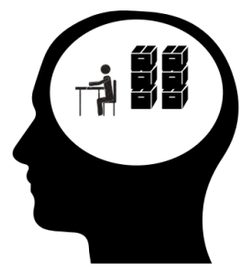
Explainers

Metaphor Mapping

	Battery	Muscle	Car	 Person in brain
Flexibility				x
More Energy / More Potential	x		x	x
Use It Or Lose It		x		x
No Pain, No Gain		x		x

Characters

Part Of Brain	Personality Aspects	Why They’re Important	Metaphor
Hippocampus			
Working Memory			
General Intelligence			

Process

Learning	

- What happens when your brain learns.
- Intelligence
    - IQ vs. general intelligence
    - Where it's fixed or not
- Brain training

    - Types of brain training
    - What works and what doesn't

- What happens to your brain when you do cognitive training.

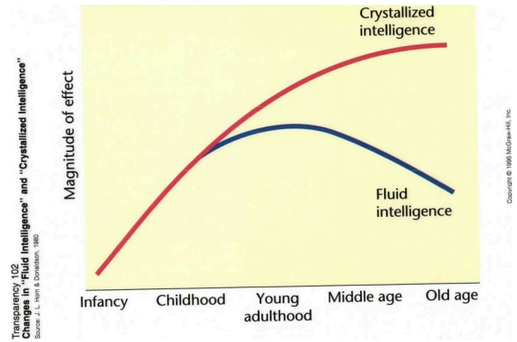
    - Brain Plasticity
    - Hippocampus - Where is it in the brain? How big is it? What does it do? How does learning impact it? What are the implications?

Resource

Resource	Metadata
Intelilgence: A very brief introduciton	

Concepts

Concept	**Worry**	**Hope**	**Angle**

Cognitive Decline			• Your “fluid intelligence” starts dropping in your 20s.  Here are ways to stop the decline and even increase fluid intelligence https://www.learning-mind.com/fluid-intelligence-develop/

Keywords

Keyword		
Intelligence	“We should start by acknowledging there is one system that we all agree is intelligence and that’s the human brain, and maybe some other mammals as well. That is the gold standard, if you will, the defining structure that we are trying to understand. “So then the question is: what does the human brain do that makes intelligence? Intelligence is a methodology of learning in the world. It’s not learning. It’s not a set of knowledge. It’s about a methodology for learning. Our brains use a particular type of learning to discover the structure in the world, and the universe, and in everything we do. It also has particular levels of sophistication. A monkey can be intelligent. A dog can be intelligent. A human can be intelligent. But they all use the same learning methodologies.” - Jeff Hawkins	
Intelligence Augmentation		
Brain Emulation	Sebatian Seung	
Augmented Intelligence		
Thinking		
Intelligence		
Intelligence Amplification		
Extended Mind	**Extended cognition** is the view that mental processes and mind extend beyond the body to include aspects of the environment in which an organism is embedded and the organism's interaction with that environment.[1] Cognition goes beyond the manipulation of symbols to include the emergence of order and structure evolving from active engagement with the world.[2] s described by Mark Rowlands, mental processes are:[3]	

	• **Embodied** involving more than the brain, including a more general involvement of bodily structures and processes. • **Embedded** functioning only in a related external environment. • **Enacted** involving not only neural processes, but also things an organism *does*. • **Extended** into the organism's environment. This contrasts with the view of the mind as a processing center that creates mental representations of reality and uses them to control the body's behaviour. The field of extended cognition focuses upon the processes involved in this creation, and subsumes these processes as part of consciousness. Which is no longer confined to the brain or body, but involves interaction with the environment. At a 'low' level, like motor learning and haptic perception,[4] the body is involved in cognition, but there is a 'high' level where cultural factors play a role.[5][6] This view of cognition is sometimes referred to as '**enaction**' to emphasise the role of interplay between the organism and its environment and the feedback processes involved in developing an awareness of, and a reformation of, the environment.[7] For example Japyassú and Laland argue that some spider's web is something between part of its sensory system and an additional part of its cognitive system.[8]	
Distributed Cognition		
Cognitive Architectures	Although admittedly a category of loose definition, cognitive architectures typically deal with relatively large software systems that have many heterogeneous parts and subcomponents, which operate together to solve general problems and tasks in more than one domain. Many of these architectures are built to control artificial agents, both agents operating in virtual worlds and physical robots acting in the real world. Work within this area displays broad diversity at all levels: underlying theoretical assumptions, inspiration, motivation, requirements, methodology, structure, and technology. Architectures also target a diverse set of cognitive functions, although learning, reasoning, planning, and memory seem to be more common than others.	

Approaches

Approach	Niches	Leaders
Genetic Engineering / Synthetic Biology	• germ line engineering - CRISPR-Cas9	• George Church (Harvard / Regenesis) • Jennifer Doudna (created CRISPR / Author of Crack In Creation) • Juan Enriquez (Evolving Ourselves)

Intelligence Types

Type	Description	
g-factor	The first, proposed by Charles Spearman in 1904, acknowledged that there are different types of intelligence but argued that they are all correlated—if people tend do well on some sections of an IQ test, they tend to do well on all of them, and vice versa. So Spearman argued for a general intelligence factor called "g," which remains controversial to this day.	

Theory Of Multiple Intelligences	Decades later, Harvard psychologist Howard Gardner revised this notion with his Theory of Multiple Intelligences, which set forth eight distinct types of intelligence and claimed that there need be no correlation among them; a person could possess strong emotional intelligence without being gifted analytically.	
Triarchic Theory Of Intelligence	Later in 1985, Robert Sternberg, the former dean of Tufts, put forward his Triarchic Theory of Intelligence, which argued that previous definitions of intelligence are too narrow because they are based solely on intelligences that can be assessed in IQ test. Instead, Sternberg believes types of intelligence are broken down into three subsets: analytic, creative, and practical.	
Emotional Intelligence		
Parieto-Frontal Integration Theory	Conflicts about the nature of intelligence have hampered studies about its neurobiological underpinnings for years. Yet neuroscientists Rex Jung and Richard Haier may have found a way around this impasse. They published a study in 2007 that reviewed 37 different neuro-imaging studies of IQ (each with a different definition of intelligence) in an attempt to locate what parts of the brain were involved. As it turns out, regardless of the definition used, the results were very similar, enough so that they were able to map a network of brain areas associated with increased IQ scores. Known as the Parieto-Frontal Integration Theory, this model has been gaining momentum among neuroscientists. Earlier this year a team of researchers from Caltech, the University of Iowa, and USC surveyed the IQ test results from 241 brain-lesion patients. Comparing the locations of the brain lesion to their scores on the tests, they were able to discover which parts of the brain were associated with different types of intelligence. And their findings were very much in line with this parieto-frontal integration theory.	

Experts

Who	Niche	Highlight	Contact Info

Reardon	Augmented Intelligence	Founder CTRL-Labs	
Bryan Johnson	Augmented Intelligence	• Founder Kernel	
Anupam Rastogi	Augmented Intelligence	• Tech investor and adviser focused on Data/AI, SaaS, Mobility & Marketplaces. Growth catalyst. Tweets Personal • https://www.cbinsights.com/research/ai-vs-intelligence-augmentation-applications/	• https://twitter.com/anupamr
Elon Musk	Augmented Intelligence	• Founder, Neurolink	
Mark Ashton Smith	Dual n-back exercise, working memory	• Researcher • Founder, IQ Mindware	

Levels Of Improvement

Level		**Strategies**
Underlying g		• Dual n-back
Brain Health		• Exercise • Sleep • Nootropics

Other		• Time of Day (ultradian cycle) • People You're Around
		• Neurofeedback Intensive Training • Tdcs
Deliberate practice in the specific area you're trying to focus on.		

