.731	.014	0.63
Nightmare distress	0.60 (0.52)	0.40 (0.50)	3.295	.004	0.76
Nightmare effects	0.59 (0.55)	0.28 (0.35)	3.934	.001	0.90

Note. DASS = Depression, Anxiety and Stress Scale.

Table 4
Change in Clinical Outcomes by Session

Clinical outcome	Session data: Group *M* (*SD*)								Repeated-measures ANOVA	
	1	2	3	4	5	6	7	8	*F*	*p*
DASS–Anxiety	1.68 (1.80)	1.21 (1.65)	1.11 (2.00)	1.16 (1.30)	0.79 (1.23)	0.89 (1.20)	0.42 (0.77)	0.84 (1.17)	3.092	.005
Nightmare distress	0.67 (0.50)	0.52 (0.44)	0.44 (0.47)	0.47 (0.49)	0.45 (0.49)	0.39 (0.44)	0.42 (0.52)	0.44 (0.51)	4.644	.000
Nightmare effects	0.59 (0.55)	0.35 (0.36)	0.32 (0.34)	0.28 (0.32)	0.26 (0.31)	0.26 (0.35)	0.26 (0.34)	0.28 (0.35)	10.301	.000

Note. DASS = Depression, Anxiety and Stress Scale; ANOVA = analysis of variance.

An estimate concerning "dose–response" effects was calculated by computing the means for each clinical outcome score for each of the eight morphing and practice sessions. Repeated-measures ANOVA revealed significant session (dose) effects for each of the three clinical outcome variables (see Table 4). Figure 1 depicts the roughly 50% decline in these clinical outcome scores relative to baseline.

The LIWC analyses demonstrated no significant word count differences from Session 1 to 8 in terms of total number of words used (dictionary words) to formulate the rescripted narratives (see Table 5). The mean of about 87 words used in both sessions is consistent with the 85 word range for the LIWC norms for paragraph length text. Reference words (personal pronouns) to self and others declined to LIWC norm levels, whereas action verb words increased significantly (14.4 to 19.8 words; $p < .006$) in rescripted narratives from baseline to Session 8. Social words declined significantly from Session 1 to 8 (6.4 to 3.7 words; $p = .005$),

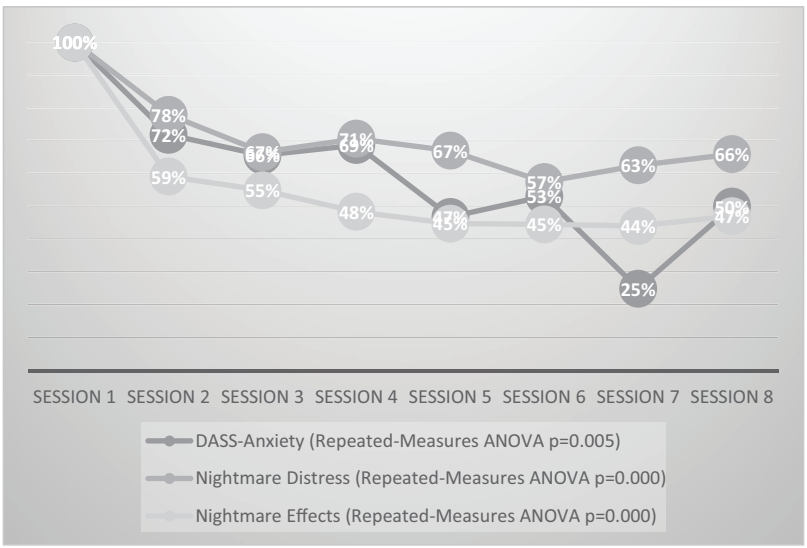


Figure 1. Dosage effect on key clinical variables. DASS = Depression, Anxiety and Stress Scale; ANOVA = analysis of variance.

