

# Virtual reality therapy set for a real renaissance

*As the technology becomes cheaper and more accessible, and as research on its effectiveness matures, virtual reality is treating an array of vexing mental ailments.*

**M. Mitchell Waldrop**, *Science Writer*

A war veteran fits a virtual-reality headset over his eyes then lowers a pair of noise-cancelling headphones over his ears. After a moment of near-silent darkness, he finds himself bathed in harsh sunlight, standing on a rocky outcrop in Afghanistan. He turns to the left and right: there's nothing in sight but barren hills. He glances up: a helicopter is passing over. The war seems distant. Suddenly, a fountain of rock and dirt erupts down in the valley: a mortar round. A few seconds pass, and another round hits farther up the hillside. Then another. He watches helplessly as the explosions approach. Closer, until the world vanishes in a roar of light and sound. . . .

It is a heart-thumping experience for anyone. But for veterans of the real thing, immersion in this virtual

Afghanistan can be the stuff of nightmares—literally. This is *Bravemind*, a virtual reality (VR) system created 14 years ago to help veterans confront and overcome horrific experiences that left them with posttraumatic stress disorder (PTSD). More precisely, this is a version of *Bravemind* that's been liberated from its original hardware, a head-mounted display that cost \$3,000, and ported to an \$800 HTC Vive: one of a new generation of lightweight, consumer-oriented VR headsets originally developed to supercharge online gaming.

These new headsets are being hailed as potential game changers for VR-based mental health applications across the board. They have rebooted interest in older therapies that, like *Bravemind*, provide a uniquely vivid and intense alternative to traditional talk-based



**Fig. 1.** First created 14 years ago, *Bravemind*, a virtual reality system for helping veterans confront horrific battlefield experiences, has recently undergone upgrades that could greatly expand its reach. Image courtesy of University of Southern California Institute for Creative Technologies.

therapies for PTSD and phobias. And the headsets are opening up experimental treatments for conditions, such as pain and depression, that take advantage of the unique properties of VR.

“Virtual reality is now in a renaissance,” says Arno Hartholt, a computer scientist at the University of Southern California and the coprincipal investigator on *Bravemind*. “And that’s good for us, because we’re getting capabilities for therapy that are affordable.”

“I think there are very few mental health conditions for which VR could not be useful,” says Daniel Freeman, a clinical psychologist who studies VR treatments for paranoia at the University of Oxford in the United Kingdom.

Freeman acknowledges the challenges, though, from the programming of complex and individualized therapeutic scenarios to continually proving that they benefit patients. But based on the clinical successes to date, Freeman is “incredibly optimistic about what can be done.” Soon, he believes, VR technology could provide the equivalent of the world’s best therapists in people’s living room.

### Tricking the Brain

VR-based therapy exploits a psychological phenomenon known in the trade as “presence”—the illusion that you are really *in* an environment, not just looking at a picture of it. This isn’t simply a matter of hyper-realistic displays, says Mel Slater, a computer scientist at the University of Barcelona in Spain. He vividly remembers his first time trying on a headset in 1990,

when he was attending a conference on computer graphics. Slater had heard of VR—the basic idea had been around since the 1960s—but this was during the first big surge of commercial interest in the technology, when enthusiasts were everywhere. “At first I was disappointed,” he says. “I just saw fat pixels. But then they said, ‘Move your head’—and suddenly, I was in a different place. I heard music. I moved over to window and looked out. I saw a lady in a boat.” It was a career-changing moment, says Slater: “From then on, I became interested in how that worked.”

The answer turned out to be fairly obvious in retrospect, Slater says. If you turn your head, or stoop down, or walk forward, the headset simply should detect that motion using built-in accelerometers or other position sensors and then shift the synthetic images in a way that the computer calculates from the 3D geometry of the scene. Because this is exactly the way your brain expects the images on your retina to shift as you move through the real world, it interprets the scene as real. “The brain doesn’t like contradictions,” says Slater. “If you’re perceiving the world the way you usually do, the brain assumes, ‘Here I am.’”

