Correction

NEWS FEATURE

Correction for "News Feature: Is video game addiction really an addiction?" by Mark Zastrow, which appeared in issue 17, April 25, 2017, of *Proc Natl Acad Sci USA* (114:4268–4272; 10.1073/pnas.1705077114).

The editors note that Tae Kyung Lee was originally misidentified as a psychologist and should be identified as a psychiatrist instead. The online version has been corrected.

www.pnas.org/cgi/doi/10.1073/pnas.1707226114

Is video game addiction really an addiction?

Adding video gaming to the list of recognized behavioral addictions could help millions in need. It could also pathologize a normal behavior and create a new stigma.

Mark Zastrow, *Science Writer*

Science fiction is replete with notions of losing oneself inside a digitally generated alternate reality. But for millions around the world, that dystopic vision could be very real.

Many governments already see excessive, compulsive playing of online video games, such as *League of Legends* and *World of Warcraft*, as a serious adolescent public health issue and have established treatment facilities, especially in China and South Korea (1). The adverse effects of teens' "addiction" to the games are not just time lost studying or socializing with their peers. Some evidence associates video game addiction with depression, attention-deficit/hyperactivity disorder (ADHD), and obsessive-compulsive disorder (2). Whether there is a cause-and-effect relationship remains unclear.

As in the case of patients diagnosed with other addictions, so-called Internet Gaming Disorder (IGD) affects those around them, too: in extreme cases, it has reportedly resulted in household violence by children against their parents, who are trying to take away their games, according to Philip Tam, a psychiatrist with the not-for-profit Network for Internet Investigation and Research Australia in Sydney. "A lot of child psychologists say, we've got parents living in fear of their kids," says Tam.

Whether video games can produce a true addiction in a clinical or scientific sense is still highly controversial. Can a game be considered an intoxicant? The neurological evidence is growing that games may act like traditional substances of abuse, with compelling similarities between the effects of drugs and of video games on the minds of users (2). But many worry that labeling teenagers "addicts" will pathologize behavior that is normal, and lead to false epidemics of other compulsive behaviors, such as sex and eating.

Mounting neurological evidence suggests that video games may act like traditional substances of abuse. But some researchers remain unconvinced that gaming can constitute an "addiction." Image courtesy of Shutterstock/eranicle.

www.pnas.org/cgi/doi/10.1073/pnas.1705077114

"I don't know that there's any consensus in this field right now," says Nancy Petry, a professor of medicine at the University of Connecticut in Farmington, who was on the American Psychiatric Association committee that considered adding IGD to the latest diagnostic manual but decided to wait. "Personally, I think it really likely is a mental disorder, but I think we need to better quantify what it is we're studying."

Subtle Distinctions

Throughout the 1970s and 1980s, the word "addiction" in a medical setting referred strictly to substances, such as alcohol, tobacco, and drugs, if it was used at all. Before 2013, "addiction" did not appear in the American Psychiatric Association's *Diagnostic and Statistical Manual of Mental Disorders* (DSM), the working dictionary of mental health. Alcohol and substance abuse were simply called alcohol- or substance-related disorders, and a diagnosis hinged on the presence of symptoms such as craving, tolerance, and withdrawal. On the other hand, pathological gambling was considered an inability to resist impulses, along with disorders like pyromania (setting things on fire), kleptomania (compulsive stealing), and trichotillomania (compulsive hair-pulling).

But over the past 15 years, the idea that it is possible to become addicted to a behavior has gained traction, especially after neuroimaging began to show that behaviors such as gambling could activate the brain's reward system in the same way as drugs. "I think there are some people that are still holding out," says Howard Shaffer, professor of psychiatry at Harvard Medical School in Boston, and director of the Division on Addiction at the Harvard-affiliated Cambridge Health Alliance. "But I think the evidence is pretty overwhelming now that all kinds of things can change neurochemistry. It simply doesn't require the ingestion of drugs."

The DSM has begun to reflect that. The authors of DSM-5, released in 2013, created a category for "substance-related and addictive disorders" that included gambling disorder, the first behavioral addiction to appear in the same class as substance addictions (3).

Video games were also considered for inclusion, but the working group decided there wasn't enough evidence—yet (4). But the group did identify IGD in an appendix as worthy of more study and proposed a set of criteria for diagnosis. "I would say that it certainly merits exploration," says George Koob, director of the National Institute on Alcohol Abuse and Alcoholism.