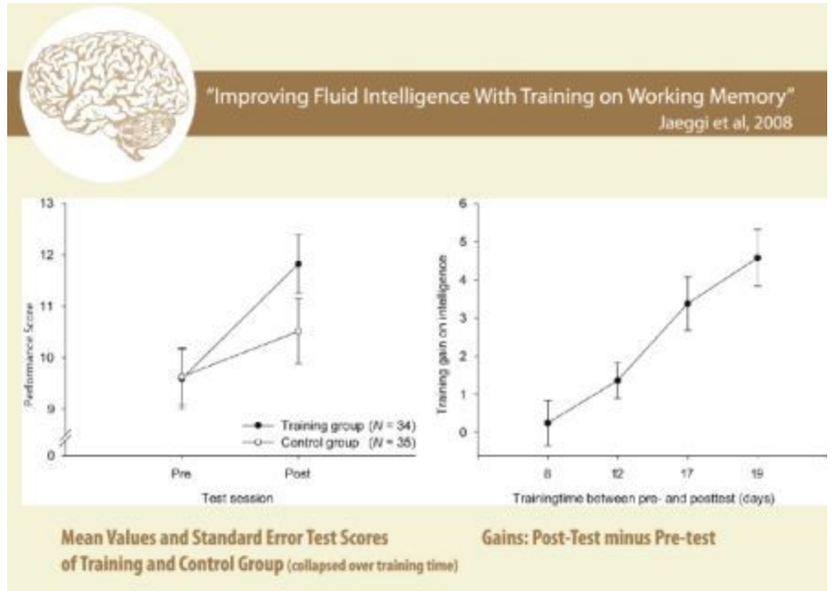
Intelligence +

Motivation + Effort

Proven Strategies For Increasing General Intelligence

Strategy	Description	IQ	Evidence
			DUAL N-BACK META-ANALYSIS

			---- Then in 2008, a very exciting study was published, Improving Fluid Intelligence with Training on Working Memory, by Jaeggi, Buschkuehl, Jonides, and Perrig. This study was pretty much a game-changer for those doing research on this topic. They showed for the first time, that it might actually be possible to increase your intelligence to a significant degree through training. What did they do different? The subjects in Jaeggi's study were trained on an intensive, multimodal (visual and auditory input) working memory task (the dual-n-back) [1] for variable lengths of time, for either one or two weeks, depending on the group. Following this training, they were tested to see how much they improved. As one would expect, after training, their scores on that task got better. But they went a step further. They wanted to see if those gains on the training task could transfer to an increase in skill on a completely different test of cognitive ability, which would indicate an increase in overall cognitive ability. What did they find? Following training of working memory using the dual n-back test, the subjects were indeed able to transfer those gains to a significant improvement in their score on a completely unrelated cognitive task. This was a super-big deal. Here's the graph of their results, and you can read about the entire study here.

			 The take-home points from this research? This study is relevant because they discovered: 1. Fluid intelligence is **trainable**. 2. The training and subsequent gains are dose-dependent—meaning, **the more you train, the more you gain**. 3. **Anyone can increase their cognitive ability**, no matter what your starting point is. 4. The effect can be gained by training on **tasks that don't resemble the test questions**. **How Can I Put This Research To Practical Use For My Own Benefit?**

			There is a reason why the dual n-back task was so successful at increasing cognitive ability. It involves dividing your attention between competing stimuli, multimodal in fashion (one visual, one auditory). It requires you to focus on specific details while ignoring irrelevant information, which helps to improve your working memory over time, gradually increasing your ability to multi-task the information effectively. In addition, the stimulus was constantly switched, so there was never a "training to the test questions" phenomenon—it was always different. If you've never taken the dual n-back test, let me tell you this: It's wicked hard. I'm not surprised there was so much cognitive gain from practicing this activity.
Mind Training	Dual n-back exercise, 30 minutes, 5 days a week	2.4 --- (9.75 from Jaeggi's study)	Working memory training revisited: A multi-level meta-analysis of n-back training studies --- Although the gain in the control groups was also significant, presumably because of retest effects (t(34) = 2.08; P < 0.05; Cohen's d = 0.25), **the improvement in the groups that received the apparent benefit of training was substantially superior** (t(33) = 5.53; P < 0.001; **Cohen's d = 0.65**), which was confirmed by the significant group test-session interaction (F(1,67) = 5.27; P 0.05; = np2 = 0.07). [Improving fluid intelligence with training on working memory: Jaeggi, et al.]
Sleep	Average person needs 7 - 8 hours + optional but recommended power nap (22 min) if needed	5-8	The performance gap caused by an hour's difference in sleep was bigger than the gap between a normal fourth-grader and a normal sixth-grader. Which is another way of saying that a slightly-sleepy sixth-grader will perform in class like a mere

			fourth-grader. “A loss of one hour of sleep is equivalent to [the loss of] two years of cognitive maturation and development,” Sadeh explained. [source] As neuroscientist Dr. Tara Swart tells CNN, disturbances to healthy sleep patterns can cause your IQ to drop by 5 to 8 points, and missing out on just a single night of sleep can reduce your IQ by one standard deviation, or 15 IQ points [source] A brief nap is beneficial for human route-learning: The role of navigation experience and EEG spectral power. The data demonstrates that non-rapid eye movement (NREM) sleep, which occurs during a nap, confers a performance advantage for spatial memory in humans.
Aerobic Exercise	70 min sessions, 3x per week, 4 months Each session consisted of dynamic stretch and light activity warm-up (10 min), intervals of speed and recovery of static walking or running (10 min), high-intensity cardio-resistance training (30 min), whole-body drill and skill training (e.g., battle ropes or sand bags; 10 min), and yoga-inspired flexibility training and static stretching (10 min).	4.2	Multi-modal fitness and cognitive training to enhance fluid intelligence ------ Effect size of fitness = 0.28 In terms of IQ: effect size of 0.28*15IQPoints = 4.2 IQ Points

Fitness+cognitive training	70 min sessions, 3x per week, 4 months Month 1: 12 sessions of fitness training Month 2: 8 sessions of fitness training + 4 sessions of cognitive training Month 3 & 4: 4 sessions of each Total: 28 sessions of fitness training + 20 sessions of cognitive training ------ Fitness training: 70 min total. Each session consisted of dynamic stretch and light activity warm-up (10 min), intervals of speed and recovery of static walking or running (10 min), high-intensity cardio-resistance training (30 min), whole-body drill and skill training (e.g., battle ropes or sand bags; 10 min), and yoga-inspired flexibility training and static stretching (10 min). Cognitive training: 60 min of mind consisting of Mind Frontiers, a suite	8.25	Multi-modal fitness and cognitive training to enhance fluid intelligence Contrary to popular belief, physical exercise or meditation alone are not sufficient in increasing in fluid intelligence and mental processing; rather a multi-modal approach incorporating physical and mental training is recommended. ------ Effect size of fitness + cognitive training on general intelligence = 0.55 In terms of IQ: effect size of 0.55*15IQPoints = 8.25 IQ points ------ From journal overview: • Fitness-cognitive-mindfulness interventions were designed to bolster intelligence. • Fitness-cognitive training showed control-adjusted gains in visuospatial reasoning. • Fitness only training did not bolster fluid intelligence performance. • Individuals varied in benefits to fluid intelligence from mindfulness training.

	of games designed to engage visuospatial working memory, executive functions, and analogical reasoning		
HIIT (High Intensity Interval Training)			
Diet			https://www.foodnavigator.com/Article/2011/02/08/Poor-childhood-diet-linked-to-low-IQ-suggests-study
Nootropics (safest, legal, most researched)	Creatine: 5g creatine supplement daily for six weeks	15	Oral creatine monohydrate supplementation improves brain performance: a double-blind, placebo-controlled, cross-over trial Taking a 5g creatine supplement daily for six weeks improved working memory, intelligence, and mental processing in healthy individuals Two cognitive tests were used: 1. Raven's Advanced Progressive Matrices (RAPMs) a. This intelligence test is well validated as a measure of general ability with minimal dependence on cultural factors 2. Wechsler Auditory backward digit span (BDS) a. This subtest of the Wechsler Adult Intelligence Scales loads on both short-term storage and verbal working memory functions supported by mid-ventrolateral and dorsolateral pre- frontal cortex, respectively

