DEEP DIVE

How to game the search for autism treatments

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Illustration by Tim Smits

The Research on Autism and Development (RAD) Laboratory is located in a Tetris-like maze of brown wooden buildings, not far from the main campus of the University of California, San Diego. The lab itself is a nondescript warren of small beige rooms. But everything else about it is extraordinary.

The first clue is a T-shirt one of the lab's young interns wears on this sunny day in April, featuring the **RAD Lab**'s motto: "We play mind games." One of the newer recruits, 20-year-old Naseem Baramki-Azar, sports a "Super Mario Bros." shirt. A half-dozen other lab members huddle around computer screens displaying none of the usual fare of charts or spreadsheets: Instead, they're hard at work making cartoon moles pop out of molehills, or fat spaceships careen toward the top of a computer screen.

The lab's director, **Jeanne Townsend**, and associate director, **Leanne Chukoskie**, periodically poke their heads in to check on the progress. The two women, a generation apart, are a study in contrasts. Townsend is reserved, with dark-framed square glasses; Chukoskie is a fast-talker with a California blond ponytail. But they finish each other's sentences when they talk about their quest: to develop video games that can help children with autism.

The project has stretched the two neuroscientists in unfamiliar directions. "I find myself doing a lot of computer science these days," Chukoskie says. They are also fledgling entrepreneurs. Last year, they launched a startup, **BrainLeap Technologies**, also based in San Diego. That step, Chukoskie says, filled her with a mix of unenthusiastic "eh" and dread-filled "ugh." Despite their discomfort, these two scientists are part of a growing cadre braving video-game development in search of novel therapies for autism.

The idea has obvious appeal: Boys with autism **spend almost twice as much time** playing video games as typical boys do. And many common game features — including predefined 'roles' and

goals, and a repetitiveness between levels — seem to mesh well with autism traits, such as social difficulties and a preference for routine, says **Micah Mazurek**, associate professor of education at the University of Virginia in Charlottesville. “If we are finding that kids with autism are especially drawn to technology,” Mazurek says, “why not try to leverage that interest to design interventions?”

One reason not to is that some ‘serious games’ — those designed for purposes other than mere entertainment, such as imparting practical skills — have drawn serious criticism, or worse. For example, the U.S. Federal Trade Commission slapped a **$2 million fine** on San Francisco, California-based Lumos Labs in 2016 for **falsely advertising** “that training with the Lumosity Program reduces cognitive impairment associated with health conditions.” Another barrier is that the gaming industry works with bigger budgets and faster timelines than research labs typically do, making it difficult for the latter to be competitive. Some researchers, such as Townsend and Chukoskie, have taken the entrepreneurial route anyway, but others have sought partnerships with game developers or treat their explorations as a purely academic exercise.

Over the past year, several small pilot studies have produced promising results for games designed to help children with autism, showing that they may improve a range of abilities — including balance, attention and gaze control. The creators of those games are working to prove that those gains persist and translate into real-life benefits. In gaming lingo, they are trying to ‘level up.’

If they succeed, it would be a welcome change to the current state of play. A directory compiled by the advocacy organization Autism Speaks lists **more than 700 apps, games** and other digital resources intended for people with autism or their families, but only around 5 percent of those have scientific data backing their effectiveness.

“My wife and I have downloaded apps, some of them free, some of them 99 cents, that are really professing to be for kids on the spectrum — and there’s nothing there of any substance,” says **Erik Linstead**, assistant professor of computer science at Chapman University in Orange, California. Linstead says he became interested in building games and other **digital resources for autism** when his daughter was diagnosed with the condition in 2012. He has since created several applications. “People know, especially with [autism], that parents are desperate to do anything they can to help their kids, and so they label these things as assistive technologies for autism or whatever,” he says. But often, “they’re poorly built; they’re poorly maintained.”

Level 1: Gamify

The power of gamification resonates with **James Tanaka**, a cognitive psychologist at the University of Victoria in Canada. In the mid-2000s, Tanaka helped develop a series of seven ‘mini-games’ aimed at helping children with autism recognize faces and interpret expressions. Designing games wasn’t the initial plan, Tanaka recalls, but he and his collaborators learned to modify their approach. “If you want an effective intervention, you’d better gamify it; you’d better make it fun for kids,” he says.

The series they developed — called “Let’s Face It!” — was one of the first games for autism to show improvements in a randomized controlled trial, and is still influential in the field. In the trial, 42 children with autism who played the games for 20 hours got **better at recognizing facial expressions** and at related tasks. But the research world can move slowly, and years passed between the game’s development and publication of its clinical trial results — during which time its aesthetic, user interface and system requirements had significantly aged by industry standards.

Tanaka has continued to work on video games to help people with autism, including an **iPad app spinoff of “Let’s Face It!”** and a “Pac-Man”-inspired game to teach children with autism to **make facial expressions**, potentially easing their **characteristic flat affect**. But his ambitions in this realm are modest. To make a game or app for autism that really succeeds in the market, he says, “you really have to have the resources; you really have to know what you’re doing.”

