



METAARI

Advanced Learning Technology Research

2017 Overview of Digital Cognitive Learning Products

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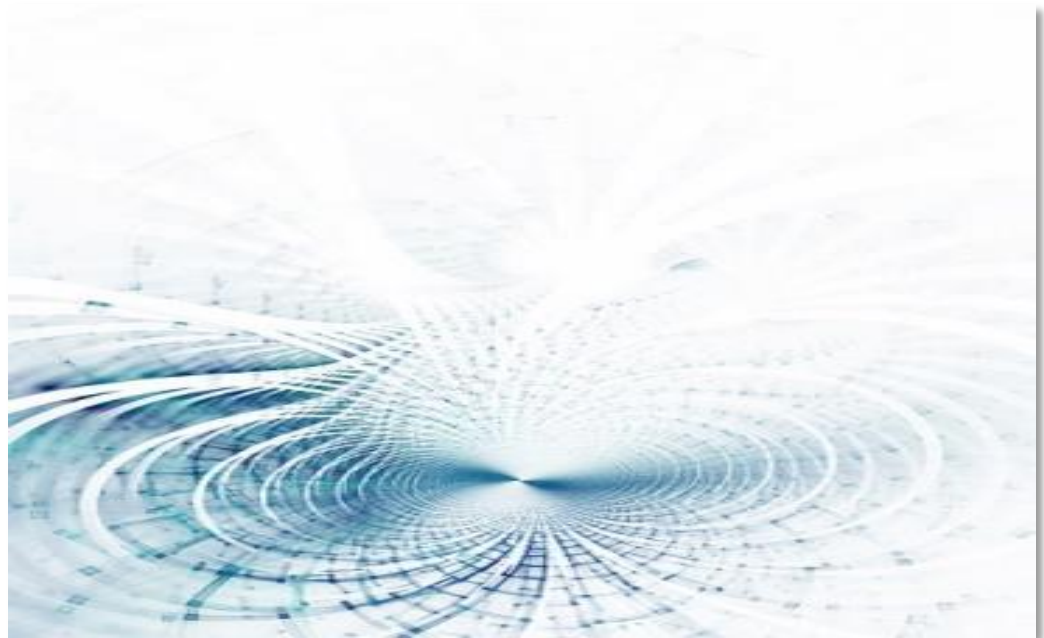


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About Metaari

Metaari (formerly Ambient Insight) is an ethics-based quantitative market research firm that identifies revenue opportunities for advanced learning technology suppliers.

Metaari publishes quantitative syndicated reports that break out revenues by customer segment (demand-side analysis) and by product category (supply-side analysis). Our forecasts are based on our industry-leading learning technology taxonomy and our Evidence-based Research Methodology (ERM).

We track the learning technology markets in 122 countries. We have the most complete view of the international learning technology market in the industry.

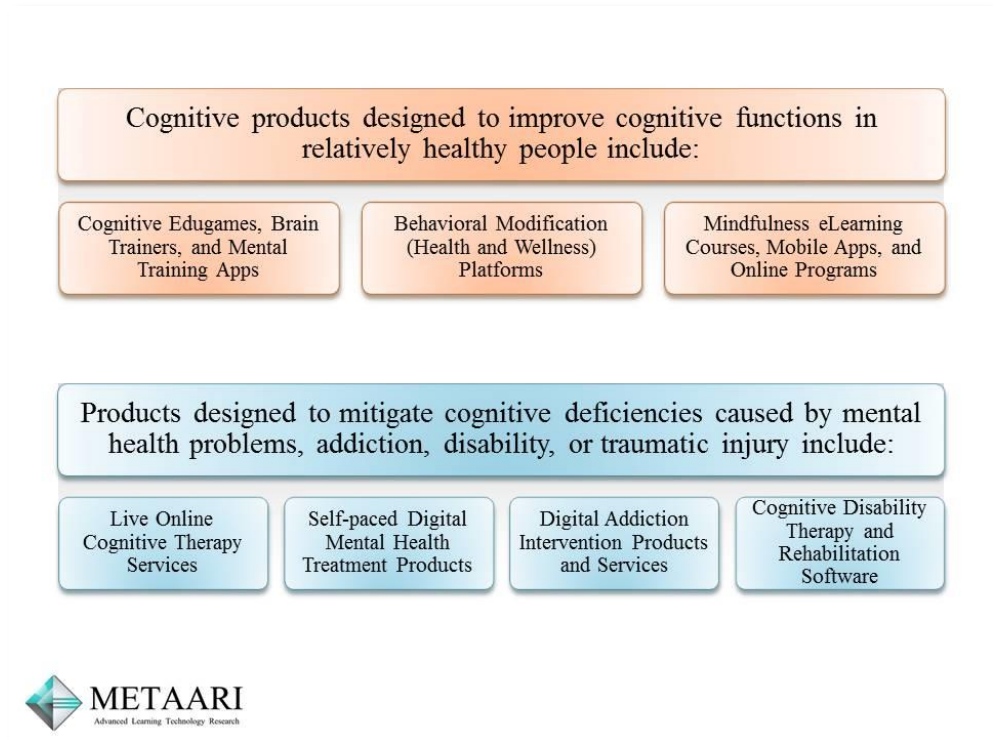
Metaari focusses solely on advanced learning technology research on products that utilize psychometrics, game mechanics, robotics, cognitive computing, artificial intelligence, virtual reality, and augmented reality.