Proven Strategies For Decreasing General Intelligence

Strategy	Description	IQ	Evidence
Sugar			This is your brain on sugar: UCLA study shows high-fructose diet sabotages learning, memory Sugar Makes You Stupid, But Omega-3s Will Smarten You Back Up
Alcohol			
Multi-tasking			Media multitaskers pay mental price, Stanford study shows
Stress			Can stress make you dumber?
Junk food			Junk food diet may lower kids' IQ, study suggests

List Item/Topic	Study	Metadata

While you may be using more than 10% of your brain, you many not be pushing your brain past 10% of its capacity	**Study Name** **Intro** Fafdasf **Body** Copy & paste **Conclusion**	
The average IQ across the worldhas been increasing incredibly rapidly for decades	**The Flynn Effect: A Meta-analysis** **Intro** The “Flynn effect” refers to the observed rise in IQ scores over time, resulting in norms obsolescence. Flynn’s study revealed a 13.8-point increase in IQ scores between 1932 and 1978, amounting to a 0.3-point increase per year, or approximately 3 points per decade. **Body** Although the Flynn effect is widely accepted, most approaches to estimating it have relied upon “scorecard” approaches that make estimates of its magnitude and error of measurement controversial and prevent determination of factors that moderate the Flynn effect across different IQ tests. We conducted a meta-analysis to determine the magnitude of the Flynn effect with a higher degree of precision, to determine the error of measurement, and to assess the impact of several moderator variables on the mean effect size.	1. Meta-analysis 2. Lisa Trahan, Karla K. Stuebing, Merril K. Hiscock, and Jack M. Fletcher 3. 2014 4. Psychological Bulletin

	Conclusion Across 285 studies (N = 14,031) since 1951 with administrations of two intelligence tests with different normative bases, the metaanalytic mean was 2.31, 95% CI [1.99, 2.64], standard score points per decade. The mean effect size for 53 comparisons (N = 3,951) (excluding three atypical studies that inflate the estimates) involving modern (since 1972) Stanford-Binet and Wechsler IQ tests (2.93, 95% CI [2.3, 3.5], IQ points per decade) was comparable to previous estimates of about 3 points per decade, but not consistent with the hypothesis that the Flynn effect is diminishing.	
We can drastically increase our group IQ	**Superminds: The Surprising Power of People and Computers Thinking Together** **Intro** If you're like most people, you probably believe that humans are the most intelligent animals on our planet. But there's another kind of entity that can be far smarter: groups of people. In this groundbreaking book, Thomas Malone, the founding director of the MIT Center for Collective Intelligence, shows how groups of people working together in superminds -- like hierarchies, markets, democracies, and communities -- have been responsible for almost all human achievements in business, government, science, and beyond. And these collectively intelligent human groups are about to get much smarter. **Body** **Conclusion**	1. Book 2. Thomas W. Malone 3. 2018
	Evidence for a Collective Intelligence Factor in the Performance of Human Groups **Intro** Psychologists have repeatedly shown that a single statistical factor—often called “general intelligence”—emerges from the correlations among people’s performance on a wide variety of	1. Study 2. Anita Williams Woolley, Christopher F. Chabris, Alex

	cognitive tasks. **Body** [No] one has systematically examined whether a similar kind of “collective intelligence” exists for groups of people. In two studies with 699 people, working in groups of two to five, we find converging evidence of a general collective intelligence factor that explains a group’s performance on a wide variety of tasks. **Conclusion** This “c factor” is not strongly correlated with the average or maximum individual intelligence of group members but is correlated with the average social sensitivity of group members, the equality in distribution of conversational turn-taking, and the proportion of females in the group.	Pentland, Nada Hashmi, Thomas W. Malone 3. 2010 4. Science
We are like a brain with 7 billion neurons		
Human culture is evolving at an exponential rate		
Anyone can increase their fluid intelligence as they age	[You Can Increase Your Intelligence: 5 Ways to Maximize Your Cognitive Potential] **Intro** We can improve our fluid intelligence. We need to think of how to simulate the same types of heavy-duty brain thrashing—using multimodal methods—that can be applied to your normal life, while still maintaining the maximum benefits, in order to get the cognitive growth. **Body**	1. Guest Blog 2. Andrea Kuszewski 3. 2011 4. Scientific American

What is "Intelligence"?

First of all, let me explain what I mean when I say the word "intelligence". To be clear, I'm not just talking about increasing the volume of facts or bits of knowledge you can accumulate, or what is referred to as crystallized intelligence—this isn't fluency or memorization training—it's almost the opposite, actually. I'm talking about increasing your fluid intelligence, or your capacity to learn new information, retain it, then use that new knowledge as a foundation to solve the next problem, or learn the next new skill, and so on.

Now, while working memory is not synonymous with intelligence, working memory correlates with intelligence to a large degree. In order to generate successfully intelligent output, a good working memory is pretty important. So to make the most of your intelligence, improving your working memory will help this significantly—like using the very best and latest parts to help a machine to perform at its peak.

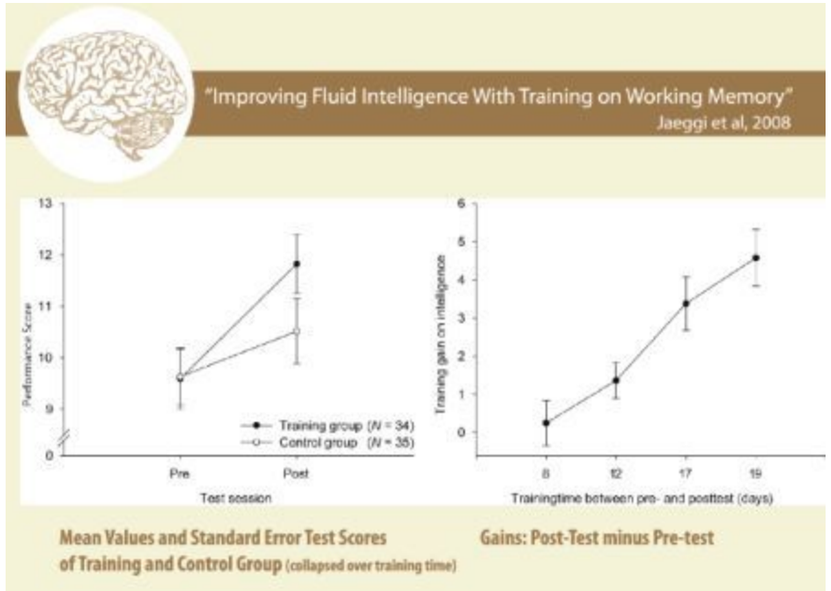
This study is relevant because they discovered:

1. Fluid intelligence is trainable.
2. The training and subsequent gains are dose-dependent—meaning, the more you train, the more you gain.
3. Anyone can increase their cognitive ability, no matter what your starting point is.
4. The effect can be gained by training on tasks that don't resemble the test questions.

So—taking all of this into account, I have come up with five primary elements involved in increasing your fluid intelligence, or cognitive ability.