Although that early generation of VR equipment never made it far beyond laboratories and industry—you could have easily paid more than \$200,000 for graphics that were pathetic by today’s standards, says Slater—it was good enough for at least some researchers to start experimenting with mental health applications. Their field was full of therapies that



**Fig. 2.** Experiencing realistic virtual scenes of war has helped some veterans overcome severe PTSD. Image courtesy of University of Southern California Institute for Creative Technologies.

worked—eventually—but that were painfully slow, expensive, and cumbersome in practice. Could VR turn them into something much quicker, easier, and more powerful?

### Safe Exposure

In Atlanta, psychologist Barbara Rothbaum at Emory University and computer scientist Larry Hodges at the Georgia Institute of Technology were among the first to ask themselves that question. For decades, explains Rothbaum, by far the most effective treatment for many anxiety disorders has been exposure therapy: encouraging someone with, say, a fear of heights to gradually walk closer to the railing of a balcony or to ride in a glass elevator. When nothing bad happens, the fear begins to diminish. But most psychiatrists don't like doing it, Rothbaum says, because it's difficult to find suitable locations and take all those trips out of the office. So in 1993, she and Hodges started asking whether exposing patients to heights via VR could be therapeutic without the hassle.

It was: in 1995, in a pilot study that was the first published account of VR used to treat any kind of psychiatric disorder, the team showed that 7 of the 10 people who received the treatment then went out and voluntarily subjected themselves to real high places—a success rate similar to non-VR-based exposure therapy (1).

Next, the group tackled a condition that's even more cumbersome to treat with exposure: fear of flying. "If you do it in the real world," says Rothbaum, "it means taking patients to the airport, getting them on board—it's expensive and time-consuming. And insurance won't pay for me to fly with them." She and her colleagues showed that sessions inside a virtual airliner cabin crammed with avatars representing real people could alleviate fear just as effectively as exposure in the real world (2). It also had some key practical advantages. "With VR, they could take off and land many times in a 45-minute session," says Rothbaum, not just once. "And if I thought the patient wasn't ready for turbulence, there would be no turbulence."

That success gave the team enough confidence to take on combat-related PTSD, which can leave its victims vulnerable to recurring nightmares, uncontrolled rage, alcohol and drug abuse, suicidal thoughts, and more. Because exposure therapy in a combat environment is impractical, the gold standard has been a variation known as "imaginal" therapy: asking the veteran to recall traumatic events maybe a dozen times per session or more. But not everyone has a vivid enough imagination—or wants to remember.

So the team's idea was to use VR to as a kind of booster for imaginal therapy, making the remembered scenes vivid and tangible. For their pilot study published in 2001, they recruited 10 male Vietnam veterans still suffering from PTSD more than two decades after the war ended in 1975 (3). Each of the veterans then experienced the researchers'

Virtual Vietnam for 90 minutes at a time, twice a week, while he talked through his specific traumas and the therapists adjusted the simulation details to get the closest match.

After two weeks, and again when they were retested six months later, the patients showed significantly reduced PTSD symptoms. And that was especially gratifying, says Rothbaum: "If they were still in the system after so many years, they were pretty resistant to standard treatments."

In New York City, JoAnn Difede hit on much the same idea in the aftermath of the terrorist attacks on September 11, 2001. "The day after 9/11, I knew we would have a public health problem," says Difede, a psychologist at the Weill Cornell Medical College on the Upper East Side of Manhattan.

By October 2001, she was collaborating with Hunter Hoffman, a computer scientist at the University of Washington, on a virtual replica of the streetscapes around the World Trade Center. "We used a

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—JoAnn Difede

\$25,000 head-mounted display that weighed 10 pounds," she says. "Dell donated a workstation; consumer technology couldn't hack it."

One of the first patients to use the system was a young woman who had had to run for her life as the twin towers collapsed behind her (4). Once an upbeat, deeply religious person, she had become moody and irritable, yet numb and flat.