What is Cognitive Learning?

In general, Digital Cognitive Learning products can be divided into two broad categories: products designed to improve cognitive functions in relatively healthy people and products designed to mitigate cognitive deficiencies caused by mental health problems, addiction, disability, or traumatic injury.

Figure 1 - Digital Cognitive Learning Product Types Grouped in Two Broad Categories



Cognitive edugames, brain training, and mental training products are designed to change or modify cognitive abilities. Webster's Dictionary defines learning as "a modification of a behavioral tendency by experience. Learning is demonstrated by a change in behavior."

The products are designed to improve or enhance perception, working memory, comprehension, emotional states, decision making, fluid intelligence (general problem solving), and reasoning.

They are meta-cognition products that enable users to modify cognitive behavior (learn) by understanding and manipulating the learning process itself. Meta-cognition was defined by the educational psychologist John W. Santrock in 2008 as the information process that, "includes

knowledge about when and where to use particular strategies for learning or for problem solving."

The barriers-to-entry for new brain training companies are now quite high as very sophisticated products continue to come on the market. These new products integrate cutting-edge neuroscience and biotechnology. Many of the therapeutic products have been developed in partnerships with clinical specialists and those products tend to command high price points.

The new mental training apps for athletes are based on sports psychology, a highly specialized discipline, and the new mental training app companies are integrating neuroscience into the apps.

Brain trainer developers are increasingly using augmented reality (AR) and virtual reality (VR) technology in their products, which requires a specific set of developer skills.

The new cognitive learning products that utilize artificial intelligence platforms such as the cognitive computing platform IBM Watson are fundamentally new types of learning technologies that require a completely different set of developer skills compared to legacy products.

Most of the successful commercial game-based brain training products target specific cognitive abilities with well-designed tasks empirically proven to improve those abilities. It is now very difficult to compete in the market without psychometrically sound feature sets.

Cognitive Learning products incorporate structured tasks designed to improve cognitive functioning such as memory, processing speed, attention, language, or executive function in healthy people and patients that have impaired cognitive abilities brought on by disability or injury.

The foundation of modern Cognitive Learning concepts and implementations is the scientific evidence of the brain's plasticity, also known as neuro-plasticity. Neuro-plasticity is defined as the brain's ability to reorganize itself by forming new neural connections throughout life.

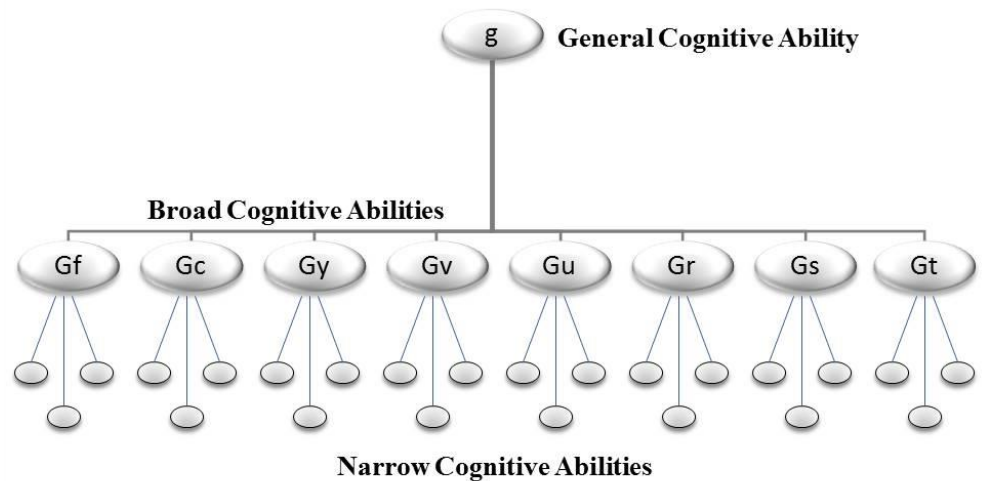
According to Posit Science's BrainHQ, "Brain plasticity is the brain's ability to change—physically, functionally, and chemically—throughout life. It is also the basis of our clinically proven Cognitive Learning exercises."