1. Seek Novelty
2. Challenge Yourself
3. Think Creatively
4. Do Things The Hard Way
5. Network

	Conclusion It would be impractical to constantly practice the dual n-back task or variations thereof every day for the rest of your life to reap cognitive benefits. But it isn't impractical to adopt lifestyle changes that will have the same—and even greater cognitive benefits. These can be implemented every day, to get you the benefits of intense entire-brain training, and should transfer to gains in overall cognitive functioning as well.	
	DUAL N-BACK META-ANALYSIS Then in 2008, a very exciting study was published, Improving Fluid Intelligence with Training on Working Memory, by Jaeggi, Buschkuehl, Jonides, and Perrig. This study was pretty much a game-changer for those doing research on this topic. They showed for the first time, that it might actually be possible to increase your intelligence to a significant degree through training. What did they do different? The subjects in Jaeggi's study were trained on an intensive, multimodal (visual and auditory input) working memory task (the dual-n-back) [1] for variable lengths of time, for either one or two weeks, depending on the group. Following this training, they were tested to see how much they improved. As one would expect, after training, their scores on that task got better. But they went a step further. They wanted to see if those gains on the training task could transfer to an increase in skill on a completely different test of cognitive ability, which would indicate an increase in overall cognitive ability. What did they find? Following training of working memory using the dual n-back test, the subjects were indeed able to transfer those gains to a significant improvement in their score on a completely unrelated cognitive task. This was a super-big deal. Here's the graph of their results, and you can read about the entire study here.	1. Meta-analysis 2. Gwern Branwen 3. 2012 (modified 2018)



The take-home points from this research? This study is relevant because they discovered:
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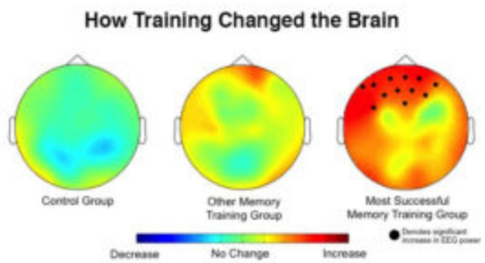
	questions" phenomenon—it was always different. If you've never taken the dual n-back test, let me tell you this: It's wicked hard. I'm not surprised there was so much cognitive gain from practicing this activity.	
	BUILDING BETTER BRAINS Yet intelligence can still be honed. Just as nutrition can in uence height, environmental variables can also either brighten or beleaguer minds [...] Many studies find that variation in working memory accounts for at least 25 percent of the variation in uid intelligence among individuals. Our own research con rms that inculcating this skill can lead to higher scores on standard tests of uid intelligence for children and adults alike.	1. Article 2. John Jonides, Susanne M. Jaeggi, Martin Buschkuehl and Priti Shah 3. 2012 4. Scientific American Mind
	Johns Hopkins Finds Training Exercise That Boosts Brain Power Though this exercise [dual n-back] didn't make anyone smarter, it greatly improved skills people need to excel at school and at work. These results, published this week by the Journal of Cognitive Enhancement, suggest it's possible to train the brain like other body parts — with targeted workouts. This one task seems to show the most consistent results and the most impact on performance and should be the one we focus on if we're interested in improving cognition through training. **Methods** [The] team assembled three groups of participants, all young adults. Everyone took an initial battery of cognitive tests to determine baseline working memory, attention and intelligence. Everyone also got an electroencephalogram (EEG) to measure brain activity. Then, everyone was sent home to practice a computer task for a month. One group used one leading brain	1. Press Release 2. Jill Rosen/JHU 3. 2017 4. Johns Hopkins University

	exercise while the second group used the other. The third group practiced on a control task. Everyone trained five days a week for 30 minutes, then returned to the lab for another round of tests to see if anything about their brain or cognitive abilities had changed. **Conclusion** The researchers found that the group that practiced what's known as a "dual n-back" exercise showed a 30 percent improvement in their working memory. That was nearly double the gains made by the group working with the other common task, known as "complex span."	
	[N-back Versus Complex Span Working Memory Training] Dual n-back exercise, 30 minutes, 5 days a week resulted in 30% increase in working memory after 1 month. The dual n-back group also showed significant changes in brain activity in the prefrontal cortex, the critical region responsible for higher learning.  	1. Article 2. Kara J. Blacker, Serban Negoita1, Joshua B. Ewen, Susan M. Courtney 3. 2017 4. Journal of Cognitive Enhancement
	[Psychobiology of plasticity: effects of training and experience on brain and behavior] **Intro**	1. Review paper 2. Mark R. Rosenzweig,

The brain of adults is incredibly plastic	This paper [reviews] several related topics: (1) research that first demonstrated use-dependent plasticity of the nervous system; (2) generalization of these findings over the entire life span and to several species; (3) extensions of this research; and (4) applications. **Body** Supporting Hebb's 1949 hypothesis of use-induced plasticity of the nervous system, our group found in the 1960s that training or differential experience induced neurochemical changes in cerebral cortex of the rat and regional changes in weight of cortex. Further studies revealed changes in cortical thickness, size of synaptic contacts, number of dendritic spines, and dendritic branching. Similar effects were found whether rats were assigned to differential experience at weaning (25 days of age), as young adults (105 days) or as adults (285 days). Enriched early experience improved performance on several tests of learning. Cerebral results of experience in an enriched environment are similar to results of formal training. Enriched experience and training appear to evoke the same cascade of neurochemical events in causing plastic changes in brain. Sufficiently rich experience may be necessary for full growth of species-specific brain characteristics and behavioral potential. Clayton and Krebs found in 1994 that birds that normally store food have larger hippocampi than related species that do not store. This difference develops only in birds given the opportunity to store and recover food. **Conclusion** Training or differential experience (i.e. learning) induces changes in neurochemistry, weight, thickness, size of synaptic contacts, number of dendritic spines, and dendritic branching changes in the cerebral cortex	Edward L. Bennett 3. 1996 4. Behavioural Brain Research
	[Experience-driven brain plasticity: beyond the synapse] **Intro** The brain is remarkably responsive to its interactions with the environment, and its morphology is altered by experience in measurable ways.	1. Review paper 2. Julie A. Markham, William T. Greenough 3. 2004

	Body Histological examination of the brains of animals exposed to either a complex ('enriched') environment or learning paradigm, compared with appropriate controls, has illuminated the nature of experience-induced morphological plasticity in the brain. For example, this research reveals that changes in synapse number and morphology are associated with learning and are stable, in that they persist well beyond the period of exposure to the learning experience. In addition, other components of the nervous system also respond to experience: oligodendrocytes and axonal myelination might also be permanently altered, whereas changes in astrocytes and cerebrovasculature are more transient and appear to be activity- rather than learning driven. The complex environment paradigm, pioneered by Donald Hebb and his students involves housing a group of animals, typically either rats or mice, in a large cage that contains numerous toys, such as balls, tunnels and ladders, which are changed daily to provide a continuously stimulating environment. This complex environment is sometimes referred to as an 'enriched condition' (EC), but it is important to note that these animals are only enriched relative to rats housed in isolation or 'impoverished condition' (IC) and rats housed in a group but without toys ('social condition' or SC) rather than animals living in the wild. As Hebb's work first demonstrated, animals exposed to EC demonstrate superior performance in several tests measuring higher-order cognitive ability, such as the Hebb-Williams maze, the Morris water maze, and the radialarm maze. Additionally, although somatic growth of adult rats is slow and not very responsive to housing condition, EC still induces plasticity in the adult brain that is similar to that observed in young animals (Black et al., 1989b). **Conclusion** Thus, experience induces multiple forms of plasticity in the brain that are apparently regulated, at least in part, by independent mechanisms.	4. Neuron Glia Biology