"But as soon as she put the headset on," says Difede, "she went 'Oh my God! I never thought I'd see the World Trade Center again!'" By the second session, the patient was reliving how she had fled the catastrophe. After several sessions, she remembered something she had repressed: a woman had begged her for help—yet she had run past without stopping. There was nothing she could do for the woman, whose legs had been severed by falling debris. But the moment left Difede's patient with crushing guilt.

"Running past this one spot brought back the memory and allowed her to process it," says Difede. And after that, the young woman's symptoms improved markedly. "That example was powerful for me," says Difede. "This was an experiment, and we had no idea if it would work."

### Trauma Meets Gaming

Difede, Rothbaum, and many other researchers were soon invited to collaborate on the *Bravemind* project, which was initiated by University of Southern California psychologist Skip Rizzo in 2003. Because *Bravemind* had Pentagon backing—Rizzo and his team adapted the first version from *Full Spectrum Warrior*, a video game they had originally developed to train small-unit commanders—it quickly became the most sophisticated

## Feeling Real

The psychological phenomenon known as “embodiment” takes the illusion of presence in the virtual environment a step further: not only do your surroundings feel real, but your avatar body feels like it’s your own. And that opens a door to using VR to give people who need it a new perspective on “self.”

“It’s pretty straightforward,” says Mel Slater, a computer scientist at the University of Barcelona in Spain. “Your whole life, you look down and you see yourself, you look in a mirror and you see yourself. Well, in VR you have the headset and motion tracking, so you can do the same.”

The correspondence doesn’t have to be exact, notes Slater’s Barcelona colleague, Maria Sanchez-Vives; the brain is remarkably good at filling in missing sensations like touch, smell, and even sound. But the sensations you do receive have to be consistent, she says: “If you sit in a chair, your virtual body should sit in a chair.”

Interestingly, says Sanchez-Vives, the sense of embodiment doesn’t seem to be affected by differences in race, gender, or age. “In one of our first papers on the full body illusion, we put adults in the body of a little girl,” she says (9). “And we’ve done several experiments with racial bias—giving subjects a virtual body with a different race. Nobody has expressed any kind of incongruence.” That conclusion is borne out by objective tests, such as showing that people’s real heart rate shifts into fright mode when their virtual body is threatened with harm.

But wearing a different body does have profound psychological effects, says Slater. When adults are given a child’s body, for example, they start to label themselves with childlike attributes in word association tests and to overestimate the size of objects in exactly the way real children do. And when white people are embedded in a black body, says Slater, they start to show marked decreases in measures of implicit racial bias—an effect that lasts at least a week after exposure (10).

With further development, says Sanchez-Vives, this could make VR a powerful training tool for increasing interpersonal compassion. And in the meantime, she says, the sense of embodiment could be used to treat a wide variety of pathologies that affect body awareness, from the loss of a limb to anorexia.

VR exposure treatment ever. And the most widely deployed: it’s currently running in more than 60 Veterans Administration hospitals, military bases, and research labs, facilitating therapies that closely conform to patients’ memories. “The clinician can set all kinds of parameters,” says Hartholt, who became the project’s coprincipal investigator in 2008. “Afghanistan or Iraq, riding or walking, urban or rural, day or night.”

In 2010, a small study using fMRI brain scans found this kind of VR exposure therapy to be at least as effective as imaginal therapy at damping down the hyperactivity typically seen in a PTSD patient’s amygdala and hippocampus—the first being the seat of the fight or flight response, and the second, a key site in memory formation and presumably the source of haunting flashbacks. Both therapies also seemed to restore normal activity in frontal-lobe areas that are inhibited in PTSD and may account for the disorder’s characteristic emotional numbing and social withdrawal (5). A much larger comparison with some 200 patients is now underway.