All digital Cognitive Learning products have integrated psychometric-based feature sets designed to modify behavior at the cognitive level. One of the most widely accepted models for categorizing cognitive abilities and intellectual processes in cognitive research is Carroll's Three-Stratum Theory of Intelligence.

The Cognitive Spectrum: Carroll's Three-Stratum Theory of Intelligence

Carroll's Three-Stratum Theory of Intelligence posits three levels of cognitive abilities: general intelligence, broad cognitive abilities, and narrow cognitive abilities. The products identified in this report map to one or more of the broad cognitive abilities.

Figure 2 - Carroll's Three-Stratum Theory of Intelligence



Carroll's framework is essentially a product classification and instructional model that developers use to design psychometrically sound products.



According to Carroll, "The three-stratum theory of cognitive abilities is an expansion and extension of previous theories. It proposes that there are a fairly large number of distinct individual differences in cognitive ability, and that the relationships among them can be derived by classifying them into three different strata: stratum I, 'narrow' abilities; stratum II, 'broad abilities; and stratum III, consisting of a single 'general' ability."

Cognition and intelligence are highly intertwined. Carroll wrote that, "To construct a theory of intelligence is to construct a theory of cognition."

General intelligence (g) is often called the "the g Factor". The g Factor is a psychometric model of intelligence. It is "a construct developed in psychometric investigations of cognitive abilities and human intelligence."

Carroll's Three-Stratum Theory of Intelligence identifies eight broad cognitive abilities. There are specialized clinical assessments that can measure each of these broad cognitive abilities and there are so-called cross-battery assessments (XBA) that measure multiple abilities in a single test.

Some Cognitive Training products are designed to improve specific broad cognitive abilities. Most Cognitive Learning products target multiple broad cognitive abilities, and are, by definition, cross battery.

For example, Posit Science sells a brain training program called BrainHQ. "BrainHQ has 29 online exercises that work out attention, brain speed, memory, people skills, navigation, and intelligence."

The two most widely researched broad cognitive abilities are fluid intelligence and crystallized intelligence developed by Raymond Cattell and later incorporated into Carroll's model. Cattell believed that crystallized intelligence interacts with fluid intelligence.

- Fluid intelligence (Gf) refers to quantitative reasoning, mental processing ability, adaptability to new environments, and problem solving ability in novel situations. Gf is based on physiological efficiency and is relatively independent of education and acculturation.
- Crystallized intelligence (Gc) refers to the accumulation of general, procedural, and declarative knowledge . Gc involves tests of knowledge, the storage of general information, the use of language, and a wide variety of acquired skills. Gc is directly related to personality, education, and cultural contexts.

Neuroscientists maintain that crystallized intelligence increases with age and that fluid processing peaks in late adolescence (and then steadily declines with age). The researchers also have scientific evidence that the decline in fluid processing can be reversed with specific mental exercises.

It should come as no surprise that many Cognitive Training products are designed to improve fluid intelligence in older adults. Recent research from Susanne M. Jaeggi has provided empirical evidence that training on working memory can improve fluid intelligence. Source: *"Improving fluid intelligence with training on working memory: a meta-analysis"* (2015) and *"How to build better memory training games"* (2015).