	A major function of the brain is thus to continuously re-organize itself, and it does so in a way that is specifically tailored to result in behavior that is adaptive in the context of the individual's own unique environment.	
	[Even Old Brains Can Make New Neurons, Study Finds] Original study: [Human Hippocampal Neurogenesis Persists throughout Aging] **Intro** Adult hippocampal neurogenesis declines in aging rodents and primates. Aging humans are thought to exhibit waning neurogenesis and exercise-induced angiogenesis, with a resulting volumetric decrease in the neurogenic hippocampal dentate gyrus (DG) region, although concurrent changes in these parameters are not well studied. **Body** Here we assessed whole autopsy hippocampi from healthy human individuals ranging from 14 to 79 years of age. We found similar numbers of intermediate neural progenitors and thousands of immature neurons in the DG, comparable numbers of glia and mature granule neurons, and equivalent DG volume across ages. Nevertheless, older individuals have less angiogenesis and neuroplasticity and a smaller quiescent progenitor pool in anterior-mid DG, with no changes in posterior DG. Highlights: - Pools of quiescent stem cells are smaller in aged human hippocampal dentate gyri - Proliferating progenitor and immature neuron pools are stable with aging - Angiogenesis and neuroplasticity decline in older humans - Granule neurons, glia, and dentate gryus volume are unchanged with aging. **Conclusion** [Healthy] older subjects without cognitive impairment, neuropsychiatric disease, or treatment display preserved neurogenesis. It is possible that ongoing hippocampal neurogenesis sustains human-specific cognitive function throughout life and that declines may be linked to	1. Study 2. Maura Boldrini, Camille A. Fulmore, Alexandria N. Tartt, et al. 3. 2018 4. Cell

	compromised cognitive-emotional resilience.	
	Experiments show we quickly adjust to seeing everything upside-down **Intro** A researcher wearing goggles that inverted everything stumbled about wildly at first, but soon enough he was able to ride a bicycle **Body** Professor Theodor Erismann, of the University of Innsbruck, devised the experiment, performing it upon his assistant and student, Ivo Kohler. Kohler later wrote about it. The two of them made a documentary film. The professor made Kohler wear a pair of hand-engineered goggles. Inside those goggles, specially arranged mirrors flipped the light that would reach Kohler's eyes, top becoming bottom, and bottom top. At first, Kohler stumbled wildly when trying to grasp an object held out to him, navigate around a chair, or walk down stairs. But over the next week, Kohler found himself adapting, in fits and starts, then more consistently, to such sights. After 10 days, he had grown so accustomed to the invariably upside-down world that, paradoxically and happily, everything seemed to him normal, rightside-up. Kohler could do everyday activities in public perfectly well: walk along a crowded sidewalk, even ride a bicycle. Passersby on the street did ogle the man, though, because his eyewear looked, from the outside, unfashionable. **Conclusion** Their impression is that many, perhaps most, maybe just about all, people are able to make	1. Science journalism 2. Marc Abrahams 3. 2012 4. The Guardian

	these kinds of adjustment. Images reach the eye in some peculiar fashion, and if that peculiar fashion is consistent, a person's visual system eventually, somehow, adjusts to interpret it — to perceive it, to see it — as being no different from normal. Kohler writes that, "after several weeks of wearing goggles that transposed right and left, one person "became so at home in his reversed world that he was able to drive a motorcycle through Innsbruck while wearing the goggles".	
	Adaptation to left–right reversed vision rapidly activates ipsilateral visual cortex in humans **Intro** Yugi Sugita [Nature 380 (1996) 523] found that after adaptation to left–right reversed vision for one and a half months, monkey V1 neurons responded to stimuli presented not only in the contralateral visual field, but also in the ipsilateral visual field. **Body** To identify the underlying neuronal mechanisms of adaptation to visual transposition, we conducted fMRI and behavioral experiments for which four adult human subjects wore left–right reversing goggles for 35/39 days The results of behavioral experiments showed that visuomotor coordinative function and internal representation of peripersonal space rapidly adapted to the left–right reversed vision within the first or second week. Accompanying these behavioral changes, we found that both primary (V1) and extrastriate (MT/MST) visual cortex in human adults responded to visual stimuli presented in the ipsilateral visual field. In addition, the ipsilateral activity started much sooner than the one and a half months, which had been expected from the monkey neurophysiological study. **Conclusion** The results of the present study serve as physiological evidence of large-scale, cross-hemisphere, cerebral plasticity that exists even in adult human brain.	1. Study 2. Satoru Miyauchi, Hiroyuki Egusa, Masahiro Amagase, et al. 3. 2004 4. Journal of Physiology - Paris

Anyone can increase their mental complexity as they age		
We can increase the speed at which we learn by learning how to learn		
Sleep, diet, and exercise make a huge difference - linking a few articles.	This Common Activity Is Reducing Your IQ, According to Research The performance gap caused by an hour's difference in sleep was bigger than the gap between a normal fourth-grader and a normal sixth-grader. Which is another way of saying that a slightly-sleepy sixth-grader will perform in class like a mere fourth-grader. "A loss of one hour of sleep is equivalent to [the loss of] two years of cognitive maturation and development," Sadeh explained.	1. Article 2. Eric Barker 3. 2015 4. TIME
	Missing sleep for just one night can lower your IQ As neuroscientist Dr. Tara Swart tells CNN, disturbances to healthy sleep patterns can cause your IQ to drop by five to eight points, and missing out on just a single night of sleep can reduce your IQ by one standard deviation	1. Article/interview 2. - 3. - 4. Nutrivene
	Moderate Physical Activity is Associated with Cerebral Glucose Metabolism in Adults at Risk for Alzheimer's Disease **Introduction** The objective of this study was to investigate the relationship between accelerometer-measured physical activity (PA) and glucose metabolism in asymptomatic late-middle-aged adults.	1. Study 2. Ryan J. Dougherty, Stephanie A. Schultzb, Taylor K. Kirby, et al. 3. 2017 4. Journal of

	Body There were associations between MPA (moderate physical activity) and glucose metabolism in all ROIs examined. In contrast, LPA (light physical activity) was not associated with glucose uptake in any ROI and VPA (vigorous physical activity) was only associated with hippocampal FDG uptake. **Conclusion** 68 minutes of moderate physical activity a day (moderate physical activity) is most effective in increasing cerebral glucose metabolism, which increases hippocampal volume and helps prevent memory loss and Alzheimer's disease	Alzheimer's Disease
	Poor childhood diet linked to low IQ, suggests study A diet high in fats, sugars, and processed foods in early childhood may result in lower IQ scores, while a diet rich in healthy foods packed with vitamins and nutrients may work in reverse, suggests new research.	1. Article 2. Nathan Gray 3. 2011 4. Food Navigator
	Physical exercise increases adult hippocampal neurogenesis in male rats provided it is aerobic and sustained Key finding: aerobic exercise enhances adult hippocampal neurogenesis (AHN), but high-intensity interval training and anaerobic resistance training have little to no effect on AHN. Duration: 6-8 weeks (3 trials with varying durations of 6, 7, and 8 weeks)	1. Study 2. Miriam S. Nokia, Sanna Lensu, Juha P. Ahtiainen, et al 3. 2016 4. The Journal of Physiology

	Frequency difficult to estimate because this was a rodent model and no translation was given for human exercise	
	Multi-modal fitness and cognitive training to enhance fluid intelligence Contrary to popular belief, physical exercise or meditation alone are not sufficient in increasing in fluid intelligence and mental processing; rather a multi-modal approach incorporating physical and mental training is recommended. Effect size of this conclusion = 0.72 for fitness + cognitive training intervention In terms of IQ: effect size of 0.2 for IQ = 3 IQ points; 0.7 = equivalent of **10.5 IQ points** From journal overview: • Fitness-cognitive-mindfulness interventions were designed to bolster intelligence. • Fitness-cognitive training showed control-adjusted gains in visuospatial reasoning. • Fitness only training did not bolster fluid intelligence performance. • Individuals varied in benefits to fluid intelligence from mindfulness training.	1. Study 2. Ana M Daugherty, Christopher Zwilling, Erick J Paul 3. 2018 4. Intelligence
	Adult Neurogenesis and Hippocampal Memory Function: New Cells, More Plasticity, New Memories? New neurons have physiologically different properties (e.g. increased excitability). Studies suggest that newly generated neurons in the adult hippocampus can enhance the synaptic plasticity and modulate the neural network through their unique physiologic properties. Promoting the survival of newly generated neurons in the process of learning may be useful and effective to shift the neural population from the existing status, in which old neurons are	1. Review 2. Yasuji Kitabatake, Kurt A. Sailor, Guo-li Ming, MD, et al. 3. 2017 4. Neurosurgery Clinics of North America