Fast-paced advances in technology are helping to fill in some of the financial and knowledge gaps. Since Tanaka’s first efforts, game design has become quicker and cheaper, in part thanks to open-source software. More sophisticated gaming systems have also opened up possibilities. For the RAD Lab, the tipping point in the move into video games came with the availability of affordable, consumer-grade **eye trackers** around five years ago. The gaming industry wanted to incorporate eye-trackers into virtual-reality headsets. Townsend and Chukoskie saw a chance to track and train children’s attention.

Townsend’s work over three decades has focused on problems with attention. She has documented how people with autism **often have trouble shifting their attention** — for example, moving their gaze to a new object. They also struggle to make rapid eye movements, known as saccades, as smoothly and accurately as typical people do. “Obviously, that interferes massively with social interactions, which are very dynamic,” Townsend says. If your eye jumps to the wrong place at the wrong time, you are liable to miss subtle social cues.

The team created three games to enhance a child’s ability to control eye movements, including saccades. In a digital version of a classic carnival game, players of “Mole Whack” smack down cartoon animals with a glance. They also have to avoid moles wearing glasses, to hone a skill called inhibitory control. As players advance through the game, the moles move faster and emerge from multiple directions, calling for more rapid and flexible eye movements. In another game, “Shroom Digger,” players blow up trippy mushroom-shaped houses by staring at them, strengthening the ability to hold a gaze steady. And in “Space Race,” players guide a spaceship

through a series of gates to build fast gaze-shifting and other skills. “We’re training control of eye movement, which trains control of attention,” Townsend says.

Other researchers are creating video games that make use of Nintendo Wii Fit boards, designed for use with exercise programs. Balance problems are common in people with autism, and can make daily skills such as dressing challenging. **Trouble with balance and other motor skills** often coincides with poor social skills and **repetitive behaviors**, although the cause-and-effect relationships between these observations are not clear, says **Brittany Travers**, assistant professor of kinesiology at the University of Wisconsin-Madison.

Travers is developing a “Ninja Training” game, in which children practice six poses inspired by yoga and tai chi on a Wii Fit board. Silhouettes of the child and the pose appear on an attached screen, and dots light up red when a part of the child’s body moves out of the correct position, providing immediate feedback. If the child holds the pose for a specified number of seconds, a new background scene — a tree or mountain peak — appears. The player advances to higher ninja levels by holding poses for longer periods of time.

The increasing accessibility of technology for augmented and virtual reality means that researchers might be able to train even complex social behaviors through gaming, Linstead says. For instance, these systems could allow for simulating whole interactions, such as what might take place in a behavioral therapy session. One of Linstead’s projects, “Bob’s Fish Shop,” is a virtual reality game in which players maintain an aquarium by interacting with the owner of a pet store, responding to his queries, interpreting his gestures and following his gaze to build joint-attention skills.

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Level 2: Achieve ‘transfer’

Nearly anyone who plays a video game will get better at playing that particular game with enough practice. Play the RAD Lab’s “Mole Whack” and, at first, sure, not whacking the bespectacled moles is difficult. But things shift after just a few minutes. The moles move faster, and some parachute down from the top of the screen, but you stay cool: You’ve got this.

The trick, however, is whether getting better at playing the game ‘transfers’ to any sort of real-life benefit. It’s the level at which Lumosity nearly hit ‘game over.’

Chukoskie believes the RAD Lab’s games will avoid the same pitfalls because they use eye-

tracking technology to connect directly to a player's physiology. "You interface with the game," she says. "So you're not just playing a game, but you're modifying the game on the basis of your performance — in our case, with gaze." That approach, part of a nascent movement called 'neurogaming,' should ease the transfer to real-life skills.

In a **small pilot study published this year**, eight adolescents with autism played "Mole Whack," "Shroom Digger" and "Space Race" for 30 minutes a day, five times a week over eight weeks. At the end of that period, the six who completed the study improved their scores on well-established tests of attention, gaze control or both. To gauge whether those gains led to benefits in daily-living skills, the researchers also surveyed the children's parents, who reported seeing more general improvements in attention. The researchers are following up these results with a larger study.

Travers and her team have also found preliminary evidence of real-life benefits. They tested their ninja game in 29 children and adolescents with autism, who came to the lab three times a week for six weeks to play the game for an hour. The players who made the most progress in the game also showed the greatest **improvements in their balance**, the team reported in January. The researchers are assessing whether the players also improve their posture and balance while getting dressed. And they are scanning the players' brains to see whether the game alters the players' brain structure.

For most autism video games under development, the results of studies so far provide only indirect or subjective evidence for the games' effectiveness. Here again, though, technology could provide a solution. Chukoskie and Townsend are experimenting with eye-tracking glasses, which might reveal how a person's visual attention shifts during a real-life social interaction. They are also trying to gamify some of the in-lab assessments, in the hopes that having them embedded in the game suite might provide objective measures enabling schools and parents to track children's progress.

Level 3: Account for autism

The scientists designing video games for autism need to walk a fine line: Make the games compelling, but not too compelling. Every 20 minutes a child spends playing a game is 20 minutes spent not engaging in social interactions. The temptation to stay in the virtual world may be particularly intense for people with autism. Mazurek has found that adults with autism are more **prone to compulsive video-game use** than their typical peers.