There are Digital Cognitive Learning products that map to the other broad capabilities identified by Carroll:

- General memory and learning (Gy) is the ability to comprehend and maintain awareness of a limited set of information in the immediate situation (events that occurred in the last minute or so.) Many of the mobile early childhood learning apps in the commercial app stores are designed to improve Gy abilities. Two good examples are Fruit Memory Match Game and Crazy Copy.
- Short-Term Memory (Gs) is the ability to understand and retain information in immediate awareness and then use it within a short time frame of a few minutes. Most commercial brain trainers incorporate Gs exercises. Mobile memory games for young children are common in all the app stores.
- Visual Processing (Gv) is the cognitive ability to distinguish, evaluate, and mentally manipulate visual patterns, including the ability to store and recall visual patterns. There are dozens of companies that specialize in visual processing improvement products. An interesting mobile app is Vismory. "Memorize the shape, color, and position of small beautifully crafted 3D objects, then answer challenges by touching the correct case and you win!"
- Reading & Writing Ability (Gr) includes basic reading and writing skills. Rosetta Stone's Lexia Learning and Scientific Learning's Fast ForWord products are Cognitive Training products designed to improve Gr. Scientific Learning describes their Fast ForWord product as "Fast ForWord does what no other intervention can do: it starts with cognitive skills like memory, attention and processing speed and works from the bottom up, using the principles of neuroplasticity."
- Broad Auditory Processing (Gu) is the cognitive ability to evaluate and distinguish auditory signals. Advanced Brain Technologies sells music-based brain training products

designed to improve Gu. "Our products, including The Listening Program, inTime, Sleep Genius, TAVS, and the Waves System. Acoustically-tuned music, like that found in The Listening Program, has been proven to help children and adults improve their focus, learning, listening and communication skills."

- Decision/Reaction Time/Speed (Gt) is the cognitive ability of reacting to sensory input as measured in seconds or fractions of seconds. This is not to be confused with Gs, which typically is measured in intervals of 2–3 minutes.

A company called i3 Mindware sells a Cognitive Training product that uses dual n-back training to train processing speed. The n-back method is a continuous performance task that commonly used as an assessment in cognitive neuroscience to measure working memory capacity.

"N-back is a memory test where 'n' refers on how many previous stimuli must be remembered. 'Dual' means that verbal auditory stimulus and spatial visual stimulus are presented at the same time."

Susanne M. Jaeggi is the researcher that found empirical evidence for the effectiveness of brain trainers that use the dual n-back process. As of February 2017, there are dozens of brain trainers on the market that use the n-back method.

The majority of these cognitive edugames are mobile apps. Many are free that offer additional fee-based premium content or in-app purchases. BrainScale.net provides a free brain trainer based on the n-back method and sells subscription-based premium upgrades for \$2.99 a month or \$14.99 a year.

In educational psychology, there are two phases of the learning process; knowledge transfer and learning transfer. Knowledge transfer is the transmission of information and skills to the learner. Learning transfer is the ability of the learner to demonstrate mastery in a real world setting.

Next-generation products (particularly those based on artificial intelligence) effectively accomplish both phases simultaneously and are dramatically more effective than legacy eLearning products.

The foundation of all Cognitive Learning methods is brain plasticity. Modern research has produced empirical evidence that the brain will

create new neural connections with targeted stimulus and Cognitive Behavior Therapy (CBT).

This targeted intervention can improve cognitive abilities in relatively healthy people and is quite effective (in terms of patient outcomes) in treating cognitive disorders, mental health problems, and addictive behavior.

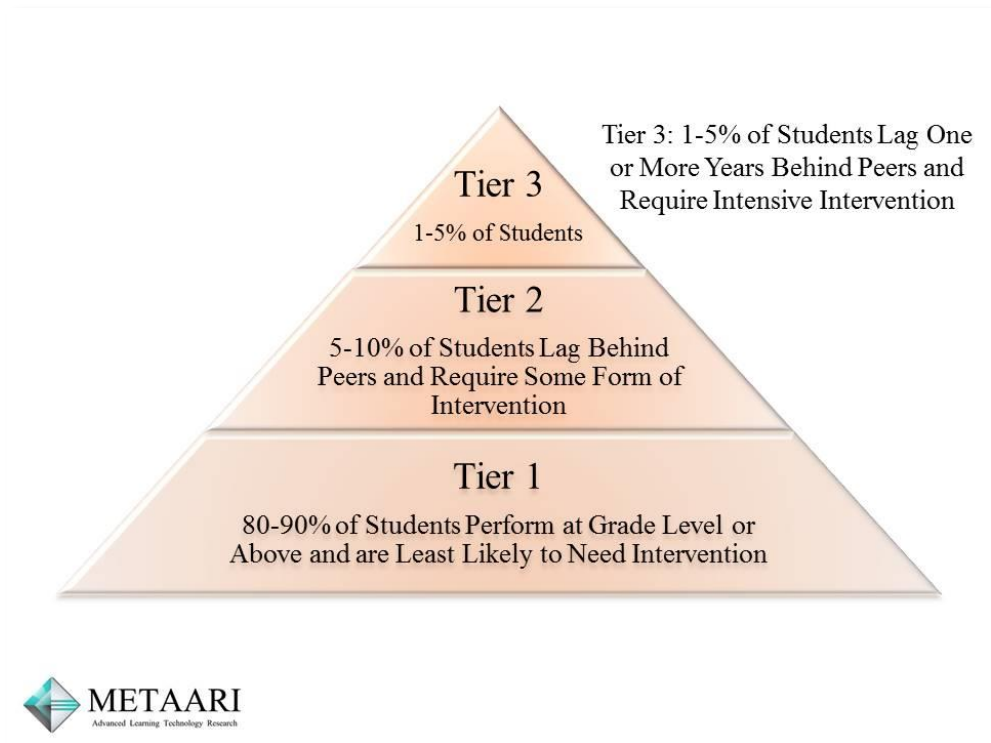
The Response to Intervention (RTI) Model