	tightly incorporated with each other, to a more flexible condition, with increased excitability and synaptic plasticity It can be reasoned that it is faster, and more biologically cost-effective, to reconstruct the neural network by increasing the “plasticity index” of the hippocampus by increasing the number of young neurons causing elevated regional plasticity rather than by remodeling the developmentally born, old established network.	
	Involvement of Adult Hippocampal Neurogenesis in Learning and Forgetting Adult hippocampal neurogenesis is a process involving the continuous generation of newborn neurons in the hippocampus of adult animals. Mounting evidence has suggested that hippocampal neurogenesis contributes to some forms of hippocampus-dependent learning and memory; however, the detailed mechanism concerning how this small number of newborn neurons could affect learning and memory remains unclear. In this review, we discuss the relationship between adult-born neurons and learning and memory, with a highlight on recently discovered potential roles of neurogenesis in pattern separation and forgetting.	1. Review 2. Sonata Suk-Yu Yau, Ang Li, Kwok-Fai So 3. 2015 4. Neural Plasticity
Nootropics	Oral creatine monohydrate supplementation improves brain performance: a double-blind, placebo-controlled, cross-over trial Taking a 5g creatine supplement daily for six weeks improved working memory, intelligence, and mental processing in healthy individuals Two cognitive tests were used: 1. Raven’s Advanced Progressive Matrices (RAPMs) a. This intelligence test is well validated as a measure of general ability with minimal dependence on cultural factors 2. Wechsler Auditory backward digit span (BDS)	1. Study 2. Caroline Rae, Alison L. Digney, Sally R. McEwan, Timothy C. Bates 3. 2003 4. Proceedings of the Royal Society B: Biological Sciences

	a. This subtest of the Wechsler Adult Intelligence Scales loads on both short-term storage and verbal working memory functions supported by mid-ventrolateral and dorsolateral pre- frontal cortex, respectively	
	Cognitive effects of creatine monohydrate adjunctive therapy in patients with bipolar depression: Results from a randomized, double-blind, placebo-controlled trial Dose: 6 g/day for 6 weeks Results showed improvement in verbal fluency in patients with bipolar depression. Effect size = 1.252	1. Study 2. Ricardo Alexandre Toniolo, Francy de Brito Ferreira, Fernandes, Michelle, Silva 3. 2017 4. Journal of Affective Disorders
	Effects of creatine supplementation on cognitive function of healthy individuals: A systematic review of randomized controlled trials. Generally, there was evidence that short term memory and intelligence/reasoning may be improved by creatine administration. Regarding other cognitive domains, such as long-term memory, spatial memory, memory scanning, attention, executive function, response inhibition, word fluency, reaction time and mental fatigue, the results were conflicting. Performance on cognitive tasks stayed unchanged in young individuals. Vegetarians responded better than meat-eaters in memory tasks but for other cognitive domains no differences were observed. Oral creatine administration may improve short-term memory and intelligence/reasoning of healthy individuals but its effect on other cognitive domains remains unclear. Findings suggest potential benefit for aging and stressed individuals.	1. Meta-analysis 2. Konstantinos I. Avgerinosa, Nikolaos Spyroua, Konstantinos I. Bougioukas, et al. 3. 2018 4. Experimental Gerontology

	A review of caffeine's effects on cognitive, physical and occupational performance Caffeine, in doses up to approximately 300 mg (~4 mg kg-1), enhances a wide array of basic cognitive functions with minimal side effects by preventing alertness and attention decrements associated with suboptimal arousal The effects of caffeine on higher-order executive skills, complex judgments, emotional discernment, and decision-making are unclear and require further study The ability of caffeine to enhance cognitive and physical function is dose-dependent. Doses of approximately 0.5–4.0 mg kg-1 (~40–300 mg) can improve cognitive function in rested individuals, whereas doses of 3–7 mg kg-1 (~200–500 mg) ingested approximately 1 h prior to exercise can enhance physical performance. However, response to a given dose shows large inter-individual variation; Caffeine is an effective strategy to counter both physical and cognitive degradation associated with sleep loss.	1. Review 2. Tom M. McLellan, John A. Caldwell, Harris R. Lieberman 3. 2016 4. Neuroscience and Biobehavioral Reviews
Curiosity increases memory	States of Curiosity Modulate Hippocampus-Dependent Learning via the Dopaminergic Circuit Abstract: People find it easier to learn about topics that interest them, but little is known about the mechanisms by which intrinsic motivational states affect learning. We used functional magnetic resonance imaging to investigate how curiosity (intrinsic motivation to learn) influences memory. In both immediate and one-day-delayed memory tests, participants showed improved memory for information that they were curious about and for incidental	1. Study 2. Matthias J. Gruber, Bernard D. Gelman, Charan Ranganath 3. 2014 4. Cell

	material learned during states of high curiosity. Functional magnetic resonance imaging results revealed that activity in the midbrain and the nucleus accumbens was enhanced during states of high curiosity. Importantly, individual variability in curiosity-driven memory benefits for incidental material was supported by anticipatory activity in the midbrain and hippocampus and by functional connectivity between these regions. These findings suggest a link between the mechanisms supporting extrinsic reward motivation and intrinsic curiosity and highlight the importance of stimulating curiosity to create more effective learning experiences. Highlights: 1) People are better at learning information that they are curious about 2) Memory for incidental material presented during curious states was also enhanced 3) Curiosity associated with anticipatory activity in nucleus accumbens and midbrain 4) Memory benefits for incidental material depend on midbrain-hippocampus involvement	

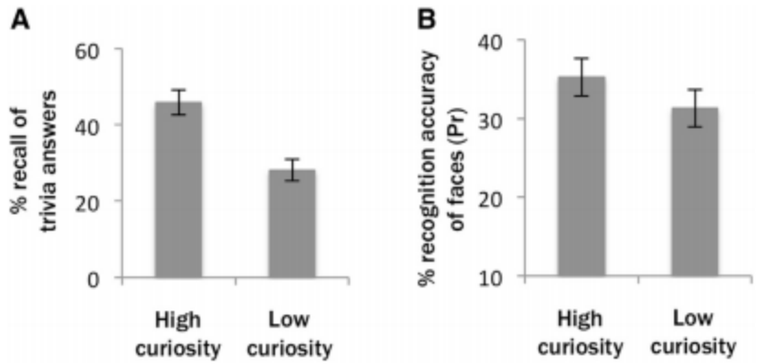


Figure 5. Follow-Up Behavioral Experiment Replicates Curiosity-Driven Memory Benefits for Interesting and Incidental Material over a 1-Day Retention Interval

(A) Participants recalled more answers to high-curiosity trivia questions than answers to low-curiosity questions.

(B) Participants showed higher rates of confident recognition for faces that were encoded during states of high curiosity than for faces encoded on low-curiosity trials. Error bars represent ±1 SEM.

Keywords

Article

Keywords		

Intelligence		
Smart		
Genius		

Academic

Categories	**Keywords**	**Definitions**	**Examples**
Measures	Crystallized Intelligence	volume of facts or bits of knowledge you can accumulate	
	Fluid Intelligence	capacity to learn new information, retain it, then use that new knowledge as a foundation to solve the next problem, or learn the next new skill, and so on.	
	Working Memory	• Working memory correlates with and predict performance on many cognitive tasks (intelligence, reading comprehension, math, academic achievement, etc.) • Limited to 7 bits of data +/- 2 • Can only work with three variables at once • A cognitive system responsible for strong and manipulating a limited amount of information for a short time.	• Multipying 56 by 13 in your head • Reading a complex paragrph • Taking notes while following a lecture
	G-Factor (general intelligence, general mental ability or general intelligence factor)	Research in the field of behavioral genetics has established that the construct of g is highly heritable. It has a number of other biological correlates, including brain size. It is also a significant predictor of individual differences in many social outcomes, particularly in education and employment. The most widely accepted contemporary theories of intelligence incorporate the g factor.[4] However, critics of g have contended that an emphasis on g is misplaced and entails a devaluation of other important abilities, as well as supporting an unrealistic reified view of human intelligence. • It is universal inborn ability. • It is general mental energy. • It is constant.	