Classification as a psychiatric diagnosis in the DSM requires clearing a very high bar, one in place to prevent the proliferation of mental disorders, Petry notes. "Certain things that were once considered mental disorders—like homosexuality—no longer are, and that's a good thing."

Petry is one of many researchers who say that more data are needed to show both that IGD persists in patient's lives and that it is a unique condition, not caused by preexisting, underlying mental health issues. "I don't think that body of research has made that clear," says Chris Ferguson, a professor of psychology at Stetson University in DeLand, Florida.

Thousands of people attend the annual *League of Legends* video game world championship competition in person and millions more view it online. Image courtesy of Flickr/Chris Yunker.

"Some people who are depressed stay in bed all day, but we wouldn't say that they have a bed addiction."

Pathways of Addiction

Arguments for video game addiction dovetail with the recent evolution in the concept of addiction itself: evidence that what causes the patient to lose control is not the substance itself, but the underlying neural circuitry that fires when presented with the reward the substance provides.

At the center of this understanding of addiction is the brain's reward system, in which using the substance triggers release of the neurotransmitter dopamine, which influences neurons in the nucleus accumbens, as well as other brain areas, such as the prefrontal cortex. Repeatedly activating these complex circuits modifies neural connections until these circuits respond to mere anticipation of the reward—as in Pavlovian conditioning—and produces the classic symptom of craving. Over time, the changes in dopamine receptors and the functioning of these pathways can diminish the sense of pleasure and produce tolerance.

At the same time, dopamine exposure forges changes in other brain areas, such as the amygdala, and this can lead to a boost in negative emotions, such as fear and stress in the drug's absence, leaving addicts seeking the drug simply to escape the pain of withdrawal. These changes in neural circuitry wrought by drug use persist, says Nora Volkow, director of the National Institute on Drug Abuse, and they go some way toward explaining why so many addicts relapse (5).

This model treats addiction as a brain disease, not a moral failing. As with other diseases, individuals may be more or less prone to it based on a complex—and so far, largely undetermined—mix of genetic and environmental factors. Although the neurobiological

South Korea's Gaming Obsession

In the late 1990s, the South Korean government led a push to bring the Internet to the masses. The result: The country led the world in broadband penetration by the early 2000s. That fueled the birth of e-sports, centered around *StarCraft*, a sci-fi real-time strategy game played at a professional level in live matches and by legions of mostly teenaged boys at the ubiquitous gaming cafes known as "PC bangs." Soon, concern rose that some were addicted.

"We know there are lots of problems for [the addicts]," says Tae Kyung Lee, a psychiatrist at Korea's National Mental Health Center in Seoul, who oversees a government-funded treatment clinic for adolescent gamers. "They drop out of school and they seclude themselves in their homes. If we cannot handle this issue, our society will face big problems."

The government's role in creating this culture partly explains why politicians felt it necessary to step in to harshly regulate the gaming industry: in 2011, South Korea enacted a "shutdown law," which tied game accounts to users' national ID and forced children under 16 off the servers from midnight until 6:00 AM. Critics say it hasn't worked—kids stole their parents' IDs to get around it—and a 2014 study by Wookjoon Sung at Seoul National University found it had made no difference in the amount of time spent playing (19).

approach does have its critics (6), proponents, including Volkow and Koob, suggest the model could explain addiction in general and its emotional side effects, leading to new medications to treat addiction, some of which are being tested (7).

"In drugs, the person gets activated when they see that syringe or they see that dealer," says Volkow. In video games, it may be the burst of speed from a successful trick or the cry of a defeated enemy. "It is exactly the same circuitry that gets involved," she says. In 2001, a key study in *Neuron* led by Hans Breiter of Massachusetts General Hospital in Boston used fMRI to show that gambling could activate reward centers in the same way as a substance (8). Neuroimaging studies of video gamers are more recent, but show many similarities, Volkow adds. One 2011 fMRI study led by Simone Kühn, of Ghent University in Belgium, of 154 14-year-olds found that frequent gamers had more gray matter in the left ventral striatum, a change that may result from increased dopamine release that also shows up in those addicted to gambling (9).