A common behavior modification process used in the PreK-12 schools is called Response to Intervention, or RTI. It was essentially mandated in the Individuals with Disabilities Education Act (IDEA) that passed in 2006.

The model was originally developed to identify students with learning disabilities, but is now used on a much broader scale and is now being used to identify gifted children as well.

The RTI model is an instructional framework that provides developers with precise design criteria and enables suppliers to create specialized products for the higher tiers, which are comprised of children with special needs.

Figure 3 - Three-tiered Response to Intervention (RTI) Model



The RTI is a three-tiered model. The first tier is general instruction at the classroom level and accounts for the vast amount of students attending

schools. The first tier is often referred to as the universal or benchmark level.

The second tier includes 5-10% of students that are struggling with specific subjects such as math or reading. Tier 2 interventions are usually small groups of students. Students with moderate learning disabilities fall into this tier. The second tier is referred to as the targeted or strategic level.

The third tier screening is used to determine eligibility for special education programs and intervention is provided at the individual level. The third tier is also called the intensive level. Cognitive intervention products designed for Tier 3 are highly specialized.

Most companies that serve the PreK-12 segment sell products that map to the RTI model. For example, Odysseyware sells a product that provides targeted instruction and personalized learning paths for the higher tiers. The reading interventions from Rosetta Stone (Lexia) and Scientific Learning (Fast ForWord) are designed for students in the second tier.

All the major educational publishers have products designed for RTI. Pearson has a comprehensive bundle of tools and educational content that map to the RTI model. McGraw-Hill's ALEKS product is specifically designed for the RTI. Carnegie Learning's MATHia and Cognitive Tutor are used to intervene in the upper tiers.

The Fourth Tier: Special Needs, English Language Learners, and Gifted Children

Educational researchers have proposed a fourth tier for the RTI model to identify the intervention levels needed for three cohorts: children with special needs (special education), English language learners (ELLs), and gifted students. Each cohort requires highly-specialized instructional interventions.

According to the US government's National Center for Education Statistics (NCES), "In 2013–14, the number of children and youth ages 3–21 receiving special education services was 6.5 million, or about 13 percent of all public school students. Among students receiving special education services, 35 percent had specific learning disabilities." Of the 6.5 million students, 21% had a speech or language impairment and 8% were diagnosed along the autism spectrum.

According to NCES, 9.3% (or 4.5 million students) were classified as English language learners in the 2013-2014 school year. Of these 4.5 million students, 76.5% spoke Spanish as their first language. It is essentially the only viable revenue opportunity for suppliers since no other language was spoken by more than 2.2% (Chinese).

The National Association for Gifted Children (NAGC) estimates that 6-10% of all schools children in the US can be categorized as gifted. There is no universal definition of so-called giftedness.

The NAGC provides this definition: "Gifted individuals are those who demonstrate outstanding levels of aptitude (defined as an exceptional ability to reason and learn) or competence (documented performance or achievement in top 10% or rarer) in one or more domains. Domains include any structured area of activity with its own symbol system (e.g., mathematics, music, language) and/or set of sensorimotor skills (e.g., painting, dance, and sports)."