Table 5
Change From Session 1 to Session 8 in Word Count Categories Due to ReScript

LIWC category	*M* and *SD* for Session 1	*M* and *SD* for Session 8	*p* value	LIWC norms
Dictionary words	87.96 ± 5.61	88.76 ± 11.32	.725	85.18 ± 5.36
Personal pronouns	11.35 ± 7.30	9.26 ± 4.73	.083	9.95 ± 3.02
Verb	14.42 ± 3.33	19.84 ± 8.73	.006	16.44 ± 2.93
Social	6.45 ± 4.22	3.78 ± 2.29	.005	9.74 ± 3.38
Positive emotion	2.83 ± 2.98	2.33 ± 2.34	.509	3.67 ± 1.63
Negative emotion	2.77 ± 2.80	2.46 ± 2.33	.638	1.84 ± 1.09
Anxiety	1.43 ± 1.33	0.47 ± 0.97	.014	0.31 ± 0.32
Cognitive processes	9.64 ± 4.39	11.75 ± 5.14	.018	10.61 ± 3.02

Note. LIWC = Linguistic Inquiry and Word Count.

but there was no change in either positive or negative emotion words. Nevertheless, anxiety-related words decreased significantly from Session 1 to 8 (1.43 to 0.47; $p = .014$), and cognitive process words increased significantly (9.64 in Session 1 to 11.7 in Session 8; $p = .018$).

Safety and side effects were assessed by taking the means on the DASS total score, Suicide Behaviors, Suicide Risk, and the two components of Depersonalization Scale (Duration and Frequency; see Table 6 and Figure 2). We ran repeated-measures ANOVA on the changes in session means to detect differences in these mean safety scores. Some safety measures displayed significant changes over baseline session by session, but in the direction of increasing safety rather than increasing risk. Other safety measures displayed no significant changes over baseline (suicide risk; duration of depersonalization episodes).

Discussion

We pilot tested a VR-enabled and IRT-related treatment for nightmares that we call ReScript. Participants used ReScript to manipulate mildly threatening images presented in an immersive VR environment so that the images were subjectively less threatening. They then formulated and rehearsed short narratives concerning the manipulated images to make them even less threatening. ReScript lasted for eight sessions across a 4-week intervention trial. We found that ReScript therapy was associated with a significant reduction (from baseline to trial end) in anxiety levels, nightmare distress, and negative daytime nightmare effects, as well as a significant decline in nightmare frequency. The effect sizes associated with the significant changes in the three key clinical outcomes were moderately large. They ranged from the moderate .63 to the large .90. In addition, there was a significant reduction relative to baseline in number of anxiety words and personal pronoun words as well as a significant increase in action verbs and cognitive process words in rescripted narratives. Reductions in anxiety, nightmare distress, and nightmare effects followed a classic dose response-type relation with gradual declines as number of practice sessions increased. No significant side or adverse effects were reported by participants during the 4-week trial. Instead, depersonalization scores and PCL scores declined significantly across sessions, whereas suicidal behaviors

Table 6
Safety Measures by Session

Safety measure	Session data: Group *M* (*SD*)								Repeated-measures ANOVA	
	1	2	3	4	5	6	7	8	*F*	*p*
DASS–Total	7.26 (5.57)	6.26 (5.63)	4.68 (4.71)	5.37 (4.57)	4.63 (4.14)	4.26 (4.42)	4.63 (5.64)	4.00 (4.68)	2.961	.007
Suicide behaviors	3.50 (0.76)	3.50 (0.76)	3.29 (0.47)	3.14 (0.36)	3.07 (0.27)	3.21 (0.58)	3.14 (0.53)	3.21 (0.58)	2.107	.051
Suicide risk	45.00 (2.98)	46.00 (2.13)	45.08 (2.15)	46.08 (2.50)	46.50 (2.91)	46.17 (1.80)	45.50 (2.71)	45.75 (1.96)	1.521	.173
Depersonalization–Duration	8.00 (12.47)	7.80 (12.19)	7.60 (12.58)	7.40 (12.42)	8.20 (12.09)	7.20 (12.56)	6.80 (12.60)	7.60 (12.58)	0.903	.518
Depersonalization–Frequency	6.08 (7.08)	4.92 (5.63)	4.31 (5.92)	4.15 (7.01)	3.31 (6.14)	3.00 (5.49)	2.69 (5.48)	2.92 (5.91)	3.709	.002

Note. DASS = Depression, Anxiety and Stress Scale; ANOVA = analysis of variance.