In the meantime, says Hartholt, *Bravemind*’s developers have focused on upgrading the underlying game technology, including the port to new-generation

headsets, and expanding its scope. Since 2014, for example, they have been adding content to help people cope with military sexual trauma. The VR system doesn’t attempt to show the actual assault, he says, but instead emphasizes the context that leads up to it—the sound of a lock turning, say, or the sight of an assailant standing in a doorway blocking any escape. Results from a Veterans Administration clinical trial of that application, currently underway, are expected in a year or two.

## VR Therapies in the Real World

The new wave of consumer headsets, which rely on the high-resolution displays being mass-produced for smartphones, started with the announcement of the Oculus Rift in 2012. It hasn’t taken long for researchers to recognize the potential for bringing existing therapies to a wider range of patients as well as for developing new treatment approaches that can really only work with VR. “Now that the technology is inexpensive and portable, applications are limitless,” says Difede.

Since 1999, for example, Difede’s colleague Hoffman and University of Washington psychologist David Patterson have been developing *SnowWorld* (6), an immersive VR environment for pain control in people with severe burns.

Rather than pain-killing drugs, which can be dangerous, *SnowWorld* offers a particularly vivid form of distraction. During their excruciating daily regimen of wound-cleaning and dressing-changes, patients don the headset and spend the time drifting through a kind of glacial canyon, launching snowballs at snowmen and penguins that pop up at random along the walls. It’s quite cartoonish—yet engrossing enough to block out the agony, turning pain into little more than an annoyance.

Now, Hoffman and his colleagues are finally able to port *SnowWorld* into new-generation headsets that are light and cheap enough for routine clinical use. And along with Difede, Hoffman is also starting to experiment with VR-based pain relief in other situations, such as chemotherapy and presurgical procedures.

One of the research frontiers for VR therapy is to make use of an extension of presence known as “embodiment,” in which users feel that the virtual body they glimpse in the simulation is literally their own (see sidebar). A particularly promising application of this phenomenon is to calm the relentless self-criticism that’s so common in conditions such as depression—perhaps the leading cause of disability worldwide (7). “People may feel that they don’t deserve to be treated kindly,” explains Christopher Brewin, a psychologist at University College London.

In 2016, he, Slater, and a team of other psychologists published an encouraging pilot study of a VR-based treatment (8). Fifteen subjects diagnosed with depression wore a headset that gave them the form of an adult avatar and were asked to comfort a distressed virtual child. The system recorded their voices as they did so. Then the subjects were taken through the scenario again from the perspective of the child. In

that guise, they listened to the adult avatar speaking their own compassionate words and gestures. After repeating this cycle once per week for 3 weeks, all the subjects showed measurable decreases in depression and self-criticism: somehow, their self-perceptions changed when they saw themselves from the outside as a caring person.

The team is currently looking for funding to do a much larger study that will nail down the clinical benefit, says Brewin—and, not incidentally, to port the software from their original, \$65,000 lab setup into consumer-level equipment. “So instead of special labs where people have to come to,” he says, “we can imagine people downloading things into their own headset in their bedroom.”

### Virtual Therapists?

At Oxford, Freeman and his team are working to make that vision a reality for far more people. “The issue is that it has so far been used in clinics, with therapists there,” says Freeman. But because good therapists are in short supply, he says, researchers need to automate that kind of feedback so that people can have access to it at home.

Freeman works closely with psychologists and programmers to put virtual coaches in the scene who “guide you through the situations that trouble you, ask you questions, give you feedback and advice, and personalize your treatment.” That takes a lot of programming effort, says Freeman, because this kind of therapy is anything but one-size-fits-all: “You have to take each condition on its own, know about its various manifestations, and then tailor the treatments within the algorithm.”

Still, Freeman says, if this kind of automation can be made to work, it would open up the possibility of instant access to therapy, without an appointment or prescription. “Traditionally in mental health, your choices for treatment have been taking medication, or talking with therapist,” says Freeman. “But for me, what’s really important is what happens outside, in the situations that people find difficult. And the best treatment happens when you can practice right there, in the moment.”

That’s where virtual reality shines, Freeman says: “It’s like having a personal trainer, a coach, right there with you.”

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