		• The amount of ‘g’ differs from individual to individual. • It is used in every activity of life. • Greater the ‘g’ in an individual, greater is his success in life. • An individual's performance on one type of cognitive task tends to be comparable to that person's performance on other kinds of cognitive tasks.	
	g-Factor	• It is learned and acquired in the environment. • It varies from activity to activity in the same individual. • Individuals differ in the amount of ‘S’ ability.	
Approaches To Measurement	Factor Analytic		
	Brain Plasticity	Neurons lose connections and make new connections, the connections become stronger and weaker, even new neuron can be incorporated into the vast network. Plasticity allows for a blind person to hear and feel better, why? because that part of the brain used for visual processing can be tweaked to deal with other types of sensory information. But there are limits to this, there are parameters set by biology and evolution to the extent that these systems can change, not everything goes.	
	Myelin	The fatty insulation that makes signals go faster,	
	Intelligence Testing	On one hand, intelligence testing is one of the great successes of psychology (Hunt, 2011). Intelligence test scores predict many real world phenomena and have many well-validated practical uses (Gottfredson, 1997; Deary et al., 2010). Intelligence test scores also correlate to structural and functional brain parameters assessed with neuroimaging (Haier et al., 1988; Jung and Haier, 2007; Deary et al., 2010; Penke et al., 2012; Colom et al., 2013a) and to genes (Posthuma et al., 2002; Hulshoff Pol et al., 2006; Chiang et al., 2009, 2012; Stein et al., 2012).	
	Intelligence Testing Standard Error	Intelligence tests generally show high test-retest reliability but they also have a standard error, and the standard error is often larger for higher scores than for lower scores. Any intelligence test score change after an intervention needs to be considered relative to the standard error of the test. Studies that use a	

		single test to estimate intelligence before and after an intervention are using less reliable and more variable scores (bigger standard errors) than studies that combine scores from a battery of tests.	
	Parieto-Frontal Integration Theory of Intelligence (P-FIT)	Describes a network of frontal and parietal brain regions as the main neural basis of intelligence. The theory proposes that large scale brain networks connect brain regions, including regions within frontal, parietal, temporal, and cingulate cortices, underlie the biological basis of human intelligence. These regions, which overlap significantly with the Task-Positive Network, allow the brain to communicate and exchange information efficiently with one another. Support for this theory is primarily based on neuroimaging evidence, with support from lesion studies. The P-FIT is influential in that it explains the majority of current neuroimaging findings, as well as increasing empirical support for cognition being the result of large-scale brain networks, rather than numerous domain-specific processes or modules.[1] Indeed, a review of the neuroscience of intelligence argues that the P-FIT is "the best available answer to the question of where in the brain intelligence resides".[2] ● http://www.sciencedirect.com/science/article/pii/S0160289615000562	
	Brain Training		
	Cognitive Training		

- Cognitive engineering
- Hacking Intelligence
- Meta Intelligence - **Enabled with BCI and AI, humans will become massively connected with each other and billions of AIs (computers) via the cloud, analogous to the first multicellular lifeforms 1.5 billion years ago. Such a massive interconnection will lead to the emergence of a new global consciousness, and a new organism I call the Meta-Intelligence.**
- Nootropics
    - Qualia
- Augmentation
    - Intelligence augmentation (IA)
    - Neural lace

- CTRL-Labs
- Brainport -

BrainPort is a technology whereby sensory information can be sent to one's brain through an electrode array which sits atop the tongue.[1] It was initially developed by Paul Bach-y-Rita as an aid to people's sense of balance, particularly of stroke victims. Bach-y-Rita founded *Wicab* in 1998.[2][3][4]

It has also been developed for use as a visual aid, demonstrating its ability to allow a blind person to see his or her surroundings in polygonal and pixel form. In this scenario, a camera picks up the image of the surrounding, the information is processed by a chip which converts it into impulses which are sent through an electrode array, via the tongue, to the person's brain. The human brain is able to interpret these impulses as visual signals and they are then redirected to the visual cortex, allowing the person to "see." This is similar in part to how a cochlear implant works, in that it transmits electrical stimuli to a receiving device in the body. [5] [6]

The BrainPort V100 oral electronic vision aid was approved by the Food and Drug Administration (FDA) on June 18, 2015.[7]

- BCI
- Human Computation Problems - Large-scale computational problems often cannot be solved by either computer or humans alone.
- Human computer interaction (HCI)
- **Intelligence amplification** (**IA**) (also referred to as **cognitive augmentation** and **machine augmented intelligence**

Bottlenecks

- BCI
  - **Output.** Even when speaking to a computer program like Alexa or Siri, you can convey at most about 40 bits per second of information and only for short bursts. Compare that to data transfer records of a trillion bits per second along a fiber-optic cable.
  - Electronics irritate its tissue and stop working after a while, and no one will get brain surgery just in order to send an e-mail.
  - Even if you can communicate with the brain, you might not know what it is saying.
- HCI

http://nautil.us/issue/28/2050/dont-worry-smart-machines-will-take-us-with-them

“But advances in genomics—both in our ability to relate complex traits to the underlying genetic codes, and the ability to make direct edits to genomes—will allow rapid advances in biologically-based cognition.”

ut perhaps we will experience a positive feedback loop: Better human minds invent better machine learning methods, which in turn accelerate our ability to improve human DNA and create even better minds.

The feedback loop between algorithms and genomes will result in a rich and complex world, with myriad types of intelligences at play: the ordinary human (rapidly losing the ability to comprehend what is going on around them); the enhanced human (the driver of change over the next 100 years, but perhaps eventually surpassed); and all around them vast machine intellects, some alien (evolved completely in silico) and some strangely familiar (hybrids). Rather than the standard science-fiction scenario of relatively unchanged, familiar humans interacting with ever-improving computer minds, we will experience a future with a diversity of both human and machine intelligences. For the first time, sentient beings of many different types will interact collaboratively to create ever greater advances, both through standard forms of communication and through new technologies allowing brain interfaces. We may even see human minds uploaded into cyberspace, with further hybridization to follow in the purely virtual realm. These uploaded minds could combine with artificial algorithms and structures to produce an unknowable but humanlike consciousness. Researchers have recently linked mouse and monkey brains together, allowing the animals to collaborate—via an electronic connection—to solve problems. This is just the beginning of “shared thought.”

People

People	Description	Bio	Email

Spearman			
Arthur Jensen	• Major proponent of the hereditarian position • Author of more than 300 articles, book chapters and books		
Susan Jaeggi	• Associate Professor Professor • School of Education • Courtesy Appointment, Cognitive Sciences • School of Social Sciences • Fellow, Center for the Neurobiology of Learning and Memory	Susanne Jaeggi (read: /ˈyakee/) grew up in a tiny village 5,407 ft above sea level in the mountains of Switzerland. She found her way down to Bern, where she completed her Ph.D.s in Psychology and Neuroscience. She later moved to Ann Arbor to expand her horizon as a Post-Doc at the University of Michigan, before joining the Department of Psychology and the Program in Neuroscience and Cognitive Science (NACS) at the University of Maryland as an Assistant Professor. She is now an Associate Professor at the UCI School of Education where she directs the Working Memory and Plasticity Laboratory. She also has a courtesy appointment in the Department of Cognitive Sciences, and is a Fellow at the UCI Center for the Neurobiology of Learning and Memory. As a Cognitive Neuroscientist and Experimental Psychologist, she has a broad interest in general processes of working memory and related higher cognitive functions, and within that domain, the investigation of cognitive training and transfer is one of her current major foci of research. She strives to determine what training regimens and training conditions result in the best transfer effects,	smjaeggi@uci.edu

		investigate the underlying neural and cognitive mechanisms, and finally, investigate for what populations and individuals cognitive training is most effective.	