Autism presents other barriers to the success of these game-based approaches. Travers observed

that some children who had a Wii system at home had developed rituals around gaming — such as idiosyncratic ways of holding the remote — that got in the way of playing the “Ninja Training” game. In the pilot study of the RAD Lab games, two of the original eight participants had to drop out: One teenager decided to take apart and tinker with the gaming system; the other child became so anxious about playing for the requisite number of minutes that he began getting up at 5 a.m. every day to get a head start.

Akili Interactive, a software company based in Boston, is trying to mitigate these complications by framing their product, called “Project: EVO,” as a training program rather than a game. “It’s designed to feel like it and to have the graphics at the level of a video game,” says **Elysa Marco**, a pediatric neurologist at the University of California, San Francisco, who has worked with Akili to validate the program. “But it’s not timed and rewarded in that way.” The pace of play and the timing of the rewards are carefully calibrated to keep children engaged but not addicted, Marco says.

“Project: EVO”— based on technology licensed from neuroscientist **Adam Gazzaley**’s lab at the University of California, San Francisco — aims to improve various aspects of attention, especially cognitive control, or the ability to juggle different tasks and ignore irrelevant information. This ability is often impaired in children with autism or attention deficit hyperactivity disorder (ADHD). The program consists of four different worlds, or mini-games, each featuring a human-like creature called an Akili. In one world, the Akili rides an ice floe along a river. Players tilt a tablet device back and forth to steer the floe, avoiding icebergs and icy walls on either side. They also have to tap the screen to catch red fish, but ignore blue and green ones.

Preliminary studies suggest the program can benefit **children with ADHD,** as well as those with **sensory processing disorder**. A study presented at the annual meeting of the **International Society for Autism Research** in May provided the first test of the intervention in autism. Of the 19 children with autism plus attention problems, 11 used “Project: EVO” for 30 minutes a day five times a week, and 8 controls used a vocabulary and spelling iPad app instead. At the end of four weeks, only the “Project: EVO” group’s scores on a standard test of attention improved.

Akili has also been evaluating whether the sights and sounds of “Project: EVO” trigger children with sensory sensitivities. And they are testing whether the dexterity required is difficult for people on the spectrum who have motor or coordination problems. Based on their preliminary findings, Akili adjusted the pacing of the game so that children reach difficult levels more gradually, and gave children more control over the volume. “There’s little, subtle things there that [game developers] might want to think about,” says **Benjamin Yerys**, a child psychologist at the Children’s Hospital of Philadelphia, who coordinated the autism trial. Yerys’ team has plans for a larger clinical trial of the app in children with autism and ADHD.

Ultimately, Akili hopes to gain U.S. Food and Drug Administration (FDA) approval of its product for attention problems, including those seen in children with autism. “Going down that FDA-approval

pathway really helps everybody think about it as a therapeutic modality," Marco says. In her clinical practice, she introduces cognitive training, either with "Project: EVO" or other approaches, after addressing any issues with a child's environment, diet, sleep and exercise, but before prescribing medications.

"Games support mastery, exploration — they're safe ways to try out things." Leanne Chukoskie

Level 4: Immersive world

In addition to their therapeutic potential, video games designed for people on the spectrum may hold other benefits. "Games support mastery, exploration — they're safe ways to try out things," Chukoskie says. "So many of our kids experience a lot of failure." Getting really good at playing a video game can be an antidote to difficulties in school and trouble making friends.

Earlier this month, the lab's internship program itself levelled up to host 25 college-age students with autism, each for up to 10 weeks. The aim is to have the interns receive career counseling and mentorship, and work on programming and art for the next version of the game suite. In this way, the program functions almost as a real-world analog to a video game — a safe and supportive space for young adults to learn the unwritten rules of the workplace, and master skills such as delivering criticism constructively or switching quickly between different projects.

Townsend has long hired young adults with autism to help out in the lab, but she says video games are "kind of an ideal project. A lot of these young people program already."

Baramki-Azar has been working in the lab for two days a week since October and upped his commitment to 20 hours a week this month. He was diagnosed with autism in elementary school, and he says his biggest challenge is that he has a tough time advocating for himself. "It kind of caused me to do not so well in some classes because I just wouldn't talk to the teacher," he says.

But he spoke up for a chance to work on the RAD Lab's games. Baramki-Azar is an avid gamer who has played "Super Smash Bros." at local tournaments and is currently hooked on "Minecraft," "Tetris" and "Dance Dance Revolution." After seeing Chukoskie give a talk on her work at a local science museum, he marched right up to her and asked to be part of the program. He says he was intrigued by the idea of using video games to gather research data: "You might be able to get better results just because it's not really boring."

Chukoskie met a lot of young adults like Baramki-Azar during the pilot study. Many weren't working or in school, and she realized they might be part of the solution to the lab's programming

woes. “There are these really smart people who are engaging our games; they’re giving me feedback,” she says. “Why are these people not plugged in?” The pilot-study dropout who tried to take apart the gaming system? Chukoskie laughs, “We should have hired him.”