With video games, as with gambling, the intermittency of the reward only heightens its conditioning power. "You don't know when you will be able to kill the adversary or find the treasure that the video game is offering—but there is that moment when you do," says Volkow. "That becomes reinforced. Because it's actually something that you did well, dopamine goes up and it keeps you going." Nor does the challenge need to be especially complex or gory.

"*Candy Crush* is a very interesting game," Volkow offers, referring to the mobile game published by Activision Blizzard, in which players try to arrange a grid of brightly colored candies into rows and columns; align them in the right pattern and they disappear with a visual poof, a chime, and a cascade of new candies to take their places. Volkow recalls boarding a flight this summer: "I would say 30% of the plane was playing this *Candy Crush*. And they would have these little sounds and colors. So you get conditioned to that sound and the color, and those become reinforcing. And that's exactly how our brain works."

Some developers take it even further, notes Philip Tam, with trained psychologists on staff to "tweak the gameplay, not make it too hard, to keep [players] in the zone" (10). In an influential 2001 article on the gaming industry website Gamasutra, then-psychology graduate student John Hopson deconstructed game design through the lens of behavioral psychology, introducing developers to language, such as "reinforcers" (game rewards: for example, advancing to higher levels or collecting new tokens or treasures) and "contingencies" (the game rules that govern when reinforcers are handed out) (11). Hopson presaged the increasingly complex rewards and achievement systems that nearly all big-budget games now implement, and that Hopson himself would later apply in games such as *Destiny* as a researcher for game studio Bungie (see www.gdcvault.com/play/1016539/Behavioral-Game). There is little to no research, however, on whether these specific awards systems contribute to cases of video game addiction.

Another way in which games may provoke an addiction-like cycle is through the march of technology: as manufacturers and developers create more powerful equipment and deliver better graphics, gamers take part in more immersive and novel experiences, mirroring—intentionally or not—drug users seeking stronger and stronger substances. "Today's *World of Warcraft* is tomorrow's *Pong*," says Shaffer.

Virtual Realities

Concern about video game addiction is perhaps most prominent in east Asia, where many feel that games offer such a vivid alternative reality that young, developing brains are being altered in unprecedented ways by spending so much time there, and that these changes may be components of a new type of addiction.

Tae Kyung Lee, a psychiatrist at Korea's National Mental Health Center in Seoul, who oversees a government-funded treatment clinic for adolescent gamers (see Sidebar), bases his therapy around the observation that many of his patients who can't control how long they play also have a disrupted sense of time in the game, implying a sort of virtual time warp. "Just 3 or 4 hours passes in real time, but they feel they have spent thousands of years finishing the game," he says. Even when they're not playing, many gamers also experience artifacts from virtual worlds—sounds, vision, or trained reactions—bleeding into the real world.

In 2010, Angelica Ortiz de Gortari was a Master's degree student in Stockholm researching internet addictions. "I'm no hardcore gamer," she says, "but I used to play." For research, she picked up *Resident Evil*, a survival horror series in which players fend off zombies and biological terrors. Then one day in a supermarket, she looked down the aisle at a distant item and found herself involuntarily trying to call up a virtual sniper scope to see further, just as she would in the game.

Struck by her reaction, Ortiz de Gortari refocused her thesis to understand what had happened, which she refers to as game transfer phenomenon (GTP). In her interviews, she found that gamers reported a wide variety of examples of virtual worlds bleeding into real life. One person reported seeing floating health bars above their opponents while playing soccer; others said they felt their bodies begin to strafe from side-to-side as if controlled by a joystick. In a 2015 study of 2,362 gamers, Ortiz de Gortari, now at the University of Liège in Belgium, and her coauthors reported that 97% of the gamers reported having experienced GTP (12). And in a study published in 2016, she and her colleagues found that people with severe GTP are more likely to have problematic or addictive gaming habits (13).

The connection is still tentative, says Ortiz de Gortari; it's not clear that addiction and GTP share the same neurological pathways. Nevertheless, in 2015, the South Korean Ministry of Health and Welfare created a public service announcement urging gamers to look for signs of GTP in their lives as a marker of addiction (see https://www.youtube.com/watch?v=D7Suuxeqjo4).

Ortiz de Gortari says new virtual reality gaming, for example with Oculus Rift and Sony PlayStation headsets, could lead to increased GTP and other cognitive and perceptual changes. But the intensity of the experience might push virtual reality gamers to shorter overall sessions, a sort of self-regulating effect.