The Demographics are Huge

According to the National Institute of Mental Health (NIMH), "Our best estimate of the number of adults with any diagnosable mental disorder within the past year is nearly 1 in 5, or roughly 46 million Americans. Although most of these conditions are not disabling, nearly 10 million American adults (1 in 25) have serious functional impairment due to a mental illness, such as a psychotic or serious mood or anxiety disorder. Fully 20 percent—1 in 5—of children ages 13-18 (24 million people) currently have and/or previously had a seriously debilitating mental disorder."

- The NIMH reports that, "Anxiety disorders are the most common mental illness in the U.S., affecting 40 million adults in the United States age 18 and older, or 18% of the population."
- According to the Anxiety and Depression Association of America (ADAA) "Anxiety disorders develop from a complex set of risk factors, including genetics, brain chemistry, personality, and life events."

According to the American Psychological Association (APA), 20% of Americans are experiencing stress levels that are extreme (8-10 on a 10-point scale).

The US demographics for the next-generation Cognitive Fitness products are massive.

In any given year, 3.6% of US adults aged 18 to 54 (5.2 million people) have Posttraumatic stress disorder (PTSD). PTSD is not limited to military veterans. The disorder is caused by severe psychological or physical trauma.

There are over 40 million adults in the US that have dyslexia. At least 20% of all school age children in the US have dyslexia according to the American Dyslexia Association. That is 11 million children.

According to the Autism Society, over 3.5 million people in the US live with an autism spectrum disorder. Autism is characterized by "persistent deficits in social communication and interaction across multiple contexts, as well as restricted, repetitive patterns of behavior, interests, or activities. These deficits are present in early childhood, and lead to clinically significant functional impairment."

The US Surgeon General released a report in November 2016. The report stated that "more than 27 million Americans currently use illicit drugs or misuse prescription meds like painkillers." Digital addiction intervention product revenues are forecast in this report. The growth rate for these products is 20.5% and revenues will more than double by 2022.

Mindfulness apps are one of the seven Cognitive Learning products forecast in this report. A survey by Fidelity Investments and the National Business Group on Health, found that 22% of employers offer mindfulness and meditation to employees.

Mindfulness apps are generally based on meditation and yoga techniques. An estimated 36 million people practice yoga in the U.S., up 44% from 2012, and another 80 million Americans will at least try yoga in 2017, according to a study by the Yoga Journal and the Yoga Alliance.

According to the HHS, people aged 65 and over accounted for 14.5% of the population in 2014, or more than 46 million people. The HHS expects this to grow to 17% by 2020 and 21.7% of the population by 2040. It should come as no surprise that many brain trainer companies market heavily to the older demographics.

Second and third-generation brain trainer and brain fitness games in the 2017 market are based on cognitive science, neuropsychology, and brain-based learning theories emerging from educational psychology and educational neuroscience. It is an instructional method that targets the

The US Department of Health and Human Services (HHS) reports that 7.7% of children in the US between the ages of 3 and 17 have some form of voice, speech, or language disorder. That is five million children.

neuro-physiological processes involved in learning and has little in common with traditional instructional design principles.

Empirical Evidence on the Effectiveness of Brain Training Products

Researchers and suppliers have a growing body of empirical evidence proving that people who use Brain Training products can condition the brain to improve memory, attention, visual and spatial awareness, auditory processing, linguistic skills, planning skills, and problem solving.

In June 2016, three neuroscientists won the one million dollar 2016 Kavli Prize in Neuroscience. The Kavli Prize is a partnership between the Norwegian Academy of Science and Letters, the Kavli Foundation (US), and The Norwegian Ministry of Education and Research. Michael Merzenich of the University of California, Carla Shatz of Stanford, and Eve Marder of Brandeis were honored for discovering “mechanisms that allow experience and neural activity to remodel brain function.”

According to the Kavli Foundation, "The Kavli Prize in Neuroscience is awarded for outstanding achievement in advancing our knowledge and understanding of the brain and nervous system, including molecular neuroscience, cellular neuroscience, systems neuroscience, neurogenetics, developmental neuroscience, cognitive neuroscience, computational neuroscience and related facets of the brain and nervous system."

Michael Merzenich is one of the founders of Scientific Learning, a company that develops cognitive intervention products for children. They sell to the schools, directly to parents, and to clinical buyers. Scientific Learning products have been tested in rigorous scientific studies and their site lists hundreds of these studies. "Merzenich has been awarded more than 50 patents and has contributed his software development skills to several therapeutic training programs."