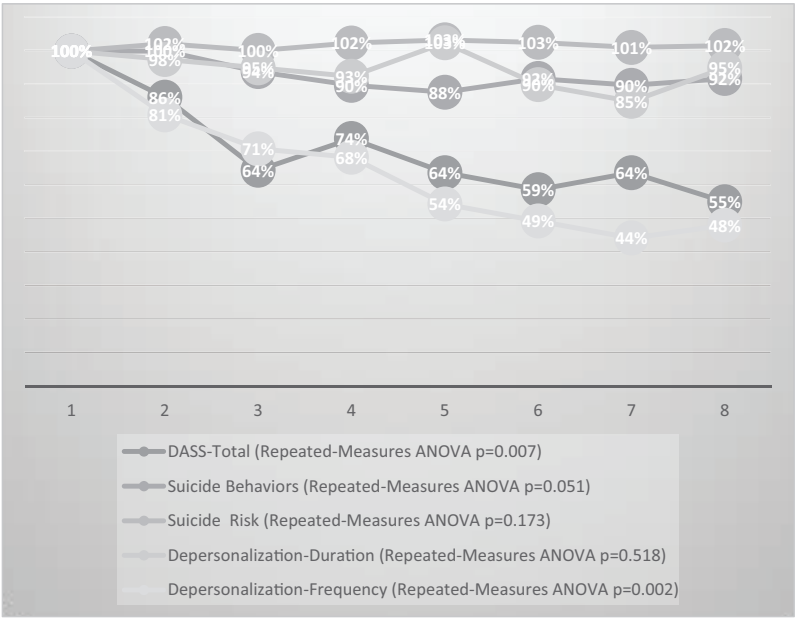


Figure 2. Percent change in safety measures by session. DASS = Depression, Anxiety and Stress Scale; ANOVA = analysis of variance.

and risk scores did not change significantly across session. Simulator sickness scores similarly did not change significantly across sessions. They were consistently low with no self-reported side effects of the VR exercises. We conclude that ReScript may be a safe and effective short-term therapy for generalized anxiety and for nightmare distress.

With regard to potential mechanisms of action of ReScript, the current data allow no firm conclusions to be drawn, as the trial was designed to establish possible efficacy and safety of the intervention—not potential mechanisms of action. Nevertheless, the dose–response analysis suggested that as number of VR practice sessions with manipulating the images increased, the greater the reductions for the three clinical outcomes. In addition, the word category analysis on the rescripted narratives suggested that the therapy resulted in a profile of increased number of cognitive process and verb/action words in tandem with significant reductions in anxiety words in the rescripted narratives. This profile is consistent with our claims that ReScript may work by increasing executive cognitive control over intrusive anxiety-laden imagery. The reduction in personal pronouns and social words is more difficult to explain. Although such a reduction is consistent with a shift away from a focus on self in social interactions (which may provoke anxiety in participants with recurrent nightmares), the current data do not allow any firm conclusions to be drawn on the significance of these findings.

What role did the medium, in this case VR, play in enhancing the positive clinical effects of the intervention? As mentioned earlier, all clinical outcomes improved as the number of VR sessions increased but obviously exposure to and time spent working with the images increased in tandem with the number of VR

sessions, so we cannot easily separate the effects of medium from the "message" in this case. Clearly, positive effects associated with basic IRT has demonstrated that you do not need VR or video games or any other medium to obtain significant reductions in nightmare distress (as long as you can generate mental images and rehearse scenarios containing these images). VR (and perhaps video games as well; see Flockhart & Gackenbach, 2017) appears to enhance existing cognitive and imaginative powers of the individual so that control over intrusive imagery is obtained more effectively and more quickly than with IRT alone.