Redefining Addiction

Although evidence continues to mount that gaming affects the brain, and may "rewire" it in some of the same ways as other addictive drugs and behaviors, some still question the equivalence between video games and substances.

Doug Hyun Han, a researcher at Chung-Ang University Hospital in Seoul, opposes classifying IGD as an addiction, partly because hardly any of the thousands of patients he has treated exhibit tolerance or withdrawal symptoms, a more traditional, pharmacological-based distinction. Han views video games not as an intoxicant, but something neutral that children are drawn to because their young minds seek novelty and cognitive complexity. Like millions of his countrymen, Han spent his teenage and college years playing *StarCraft*. "I am a good gamer, you know! I loved that," he laughs. "Now, I don't like *StarCraft* anymore because I am old. I like just very simple games, very casual games, because my brain is too old to respond to complex games."

Han considers IGD to be an impulse-control disorder, even as he admits that he's "in a very small minority." But he bases his distinction, in part, on a recent series of fMRI findings he's made with colleagues. One study finds weakened connectivity between the frontal lobe and basal ganglia in gamers with IGD. That's the opposite of what's seen in alcohol-dependent patients, and more similar to disorders, such as ADHD (14). Problematic gamers also have increased activity between the dorsolateral prefrontal cortex and temporoparietal junction, a characteristic found in people with schizophrenia, autism, and poor impulse control (15). This kind of evidence could suggest that youngsters with existing behavioral or cognitive problems are more likely to be drawn to the escapist fantasy world of games, perhaps even as a form of self-medication. But ultimately the gaming would be a symptom, not a cause of the other problems.

Another reason some oppose classifying IGD as an addiction is the term's derogatory connotation. "I don't think it's in anyone's interest to label a 13-year-old who's screaming, wanting to play *Minecraft* as an 'addict'," says Tam.

Many also argue that criteria currently in use overdiagnose the disorder, especially those based on traditional concepts of addiction. More than a dozen different sets of diagnostic criteria have been proposed by researchers, and the ones that take a "pathological gaming" approach produce an average prevalence of 9%, according to a 2011 study in the *Journal of Psychiatric Research* (16). "Personally, if that really was the case, I'd expect to see a video game addiction treatment center in every major city up and down America, but that's obviously not the case," argues psychologist Mark Griffiths of Nottingham Trent University, United Kingdom. "I passionately believe that video game addiction exists," says Griffiths, one of the topic's earliest and most prolific researchers. "I just don't think it exists on the scale that most of the literature would have you believe."

> **"That's always been the problem with these behavioral addictions. Where do you draw the line?"**
>
> **—George Koob**

Furthermore, no set of diagnostic criteria has gained widespread acceptance. A study published this March in the *American Journal of Psychiatry* that found up to 1% of the general population would fit the DSM criteria for addiction, but found little evidence of impairment (17). "They're not good symptoms," says Ferguson. "I am absolutely convinced that as it's currently being defined by the DSM, this Internet Gaming Disorder thing is absolute crap."

For some clinical psychiatrists, the debate is moot. "In a sense, I don't care about the definition, whether it's an addiction or what's happening at a neurobiological level," says Tam. "What interests me is what's happening to the client in the real world."

The next opportunity for researchers to define the disorder comes in 2018, when the World Health Organization (WHO) will release the 11th edition of the International Classification of Diseases (ICD). Last year, the WHO floated a hotly debated proposal to include "Gaming Disorder" in a category titled "Disorder due to addictive behaviors" in the ICD-11. "At this point, suggesting formal diagnoses and categories is premature," stated a paper in the *Journal of Behavioral Addictions*. "The ICD-11 proposal for Gaming Disorder should be removed to avoid a waste of public

health resources as well as to avoid causing harm to healthy video gamers around the world" (18).

Some skeptics question whether video games are being pushed for inclusion faster than other potential behavioral addictions—like food and sex addictions—because of media hype or politics, where video games have often been a useful foil. "I think people in some ways have gotten kind of addicted to video game addiction," says Ferguson. "They just can't let go of this concept even though it's fairly problematic."