Merzenich is a Professor Emeritus in Neuroscience at the University of California, San Francisco. He is also the Chief Scientific Officer of Posit Science, the developer of the popular BrainHQ product. Their site lists over 100 studies that provide evidence for the effectiveness of their brain training products. "Our exercises and assessments have been rigorously tested and scientifically proven to be beneficial in more than 100

independent, peer-reviewed research papers published in scientific journals."

The American Journal of Psychiatry published the results of a study in November 2016 called "*Computerized Cognitive Training in Older Adults With Mild Cognitive Impairment or Dementia: A Systematic Review and Meta-Analysis*". Dr. Amit Lampit (who led the study) said the results showed brain training could play an important role in helping to prevent dementia. "Our research shows that brain training can maintain or even improve cognitive skills among older people at very high risk of cognitive decline - and it's an inexpensive and safe treatment." The research team performed a meta-analysis in which they combined outcomes from 17 randomized clinical trials including nearly 700 participants.

A meta-analysis study published in Neuro-psychology Review in January 2017 called "*Enhancing Cognitive Functioning in Healthy Older Adults: a Systematic Review of the Clinical Significance of Commercially Available Computerized Cognitive Training in Preventing Cognitive Decline*." The researchers culled empirical studies that included commercial brain training products and then classified them into three levels, with the highest levels indicating empirical evidence of effectiveness. Posit Science and Cognifit came in at the highest level and Pearson's Cogmed, Nintendo's Brain Age, and MyBrainTrainer came in at the second-highest level.

Perhaps the most compelling evidence is the research done by Jaeggi on the use of so-called dual n-back tasks in brain training. The dual n-back tasks require users to process information simultaneously from two different sensory domains. She found that performing dual n-back tasks "accrues transferable benefits in Gf (fluid intelligence), over and above any gains in working memory capacity. This finding merits particular attention because Gf has traditionally been viewed as highly heritable and stable and is positively correlated with a large number of desirable outcomes including academic success, and neurological, psychological and physical health."

Jaeggi's research has been replicated by other researchers. "These findings constitute preliminary evidence that intensive cognitively demanding brain-training can improve not only our abstract problem-solving capacity, but also ameliorate cognitive control processes (e.g. decision-making) in our daily emotive environments" (National Center for Biotechnology).

In a Japanese study conducted in 2013, the researchers found that playing brain training games does improve cognitive abilities. "To evaluate the transfer effects of the commercial brain training game on cognitive functions, we assessed a broad range of cognitive functions (fluid intelligence, executive functions, working memory, short-term memory, attention, processing speed, visual-spatial ability, and reading ability). The present study showed scientific evidence that the brain training game had the beneficial effects on cognitive functions (executive functions, working memory and processing speed)."

In June 2016, MyBrainSolutions released the study results of over 10,000 addiction patients that used their brain health products. Over 350 clinicians participated. "In 2015, data from a patient's baseline assessment to their follow-up assessment at the end of treatment showed that thinking improved by 18%, emotional functioning improved by 31%, and self-regulation improved by 57%."

In July 2016, the results of the ten-year ACTIVE (Advanced Cognitive Training for Independent and Vital Elderly) study on 2,785 people (65 and older) funded by the National Institutes of Health (NIH) provided empirical evidence for the effectiveness of cognitive training. The study found that older adults' risk for dementia was reduced by 48 percent over 10 years when they completed 11 or more sessions of brain-training. The scientists say this is the first time a cognitive training intervention has been shown to protect against dementia in a large, randomized, controlled trial."

People in the ACTIVE study were given exercises along three cognitive domains: memory, reasoning, and speed-of-processing abilities. "After 10 years, only the speed-of-processing training had a statistically significant effect on cognition. Participants in this group were 33% less likely than control participants to develop cognitive impairment or dementia." The speed-of-processing exercise was a commercial product called Double Decision from Posit Science.

Leading Indicator: Spike in Private Investment in Cognitive Learning Firms

The presence of concentrated investment activity in specific learning technology types or in products that target particular buying segments indicates that investors are banking on a significant return on their investment in those areas.