Overall our results suggest that with VR, participants can be trained to develop control over intrusive, arousing, or frightening imagery, thereby reducing nightmare effects and distress. The ReScript intervention is innovative in that it includes exposure to, and manipulation of, fear-eliciting images *and* rescripting (of nightmare narrative) exercises delivered in a VR environment. Participants do not have to generate their own mental images to learn to control intrusive imagery.

In this innovative VR intervention, participants select an emotionally charged image from a library of images developed from the standardized and well-studied IAPS (Lang et al., 2008) database and embedded in the VR application. Participants are then trained to morph the image into a less threatening depiction using easy to use manual controls in the application. All images ($N = 956$) in IAPS have previously been ranked in terms of arousal (the extent to which the image arouses the viewer), valence (the degree of unpleasantness in the image), and dominance (degree to which the image makes the viewer feel powerless). Because, as we have seen, nightmare images are characterized (by participants and independent raters) as highly arousing, unpleasant, and disempowering, selecting IAPS stimuli that reproduce these three dimensions *but at lower intensities* than actual nightmare images allows participants to work on all three affective dimensions that make an image distressing, thus increasing the effectiveness of this therapy for recurrent nightmares.

Despite the largely encouraging results of this study, a methodologic shortcoming should be noted. This was not a randomized, double-blinded, placebo-controlled trial. Change in participant scores could have been due simply to the attention participants received and to placebo effects associated with any therapy. Although the session by clinical outcome dose–response curves generally demonstrated a decline in nightmare distress or effects and anxiety as session number increased, the decline leveled off near trial-end toward Sessions 7 and 8. If placebo effects were working, one would expect an initial positive effect and a leveling off over time. On the other hand, the leveling off effect never reached or returned to baseline levels of anxiety or nightmare distress, and it may be that no further benefit could be achieved after benefits accruing in Sessions 1–6. Effect sizes associated with improved clinical outcomes in this pilot trial exceeded standard effect sizes associated with placebo, which are generally small to moderate for clinical psychology interventions (Hunsley & Westmacott, 2007). Only a double-blind, placebo-controlled trial can settle these issues for ReScript. The therapy as currently constituted (i.e., with the current stock of images, the current twice a week practice sessions, or the current set of morphing choices) can likely be improved to obtain larger effect sizes for each clinical outcome. It may be that more highly arousing or negative images would yield larger effect sizes, or perhaps more frequent practice sessions or perhaps a greater range of morphing abilities (than

painting over or resizing the image etc.) would create a greater sense of control over intrusive imagery and thus greater effect sizes.

In conclusion, we have presented pilot findings on a new therapy for nightmares, which we call ReScript. It is a VR-enabled treatment that allows the patient to manipulate mildly threatening images until he or she gains a sense of mastery over intrusive anxiety-laden imagery. Results of the pilot investigation demonstrated that rescript significantly reduces anxiety, nightmare distress, and daytime nightmare effects without significant side effects. ReScript should now be tested with the gold standard randomized, double-blinded, placebo-controlled clinical trial.

References

American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders* (4th ed.). Washington, DC: Author.

Aurora, R. N., Zak, R. S., Auerbach, S. H., Casey, K. R., Chowdhuri, S., Karippot, A., . . . Morgenthaler, T. I. (2010). Best practice guide for the treatment of nightmare disorder in adults. *Journal of Clinical Sleep Medicine, 6,* 389–401.

Belicki, D., & Belicki, K. (1982). Nightmares in a university population. *Sleep Research, 11,* 116.