If IGD is included in the next revision of either the ICD or the DSM, there is concern that floodgates will open to other disorders, such as sex and food addictions, many of which also show evidence of activating the brain's reward system but exhibit even fewer of the traditional addiction markers, such as tolerance and withdrawal. Some, like Griffiths—who works from a set of criteria that consists of tolerance, withdrawal, salience, mood modification, relapse, and conflict with others—have no problem with that. "I don't care what the behavior is; if any behavior fulfills those six criteria, then I operationally define that person as addicted to that activity." But others are wary.

"That's always been the problem with these behavioral addictions," says George Koob. "Where do you draw the line? There are those who will argue that compulsive sexual behavior can be addiction-like and others that consider it a joke." But, he adds, "Anything that's causing—in my view—pain and suffering and manifests itself as a pathology deserves some attention."

1 PBS Newshour, News desk (2014) Treating China's Internet Addicts. Available at www.pbs.org/newshour/rundown/treating-chinas-internet-addicts/. Accessed April 4, 2017.
2 Kuss DJ, Griffiths MD (2012) Internet and gaming addiction: A systematic literature review of neuroimaging studies. *Brain Sci* 2:347–374.
3 American Psychiatric Association (2013) *Diagnostic and Statistical Manual of Mental Disorders* (American Psychiatric Association, Arlington, VA), 5th Ed.
4 Petry NM, Rehbein F, Ko CH, O'Brien CP (2015) Internet gaming disorder in the DSM-5. *Curr Psychiatry Rep* 17:72.
5 Volkow ND, et al. (2006) Cocaine cues and dopamine in dorsal striatum: Mechanism of craving in cocaine addiction. *J Neurosci* 26:6583–6588.
6 Hall W, Carter A, Forlini C (2015) The brain disease model of addiction: Is it supported by the evidence and has it delivered on its promises? *Lancet Psychiatry* 2:105–110.
7 Volkow ND, Koob G (2015) Brain disease model of addiction: Why is it so controversial? *Lancet Psychiatry* 2:677–679.
8 Breiter HC, Aharon I, Kahneman D, Dale A, Shizgal P (2001) Functional imaging of neural responses to expectancy and experience of monetary gains and losses. *Neuron* 30:619–639.
9 Kühn S, et al. (2011) The neural basis of video gaming. *Transl Psychiatry* 1:e53.
10 Ambinder M (2011) Biofeedback in Gameplay: How Valve Measures Physiology to Enhance Gaming Experience. Game Developer Conference 2011 presentation. Available at www.valvesoftware.com/company/publications.html. Accessed April 4, 2017.
11 Hopson J (2001) Behavioral Game Design. *Gamasutra*. Available at www.gamasutra.com/view/feature/131494/behavioral_game_design.php. Accessed April 4, 2017.
12 Ortiz de Gortari AB, Griffiths MD (2015) Game Transfer Phenomena and its associated factors: An exploratory empirical online survey study. *Comput Human Behav* 51:195–202.
13 de Gortari A, Oldfield B, Griffiths MD (2016) An empirical examination of factors associated with Game Transfer Phenomena severity. *Comput Human Behav* 64:274–284.
14 Han JW, et al. (2015) Differences in functional connectivity between alcohol dependence and internet gaming disorder. *Addict Behav* 41:12–19.
15 Han DH, Kim SM, Bae S, Renshaw PF, Anderson JS (2015) Brain connectivity and psychiatric comorbidity in adolescents with Internet gaming disorder. *Addiction Biology*. Available at onlinelibrary.wiley.com/doi/10.1111/adb.12347/abstract. Accessed April 4, 2017.
16 Ferguson CJ, Coulson M, Barnett J (2011) A meta-analysis of pathological gaming prevalence and comorbidity with mental health, academic and social problems. *J Psychiatr Res* 45:1573–1578.
17 Przybylski AK, Weinstein N, Murayama K (2017) Internet gaming disorder: Investigating the clinical relevance of a new phenomenon. *Am J Psychiatry* 174:230–236.
18 Aarseth E, Bean AM, Boonen H (December 30, 2016) Scholars' open debate paper on the World Health Organization ICD-11 Gaming Disorder proposal. *J Behav Addict*, 10.1556/2006.5.2016.088.
19 Sung W (2014) A study on the effect of the policy of online game shutdown on the game time of youth. *Social Science Research Review* 30:233–256.