- Bryan Johnson, Kernel
- Elon Musk, Neuralink
- Terry Winograd
    - Stanford
    - Advised google founder

Resources

Cognitive Architectures and Autonomy: A Comparative Review One of the original goals of artificial intelligence (AI) research was to create machines with very general cognitive capabilities and a relatively high level of autonomy. It has taken the field longer than many had expected to achieve even a fraction of this goal; the community has focused on building specific, targeted cognitive processes in isolation, and as of yet no system exists that integrates a broad range of capabilities or presents a general solution to autonomous acquisition of a large set of skills. Among the reasons for this are the highly limited machine learning and adaptation techniques available, and the inherent complexity of integrating numerous cognitive and learning capabilities in a coherent architecture. In this paper we review selected systems and architectures built expressly to address integrated skills. We highlight principles and features of these systems that seem promising for creating generally intelligent systems with some level of autonomy, and discuss them in the context of the development of future cognitive architectures. Autonomy is a key property for any system to be considered generally intelligent, in our view; we use this concept as an organizing principle for comparing the reviewed systems. Features that remain largely unaddressed in present research, but seem nevertheless necessary for such efforts to succeed, are also discussed.	Academic Article 2012

Ray Kurzweil: Get Ready For Hybrid Thinking	Ray Kurweil TED Talk 2014
Genome-wide association meta-analysis of 78,308 individuals identifies new loci and genes influencing human intelligence Intelligence is associated with important economic and health-related life outcomes[1]. Despite intelligence having substantial heritability[2] (0.54) and a confirmed polygenic nature, initial genetic studies were mostly underpowered[3, 4, 5]. Here we report a meta-analysis for intelligence of 78,308 individuals. We identify 336 associated SNPs (METAL $P < 5 \times 10^{-8}$) in 18 genomic loci, of which 15 are new. Around half of the SNPs are located inside a gene, implicating 22 genes, of which 11 are new findings. Gene-based analyses identified an additional 30 genes (MAGMA $P < 2.73 \times 10^{-6}$), of which all but one had not been implicated previously. We show that the identified genes are predominantly expressed in brain tissue, and pathway analysis indicates the involvement of genes regulating cell development (MAGMA competitive $P = 3.5 \times 10^{-6}$). Despite the well-known difference in twin-based heritability[2] for intelligence in childhood (0.45) and adulthood (0.80), we show substantial genetic correlation ($rg = 0.89$, LD score regression $P = 5.4 \times 10^{-29}$). These findings provide new insight into the genetic architecture of intelligence.	*Nature Genetics* **49**, 1107–1112 (2017) doi:10.1038/ng.3869 Received 10 January 2017 Accepted 24 April 2017 Published online 22 May 2017 Corrected online **31 May 2017**
Three Types of Intelligence Augmentation: A Thought Experiment Imagine watching a math competition. Three seemingly smart individuals compete on stage to answer a series of hard questions. The final result is a three-way tie. Later you learn that these three individuals, who resemble each other externally, are actually very different on the inside.	Jon Perry 2013 Blog

The first individual is a math professor who's spent his entire life studying the subject. The second individual has only studied math up to the high school level. However, a revolutionary new smart drug has increased his brain functioning to the point that he can learn and master new math concepts as soon as he is exposed to them. The third individual has no knowledge of math whatsoever. But a smart earpiece connected to the internet feeds him the right answers at lightning speed. These three individuals are analogous to the three different types of intelligence augmentation. The first type, education, optimizes the existing brain for a particular task. The second, enhancement, upgrades the brain's ability to master new tasks. And the third method, extension, offloads the task to an external module. Interestingly, from an outsider perspective, the functional result of all three methods can appear to be the same. But the conscious experience of the individual in question is qualitatively different.	
Neuralink and the Brain's Magical Future	*Tim Urban* *Wait But Why* *2017* *Longform Article*

https://www.edge.org/conversation/pattie_maes-intelligence-augmentation

MAES: Jaron and I already had our debate on Hot Wired's "brain tennis" pages. We've already gone through this whole thing. But let me continue. I talked initially about very simple agents that would be completely programmed, like the milk monitor in your fridge; I talked about agents that can do some machine learning and that can pick up patterns and offer to automate them. A third approach that we have been pursuing the most actively is one where agents are not necessarily smart at all themselves, but what they do is they allow you to benefit from the intelligence of other people that have solved the problem that you are currently dealing with.

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https://www.inverse.com/article/20322-elon-musk-neural-lace-progress

Neural lace - elon musk

> Neural lace is, in effect, a computer interface woven into the brain. The idea dates back to science fiction author Iain M. Banks's *Culture* series: In these, neural lace basically enabled its bearers to access Google in thought. As the neural lace grew with the brain and understood each recipient's brain's makeup, it could alsorestore consciousness after bodily death. The lace picks up on neuronal communication but does not necessarily interfere with the signals.

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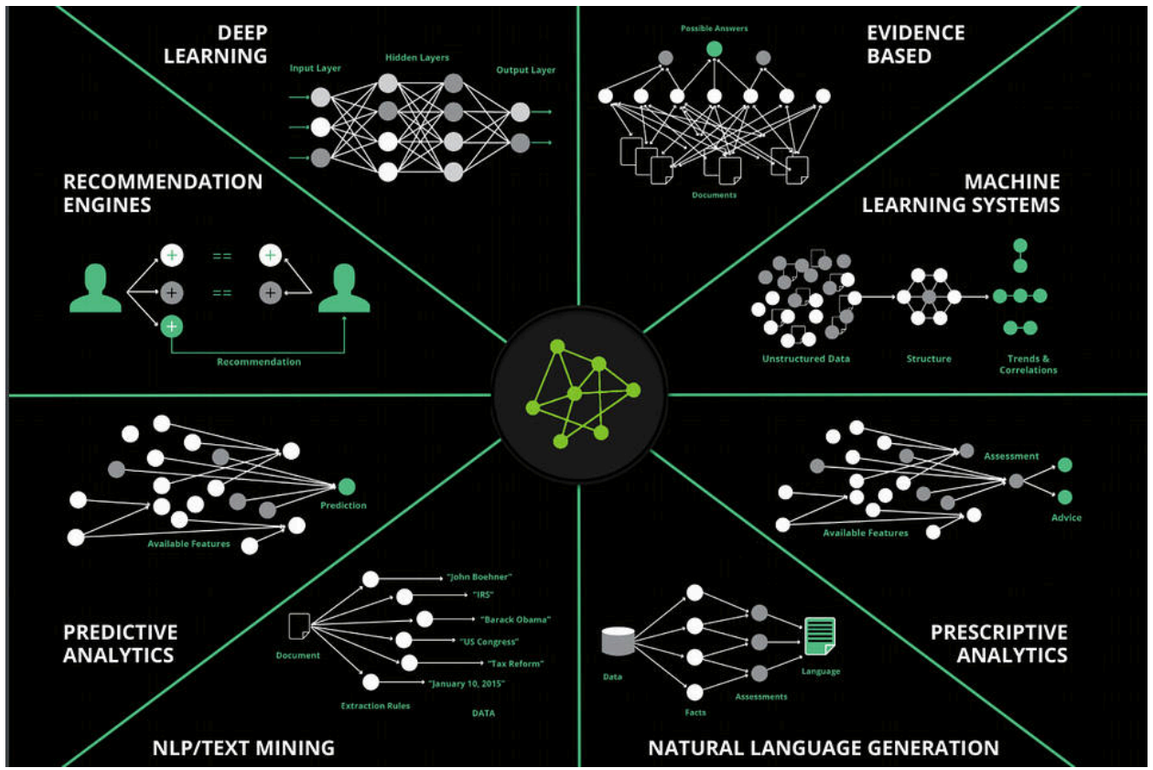
https://www.edge.org/conversation/pattie_maes-intelligence-augmentation

http://www.financialsense.com/contributors/guild/artificial-intelligence-vs-intelligence-augmentation-debate

https://en.wikipedia.org/wiki/Intelligence_amplification

People

- Stephen Hsu, [Cognitive Genomics Lab]



Some of the artificial intelligence (AI) algorithms currently helping machines think. *Credit: CIO Journal/Narrative Science*