Belicki, K. (1992). Nightmare frequency versus nightmare distress: Relations to psychopathology and cognitive style. *Journal of Abnormal Psychology*, *101,* 592–597. http://dx.doi.org/10.1037/0021-843X.101.3.592

Bixler, E. O., Kales, A., Soldatos, C. R., Kales, J. D., & Healey, S. (1979). Prevalence of sleep disorders in the Los Angeles metropolitan area. *The American Journal of Psychiatry, 136,* 1257–1262. http://dx.doi.org/10.1176/ajp.136.10.1257

Blanchard, E. B., Jones-Alexander, J., Buckley, T. C., & Forneris, C. A. (1996). Psychometric properties of the PTSD Checklist (PCL). *Behaviour Research and Therapy, 34,* 669–673. http://dx.doi.org/10.1016/0005-7967(96)00033-2

Boyes, A., & Gackenbach, J. I. (2016). Nightmare protection, gender and video game play. *Dreaming, 26,* 29–41. http://dx.doi.org/10.1037/drm0000014

Brown, T. A., Chorpita, B. F., Korotitsch, W., & Barlow, D. H. (1997). Psychometric properties of the Depression Anxiety Stress Scales (DASS) in clinical samples. *Behavior Research and Therapy, 35,* 79–89.

Bryant, R. A., & Harvey, A. G. (1996). Visual imagery in posttraumatic stress disorder. *Journal of Traumatic Stress, 9,* 613–619. http://dx.doi.org/10.1002/jts.2490090317

Fantini, M., Corona, A., Clerici, S., & Ferini-Strambi, L. (2005). Aggressive dream content without daytime aggressiveness in REM sleep behavior disorder. *Neurology, 65,* 1010–1015. http://dx.doi.org/10.1212/01.wnl.0000179346.39655.e0

Fisher, H. L., Lereya, S. T., Thompson, A., Lewis, G., Zammit, S., & Wolke, D. (2014). Childhood parasomnias and psychotic experiences at age 12 years in a United Kingdom birth cohort. *Sleep, 37,* 475–482.

Flockhart, C., & Gackenbach, J. I. (2017). The nightmare protection hypothesis: An experimental inquiry. *International Journal of Dream Research, 10,* 1–9. Retrieved from https://journals.ub.uni-heidelberg.de/index.php/IJoDR/article/view/27213

Gackenbach, J. I., Darlington, M., Ferguson, M. L., & Boyes, A. (2013). Video game play as nightmare protection: A replication and extension. *Dreaming, 23,* 97–111. http://dx.doi.org/10.1037/a0032455

Gackenbach, J. I., Ellerman, E., & Hall, C. (2011). Video game play as nightmare protection: A preliminary inquiry in military gamers. *Dreaming, 21,* 221–245. http://dx.doi.org/10.1037/a0024972

Germain, A., Krakow, B., Faucher, B., Zadra, A., Nielsen, T., Hollifield, M., . . . Koss, M. (2004). Increased mastery elements associated with imagery rehearsal treatment for nightmares in sexual assault survivors with PTSD. *Dreaming, 14,* 195–206. http://dx.doi.org/10.1037/1053-0797.14.4.195

Hartmann, E. (2008). The central image makes 'big' dreams big: The central image as the emotional heart of the dream. *Dreaming, 18,* 44–57. http://dx.doi.org/10.1037/1053-0797.18.1.44

Hartmann, E., Kunzendorf, R., Rosen, R., & Grace, N. G. (2001). Contextualizing images in dreams and daydreams. *Dreaming, 11,* 97–104. http://dx.doi.org/10.1023/A:1009488705828

Haynes, S. N., & Mooney, D. K. (1975). Nightmares: Etiological, theoretical, and behavioral treatment considerations. *The Psychological Record, 25,* 225–236. http://dx.doi.org/10.1007/BF03394308

Hublin, C., Kaprio, J., Partinen, M., & Koskenvuo, M. (1999). Nightmares: Familial aggregation and association with psychiatric disorders in a nationwide twin cohort. *American Journal of Medical Genetics, 88,* 329–336. http://dx.doi.org/10.1002/(SICI)1096-8628(19990820)88:4<329::AID-AJMG8>3.0.CO;2-E