Despite the maturity of the market for cognitive edugames, brain trainers, and mental training apps, investors continue to fund new cognitive edugame, brain trainer, and mental training app companies:

- Lumos Labs (Lumosity) has garnered \$67.4 million in private equity since 2008
- ATENTIVmynd Games raised \$8 million in funding in April 2013 and an additional \$3 million in early 2016. They have obtained \$19 million since they launched in 2010
- Berlin-based NeuroNation obtained \$2 million in late 2013
- Berlin-based Memorado raised \$3.3 million in March 2015, on top of the \$1.3 million they obtained in 2014
- London-based Brainbow (acquired by France-based Hachette in December 2016), launched the Peak brain trainer in 2014 and obtained \$7 million in April 2015. Brainbow had obtained a total of \$10.5 million by the time of the acquisition.

In October 2015, US-based Monclarity garnered \$5 million in seed funding for their new brain trainer product called Brainwell. "Designed by a team of neuroscientists, cognitive psychologists, and game designers, Brainwell utilizes an algorithm to create a cognitive exercise regimen. To date, the company has designed over 50 scientifically-backed games."

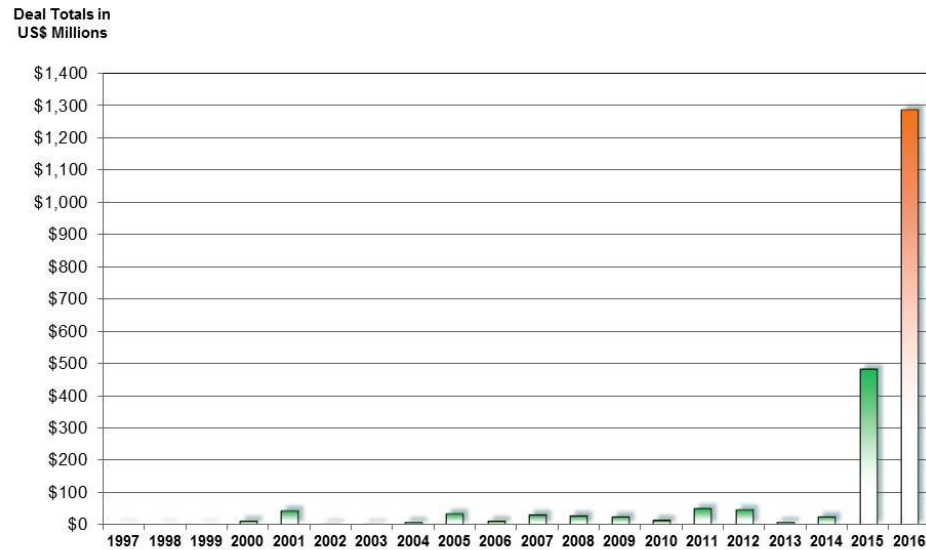
A major investment pattern that appeared in 2015 was the investor interest in next-generation Cognitive Training (behavior modification) companies based on Cognitive Behavior Therapy (CBT, neuroscience, and artificial intelligence).

Investments made to Cognitive Training companies spiked dramatically to \$483.5 million in 2015, up from a mere \$24 million in 2014. There were 52 Cognitive Training companies funded in 2015, up from just eight companies funded in 2014 and the three funded in 2013.

As dramatic as the investment patterns were in 2015, it pales in comparison the investments made to Cognitive Training companies in 2016. ***In 2016, 130 Cognitive Training companies (more than double from 2015) were funded for a breathtaking total of \$1.28 billion in investment.*** Clearly, investors are now interested in this type of learning technology company.

Brainwell has three free games and a subscription model for the full catalog of 50 brain trainers. A one-month subscription is \$9.99 and a six-month subscription is \$69.99.

Figure 4 - 1997 to 2016 Global Investments Made to Cognitive Learning Companies (in US\$ Millions)



Prior to 2000, there were no recorded investments made to Cognitive Training companies. Before the first three quarters of 2015, there was never more than \$50 million invested in commercial Cognitive Training companies in any given year.

Lumos Labs, the developers of the Lumosity brain trainers) garnered \$32.5 million in 2011 and \$31.5 million in 2012, both records for brain training companies at the time.

This record was breached in February 2016 when MindMaze raised \$100 million in funding. "MindMaze has developed a breakthrough platform combining virtual reality (VR), computer graphics, brain imaging, neuroscience and rehabilitation."

Akili Interactive Labs garnered \$30.5 million in investment in January 2016 and another \$11.9 million in July 2016. Their product is quite sophisticated. They develop games that assess the cognitive states of users. Their edugame is being used in clinical trials for attention deficit. "Akili Interactive Labs is a medical device company that makes mobile video games—and not the other way around."