Hunsley, J., & Westmacott, R. (2007). Interpreting the magnitude of the placebo effect: Mountain or molehill? *Journal of Clinical Psychology, 63,* 391–399. http://dx.doi.org/10.1002/jclp.20352

Ito, T. A., Cacioppo, J. T., & Lang, P. J. (1998). Eliciting affect using the International Affective Picture System: Trajectories through evaluative space. *Personality and Social Psychology Bulletin, 24,* 855–879. http://dx.doi.org/10.1177/0146167298248006

Keen, S. M., Kutter, C. J., Niles, B. L., Krinsley, K. E. (2008). Psychometric properties of PTSD Checklist in sample of male veterans. *Journal of Rehabilitation Research and Development, 45,* 465–474.

Keizer, A., van Elburg, A., Helms, R., & Dijkerman, H. C. (2016). A virtual reality full body illusion improves body image disturbance in anorexia nervosa. *PLoS ONE, 11,* e0163921. http://dx.doi.org/10.1371/journal.pone.0163921

Kennedy, R. S., Lane, N. E., Berbaum, K. S., & Lilienthal, M. G. (1993). Simulator Sickness Questionnaire: An enhanced method for quantifying simulator sickness. *The International Journal of Aviation Psychology, 3,* 203–220. http://dx.doi.org/10.1207/s15327108ijap0303_3

Krakow, B., Hollifield, M., Schrader, R., Koss, M., Tandberg, D., Lauriello, J., . . . Kellner, R. (2000). A controlled study of imagery rehearsal for chronic nightmares in sexual assault survivors with PTSD: A preliminary report. *Journal of Traumatic Stress, 13,* 589–609. http://dx.doi.org/10.1023/A:1007854015481

Krakow, B., & Zadra, A. (2010). Imagery rehearsal therapy: Principles and practice. *Sleep Medicine Clinics, 5,* 289–298. http://dx.doi.org/10.1016/j.jsmc.2010.01.004

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (2005). *International Affective Picture System (IAPS): Affective ratings of pictures and instruction manual* (Technical Report No. A-6). University of Florida, Gainesville, FL.

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (2008). *International Affective Picture System (IAPS): Affective ratings of pictures and instruction manual* (Technical Report No. A-8). University of Florida, Gainesville, FL.

Lang, P. J., Bradley, M. M., Fitzsimmons, J. R., Cuthbert, B. N., Scott, J. D., Moulder, B., & Nangia, V. (1998). Emotional arousal and activation of the visual cortex: An fMRI analysis. *Psychophysiology, 35,* 199–210. http://dx.doi.org/10.1111/1469-8986.3520199

Laor, N., Wolmer, L., Wiener, Z., Weizman, R., Toren, P., & Ron, S. (1999). Image control and symptom expression in posttraumatic stress disorder. *Journal of Nervous and Mental Disease, 187,* 673–679. http://dx.doi.org/10.1097/00005053-199911000-00004

Levin, R. (1994). Sleep and dreaming characteristics of frequent nightmare subjects in a university population. *Dreaming, 4,* 127–137. http://dx.doi.org/10.1037/h0094407

Lovibond, P. F., & Lovibond, S. H. (1995). The structure of negative emotional states: Comparison of the Depression Anxiety Stress Scales (DASS) with the Beck Depression and Anxiety Inventories. *Behaviour Research and Therapy, 33,* 335–343. http://dx.doi.org/10.1016/0005-7967(94)00075-U

Maples-Keller, J. L., Bunnell, B. E., Kim, S. J., & Rothbaum, B. O. (2017). The use of virtual reality technology in the treatment of anxiety and other psychiatric disorders. *Harvard Review of Psychiatry, 25,* 103–113. http://dx.doi.org/10.1097/HRP.0000000000000138

McNamara, P., Minsky, A., Pae, V., Harris, E., Pace-Schott, E., & Auerbach, S. (2015). Aggression in nightmares and unpleasant dreams and in people reporting recurrent nightmares. *Dreaming, 25,* 190–205. http://dx.doi.org/10.1037/a0039273

Nadorff, M. R., Nadorff, D. K., & Germain, A. (2015). Nightmares: Under-reported, undetected, and therefore untreated. *Journal of Clinical Sleep Medicine, 11,* 747–750.

Ohayon, M. M., Morselli, P. L., & Guilleminault, C. (1997). Prevalence of nightmares and their relationship to psychopathology and daytime functioning in insomnia subjects. *Sleep, 20,* 340–348. http://dx.doi.org/10.1093/sleep/20.5.340

Osman, A., Bagge, C. L., Guitierrez, P. M., Konick, L. C., Kooper, B. A., Barrios, F. X. (2001). The Suicidal Behaviors Questionnaire-Revised (SBQ-R): Validation with clinical and nonclinical samples. *Assessment, 5,* 443–454.

Patel, H., & Joseph, J. (Eds.). (2012). *Simulation training in laparoscopy and robotic surgery*. New York, NY: Springer. http://dx.doi.org/10.1007/978-1-4471-2930-1

Pennebaker, J. W., Francis, M. E., & Booth, R. J. (2001). *Linguistic inquiry and word count: LIWC*. Mahwah, NJ: Lawrence Erlbaum Associates.

Plutchik, R., van Praag, H. M., Conte, H. R., & Picard, S. (1989). Correlates of suicide and violence risk 1: The suicide risk measure. *Comprehensive Psychiatry, 30,* 296–302. http://dx.doi.org/10.1016/0010-440X(89)90053-9

Rose, A. K. (2013). "Imagery rehearsal therapy for posttraumatic nightmares: Symptom severity and control appraisal outcomes". *Theses, Dissertations and Capstones,* Paper 767. Retrieved from http://mds.marshall.edu/cgi/viewcontent.cgi?article=1775&context=etd

Rothbaum, B. O., Rizzo, A. S., & Difede, J. (2010). Virtual reality exposure therapy for combat-related posttraumatic stress disorder. *Annals of the New York Academy of Sciences, 1208,* 126–132. http://dx.doi.org/10.1111/j.1749-6632.2010.05691.x

Schultheis, M. T., & Rizzo, A. A. (2001). The application of virtual reality technology in rehabilitation. *Rehabilitation Psychology, 46,* 296–311. http://dx.doi.org/10.1037/0090-5550.46.3.296

Sierra, M., & Berrios, G. E. (2000). The Cambridge Depersonalization Scale: A new instrument for the measurement of depersonalization. *Psychiatry Research, 93,* 153–164. http://dx.doi.org/10.1016/S0165-1781(00)00100-1

Smith, J. C., Löw, A., Bradley, M. M., & Lang, P. J. (2006). Rapid picture presentation and affective engagement. *Emotion, 6,* 208–214. http://dx.doi.org/10.1037/1528-3542.6.2.208

Spiegel, R. (2016). Virtual reality: The new prototype is digital. *Design News, 71,* 28–31.

Spoormaker, V. I., Schredl, M., & van den Bout, J. (2006). Nightmares: From anxiety symptom to sleep disorder. *Sleep Medicine Reviews, 10,* 19–31. http://dx.doi.org/10.1016/j.smrv.2005.06.001

Weathers, F., Litz, B., Herman, D., Huska, J., & Keane, T. (1993). *The PTSD Checklist (PCL): Reliability, validity, and diagnostic utility*. Paper Presented at the Annual Convention of the International Society for Traumatic Stress Studies, San Antonio, TX.

Weiss, P. L., Keshner, E. A., & Levin, M. F. (2014). *Virtual reality for physical and motor rehabilitation*. New York, NY: Springer. http://dx.doi.org/10.1007/978-1-4939-0968-1